

# **Holcombe Department of Electrical and Computer Engineering**

## **Graduate Student Handbook**

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# General Information

## Overview of ECE Graduate Program

The Holcombe Department of Electrical and Computer Engineering (ECE) at Clemson University (“the Department”) offers Master of Science (M.S.) and Doctorate of Philosophy (Ph.D.) degrees in both Electrical Engineering (EE) and Computer Engineering (CpE). The M.S. program includes a non-thesis option and a thesis option. The Ph.D. program is normally entered only after completion of an M.S. degree in the same major; however, highly qualified students may be allowed to enter the program directly after completion of a B.S. degree in the major. In addition, the Department offers a Master of Engineering (MENGR) degree in Electrical Engineering which is designed for students who are employed as full-time engineering professionals. The M.S. and Ph.D. degrees are offered on the Clemson main campus, whereas the MENGR program is offered both on the main campus and as an on-line program.

This handbook defines the requirements, policies, and procedures of the ECE Graduate Program; it also describes other operational aspects of the Department that pertain to the program. The requirements specified herein are in addition to those described in the Clemson University Graduate School Admissions Policies and Academic Regulations.

The Graduate School policies and regulations are specified in [The Graduate School Announcements](#) and at the Graduate School Web site. It is very important that each student familiarize himself or herself with all Graduate School and departmental requirements and information pertaining to the student’s program of study. (Note in particular that the Department may have additional requirements for a degree program beyond the requirements specified by the Graduate School.)

All new students are required to attend orientations held by the Department and the Graduate School to become acquainted with the Department's instructional activities and research as well as with general regulations. Information from these orientations helps students to select specific research areas and allows them to make a more effective choice of advisory committee members. Dates and times of the orientation meetings are announced each semester.

We hope this handbook is useful both to graduate students and faculty. Any inconsistencies or omissions should be brought to the attention of the graduate program coordinator.

## Personnel

The following is a list of key people involved with the graduate program along with their responsibilities.

Dr. Adam Hoover, Chair of the ECE Graduate Committee. The Committee establishes and oversees the academic policies of the Graduate Program. Student petitions concerning academic policies should be submitted to the Committee Chair through the student's academic advisor.

Dr. Dan Noneaker, Chair of the Department, exercises the final authority on all matters involving resources available to graduate students and final approval on all assistantship and fellowship offers.

Dr. Robert Schalkoff, Graduate Program Coordinator, is responsible for decisions concerning admissions. He makes recommendations to the Department Chair regarding teaching assistantship and fellowship offers and interacts with the Graduate School on many matters including student status, assistantships, and fellowships. He also coordinates graduate student recruitment activities and is in charge of making laboratory teaching assistant and grader assignments.

Ms. Trish Nigro, Graduate Student Services Coordinator (102A Riggs Hall), assists the Graduate Program Coordinator with all aspects of Graduate Program administration. In general, she is the first person who a student should contact with any questions regarding the Graduate Program. She coordinates all graduate students' applications and reviews of applications. She also coordinates the payroll for ECE graduate students. In addition, she assists in maintaining all records for the Graduate Program and has copies of all forms associated with the program.

Ms. Courtney Honeycutt, Registration Coordinator, Graduate Student Services (102C Riggs Hall), coordinates computer center accounts, maintains official copies of course syllabi, and maintains all records for the Graduate Program, including copies of all forms associated with the program. She prepares Graduate School forms (GS-5, GS-7) for students and distributes official notices of oral exams and thesis and dissertation presentations. She has copies of all documents associated with the Graduate Program.

The following is a list of administration staff members and their association with the Graduate Program.

Ms. Gale Black, Administrative Assistant (104 Riggs Hall), initiates all purchases for the Department.

Ms. Janet Hendricks, Administrative Assistant to the Department Chair (105 Riggs Hall).

Ms. Wendy Howard, Accountant/Fiscal Analyst II for Electrical and Computer Engineering Program (221C Riggs Hall), maintains accounting information for all ECE financial accounts.

Ms. Patty McNulty, Student Services Program Coordinator for Electrical and Computer Engineering Undergraduate Program (102B Riggs Hall), provides support for both electrical and computer engineering undergraduates.

