Department of Electrical and Computer Engineering Graduate Student Handbook

It will be helpful for you to read the Graduate Studies Handbook to become familiar with the policies and procedures of the program. We hope you find your time at the University of Minnesota to be challenging and rewarding.

Please also review the New or Revised University-wide Graduate Education Policies.

For questions or concerns about information in the ECE Graduate Handbook or graduate policies, please contact Linda Jagerson (phone: 612-625-3564; email: jager001@umn.edu)

Contents

The Graduate School has provided some links that you might find helpful. Please see link.

Ph.D. Degree and Credit Requirements

Please review the Graduate School's degree completion steps.

EE PhD Credit Requirements

You must file your Graduate Degree Plan **before** you begin your fifth semester of study. Only coursework used to satisfy degree requirements should be listed on the Graduate Degree Plan.

EE Major Field Coursework Requirement = 14

- All major coursework must be taken A-F.
- All major course work must be numbered EE 5XXX or EE 8XXX.
- Coursework that is cross listed with another department must be registered as an EE course, not the cross listed department to be counted toward degree requirements.
- No seminars, special investigation or directed study coursework may be applied toward meeting the major field requirements.

Non-EE Coursework Requirement = 12

- All Non-EE coursework must be taken A-F.
- All Non-EE coursework must be College of Science and Engineering courses unless you have the non-CSE course pre-approved by the Director of Graduate Studies. Acceptance must be in writing and attached to the Degree Plan at the time of submission.
- Non-EE coursework that is cross listed with Electrical Engineering does not count toward the non-EE coursework requirement.
- Non-EE 4XXX coursework will only be accepted from the following list: **Non-EE 4000 Level Courses Acceptable for Graduate Credit (effective June 2014)** in Appendix A and are subject to the **4XXX Coursework Rule**.*
- Beginning Fall 2015, non-EE 5xxx coursework will only be accepted from the following list: **Non-Electrical Engineering 5xxx Level Approved List of Courses (Effective fall 2015)** in Appendix B.
- No seminars, special investigation or directed study coursework may be applied toward meeting the Non-EE course requirement.
- To designate a minor, please talk with the minor department to learn their requirements.

Additional Coursework Credits = 14

- Additional credits must be College of Science and Engineering coursework (includes Electrical Engineering).
- Can include up to 8 MS thesis credits.
- Cannot include EE 8965 Plan C Project.
- Can include 4XXX coursework subject to the 4XXX coursework rule*
- Can include up to 2 credits of seminars (S-N) or special investigation/directed study (A-F) type courses (except department seminars like EE 8970 and EE 8980) (topics seminars like

magnetics seminar or communications seminar are examples of seminars that may be used toward meeting additional coursework credits).

Ph.D. Thesis Credit Requirement (EE 8888) = 24

Total Credits for the Degree = 64

Department 6 Credit 8XXX Requirement

Your program must include 6 credits at the 8XXX level. Courses can be EE or Non-EE (College of Science and Engineering). Coursework must be regular coursework. Seminars, directed study/special investigations may not be used to satisfy this requirement.

A minimum of 12 course credits and 24 Ph.D. thesis credits must be taken at the University of Minnesota.

**4XXX Coursework Rule*

A maximum of nine 4000-level course credits may be used to satisfy doctoral degree requirements.
Of these, only six credits may be EE 4000-level (regular coursework, no seminars, projects, directed study courses).
Do not list more than nine credits of 4000-level coursework on your degree plan. Partial credits from a course are not accepted.
Non-EE 4XXX coursework will only be accepted from the **Non-EE 4000 Level Courses Acceptable for Graduate Credit (effective June 2014)** list in Appendix A.

Curricular Practical Training (CPT)

EE 5990 Curricular Practical Training (CPT) does not count toward degree requirements and should not be listed on the Graduate Degree Plan.

Transfer Credits for the Doctoral Degree

Please see the General Information section of the Graduate School Catalog which describes in detail what can be transferred.

All transfer credits need to be approved by the Director of Graduate Studies. Students should make an appointment with the Director to go over their degree plan. Please include a copy of the transcript for the courses you want to transfer along with the syllabus for each class.

Performance Standards and Progress

- Coursework must be taken A-F unless only offered S-N.
- Minimum Graduate Degree Plan CPA for graduation is 3.3 GPA.
- Lowest grade accepted on the degree program form is 2.0 (grade C).

• Students whose GPA falls below 3.3 will have an OL registration hold placed on their account preventing further registration. To have the hold removed they will need to meet with the Director of Graduate Studies.
• Students are required to register every fall and spring term from the time of matriculation to degree conferral.
• With justification Grad 999 can be used once to satisfy fall/spring term registration requirements. Submit your request to Linda Jagerson in 3-166 Keller Hall.
• Students admitted to our program before Spring 2013 must complete their Ph.D. degree within 5 calendar years after pass the Ph.D. Preliminary Oral exam.
• Students entering the program after January 2013, must complete their degree within eight calendar years after initial enrollment in the Graduate School.
• Students unable to complete the degree within the time limits described may petition the department and the college for one extension up to 24 months.
• Students must obtain the approval of their advisor(s) and EE DGS and submit the petition for an extension at least six months prior to the end of the time limit.

Ph.D. Preliminary Written Examination

The Preliminary Written Examination must be passed by every Ph.D. candidate. The purpose of the exam is for the student to demonstrate a comprehensive knowledge of a wide range of Electrical Engineering topics and to show an understanding of the relationship among these areas. The exam also helps faculty assess the student's analytical ability, creativity, and potential for successful completion of the Ph.D. program in Electrical Engineering.

- Ph.D. students who enter the department with a Master of Science degree in Electrical Engineering must pass the Ph.D. Preliminary Written Examination during their first academic year in residence.
- Ph.D. Students who enter the department with a MS degree NOT in Electrical Engineering, must pass the examination before the end of their second academic year in residence in the Graduate School
- MS students interested in continuing on to the Ph.D., must pass the Ph.D. Preliminary Written Examination by the end of their second academic year in residence in the Graduate School.
  - MS students who pass the exam must file a request for a change of status with the Graduate School if they wish to enter the doctoral program.
  - MS students must file the request to change their status to Ph.D. no later than the second semester following passing the WPE.

NOTE: To request an exception to the above timing, file a petition with the Director of Graduate Studies with your adviser's signature and support. Submit your petition to Linda Jagerson in 3-166 Keller Hall.

Exam Date

The Ph.D. Preliminary Written Exam is typically held in November and in April.

Chances to Pass the Exam

Students have two chances to pass the exam. On rare occasions, a student may be permitted a third attempt. Such a request can only be made by the Faculty Adviser (not by the student) and must be approved by a vote of the entire faculty.

Registration

Approximately one month before the exam, Linda Jagerson will send you an e-mail which will include the date of the exam and the deadline for registering online. Students registering for the exam must declare a major Research Area. The three major Research Areas are Applied Sciences and Devices, Computer Engineering, and Systems.

GPA Requirement to take the Ph.D. Preliminary Written Exam

Students must have an average GPA of 3.3 (unless you are a new student to the Graduate Program) to take the exam. If your GPA is below 3.3 and you wish to take the Preliminary Written Exam, file a petition with the Director of Graduate Studies with your adviser's signature

and support. Submit your petition to Linda Jagerson in 3-166 Keller Hall. The petition will be reviewed by the Graduate Committee. In most cases, this petition will be approved the first time. (This rule was voted in by faculty in November 2008.)

Ph.D. Preliminary Examination Committee

The names of the Ph.D. Preliminary Examination Committee who prepare the questions for the exam will not be made available to students taking the exam.

The Ph.D. Preliminary Written Exam is Closed Book, Closed Notes.

Exam Questions

Exam questions are based on material typically covered in junior, senior and beginning graduate courses (See Appendix C). The exam consists of 13 questions (the software question was eliminated beginning Fall 2009), each question related to an advanced undergraduate or early graduate course. Each student **must** turn in answers to at least three of the questions, and *may*, turn in answers to four questions.

The decision to answer three or four questions is up to the individual graduate student taking the exam. If a student studies for and is confident of only three question areas, the decision will be clear—answer three and turn in three answers. However, if the student gets to the exam and is confident of working four of the questions and would rather have his or her grade based on the best three out of four, then they should attempt four questions and turn in four. At the end of the exam, each student will be asked to mark a form indicating which three or four answers they want graded. The graduate committee will not permit a student to turn in and designate more than four answers for grading. To view previous exams, see Past Exams and Course Information link on the Graduate Student page on the ECE web site.