Ms. Lillian Burns, Administrative Assistant (337 EIB), maintains desk copies of texts and laboratory manuals for use by graduate students teaching lecture courses and some laboratory courses. She also coordinates student evaluations of graduate teaching assistants.

The following is a list of technical staff members and their association with the Graduate Program.

Mr. John Hicks, Instrument Technician II (202A Riggs), maintains analog and digital instrumentation in the ECE Department and assists the students in the use of equipment for lab experiments, research and projects. He is also responsible for oversight of the Department's electronics shop.

Mr. David Moline, Technical Support Manager (221F Riggs Hall), is in charge of graduate student office assignments and key distribution and provides some lab support. He also provides analysis of computer systems with responsibility for the design, programming, testing, debugging and implementation of systems; serves as an independent leader and user contact for design of special system projects; and provides electronic servicing of computer boards and peripheral devices. In addition, he assists with design projects for graduate students and undergraduate students.

### Relevant Phone Numbers

The following is a list of places and phone numbers relevant to the Graduate Program.

Campus Police	656-2222
Computer Center	656-3494
Graduate School Office	656-3195
Graduate Student Association Office	656-2697
Office of International Affairs	656-3614
ECE Graduate Student Services Coordinator	656-5902

# Prospective ECE Graduate Students

## Application Procedure and Requirements

To apply for our graduate program, please visit the Graduate School application at <http://www.clemson.edu/graduate/admissions/apply/index.html>.

Details regarding requirements for the application may be found on the ECE website, <http://www.clemson.edu/ces/departments/ece/grad/apply.html>. Please pay special attention to the undergraduate prerequisite requirements.

Required application material includes the following items:

- On-line application, including Personal Statement/Statement of Purpose
- Transcripts of prior and current undergraduate and graduate course work
- Results from the Graduate Record Examination (GRE) General Test
  - GRE required for application to the M.S. or Ph.D. program
  - GRE *not* required for application to the MENG program
- Results from the Test of English as a Foreign Language (TOEFL) or International English Language Testing System (IELTS) (for applicants whose native language is not English)
- A minimum of two Letters of Recommendation (three Letters are highly encouraged)

Completed applications will be reviewed as they are received, and there is no application deadline. Applicants are strongly encouraged to complete applications by the dates listed below, however. Failure to provide a completed application by the specified dates will significantly reduce an admitted applicant's opportunity for financial support, and it may delay the student's entrance until a later semester.

Students interested in admission for Fall semester are encouraged to complete their application (including all supporting material) no later than the preceding February 1.

Students interested in admission for first Summer semester are encouraged to complete their application (including all supporting material) no later than the preceding December 1.

Students interested in admission for Spring semester are encouraged to complete their application (including all supporting material) no later than the preceding September 1.

## Combined BS/MS Program for Electrical and Computer Engineering

The Combined BS/MS program is designed to allow Electrical and Computer Engineering (ECE) undergraduates with very strong academic credentials the opportunity to earn credit as undergraduates for a limited number of graduate courses that can be used to satisfy the requirements of both the Bachelor of Science (B.S.) degree and the Master of Science (M.S.) degree in either CpE or EE. Interested undergraduates must apply for admission into the Combined BS/MS program and obtain approval of the application. See appendix D of this handbook for details.

### Undergraduate Course Deficiencies

Students who enter the M.S. or Ph.D. program in either computer engineering or electrical engineering typically hold a B.S. degree in the same major. A student with a B.S. degree in a different major and a strong academic record may also be granted admission into the program in some instances. Undergraduate course deficiencies may be specified for an admitted student deemed to lack some necessary foundational background for the M.S. or Ph.D. program in the major. In such an instance, the student must remedy the deficiencies in a manner specified by the Department prior to completing the normal requirements of the degree.

Students who enter the MENG program in electrical engineering typically hold a B.S. degree in an engineering major with a strong undergraduate-level course-work background in topics related to electrical engineering. Undergraduate course deficiencies may be specified for an admitted student deemed to lack some necessary foundational background for the MENG program in electrical engineering. In such an instance, the student must remedy the deficiencies in a manner specified by the Department prior to completing the normal requirements of the degree.

### Financial Aid

Admission to the graduate program in electrical and computer engineering is considered separately from offers of financial aid (graduate assistantships or fellowships).

All accepted applicants are automatically considered for departmental graduate teaching assistantships and graduate grading assistantships, unless they have indicated otherwise on their application. Graduate research assistantships are awarded by individual faculty members.

Accepted applicants with strong academic credentials may also be considered for a fellowship. The ECE departmental fellowships, the College of Engineering and Science fellowships, and the Clemson University recruitment fellowships are all supplemental; they can only be awarded in conjunction with an assistantship offer. All qualified accepted applicants are considered automatically for supplemental

fellowships; the applicant does not need to apply for consideration. A variety of fellowships funded by external organizations are also available (e.g., DOE, NDSEG, NSF, and SMART fellowships). Students should apply directly to the organization awarding an external fellowship.

Federal loans are another option for some graduate students in electrical and computer engineering. For more details on financial aid, please visit the [Clemson University Financial Aid website](#).

# Current ECE Graduate Students

## Selecting an Advisor

Each graduate student is admitted into a selected focus area (area of specialization) after review by faculty in that area based upon the student's expressed interests. The initial academic advisor for each entering M.S. student is the faculty chairperson of the student's focus area; the initial academic advisor of each entering Ph.D. student is the faculty member who has agreed to advise the student. The initial academic advisor should be consulted in selecting courses for the first semester of study. It is possible to change the area of focus after admission into the program, but it should be understood that acceptance criteria may vary from one focus to another and resource limitations may preclude a change. A change of focus area is subject to approval by the faculty in the new focus area.

After the first semester of study, the student should select a faculty member as the permanent academic advisor for the student's program of study. The academic advisor will serve as the chair of the student's advisory committee; thus, the selected advisor's research interests and expertise should relate closely to the student's focus area of study. The advisor serves as the student's first and primary contact for planning the student's program of study and selecting courses. The advisor and the rest of the advisory committee should be determined by the end of the student's second semester of study. (Refer to M.S. committee details or Ph.D. committee details as appropriate.)

Current Chairpersons for the focus areas are as follows:

Communication Systems and Networks (EE or CpE)	<u>H.B. Russell</u>
Computer Systems Architecture (CpE)	<u>M.C. Smith</u>
Digital Signal Processing(EE or CpE)	<u>C. W. Baum</u>
Intelligent Systems(EE or CpE)	<u>R. R. Brooks</u>
Electronics (EE)	<u>W. R. Harrell</u>
Applied Electromagnetics (EE)	<u>A. Q. Martin</u>
Power & Energy Systems (EE)	<u>K. A. Corzine</u>

## Course Selection

The student should meet with his or her initial academic advisor prior to the first semester of study to select courses for the first semester. Once the student has selected a permanent academic advisor, the student and the advisor should meet for an initial discussion of the student's program of study; this should be followed by a meeting at least once per semester to discuss courses for the subsequent semester. The courses should be chosen so as to make significant progress towards meeting the requirements of the student's degree program. The requirements are given in later sections of the Handbook.

The student should work with his or her academic advisor to complete a GS-2 (Graduate Degree Curriculum) form. The form should list exactly those courses that are to be used to satisfy the requirements for the degree as well as the membership of the student's faculty advisory committee. The composition of the committee depends on whether the student is enrolled in the M.S. program, the MENG program, or the Ph.D. program; details are provided in later sections of the Handbook.

The courses listed on the GS-2 form must be approved by the student's advisory committee. Once the student and the committee agree upon the courses to be included on the GS-2, a handwritten copy (without signatures) should be given to the ECE Graduate Student Services Coordinator. The information will be entered into a database, and a typed copy will be provided for signatures from the committee. After the signatures are obtained, the GS-2 should be returned to the Coordinator for submission to the Graduate School. Each student enrolled in the M.S. or MENG program is required to submit an approved GS-2 form no later than mid-term during his or her second semester in the program. Each student enrolled in the Ph.D. program is required to submit an approved GS-2 form no later than the beginning of the fourth semester of the program. The Graduate School assesses significant late fees for students who do not meet these deadlines.