Subject topics include:

- Analog and Digital Electronics
- Communications
- Computer Aided Design
- Computer Architecture
- Controls
- Digital Design
- Fields and Transmission Lines
- Magnetics
- Optics
- Power Systems and Power Electronics
- Semiconductor Devices
- Semiconductor Materials
- Signal Processing
- Software (omitted Fall 2009)

Calculator for the Exam

Standard, department owned, Texas Instruments TI-30XA engineering/scientific calculators will be distributed at the beginning of the exam for use by those taking the exam. These calculators will not be programmable and will not graph results. Students will not be allowed to bring their own calculators. All calculators will be collected at the conclusion of the exam.

Grading Steps

Pass/fail decisions will be made in three steps. First, each answer will be graded by the faculty member responsible for the question and a pass/fail grade given for the answer. These grades can be P, P-, F+, F. Second, the individual answer grades (along with numerical scores) then are made available to the Chair of the Faculty Subgroup of the major Research Area (Applied Sciences and Devices, Computer Engineering, or Systems). The Subgroup Chair calls a meeting of the faculty in the Research Subgroup. The student's performance is discussed by the faculty of that subgroup.

For those students who have turned in four questions, the three best will be considered for evaluation. Typically, a student who passes all three questions is recommended to pass the Preliminary Written Exam. A student who fails two questions fails the exam. If a student passes two questions, the student's research performance is considered. Some students who demonstrate research accomplishments and who have marginally failed one question (scored F+) may be recommended to pass the exam. All Research Subgroup faculty participate in this step.

The Subgroup Chairs send their recommendations to the Director of Graduate Studies (DGS). In the third step, the Director of Graduate Studies presents the recommendations of the subgroups at a meeting of all EE Faculty and the faculty vote on the Final Pass/Fail decisions.

When can I find out if I passed the exam?

Students can get Pass/Fail decisions and a score (P, P-, F+, F) for each question from their Faculty Advisers after the faculty meeting. No numerical score for each question will be made available. No overall ranking will be available, since the students will not be ranked.

What happens if I fail the exam?

If a student fails the exam, the student can take the exam during the next semester. Any student who wishes to defer the exam to a subsequent semester may file a petition to the Graduate Committee and must include reasons for the petition. This must be supported by the Faculty Adviser.

A student who fails the Written Preliminary Exam two times is removed from the Ph.D. program. Often students graduate with a MSEE degree. On rare occasions, a student may be permitted a third attempt. Such a request can only be made by the Faculty Adviser (and not by the student) and must be approved by voting by the entire faculty.

Can I see my graded exam?

Students who have failed the exam and want to see a copy of their graded exam should contact the Director of Graduate Studies, Prof. Murti Salapaka, at murtis@umn.edu, 5-161 Keller Hall, 612-625-7811.

What if I am not satisfied with how a problem was graded?

Any student who is not satisfied with the grading of a specific question should discuss this with his or her Faculty Adviser and the Director of Graduate Studies. The student should not contact the individual faculty member who graded that question.

Ph.D. Preliminary Oral Examination

Preliminary Oral Examination

Students take the preliminary oral examination after completing a substantial part of the coursework and passing the preliminary written examination, but before writing the dissertation. Oral prelims should take place during the third year of study.

Preliminary Oral Examining Committee

Committee assignments and updates are initiated by the student. Please see the link above.

For information on who can serve on the Preliminary Oral Examination committee, including external committee member information, please review the Committee Membership Information.

Scheduling the Preliminary Oral Examination

Please see the link above for details on scheduling the preliminary oral examination.

Preliminary oral examinations should not be scheduled during the summer unless the members of the assigned committee can be assembled without substitution.

Before the oral examination can be scheduled, a degree program form approved by the Graduate School must be on file, along with a written examination report form indicating that the student has passed the preliminary written examination. The Graduate School also must confirm that the student has maintained active status.

Preliminary Oral Examination Content and Outcome

All doctoral students are required to pass a preliminary oral examination in the major field. The preliminary oral examination covers the major field, the minor field or supporting program, and any work fundamental to these areas, including possible plans for thesis research. Unlike the doctoral final oral examination, the preliminary oral examination is conducted as a closed examination, attended by only the student and the examining committee.

Immediately before the preliminary oral examination, the committee chair stipulates the objectives of the examination and, in consultation with other members of the examining committee, determines how the examination is to be conducted. Immediately after the examination, the candidate is excused from the room and a written secret ballot is taken before discussing the examination. Following the discussion, a second and final vote is taken, and the participants sign in the appropriate place on the report form, which is to be returned to the Graduate School, 316 Johnston Hall, no later than the first workday after the examination.

The outcome of the examination, with all committee members present and voting, is recorded in one of three ways: pass, pass with reservations, or fail. The voting proportions necessary for

these decisions are as follows: if the committee consists of four members, a favorable verdict for passing consists of either a unanimous vote or a vote of 3-1; if the committee consists of five members, a unanimous vote or a vote of 4-1 is needed; if the committee consists of six members, a unanimous vote or a vote of 5-1 or 4-2 is needed; and if there are seven members, a unanimous vote or a vote of 6-1 or 5-2 is needed. Candidates who do not earn committee votes in these proportions fail the examination. If, to achieve the minimum number of votes to reach a verdict of pass, any vote of pass with reservations is included, then the outcome will be recorded as a pass with reservations. A vote to pass the student with reservations still constitutes a passing vote.

Pass With Reservations

If the student passes the examination with reservations, the student is informed immediately, but the committee is permitted one week in which to convey its reservations to the student in writing, informing the student of the steps that must be taken to remove them. A copy of this letter must be sent to the Graduate School and should accompany the signed oral examination report form. When the student has satisfied the committee's reservations, a second letter informing the student and the Graduate School that the reservations have been removed and that the student may proceed toward the degree also is required. Both letters should be written by the committee chair. The final oral examination may not be scheduled until the Graduate School has received a copy of the letter indicating that the reservations have been removed.

If the committee members disagree as to whether the reservations have been removed satisfactorily, the committee chair asks for another vote, the results of which are subject to the same voting proportions as the initial vote. If the student is unable to satisfy the committee's reservations, his or her doctoral candidacy and graduate student status may be terminated.

Failure of the Preliminary Oral Examination

Students who fail the examination may be excluded from candidacy for the degree or may be allowed, on unanimous recommendation of the examining committee, to retake the examination, providing the reexamination is conducted by the original preliminary oral examining committee.

In no case may the reexamination take place before 10 weeks have passed. No more than one reexamination is allowed.

Recess of a Preliminary Oral Examination

If the preliminary oral examining committee recesses without having determined whether a student has passed the examination, the chair of the committee must send a letter to the dean of the Graduate School explaining the reasons for the recess and noting the date on which the examining committee will reconvene. If the recess will be longer than one week, the examination report form must be returned to the Graduate School, 160 Williamson Hall, and the student must reschedule the examination with the Graduate School one week in advance. A new examination report form will be mailed to the chair of the committee one week before the date

on which the committee will reconvene. The reconvened committee must be composed of the same members as the original preliminary oral examining committee.

Ph.D. Off-Campus Thesis Research Petition

A student who has completed at least one year of full-time graduate study on campus and who has been admitted to candidacy for a degree may Petition the department's Graduate Committee to do thesis research off-campus. This Petition should be written in the form of a memo and must be accompanied by an outline, in moderate detail, of the proposed research. It should be signed by your adviser and should be submitted to Linda Jagerson (jager001@umn.edu) for departmental handling. The burden of proof of the desirability of such an arrangement rests upon the student and his/her adviser. Approval must be obtained before the project begins. The following principles will apply:

1. The specific area of the thesis research must be represented in the Graduate School; i.e., the faculty adviser must be competent to direct the thesis research.
2. The off-campus site must offer special opportunities, such as experimental facilities, installations, specialized collections, or collaborative research items, which are unavailable on campus.
3. A member of the graduate faculty must actively join in the direction of the research of the student.
4. An outline of the proposed research study must be approved by the student's examining committee before the research begins.

Ph.D. Final Oral Examinations

Students are responsible for meeting all requirements for completing the doctoral degree, including dissertation defense and submission.

The Ph.D. Final Oral Examination

The Ph.D. final oral committee must consist of at least four members, including the advisor(s). All members of the committee and the candidate must participate in the final oral examination. Committee members and/or the student may participate remotely as long as all conditions for remote participation in the examination are met.

Doctoral Final Oral Examination Scheduling

Committee assignments and updates are initiated by the student. Please see the link above.

How it Works

- The student must schedule the Final Oral Examination with Graduate Student Services and Progress (GSSP) online as soon as a date is set, but *no later than one week* prior to the examination.
- Once the student schedules online, a confirmation email will be sent to the student's UMN email account.
- At least one week prior to the exam, an email will be sent to the student's UMN email account that will include information regarding outstanding requirements and/or the status of the Final Oral Examination form.

Please note that the student is responsible for scheduling and confirming the time and place of the examination with all committee members and for following their program's internal scheduling procedures. In certain health science fields the faculty requires 30 days' notice of the date of the final oral examination.