## Registration

Information on graduate student registration can be found at the [Registrar's web site](#) and in the [Graduate School Announcements](#). Pre-registration is required for all graduate students. The information obtained from pre-registration is essential to plan graduate course offerings properly. Failure on the part of students to pre-register may result in course cancellations and the inability to offer desired courses. Students are strongly encouraged to register early to ensure that courses are not canceled.

All ECE graduate students must also complete and keep up to date a Departmental Information Form, available from the ECE Graduate Student Services Coordinator. Registration is not complete until the form has been completed. The form is the starting point for student records in the Department.

## Enrollment Requirements for Students Receiving an ECE Assistantship

Each graduate student receiving an assistantship in ECE (whether a research assistantship, a teaching assistantship, or a grading assistantship) is required to maintain full-time enrollment status during the semester of the assistantship. (If the student is conducting directed research with an ECE faculty member, the student should enroll in ECE 891 (thesis research) or ECE 991 (dissertation research) for enough credits to accurately reflect the level of research effort of the student, even if the resulting number of course and research credits for the semester exceeds the minimum number required to maintain full-time status.) Some additional requirements for Graduate Assistants are given in Appendix C, and the requirements are detailed in the assistantship contract. Every Graduate Assistant should read Appendix C and the contract carefully.

### Conduct of ECE Graduate Students

Please be familiar with the following Clemson University and College of Engineering and Science policies regarding the conduct of graduate students. ECE graduate students are expected to understand and abide by these policies.

[Clemson University Academic Integrity Policy](#)

[Clemson University Non-Discrimination Policy](#)

[Clemson University Sexual Harassment Policy](#)

[College of Engineering and Science Honor Code](#)

College of Engineering and Science Policy on Alcohol: Alcoholic beverages are prohibited for any activity held in a College of Engineering and Sciences facility unless prior approval has been granted through University-defined procedures. Under no circumstance should alcohol be made available to or consumed by anyone under 21 years of age.

### Miscellaneous Information

#### Thesis Guide

An online booklet entitled "[The Guide: Manuscript Preparation and Graduation Clearance](#)" should be read by all students before writing a thesis or dissertation.

#### Computer Facilities

All graduate students enrolled are automatically assigned a Clemson University ID (user ID) that allows access to the University mainframe and class registration system and to a variety of personal computer labs. Passwords for these systems may be (re)set with a picture ID at the [CCIT Help Desk](#). Accounts to machines under the

control of particular research groups are arranged by the faculty members in charge of these machines.

### Desks

It is the goal of the Department to provide a desk for each graduate student employed by the department. However, due to the limited available space, it may not always be possible to accommodate each student. Therefore, a priority system is used which first assigns a desk to each Graduate Assistant and Graduate Fellow, and then allocates desks to as many other students as possible, based on seniority. New students should see the Technical Support Manager in Room 221F Riggs concerning a desk assignment.

Note: Study facilities for graduate students are intended solely for the purpose of studying and, in some cases, interfacing with students during office hours. They are not to be used for socializing or temporary housing. Students abusing these privileges will forfeit them.

### Keys

Each graduate student who is assigned a desk will be given a key to his/her office and to the building his/her office is in. Keys for labs and classrooms are available for students who have teaching responsibilities there. See the Technical Support Manager in 221F Riggs for assignment of keys.

### Mailboxes

Each student will be assigned a mailbox. Mailboxes should be checked regularly for mail and other informational items. Mailboxes are currently located in the basement hallway of Riggs Hall.

### Office Supplies

The department does not furnish office supplies to graduate students.

### Copying Machines

Located in 104 Riggs is a copy machine for *graduate assistant* use only. Copying of text books is definitely not allowed. Such copying violates copyright laws and is strictly forbidden.

### Telephone/Fax Policy

University funds are not available to support long distance telephone charges for graduate students. Graduate research assistants supported by external funds should coordinate their telephone usage through their faculty supervisor. Calls must be charged to the appropriate contract number. An authorization code number from a faculty supervisor is required to use the Fax machine.

## Graduate Student Government

The Graduate Student Government (GSG) is a university-wide organization of all graduate students for the purpose of promoting graduate student interests. At the start of the fall semester, department GSG representatives are elected. The senate meetings are open to all graduate students. See the [GSG web site](#) for more information.

## IEEE/ACM Membership

Application forms for membership in IEEE, the IEEE Computer Society and the ACM may be obtained from the IEEE advisor. Graduate students are encouraged to associate with the national society, as well as the Piedmont section. Additional information is available at [this link](#).

# Graduate Academic Programs in ECE

## Requirements of the Clemson University Graduate School

All degree requirements of the Clemson University Graduate School must be met in addition to the requirements specified in this Handbook. See the [Graduate School Website](#) for further information.

### Use of Term “ECE Faculty” in Degree Requirements

The term “ECE faculty” in subsequent descriptions refers to full-time tenured or tenure-track faculty with a majority-time appointment in Clemson University’s Holcombe Department of Electrical and Computer Engineering.

### How to Remedy Undergraduate Course Deficiencies

Undergraduate course deficiencies may be specified as a condition of admission for a student deemed to lack some necessary foundational background for the M.S., MEGNR, or Ph.D. degree program. The student must remedy the deficiencies in a manner specified by the Department prior to completing the normal requirements of the degree. The Department provides several options for remedying an undergraduate course deficiency. For any option that requires a grade (such as a proficiency examination or the completion of a graded undergraduate course), a grade of A, B or C is required. All deficiencies must be resolved at least one semester prior to the student’s anticipated graduation.

### Courses Applicable to the ECE Graduate Program Requirements

Graduate credit can be earned only for courses numbered “6000” or above. Courses enumerated “6xxx” (6000-level courses) are the graduate-course counterparts of undergraduate courses enumerated “4xxx” (4000-level courses). (A student enrolled in a 6000-level course must perform additional work beyond that required of a student enrolled in the corresponding 4000-level course.) Courses enumerated “7xxx” (7000-level courses) are graduate-only courses emphasizing professional practice. Courses enumerated “8xxx” (8000-level courses) are graduate-only courses providing research-oriented preparation. Courses enumerated “9xxx” (9000-level courses) are graduate-only courses providing advanced research-oriented preparation.

### Restrictions on 6000-Level Courses

A student may not enroll in a 6000-level course for which the corresponding undergraduate 4000-level credit has been awarded, nor can graduate credit be awarded retroactively for undergraduate courses already completed.

## **Master of Science Program in Electrical Engineering and Computer Engineering**

### **M.S. Advisory Committee**

Each M.S. student must have an advisory committee of at least three Clemson University faculty members. A majority (more than 50%) of the committee members must be tenured or tenure-track ECE faculty. One of the ECE faculty on the committee must serve as the student's academic advisor and as the chair of the committee. A committee member from outside the ECE faculty may serve as a co-chair of the committee with the approval of the Dean of the Graduate School.

The student's academic advisor is his/her first contact in planning a program of study. The advisor, along with the student's advisory committee, will serve the following functions:

- Work with the student to determine course selection for each semester.
- Approve the student's program of study (specified in the GS-2 form).
- Supervise the thesis research (if the thesis option is chosen).
- Administer the final examination (if the thesis option is chosen).
- Initiate recommendations for awarding the degree.

### **M.S. Plan of Study**

The student's planned program of study, documented on the GS-2 form, must be submitted no later than the mid-term of the second semester of the program. Please note that as of Fall 2015, all GS-2 forms are submitted electronically. If circumstances necessitate later changes to the plan a revised GS-2 form must be completed and given to the ECE Graduate Student Services Coordinator for submission to the Graduate School.

### **Summary of M.S. Degree Requirements**

The requirements of the M.S. degrees in CpE and EE are as follows:

- Satisfy any undergraduate course deficiencies specified at the time of admission.
- Complete the graduate course-work requirements specific to the thesis option or the non-thesis option as detailed below.
- Complete a written M.S. thesis (thesis option only).
- Pass the final examination (thesis option only).

Click [here](#) for Graduate School deadlines.

Each student's program of study, as specified by the GS-2 form, must satisfy one of the following two options.