For information on who can serve on the Final Oral Examination committee, including external committee member information, please review the Committee Membership Information.

Doctoral Final Oral Examination

• A public presentation of the candidate's dissertation to the doctoral final oral examination committee and the invited scholarly community.
• A closed session (open only to the doctoral final oral examination committee and the candidate) immediately following the public presentation.
• To be recommended for the award of the doctoral degree, all committee members, or all committee members save one, must certify that the student has passed the doctoral final oral examination.
• Students are not allowed to retake the final oral examination.

Electrical Engineering MS Plan A (with thesis) - Credit Requirements

Full-time students must file the degree program form at least two months before beginning the last semester.

Part-time students taking one course per semester must file the degree program form after they have taken 14 course (not thesis) credits.

Only coursework used to satisfy degree requirements should be listed on the Graduate Degree Plan.

Please review the Graduate School's degree completion steps.

EE MS Plan A Credit Requirements

EE Major Field Coursework Requirement = 14

• All major coursework must be taken A-F.
• All major course work must be numbered EE 5XXX or EE 8XXX or EE 4XXX subject to the 4XXX coursework rule*.
• Coursework that is cross listed with another department must be registered as an EE course, not the cross listed department to be counted toward degree requirements.
• Can include up to 2 credits of seminars (S-N) or special investigation/directed study (A-F) type courses (except department seminars like EE 8970 and EE 8980) (topics seminars like magnetics seminar or communications seminar are examples of seminars that may be used toward meeting additional coursework credits).

Non-EE Coursework Requirement = 6

• All Non-EE coursework must be taken A-F.
• All Non-EE coursework must be College of Science and Engineering courses unless you have the non-CSE course pre-approved by the Director of Graduate Studies. Acceptance must be in writing and attached to the Degree Plan at the time of submission.
• Non-EE coursework that is cross listed with Electrical Engineering does not count toward the non-EE coursework requirement.
• Non-EE 4XXX coursework will only be accepted from the following list: **Non-EE 4000 Level Courses Acceptable for Graduate Credit (effective June 2014)** in Appendix A and will be subject to the **4XXX Coursework Rule**.*
• Beginning Fall 2015, non-EE 5xxx coursework will only be accepted from the following list: **Non-Electrical Engineering 5xxx Level Approved List of Courses (Effective fall 2015)** in Appendix B.
• No seminars, special investigation or directed study coursework may be applied toward meeting the Non-EE course requirement.

• To designate a minor, please talk with the minor department to learn their requirements.

MSEE Thesis Credit Requirement (EE 8777) = 10

• Plan A thesis credits can be registered for at any time during a master's student's degree program.

Total Credits for the Degree = 30

**4XXX Coursework Rule*

• A maximum of nine 4000-level course credits may be used to satisfy master's degree requirements. Of these, only six credits may be EE 4000-level (regular coursework, no seminars, projects, directed study courses).
• Do not list more than nine credits of 4000-level coursework on your degree plan. Partial credits from a course are not accepted.
• Non-EE 4XXX coursework will only be accepted from the following list: **Non-EE 4000 Level Courses Acceptable for Graduate Credit (effective June 2014)** in Appendix A.

Curricular Practical Training (CPT)

EE 5990 Curricular Practical Training (CPT) does not count toward degree requirements and should not be listed on the Graduate Degree Plan.
Full-time CPT is allowed in summer.
Full-time CPT is allowed during the academic year if all course credits for the degree have been completed.
Full-time CPT during the academic year must be approved by your advisor and the Director of Graduate Studies.

Transfer Credits for the MSEE Degree

Please see the General Information section of the Graduate School Catalog which describes in detail the percentage of coursework that can be transferred. Coursework must be taken post-baccalaureate, be graduate level, and taken for graduate credit an accredited institution.

Students Pursuing Two Master's Degrees

• There can be a maximum of eight credits in common between two University master's level degrees.

Performance Standards and Progress

• Coursework must be taken A-F unless only offered S-N.
• Minimum Graduate Degree Plan GPA for graduation is 3.0 GPA.
• Lowest grade accepted on the degree program form is 2.0 (grade C).
• Students whose GPA falls below 3.0 will have a registration hold placed on their account preventing further registration. To have the hold removed they will need to meet with the Director of Graduate Studies.

• Students are required to register every fall and spring term from the time of matriculation to degree conferral.
• With justification Grad 999 can be used once to satisfy fall/spring term registration requirements. Submit your request to Linda Jagerson in 3-166 Keller Hall.
• Students admitted to our program before Spring 2013 must complete their MSEE degree within 7 years of the earliest coursework listed on the degree program form.
• Students entering the program after January 2013, must complete their degree within five calendar years after initial enrollment in the Graduate School.
• To request an extension to the maximum time limit, see link.

MSEE Plan A Off-Campus Thesis Research Petition

Off-Campus Research

A student who has completed at least one year of full-time graduate study on campus and who has been admitted to candidacy for a degree may petition the de-partment's Graduate Committee to do thesis research off-campus. This petition should be written in the form of a memo and must be accompanied by an outline, in moderate detail, of the proposed research. It should be signed by your adviser and should be submitted to Linda Jagerson for departmental handling. The burden of proof of the desirability of such an arrangement rests upon the stu-dent and his/her adviser. Approval must be obtained before the project begins.

The following principles will apply:

1. The specific area of the thesis research must be represented in the Graduate School; i.e., the faculty adviser must be competent to direct the thesis research.
2. The off-campus site must offer special opportunities, such as experimental facili-ties, installations, specialized collections, or collaborative research items, which are unavailable on campus.
3. A member of the graduate faculty must actively join in the direction of the re-search of the student.
4. An outline of the proposed research study must be approved by the student's examining committee before the research begins.

Electrical Engineering MS Plan C (coursework only) - Credit Requirements

Full-time students must file the degree program form at least two months before beginning the last semester.
Part-time students taking one course per semester must file the degree program form after they have taken 20 course credits.
Only coursework used to satisfy degree requirements should be listed on the Graduate Degree Plan.

EE MS Plan C Credit Requirements

*EE Major Field Coursework Requirement = 18**

• All major coursework must be taken A-F.
• All major course work must be numbered EE 5XXX or EE 8XXX.
• Coursework that is cross listed with another department must be registered as an EE course, not the cross listed department to be counted toward degree requirements.
• No seminars, special investigation or directed study coursework may be applied toward meeting the major field requirements.
*Students beginning their studies prior to Fall 2012 semester, EE Major Field Coursework Credit Requirement = 14.

Non-EE Coursework Requirement = 6

• All Non-EE coursework must be taken A-F.
• All Non-EE coursework must be College of Science and Engineering courses unless you have the non-CSE course pre-approved by the Director of Graduate Studies. Acceptance must be in writing and attached to the Degree Plan at the time of submission.
• Non-EE coursework that is cross listed with Electrical Engineering does not count toward the non-EE coursework requirement.
• Non-EE 4XXX coursework will only be accepted from the following list: **Non-EE 4000 Level Courses Acceptable for Graduate Credit (effective June 2014)** in Appendix A and will be subject to the **4XXX Coursework Rule**.*
• Beginning Fall 2015, non-EE 5xxx coursework will only be accepted from the following list: **Non-Electrical Engineering 5xxx Level Approved List of Courses (Effective fall 2015)** in Appendix B.
• No seminars, special investigation or directed study coursework may be applied toward meeting the Non-EE course requirement.
• To designate a minor, please talk with the minor department to learn their requirements.

*Additional Coursework Credits = 6***

• Additional credits must be College of Science and Engineering coursework (includes Electrical Engineering).
• Can include 4XXX coursework subject to the 4XXX coursework rule*
• Can include EE 8965 Plan C Project I (3 credits)

• Can include EE 8967 Plan C Project II (1-3 credits). EE 8967 will only count if EE 8965 has already been completed.
• Can include up to 2 credits of seminars (S-N) or special investigation/directed study (A-F) type courses (except department seminars like EE 8970 and EE 8980) (topics seminars like magnetics seminar or communications seminar are examples of seminars that may be used toward meeting additional coursework credits). A maximum of 2 credits of seminars or industrial assignment can be used.
Seminars: EE 8190, EE 8210, EE 8230, EE 8360, EE 8370, EE 8500, EE 8610, EE 8660, EE 8920, EE 8925, EE 8940.
Industrial Assignment: EE 5041.

**Students beginning their studies prior to Fall 2012 semester, Additional Coursework Credit Requirement = 10.

Plan C must meet the paper/project/oral requirements for the degree
(see MS Plan C Form in Appendix C of the handbook)
Total Credits for the Degree = 30

*4XXX Coursework Rule

• A maximum of nine 4000-level course credits may be used to satisfy master's degree requirements.
• Of these, only six credits may be EE 4000-level (regular coursework, no seminars, projects, directed study courses).
• Do not list more than nine credits of 4000-level coursework on your degree plan. Partial credits from a course are not accepted.
• Non-EE 4XXX coursework will only be accepted from the following list: **Non-EE 4000 Level Courses Acceptable for Graduate Credit (effective June 2014)** in Appendix A.