### Thesis Option

The GS-2 form for the thesis option must include a minimum of 30 credit hours of graduate-level course work at the 6000-level, 8000-level, or 9000-level, including the following:

- Exactly six (6) credit hours of ECE 8910 (M.S. Thesis Research)
- A minimum of 24 credit hours of letter-graded course work.
  - The Focus Area Requirements for one of the focus areas in the major must be satisfied as detailed below.
  - At least twelve (12) credit hours of the letter-graded course work must consist of ECE courses.
  - At least twelve (12) credit hours of the letter-graded course work must be at the 800-level or 9000-level.
  - No credit for course work at the 7000-level can be applied towards the degree requirements.
  - No credit for either ECE 8900 or MTHSC 6000 can be applied towards the degree requirements.

A student electing the thesis option in the M.S. program must write a thesis that is approved by the student's advisory committee and the Graduate School. The student must also take a final examination administered by his/her advisory committee. At a minimum, the student must pass an examination consisting of an oral defense of the student's thesis. The advisory committee has the option of administering an additional written and/or oral examination on coursework.

[Note: Each M.S. student receiving a graduate teaching assistantship or a graduate grading assistantship from the Department is required to select the thesis option. An M.S. student supported as a graduate research assistant is almost always required by his or her advisor to select the thesis option as well. M.S. students anticipating entry into the Ph.D. program are strongly encouraged to consider selecting the thesis option.

### Non-Thesis Option

The GS-2 form for the non-thesis option must include a minimum of 33 credit hours of graduate-level course work at the 6000-level, 8000-level, or 9000-level, including the following:

- The Focus Area Requirements for one of the focus areas in the major must be satisfied as detailed below.
- At least twelve (12) credit hours of the letter-graded course work must consist of ECE courses.
- At least 18 credit hours of the letter-graded course work must be at the 8000-level or 9000-level.

- No credit for course work at the 7000-level can be applied towards the degree requirements.
- No credit for ECE 8900, ECE 8910, or MTHSC 6000 can be applied towards the degree requirements.

No thesis or engineering report is required with the non-thesis option, and there is no final examination.

## Focus Area Requirements for the M.S. Program

Each student must satisfy the course requirements for one approved focus area in the corresponding M.S. degree program, regardless of whether the thesis option or the non-thesis option is selected.

### M.S. in Electrical Engineering Requirements for the Focus Area

The following focus areas are acceptable for satisfying the core requirement in Electrical Engineering. For detailed information on a particular focus area, see Appendix A of this Handbook.

Applied Electromagnetics  
 Communications Systems and Networks  
 Digital Signal Processing  
 Electronics  
 Intelligent Systems  
 Power & Energy Systems

### M.S. in Computer Engineering Requirements for the Focus Area

The following focus areas are acceptable for satisfying the core requirement in Computer Engineering. For detailed information on a particular focus area, see Appendix A of this Handbook.

Communications Systems and Networks  
 Computer Systems Architecture  
 Digital Signal Processing  
 Intelligent Systems

## M.S. Thesis

The M.S. thesis (required of each M.S. student electing the thesis option) must demonstrate mastery of available scholarship in the presentation of a substantive idea or problem solution in the major field of the student.

## Minor Subject Option

Each M.S. candidate may include a minor subject in the degree program. To accomplish a minor the student must take 2 courses (6 credit hours) in a subject outside of electrical and computer engineering, such as Math, Physics, Computer Science, or Industrial Engineering, as approved by their advisory committee. If a minor is declared, this subject must be represented on the Advisory Committee by a faculty member from the corresponding department. The minor is designated on the GS-2 form only. A minor discipline will not be listed on the student's transcript.

## Restrictions on Use of ECE 8920

A maximum of 3 hours of ECE 8920, Special Problems in Electrical and Computer Engineering, may be included on the GS-2 form for an M.S. degree in computer engineering or electrical engineering. An M.S. student must obtain advance approval of his/her advisory committee before taking this course if it is to be used on the GS-2 form.

## Transferring Coursework

A maximum of one third (1/3) of the required graded coursework may be transferred to an ECE graduate program. All transfer coursework must be approved by the student's advisor and advisory committee prior to being included on the GS-2. Coursework eligible for transfer must be: from a regionally accredited institution, graded with a B or higher, and is subject to the Graduate School's six-year time limit for validity. Please note all limitations for transfer work set forth by the Graduate School apply. An official transcript must be available prior to transferring the coursework. Coursework applied towards the requirements of a prior degree earned by the student cannot be used for transfer credit. (If requested by the Department, the student must be able to provide verification of eligibility for each course requested for transfer.)