Curricular Practical Training (CPT)

EE 5990 Curricular Practical Training (CPT) does not count toward degree requirements and should not be listed on the Graduate Degree Plan.
Full-time CPT is allowed only during summer.

Industrial Assignment

EE 5041:
• Students who register for EE 5041 will work full time.
• Students will pay for 1 credit, but it will count as 6 credits (full time).
• EE 5041 must appear on students' degree program forms.
• The industrial assignment/co-op is a semester long work assignment.
• It is not repeatable and it cannot be extended.
• EE 5041 can be taken during their final semester and it must be recorded on the degree program form.
• Students should submit a CPT application.
• The co-op agreement must accompany the CPT application.

• EE 5041 is offered during the fall and spring semesters only.
• EE 5041 (Industrial Assignment) and EE 5990 (CPT) cannot be taken concurrently.

Transfer Credits for the MSEE Degree

Please see the General Information section of the Graduate School Catalog which describes in detail the percentage of coursework that can be transferred. Coursework must be taken post-baccalaureate, be graduate level, and taken for graduate credit an accredited institution.

Students Pursuing Two Master's Degrees

There can be a maximum of eight credits in common between two University master's level degrees.

Performance Standards and Progress

• Coursework must be taken A-F unless only offered S-N.
• Minimum Graduate Degree Plan GPA for graduation is 3.0 GPA.
• Lowest grade accepted on the degree program form is 2.0 (grade C).
• Students whose GPA falls below 3.0 will have a registration hold placed on their account preventing further registration. To have the hold removed they will need to meet with the Director of Graduate Studies.
• Students are required to register every fall and spring term from the time of matriculation to degree conferral.
• With justification Grad 999 can be used once to satisfy fall/spring term registration requirements. Submit your request to Linda Jagerson in 3-166 Keller Hall.
• Students admitted to our program before Spring 2013 must complete their MSEE degree within 7 years of the earliest coursework listed on the degree program form.
• Students entering the program after January 2013, must complete their degree within five calendar years after initial enrollment in the Graduate School.
• To request an extension to the maximum time limit, see link.

Integrated Five-Year BEE/MSEE and BCompE/MSEE Degree Program

The Department of Electrical and Computer Engineering offers the 5-year integrated BEE/MSEE and BCompE/MSEE degree programs, also referred to as the combined degree program. The programs were established to allow high-achieving undergraduates the opportunity to work toward a master's degree while simultaneously working toward their undergraduate degree.

Application Deadlines:

• May 15 for admission the following fall semester
• Dec.15 for admission the following spring semester

Reasons to Complete a Master's Degree:

• A master's degree is necessary for those interested in design and development, or research and development. The program provides additional coursework and/or project experience for advanced design and development jobs.
• The competencies learned in a master's program are difficult to obtain by other means.
• A master's degree makes you more competitive in the job market.
• More employers are requiring a master's degree.
• Increased salary.
• Technology changes 10% per year and almost completely in 10 years.

The combined degree offers several advantages:

• Students are able to work on the undergraduate and graduate degrees simultaneously.
• The amount of time to complete a master's degree can be shortened by as much as one year.
• Students in the combined degree program qualify for graduate research/teaching assistantships and fellowships once they activate their graduate status. These positions provide a stipend, tuition, and health insurance benefits.
• There is an increased chance of winning external fellowships. Students in the combined degree program will be eligible to apply for NSF and other external fellowships.
• Students save money because they are able to complete as many as 16 graduate credits at the undergraduate tuition rate. Since the master's degree is 30 semester credits, this leaves only 14 credits to be taken at the higher graduate tuition rate.

How to Apply:

• Carefully fill in the **Five Year Master's Application Form**
• Include a copy of your current APAS Report and a statement of purpose
• Submit by May 15 for admission to the fall semester or by December 15 for admission to the spring semester

Application Decision:

Applications are evaluated after semester grades are received. Applicants will be notified in early June or early January. If you are accepted to the program, you must submit a graduate school application within a week of notification to indicate your acceptance of our offer of admission.

• Go to the **Graduate School's admissions page**
• Submit an unofficial University of Minnesota transcript
• Enter the name Linda Jagerson (jager001@umn.edu) as a recommender. This will fulfill the form requirement for a recommender
• Fill out the application as completely as possible
• Submit the application fee

Frequently Asked Questions

What should I write in my Statement of Purpose?

• Your statement of purpose should speak primarily to your education, background, and fit for our program. Describe your undergraduate education. Describe your specific areas of interest in Electrical Engineering and your goals after the award of your degree. If your interests are broad, state that. Specifically, the statement should address the area or areas of research you are interested in according to the research groups available on the Research section

What GPA does a student need to apply?

• Students with a GPA of 3.4 or better are eligible to apply. Students with a GPA between 3.2 and 3.4 may apply, but they must also submit a GRE score.

When should students apply?

• Students should apply for a semester in which they will have completed a majority of their upper division required (non elective) courses for their BEE degree.
• Students may apply up to their final semester of their undergraduate work but are encouraged to apply earlier for planning purposes.

If accepted into the program, students need to complete the Graduate School application within one week of notification of acceptance.

Can the two degrees be granted at same time?

• The two degrees cannot be granted at same time. The BEE or BCompE degree must always precede the MSEE degree.

Can I double count course credits?

• Students may not double count credits toward both degrees.

Can I enter the Ph.D. program through the Combined Degree Program?

• Yes, but you must complete the MS degree before entering the PhD program. Credits from the MS program count toward the PhD, not making the time to degree any longer.

How is GPA calculated?

• Courses taken as an undergraduate student count toward your undergraduate GPA even if the course is eventually transferred to the graduate program. Courses transferred to the graduate program do not affect your graduate school GPA.

For additional information please contact:
Frances Wood (Undergraduate Advisor: 612-625-4327 or fkwood@umn.edu)
Linda Jagerson (Graduate Advisor: 612-625-3564 or jager001@umn.edu)

Adviser Information

Academic Adviser

Students admitted to our program are assigned academic advisers to help with the planning of their academic programs. The academic adviser has no financial commitment to the students they are advising. The academic adviser also has no commitment to be the students' research adviser.

Research Adviser

Finding a research adviser is the responsibility of the student. The research adviser will help plan the degree program, will sign the necessary forms for the student's degree, and will serve as the student's advocate in the department. Identifying a research adviser early in the graduate career is essential. The academic adviser can offer advice on which faculty member the student should consider approaching to be his or her research adviser based on research interests. A student's academic adviser, by mutual consent, can become the student's research adviser. For a doctoral student, the research adviser will serve as a guide for the student's Ph.D. dissertation research.

Students who are uncertain who they would like as their research advisers should schedule a time to meet with faculty members in their interest areas. Students also might develop an interest in working with a faculty member after taking a class from a professor. The department faculty directory on the ECE web site is a good source for information about faculty members' research interests along with their e-mail addresses and telephone numbers.

Students who have changed advisers should e-mail Linda Jagerson (jager001@umn.edu) so that she can contact the Graduate School to update their graduate school records/transcripts. Include the following information in your email: complete name, student ID number, current adviser's name, and new adviser's name.

Curricular Practical Training EE 5990

• Curricular Practical Training EE 5990 does not qualify toward Electrical Engineering graduate degree program requirements.
• Curricular Practical Training should be taken SUMMER SEMESTER ONLY unless approved by both your adviser and the Director of Graduate Studies (give your request to Linda Jagerson).
• Any international student wishing to do Curricular Practical Training to work off-campus, must register for EE 5990. DO NOT register for Directed Studies, or Special Investigations.
• If you work off-campus, you must register for EE 5990 the semester you work off campus. DO NOT delay your registration to another semester.
• Directed Study and Special Investigation classes do not qualify for working off-campus, only EE 5990 qualifies. This is a department rule.
• If you have any questions about curricular practical training with regard to department requirements, please make an appointment with Linda Jagerson, by phone at 612-625-3564, or stop in during her office hours.

University Email

Email is the University's official means of communication with students. **Students are responsible for all information sent to their University email account.** Students who forward their University email account are still responsible for all the information, including attachments, sent to the account.

The department uses your University email address to communicate information regarding your degree program. **Please check your email at least once a day to be certain you are not missing important information you need to know**.

The ECE_Grads email list is made up of all active Electrical Engineering graduate students. Important information is sent via the email list. If you are not receiving email from ECE_Grads@lists.umn.edu, please email Linda Jagerson at jager001@umn.edu, call 612-625-3564, or stop in the Student Services Office at 3-166 Keller Hall to ask to be added to the list.