## M.S. Coursework Expiration

All coursework for the M.S. degree must be completed in the six (6) calendar years prior to graduation as per Graduate School policy. Any course work completed before this time window may not be applied towards the requirements of the degree except under special conditions defined by the Graduate School.

## **Master of Engineering Program in Electrical Engineering (MENGR)**

The MENGR degree is designed and intended for professionals who are working full-time as practicing engineers. Courses taught on campus and courses delivered via distance-learning methods (such as on-line delivery) can both be applied towards the requirements of the degree. Thus the degree is available to off-campus students who enroll in distance-education courses. The MENGR degree is different from the M.S. degree in several respects: the MENGR applicant is not required to take the Graduate Record Examination (GRE), the MENGR student is not required to satisfy focus-area requirements, and the student must submit an Engineering Report instead of a conventional M.S. thesis. (The Engineering Report addresses the solution of a problem in engineering design, whereas the M.S. thesis details original discoveries in engineering research.) The Engineering Report must conform to a format specified by Clemson University's College of Engineering and Science (whereas the M.S. thesis must satisfy the University's thesis format requirements).

### **MENGR Advisory Committee**

Each MENGR student must have an advisory committee of at least three Clemson University faculty members. A majority (more than 50%) of the committee members must be ECE faculty. One of the ECE faculty on the committee must serve as the student's academic advisor and as the chair of the committee. A committee member from outside the ECE faculty may serve as a co-chair of the committee with the approval of the Dean of the Graduate School.

The student's academic advisor is his/her first contact in planning a program of study. The advisor, along with the student's advisory committee, will serve the following functions:

- Work with the student to determine course selection for each semester.
- Approve the student's program of study (specified in the GS-2 form).
- Supervise the engineering report project.
- Administer the final examination.
- Initiate recommendations for awarding the degree.

### **MENGR Plan of Study**

The student's planned program of study, documented on the GS-2 form, must be submitted no later than the mid-term of the second semester of the program. Please note that as of Fall 2015, all GS-2 forms are submitted electronically. If circumstances necessitate later changes to the plan a revised GS-2 form must be completed and given to the ECE Graduate Student Services Coordinator for submission to the Graduate School.

## Summary of MENGR Degree Requirements

The requirements of the MENGR degree in EE are as follows:

- Satisfy any undergraduate course deficiencies specified at the time of admission.
- Complete the graduate course-work requirements as detailed below.
- Complete a written engineering report.
- Pass the final examination.

Click [here](#) for Graduate School deadlines.

The GS-2 form for the MENGR degree must include a minimum of 30 credit hours of graduate-level course work at the 6000-level, 7000-level, 8000-level, or 9000-level, including the following:

- Exactly six (6) credit hours of ECE 7010 (MENGR Design Report)
- A minimum of 24 credit hours of letter-graded course work.
  - At least twelve (12) credit hours of the letter-graded course work must consist of ECE courses.
  - At least twelve (12) credit hours of the letter-graded course work must be at the 8000-level or 9000-level.
  - No credit for ECE 8910 can be applied towards the degree requirements.
  - No credit for MTHSC 6000 can be applied towards the degree requirements.

A student in the Master of Engineering Program must write an Engineering Report which is approved by the student's advisory committee. (Administratively, the Engineering Report is approved by the Dean of Engineering.) The project serving as the basis for the Engineering Report must be focused on a problem in engineering design.

The student must also pass a final examination administered by the student's advisory committee, which includes an oral presentation of the student's work in the Engineering Report.

### MENGR Engineering Report

The MENGR Engineering Report must demonstrate the solution to a substantive problem in engineering design following best practices of the electrical-engineering profession.

## Minor Subject Option

Each MENGGR candidate is eligible to include a minor subject in the degree program. To accomplish a minor the student must take 2 courses (6 credit hours) in a subject outside of electrical and computer engineering, such as Math, Physics, Computer Science, or Industrial Engineering, as approved by their advisory committee. If a minor is declared, this subject must be represented on the Advisory Committee by a faculty member from the corresponding department. The minor is designated on the GS-2 form only. A minor discipline will not be listed on the student's transcript.