The Office of Student Finance (OSF) uses email as the means of sending tuition bills to all University of Minnesota Twin Cities students. **If you use a different email account such as 'Hotmail' or 'Yahoo', you must regularly check your University-assigned email for University communications such as tuition bills**. You have the option of having email sent to your University email account forwarded to your preferred account. But YOU must initiate this action by contacting the Technology Helpline at 612-301-4357 (1-HELP).

Electrical Engineering Libraries

Subject Librarian: Brian Conn
• Email: baconn@umn.edu
• Phone: 612-626-5764
• Mail: 108 Walter Library
117 Pleasant St. SE
Minneapolis, MN 55455

The University of Minnesota Library System, with over 3.5 million volumes, is one of the 13 largest university collections in the United States. Bibliographic and other services of professional librarians are available to graduate students, and the library system is an invaluable asset for serious research. The main library site is http://www.lib.umn.edu and the Science and Engineering Library is available at https://www.lib.umn.edu/walter.

The physical sciences and engineering collections are housed primarily in Walter Library. College of Science and Engineering librarians in Walter Library will be happy to discuss the collections and explain how to use the library services (including LUMINA). Students need a University identification card to withdraw books or periodicals from the library system.

Financial Assistance and Employee Benefits

Teaching Assistants

Current students who wish to be considered for a teaching assistantship for the following academic year should apply online by March 15 for consideration for the following summer and academic year. Appointments typically are made in May. Hiring decisions are based on satisfactory performance and progress towards the degree. Priority for funding is given to Ph.D. students. Students admitted to graduate study with a warning about limited departmental support have the lowest priority in these decisions.

University of Minnesota Language Proficiency Requirements policy requires high standards of English language proficiency for nonnative English speaking graduate and undergraduate students who are appointed to teaching assistant (TA) positions.

The English Language Proficiency Requirements Appendix lists details on required scores for various levels of TA duties

Research Assistants

Research Assistantship positions are determined by individual professors. We are looking for diligent researchers capable of working hard and a consistent individual able to stick to a difficult task for a long time. The positions are funded from research grants awarded to faculty members to support their research. A project carried out by a research assistant may be used to satisfy dissertation requirements, subject to adviser approval.

Conditions

Continuation of research assistantships through the period indicated in offer letters is subject to the availability of funds, satisfactory research progress, and satisfactory academic progress. Satisfactory progress in research activities, which will be monitored by your research adviser, includes (but is not limited to) timely progress towards publication and laboratory work, timely completion of other specific research activities or requirements, regular physical presence at your lab/office, etc., as determined by your research adviser.

As requirements for research vary considerably between research groups, please consult with your research adviser for a detailed description and timeline of the research tasks you are expected to accomplish as a condition of this offer. Satisfactory academic progress is measured in terms of your grade point average and your timely completion of requirements and meeting of milestones, both academic and administrative, as listed in the Electrical Engineering Graduate Student Handbook.

Fellowships Funding Resources

Employment Terms and Conditions for University of Minnesota Graduate Assistants

Policy and guideline information pertaining to graduate assistantship employment is available online, from your hiring department, or from Graduate Assistant Employment. Please be aware you are responsible for knowing the policies and guidelines applicable to your appointment as a graduate assistant.

Tuition benefits will be available to you if you meet eligibility requirements. These benefits are summarized below. Further details may be found online at the Graduate Assistant Employment Office Web site.

International Students

If you have F-1 or J-1 visa status, federal law prohibits the University from employing you more than 20 hours per week (50% time) during scheduled class periods and finals weeks. Exceptions exist if you have been authorized for 'practical or academic training.' Consult with the Office of International Student and Scholar Services about these matters.

Employment Benefits

As a graduate assistant, there are various benefits available. Please review these benefits and how they may apply to you.

- Medical and Dental Benefits
- Tuition Benefits
- Informal Sick Leave
- Leaves
- Vacation Benefits

Medical and Dental Benefits

The Graduate Assistant Health Insurance Plan, through Boynton Health Service, provides medical and dental coverage to eligible Graduate Assistants working 195 hours during the official semester payroll dates. For information about eligibility or coverage, contact the Graduate Assistant Insurance Office at Boynton Health Service, 612-624-0627 or gradins@bhs.umn.edu. Graduate Assistant Insurance Office is located at N323 Boynton Health Service. You must enroll during the enrollment period in order to receive Graduate Assistant Health Insurance.

Grading Policies

Because grades have a bearing on the award of fellowships and on vital deci-sions concerning a graduate student's career, the Electrical Engineering faculty, with the concurrence of the Dean of the Graduate School, has adopted the following policy concerning course grading: Electrical Engineering majors are required to register on an A/F basis for all courses in their graduate program except those courses offered only on an S/N basis (only seminars are graded on an S/N basis in this Department).

Grade Point Average

- Master's students must maintain a cumulative GPA of 3.0 to remain in the program.
- Ph.D. students must maintain a cumulative GPA of 3.3 to remain in the program.

Degree Program Form

Grades of C- and below do not count toward degree program requirements.

Retaking Courses

The Graduate School discourages the retaking of courses to improve grades. If a course is retaken, appropriate tuition and fees will be assessed. All registrations and grades for the course remain on the student's transcript and are calculated into the cumulative GPA.
If a course is retaken, all registrations and grades for the course remain on the student's transcript and are calculated into the cumulative GPA.

Grades and Grade Basis

Undergraduate and graduate courses on the Twin Cities campus have two main grading basis: A-F or S/N.

Graduation

Graduate School Deadlines

Graduate School degrees are awarded monthly. To graduate at the end of any given month you must:

• Request a Graduation Packet. This will include your application for degree and reviewers and/or final exam form.

Commencement

Commencement is held once a year in late April or early May. You must register to take part, usually by the end of February of that year.

Details on the graduate student commencement can be found by scrolling down the page at the previous link.

Grievance Procedures

The Department of Electrical and Computer Engineering has instituted a grievance procedure for graduate students for matters relating to graduate student and faculty relationships. If the parties in question cannot work through the issue themselves, then the following procedures can be followed:

Step 1

First point of contact is the graduate advisor, Linda Jagerson. Set up a meeting with her to discuss the issue. Traditionally, many issues can be resolved at this level. Students also may wish to consult with community representatives like the Electrical Engineering Graduate Student Association (EEGSA) to discuss further options.

Step 2

If Step 1 does not result in a satisfactory resolution, the graduate advisor or the student can initiate a meeting with the ECE Director of Graduate Studies Prof. Murti Salapaka, to further explore this issue and a possible resolution. For matters relating to TA issues Prof. William Robbins and/or the Center for Teaching and Learning is available for consultation.

Step 3

If Step 2 does not result in a satisfactory resolution, the ECE Director of Graduate Studies may recommend either a meeting with ECE Department Chair Prof.Randall Victora, or with University resolution personnel (see Step 4).

Step 4

University resolution options:

The University's Office for Conflict Resolution provides various services for faculty, TAs, RAs, and staff including anonymous consultation and mediation by a neutral third-party. Some aspects that they deal with include employment concerns such as expectations and workload in TA and RA relationships. For more information, please see their web site.

The Student Conflict Resolution Center (SCRC) provides a full range of services to students with campus-based complaints or concerns. An ombudsman helps students resolve problems informally. An advocate also is available to assist students in formal grievance or disciplinary hearings. SCRC can help students deal with university regulations and policies, or misunderstandings between students and instructors or administrators. Students also may have concerns about unfair treatment or may have been accused of a violation of the student conduct code.

Professional Ethics in Research

The Department of Electrical and Computer Engineering expects that students will respect and maintain the high ethical standards that govern all phases of research and graduate studies. The dissertation is not only a representation of a student's hard work, it is also a reflection on the adviser, the department, the Graduate School, and the University of Minnesota.

We strongly encourage you to read:
On Being a Scientist: Responsible Conduct in Research
Online Ethics Center - The National Academy of Engineering
National Institute for Engineering Ethics
IEEE Code of Ethics
Ethics Training for Research Assistants on NSF Grants

The National Science Foundation (NSF) requires institutions to provide appropriate training and oversight in the responsible and ethical conduct of research to everyone who participates in or conducts research supported by NSF, including undergraduate and graduate students, postdoctoral fellows and staff.

Many University of Minnesota courses and seminars meet the research ethics training requirement for NSF. Some are for-credit offerings and some are not. Enrollment for some will be limited to students accepted into a specific degree program. All courses, seminars or other activities must include the following core topics:

- Authorship and plagiarism - roles and responsibilities of being an author; how different disciplines approach co-authorship; how to define, identify and avoid the many forms plagiarism can take
- Data/research integrity - how to collect, store, protect and share data in ways that protect the validity and accuracy of the research and scholarship
- Reporting misconduct - responsibilities of student researchers for identifying and reporting misconduct; University resources for reporting and for self-protection

See the list of approved courses

APPENDIX A: Non-EE 4000 Level Courses Acceptable for Graduate Credit (effective June 2014)

AEM 4203 - Aerospace Propulsion
AEM 4295 - Problems in Fluid Mechanics
AEM 4301 - Orbital Mechanics
AEM 4303W - Flight Dynamics and Control (WI)
AEM 4305 - Spacecraft Attitude Dynamics and Control
AEM 4331 - Aerospace Vehicle Design
AEM 4333 - Aerospace Design: Special Projects
AEM 4371 - Helicopter Aerodynamics
AEM 4495 - Problems in Aerospace Systems
AEM 4501 - Aerospace Structures
AEM 4502 - Computational Structural Analysis
AEM 4511 - Mechanics of Composite Materials
AEM 4581 - Mechanics of Solids
AEM 4595 - Problems in Mechanics and Materials
AEM 4601 - Instrumentation Laboratory
AEM 4602W - Aeromechanics Laboratory (WI)

BIOL 4003 - Genetics
BIOL 4004 - Cell Biology
BIOL 4035 - Metagenomics Laboratory
BIOL 4121 - Microbial Ecology and Applied Microbiology
BIOL 4700 - Cell Physiology
BIOL 4850 - Special Topics in Biology
BIOL 4862 - Biological Photography and Digital Imaging Techniques
BIOL 4950 - Special Topics in Biology

CHEM 4001 - Chemistry of Biomass and Biomass Conversion to Fuels and Products
CHEM 4011 - Mechanisms of Chemical Reactions
CHEM 4021 - Computational Chemistry
CHEM 4066 - Chemistry of Industry
CHEM 4101 - Modern Instrumental Methods of Chemical Analysis
CHEM 4111W - Modern Instrumental Methods of Chemical Analysis Lab (WI)
CHEM 4201 - Materials Chemistry
CHEM 4214 - Polymers
CHEM 4221 - Introduction to Polymer Chemistry
CHEM 4223W - Polymer Laboratory (WI)
CHEM 4301 - Applied Surface and Colloid Science
CHEM 4311W - Advanced Organic Chemistry Lab (WI)
CHEM 4321 - Organic Synthesis
CHEM 4322 - Advanced Organic Chemistry

CHEM 4352 - Physical Organic Chemistry
CHEM 4361 - Interpretation of Organic Spectra
CHEM 4411 - Introduction to Chemical Biology
CHEM 4412 - Chemical Biology of Enzymes
CHEM 4413 - Nucleic Acids
CHEM 4501 - Introduction to Thermodynamics, Kinetics, and Statistical Mechanics
CHEM 4502 - Introduction to Quantum Mechanics and Spectroscopy
CHEM 4511W - Advanced Physical Chemistry Lab (WI)
CHEM 4601 - Green Chemistry (ENV)
CHEM 4701 - Inorganic Chemistry
CHEM 4711W - Advanced Inorganic Chemistry Lab (WI)
CHEM 4715 - Physical Inorganic Chemistry
CHEM 4725 - Organometallic Chemistry
CHEM 4735 - Bioinorganic Chemistry
CHEM 4745 - Advanced Inorganic Chemistry
CHEN 4214 - Polymers
CHEN 4401W - Senior Chemical Engineering Lab (WI)
CHEN 4402W - Chemical Engineering Lab II (WI)
CHEN 4501W - Chemical Engineering Design I (WI)
CHEN 4502W - Chemical Engineering Design II (WI)
CHEN 4601 - Process Control
CHEN 4701 - Advanced Undergraduate Applied Math I: Linear Analysis
CHEN 4702 - Advanced Undergraduate Rheology
CHEN 4704 - Advanced Undergraduate Physical Rate Processes I: Transport
CHEN 4706 - Advanced Undergraduate Physical and Chemical Thermodynamics
CHEN 4707 - Advanced Undergraduate Statistical Thermodynamics and Kinetics
CHEN 4708 - Advanced Undergraduate Chemical Rate Processes: Analysis of Chemical Reactors
CHEN 4712 - Rheology Laboratory Project

CSCI 4011 - Formal Languages and Automata Theory
CSCI 4041 - Algorithms and Data Structures
CSCI 4041H - Algorithms and Data Structures
CSCI 4061 - Introduction to Operating Systems
CSCI 4107 - Introduction to Computer Graphics Programming
CSCI 4131 - Internet Programming
CSCI 4211 - Introduction to Computer Networks
CSCI 4511W - Introduction to Artificial Intelligence (WI)
CSCI 4611 - Programming Interactive Computer Graphics and Games
CSCI 4707 - Practice of Database Systems
CSCI 4921 - History of Computing (TS, HIS)
CSCI 4970W - Advanced Project Laboratory (WI)

MATH 4065 - Theory of Interest
MATH 4152 - Elementary Mathematical Logic

MATH 4242 - Applied Linear Algebra
MATH 4281 - Introduction to Modern Algebra
MATH 4428 - Mathematical Modeling
MATH 4512 - Differential Equations with Applications
MATH 4567 - Applied Fourier Analysis
MATH 4603 - Advanced Calculus I
MATH 4604 - Advanced Calculus II
MATH 4606 - Advanced Calculus
MATH 4653 - Elementary Probability
MATH 4707 - Introduction to Combinatorics and Graph Theory
MATH 4990 - Topics in Mathematics

MOT 4001 - Leadership, Professionalism and Business Basics for Engineers (MOT 4001 counts only toward additional coursework credits, seminar/directed study 2 credit rule)

PHYS 4001 - Analytical Mechanics
PHYS 4002 - Electricity and Magnetism
PHYS 4041 - Computational Methods in the Physical Sciences
PHYS 4051 - Methods of Experimental Physics I
PHYS 4052W - Methods of Experimental Physics II (WI)
PHYS 4071 - Concepts in Physics
PHYS 4101 - Quantum Mechanics
PHYS 4121W - History of 20th-Century Physics (WI)
PHYS 4201 - Statistical and Thermal Physics
PHYS 4211 - Introduction to Solid-State Physics
PHYS 4303 - Electrodynamics and Waves
PHYS 4511 - Introduction to Nuclear and Particle Physics
PHYS 4611 - Introduction to Space Physics
PHYS 4621 - Introduction to Plasma Physics
PHYS 4911 - Introduction to Biopolymer Physics

STAT 4101 - Theory of Statistics I
STAT 4102 - Theory of Statistics II
STAT 4931 - Topics in Statistics
STAT 4932 - Topics in Statistics

APPENDIX B: Non-Electrical Engineering 5xxx Level Approved List of Courses (Effective fall 2015)

AEM 5247 - Hypersonic Aerodynamics
AEM 5253 - Computational Fluid Mechanics
AEM 5333 - Design-to-Flight: Small Uninhabited Aerial Vehicles
AEM 5401 - Intermediate Dynamics
AEM 5431 - Trajectory Optimization
AEM 5501 - Continuum Mechanics
AEM 5503 - Theory of Elasticity
AEM 5581 - Mechanics of Solids
AEM 5651 – Aeroelasticity
BBE 5023 - Process Control and Instrumentation
BBE 5333 - Off-Road Vehicle Design
BBE 5413 - A Systems Approach to Residential Construction
BBE 5416 - Building Testing & Diagnostics
BBE 5733 - Renewable Energy Technologies
BioC 5001 - Biochemistry and Cellular Biology
BioC 5361 - Microbial Genomics and Bioinformatics
BioC 5527 - Introduction to Modern Structural Biology
BioC 5528 - Spectroscopy and Kinetics
BioC 5001 - Biochemistry and Cellular Biology
BIOL 5272 - Applied Biostatistics
BIOL 5485 - Introductory Bioinformatics
BMEN 5001 - Advanced Biomaterials
BMEN 5041 - Tissue Engineering
BMEN 5101 - Advanced Bioelectricity and Instrumentation
BMEN 5111 - Biomedical Ultrasound
BMEN 5151 - Introduction to BioMEMS and Medic Microdevices
BMEN 5201 - Advanced Biomechanics
BMEN 5311 - Advanced Biomedical Transport Processes
BMEN 5321 - Microfluidics in Biology and Medicine
BMEN 5351 - Cell Engineering
BMEN 5401 - Advanced Biomedical Imaging
BMEN 5411 - Neural Engineering
BMEN 5412 - Neuromodulation
BMEN 5413 - Neural Decoding and Interfacing
BMEN 5421 - Introduction to Biomedical Optics
BMEN 5444 - Muscle
BMEN 5501 - Biology for Biomedical Engineers
BMEN 5701 - Cancer Bioengineering

CHEM 5755 - X-Ray Crystallography
CHEN 5751 - Biochemical Engineering
CHEN 5753 - Biological Transport Processes
CHEN 5771 - Colloids and Dispersions
CE 5211 - Traffic Engineering
CE 5214 - Transportation Systems Analysis
CE 5341 - Wave Methods for Nondestructive Testing
CE 5411 -Applied Structural Mechanics
CMB 5200 - Statistical Genetics and Genomics
CSCI 5103 - Operating Systems
CSCI 5105 - Introduction to Distributed Systems
CSCI 5106 - Programming Languages
CSCI 5115 - User Interface Design, Implementation and Evaluation
CSCI 5125 - Collaborative and Social Computing
CSCI 5143 - Real-Time and Embedded Systems
CSCI 5161 - Introduction to Compilers
CSCI 5211 - Data Communications and Computer Networks
CSCI 5221 - Foundations of Advanced Networking
CSCI 5231 - Wireless and Sensor Networks
CSCI 5271 - Introduction to Computer Security
CSCI 5302 - Analysis of Numerical Algorithms
CSCI 5304 - Computational Aspects of Matrix Theory
CSCI 5403 - Computational Complexity
CSCI 5421 - Advanced Algorithms and Data Structures
CSCI 5451 - Introduction to Parallel Computing: Architectures, Algorithms, and Programming
CSCI 5461 - Functional Genomics, Systems Biology, and Bioinformatics
CSCI 5471 - Modern Cryptography
CSCI 5481 - Computational Techniques for Genomics
CSCI 5511 - Artificial Intelligence I
CSCI 5512 - Artificial Intelligence II
CSCI 5521 - Introduction to Machine Learning
CSCI 5523 - Introduction to Data Mining
CSCI 5525 - Machine Learning
CSCI 5551 - Introduction to Intelligent Robotic Systems
CSCI 5552 - Sensing and Estimation in Robotics
CSCI 5561 - Computer Vision
CSCI 5607 - Fundamentals of Computer Graphics 1
CSCI 5608 - Fundamentals of Computer Graphics II
CSCI 5609 - Visualization
CSCI 5611 - Animation & Planning in Games

CSCI 5619 - Virtual Reality and 3D Interaction
CSCI 5707 - Principles of Database Systems
CSCI 5708 - Architecture and Implementation of Database Management Systems
CSCI 5801 - Software Engineering I
CSCI 5802 - Software Engineering II
ESCI 5201 - Time-Series Analysis of Geological Phenomena
ESCI 5204 - Geostatistics and Inverse Theory
ESCI 5205 - Fluid Mechanics in Earth and Environmental Sciences
ESCI 5302 - Isotope Geology
ESCI 5353 - Electron Microprobe Theory and Practice
GCD 5036 - Molecular Cell Biology
IE 5111 - Systems Engineering I
IE 5112 - Introduction to Operations Research
IE 5113 - Systems Engineering II
IE 5441 - Financial Decision Making
MATS 5517 - Electron Microscopy
MATS 5531 - Electrochemical Engineering
MATS 5771 - Colloids and Dispersions
MATH 5067 - Actuarial Mathematics I
MATH 5068 - Actuarial Mathematics II
MATH 5075 - Mathematics of Options, Futures, and Derivative Securities I
MATH 5076 - Mathematics of Options, Futures, and Derivative Securities II
MATH 5165 - Mathematical Logic I
MATH 5166 - Mathematical Logic II
MATH 5248 - Cryptology and Number Theory
MATH 5251 - Error-Correcting Codes, Finite Fields, Algebraic Curves
MATH 5335 - Geometry I
MATH 5336 - Geometry II
MATH 5378 - Differential Geometry
MATH 5385 - Introduction to Computational Algebraic Geometry
MATH 5445 - Mathematical Analysis of Biological Networks
MATH 5447 - Theoretical Neuroscience
MATH 5467 - Introduction to the Mathematics of Image and Data
MATH 5485 - Introduction to Numerical Methods I
MATH 5486 - Introduction to Numerical Methods II
MATH 5525 - Introduction to Ordinary Differential Equations
MATH 5535 - Dynamical Systems and Chaos
MATH 5583 - Complex Analysis
MATH 5587 - Elementary Partial Differential Equations I
MATH 5588 - Elementary Partial Differential Equations II
MATH 5651 - Basic Theory of Probability and Statistics

MATH 5652 - Introduction to Stochastic Processes
MATH 5654 - Prediction and Filtering
MATH 5705 - Enumerative Combinatorics
MATH 5707 - Graph Theory and Non-enumerative Combinatorics
MATH 5711 - Linear Programming and Combinatorial Optimization
ME 5113 - Aerosol/Particle Engineering
ME 5223 - Materials in Design
ME 5228 - Introduction to Finite Element Modeling, Analysis, and Design
ME 5241 - Computer-Aided Engineering
ME 5243 - Advanced Mechanism Design
ME 5247 - Stress Analysis, Sensing, and Transducers
ME 5281 - Analog and Digital Control
ME 5286 - Robotics
ME 5312 - Solar Thermal Technologies
ME 5344 - Thermodynamics of Fluid Flow With Applications
ME 5351 - Computational Heat Transfer
ME 5461 - Internal Combustion Engines
MPHY 5170 - Basic Radiological Physics
MPHY 5171 - Medical and Health Physics of Imaging I
MPHY 5174 - Medical and Health Physics of Imaging II
NSC 5040 - Brain Networks: From Connectivity to Dynamics
NSE 5202 - Theoretical Neuroscience: Systems and Information Processing
NSE 5203 - Neuroscience of Vision
NSE 5661 - Systems Neuroscience
PHSL 5061 - Physiology for Biomedical Engineers
PHSL 5101 - Human Physiology
PHSL 5201 - Computational Neuroscience I: Membranes and Channels
PHYS 5001 - Quantum Mechanics I
PHYS 5002 - Quantum Mechanics II
PHYS 5011 - Classical Physics I
PHYS 5012 - Classical Physics II
PHYS 5041 - Mathematical Methods for Physics
PHYS 5081 - Introduction to Biopolymer Physics
PHYS 5201 - Thermal and Statistical Physics
PHYS 5402 - Radiological Physics
PHYS 5701 - Solid-State Physics for Engineers and Scientists
PHYS 5702 - Solid State Physics for Engineers and Scientists
PSY 5036W - Computational Vision (WI)
PSY 5038W - Introduction to Neural Networks (WI)
STAT 5021 - Statistical Analysis
STAT 5031 - Statistical Methods for Quality Improvement

STAT 5041 - Bayesian Decision Making
STAT 5101 - Theory of Statistics I
STAT 5102 - Theory of Statistics II
STAT 5201 - Sampling Methodology in Finite Populations
STAT 5302 - Applied Regression Analysis
STAT 5303 - Designing Experiments
STAT 5401 - Applied Multivariate Methods
STAT 5421 - Analysis of Categorical Data
STAT 5511 - Time Series Analysis

APPENDIX C: PhD Preliminary Written Examination Reading List

COMMUNICATIONS
Textbook examples:
Rodger E. Ziemer and William H. Tranter
Principles of Communications
Wiley; 6th edition (December 10, 2008)

B.P. Lathi and Zhi Ding
Modern Digital and Analog Communication Systems
Oxford University Press; Fourth Edition (January 23, 2009)

Typically covered in a course such as:
EE 4501 - Communications Systems (fall, every year)
Systems for transmission/reception of digital/analog information. Characteristics/design of wired/wireless communication systems. Baseband, digital, and carrier-based techniques. Modulation. Coding. Electronic noise and its effects on design/performance.

SIGNAL PROCESSING
Textbook examples:
Alan V. Oppenheim and Ronald W. Schafer
Digital Signal Processing
Prentice Hall, 1975

Alan V. Oppenheim and Ronald W. Schafer
Discrete-Time Signal Processing
Prentice Hall, Third Edition (August 28, 2009)

Typically covered in a course such as:
EE 4541 - Digital Signal Processing (fall, spring, summer, every year)
Review of linear discrete time systems and sampled/digital signals. Fourier analysis, discrete/fast Fourier transforms. Interpolation/decimation. Design of analog, infinite-impulse response, and finite impulse response filters. Quantization effects.

CONTROLS
Textbook examples:
Gene Franklin, J.D. Powell, and Abbas Emami-Naeini
Feedback Control of Dynamic Systems
Prentice Hall, 2005

Farid Golnaraghi and Benjamin C. Kuo

Automatic Control Systems
Wiley, Ninth Edition (July 7, 2009)

Typically covered in a course such as:
EE 4231 - Linear Control Systems: Designed by Input/Output Methods (fall, every year)
Modeling, characteristics, and performance of feedback control systems. Stability, root locus, and frequency response methods. Digital implementation, hardware considerations.

ANALOG AND DIGITAL ELECTRONICS
Textbook examples:
Adel S. Sedra and Kenneth C. Smith
Microelectronic Circuits Revised Edition
Oxford University Press, USA; 5 Har/Cdr edition (August 30, 2007)

Paul R. Gray, Paul J. Hurst, Steven Lewis, and Robert G. Meyer
Analysis and Design of Analog Integrated Circuits
John Wiley & Sons Inc; 5 edition (April 30, 2009)

Typically covered in a course such as:
EE 3115 - Analog and Digital Electronics (fall, spring, summer, every year)
Feedback amplifiers. Stability and compensation. Oscillators. Internal structure of operational amplifiers. Switching active devices. BJT and FET logic gates. Sequential circuits. Designing complex digital circuits.

SEMICONDUCTOR MATERIALS
Textbook examples:
David A. Neaman
Semiconductor Physics and Devices
(McGraw Hill Higher Education, 2002)

Robert F. Pierret
Advanced Semiconductor Fundamentals
Prentice Hall; Second Edition (August 19, 2002)

Typically covered in a course such as:
EE 5163 - Semiconductor Properties and Devices I (fall, every year)
Principles/properties of semiconductor devices. Selected topics in semiconductor materials, statistics, and transport. Aspects of transport in p-n junctions, heterojunctions.

SEMICONDUCTOR DEVICES
Textbook example:
Robert F. Pierret
Semiconductor Device Fundamentals
Addison-Wesley; Second Edition (April 12, 1996)

Typically covered in a course such:
EE 3161 - Semiconductor Devices (fall, spring, every year)
Elementary semiconductor physics; physical description of pn junction diodes, bipolar junction transistors, field-effect transistors.

OPTICS
Textbook example:
Amnon Yariv and Pochi Yeh
Photonics: Optical Electronics in Modern Communications
Oxford University Press, 1997, Chapters 1-6 and 9 inclusive

Typically covered in a course such as:
EE 5624 - Optical Electronics (fall, every year)
Fundamentals of lasers, including propagation of Gaussian beams, optical resonators, and theory of laser oscillation. Polarization optics, electro-optic, acousto-optic modulation, nonlinear optics, phase conjugation.

FIELDS AND TRANSMISSION LINES
Textbook example:
Fawaz Ullaby, Pearson
Fundamentals of Applied Electromagnetics
Prentice Hall; Fifth edition (September 10, 2006)

Typically covered in a course such as:
EE 3601 - Transmission Lines, Fields, and Waves (fall, spring, summer, every year)
Properties of transmission lines, electrostatics, magnetostatics, and electromagnetic waves in unbounded space. Guides, cavities, radiation theory, antennas.

POWER SYSTEMS AND POWER ELECTRONICS
Textbook Examples:
Ned Mohan
First Course on Power Systems
MNPERE, 2009 edition
Available through the University Bookstore

Ned Mohan
First Course on Power Electronics
MNPERE, 2009 edition
Available through the University Bookstore

Typically covered in courses such as EE4721 and EE 4741 Power Electronics
(question will cover material from both courses).

EE 4721 - Introduction to Power System Analysis (fall, every year) AC power systems. Large power system networks. Mathematics/techniques of power flow analysis. Short-circuit analysis, transient stability analysis. Use of power system simulation program for design.

EE 4741 - Power Electronics (fall, every year)
Switch-mode power electronics. Switch-mode DC power supplies. Switch-mode converters for DC and AC motor drives, wind/photovoltaic inverters, interfacing power electronics equipment with utility system. Power semiconductor devices, magnetic design, electro-magnetic interference (EMI). Integral lab.

COMPUTER AIDED DESIGN
Syllabus:
Basic graph/numerical algorithms. Algorithms and data structures for logic-level and high-level synthesis, optimization and verification. Physical-design algorithms.Basic electrical lements/devices and their equations. Modified Nodal Analysis nonlinear differential equation formulations. Newton-Raphson algorithm. DC and AC analyses.

Textbook examples:
Sabih H. Gerez
Algorithms for VLSI Design Automation
1998, John Wiley & Sons, ISBN: 0-471-98489-2?

L.O. Chua and P.M. Lin
Computer-aided Analysis of Electronic Circuits: Algorithms and Computational Techniques
Prentice Hall, 1975.
ISBN: 978-0131654150

Typically covered in courses such as:
EE 2011 - Linear Systems and Circuits (spring, summer, every year)
Elements of signals and of linear system analysis. Time-domain modeling of linear systems by differential equations. Laplace and Fourier domain modeling/analysis. High frequency models of diodes/transistors. Frequency response of amplifiers. Design of electronic filters. Multistage amplifiers.

EE 3015 - Signals and Systems (fall, spring, every year)
Basic techniques for analysis/design of signal processing, communications, and control systems. Time/frequency models, Fourier-domain representations, modulation. Discrete-time/digital signal/system analysis. Z transform. State models, stability, feedback.

EE 3161 - Semiconductor Devices (fall, spring, every year)
Elementary semiconductor physics; physical description of pn junction diodes, bipolar junction transistors, field-effect transistors.

The syllabus for the CAD WPE is also covered in the introductory graduate-level CAD course sequence:

EE 5301 - VLSI Design Automation I (fall, spring, offered periodically)
Basic graph/numerical algorithms. Algorithms for logic/high-level synthesis. Simulation algorithms at logic/circuit level. Physical-design algorithms.

EE 5302 - VLSI Design Automation II (3.0 cr; Prereq-[spring, every year).
(Only material taught in the first 8 weeks of class is relevant to the CAD WPE)
Basic algorithms, computational complexity. High-level synthesis. Test generation. Power estimation. Timing optimization. Current topics.

COMPUTER ARCHITECTURE
Textbook examples:
David J. Lilja and Sachin S. Saptnekar
Designing Digital Computer Systems with Verilog
Cambridge University Press; First Edition (November 5, 2007)
AND
David A. Patterson and John L. Hennessy
Computer Organization and Design: The Hardware/Software Interface
Morgan Kaufmann Publisher; Fourth edition (October, 2008)

Typically covered in a course such as:
EE 4363 - Computer Architecture and Machine Organization
Introduction to computer architecture. Aspects of computer systems, such as pipelining, memory hierarchy, and input/output systems. Performance metrics. Examination of each component of a complicated computer system.

DIGITAL DESIGN
Textbook examples:
Charles H. Roth, Jr. and Larry L. Kinney
Fundamentals of Logic Design
Thomson Engineering; Sixth edition (March 13, 2009)

Michael Ciletti, Advanced Digital Design with the
Verilog HDL, Prentice-Hall, Second Edition, 2011
[The questions will be related to design concepts but not to the specifics of any hardware description language.]

Typically covered in courses such as:
EE 2301 - Introduction to Digital System Design
Boolean algebra, logic gates, combinational logic, logic simplification, sequential logic, design of synchronous sequential logic, VHDL modeling, design of logic circuits. Integral lab.
EE 4301 - Digital Design with Programmable Logic
Introduction to system design and simulation. Design using VHDL code and synthesis. Emulation using VHDL code.

MAGNETICS
Textbook example:
Robert C. O'Handley
Modern Magnetic Materials
Wiley-Interscience, (November 1999)

Typically covered in a course such as:
EE 5653 - Physical Principles of Magnetic Materials
Physics of diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism; ferromagnetic phenomena; static and dynamic theory of micromagnetics, magneto-optics, and magnetization dynamics; magnetic material applications.

APPENDIX D: MSEE Plan C Form

MSEE Plan C
Project
Written Report
Oral Presentation

Name ID# Email

From the list provided below, please circle the courses used to satisfy the **project**, **written report**, and **oral presentation** requirements.

- EE 5171 satisfies the **written report requirement only**.
- The following courses satisfy **project and written report requirements**.
  EE 5324 EE 5329 EE 5505 EE 5611 EE 8161
- The following courses satisfy the **project, written report, and oral presentation requirements**.
  EE 5235 EE 5364 EE 5602 EE 5811 EE 8611
  EE 5301 EE 5371 EE 5613 EE 5821
  EE 5327 EE 5545 EE 5657 EE 8337
  EE 5333 EE 5601 EE 5725 EE 8591 EE 8965 Plan C Project

The courses listed below satisfy a portion or offer the option to satisfy one or more **project**, **written report**, and **oral presentation requirements**. If you want to use one or more of these courses, we need the instructor(s) to certify what portion of the Plan C requirements you satisfied. Please ask the instructor(s) to email Linda Jagerson at jager001@umn.edu the following information: your name, the course number, the Plan C requirement(s) satisfied (project, written report, or oral presentation).

List the names of the faculty who will email certifying Plan C project/written report/oral presentation requirements have been met.

- The following courses offer you the OPTION of doing a **project**, **written report**, and **oral presentation**. You must do all three to satisfy Plan C requirements.
  EE 5621 EE 5624 EE 5627
- The following courses require a **project** in the course and students choose to do a **written report** or an **oral presentation**.
  EE 5653 EE 5655