## Restrictions on Use of ECE 8920

A maximum of 3 hours of ECE 8920, Special Problems in Electrical and Computer Engineering, may be included on any MENGGR candidate's GS-2 form. In addition, a student must obtain advance approval of his/her advisory committee before taking this course if it is to be used on the GS-2 form.

## Transferring Coursework

A maximum of one third (1/3) of the required graded coursework may be transferred to an ECE graduate program. All transfer coursework must be approved by the student's advisor and advisory committee prior to being included on the GS-2. Coursework eligible for transfer must be from a regionally accredited institution, graded with a B or higher, and is subject to the Graduate School's six-year time limit for validity. Please note all limitations for transfer work set forth by the Graduate School apply. Coursework applied towards the requirements of a prior degree earned by the student cannot be used for transfer credit. (If requested by the Department, the student must be able to provide verification of eligibility for each course in which transfer credit is requested.)

## MENGGR Coursework Expiration

All coursework for the MENGGR degree must be completed in the six (6) calendar years prior to graduation as per Graduate School policy. Any course work completed before this time window may not be applied towards the requirements of the degree except under special conditions defined by the Graduate School.

## **Doctorate of Philosophy Program in Electrical Engineering and Computer Engineering**

There are two circumstances in which a student can enter the Ph.D. program in electrical engineering or computer engineering. In one circumstance, the student enters the Ph.D. program with a prior M.S. degree in the same major. (A prior M.S. degree in a closely related engineering major may be treated as equivalent to a prior M.S. degree in the major of the Ph.D. program if so determined by the Department at the time of admission into the Ph.D. program.) In the other circumstance, the student enters the Ph.D. program with only a prior B.S. degree in the same major. (Direct entry to the doctoral program from the baccalaureate is permitted only for students with an exceptionally strong academic record and exceptional potential for research as determined by the ECE faculty during evaluation of the student's application.) The requirements listed in the next several pages apply to both circumstances except where otherwise specified.

A student currently enrolled in the M.S. program in computer engineering or electrical engineering at Clemson University can petition for entry into the Ph.D. program in the same major at any time during the M.S. program. If the student is admitted into the Ph.D. program as a result (prior to receiving the M.S. degree), the requirements for the Ph.D. degree will correspond to those for a student entering the Ph.D. program with only a prior B.S. degree. (Graded coursework taken while enrolled in the M.S. program can normally be applied towards the requirements of the Ph.D. program in this instance, subject to the course-level restrictions of the Ph.D. program.)

A student who enters the Ph.D. program with only a prior B.S. degree may obtain a thesis-option M.S. degree in the major while enrolled in the Ph.D. program (i.e., "en route"). If the student receives the M.S. degree under this circumstance, the student is subsequently considered to have entered the Ph.D. program with a prior M.S. degree. The student must subsequently satisfy only the lesser coursework requirements for the Ph.D. degree required of someone entering with an M.S. degree. The coursework applied towards the requirements for the en-route M.S. degree cannot also then be applied towards the requirements for the Ph.D. degree, however.

### **Ph.D. Advisory Committee**

Each Ph.D. student must have an advisory committee of at least four tenured or tenure-track Clemson University faculty members. A majority (more than 50%) of the committee members must be ECE faculty. At least one committee member must be a faculty member from a department other than ECE. (For example, if there are four committee members, three must be ECE faculty members and one must be a non-ECE faculty member.) One of the ECE faculty on the committee must serve as the student's academic advisor and as the chair of the committee. A committee member from outside the ECE faculty may serve as a co-chair of the committee with the approval of the Dean of the Graduate School.

The student selects the academic advisor, also chair of the committee, who, in consultation with the student, selects the additional committee members. Keep in mind that faculty members must consider their existing workloads before consenting to serve.

A student's academic advisor is his/her first contact in planning a program of study. The advisor, along with the student's advisory committee, will serve the following functions:

- Work with the student to determine course selection for each semester.
- Approve the student's program of study (specified in the GS-2 form).
- Supervise the dissertation research.
- Administer the Comprehensive Exam.
- Administer the final examination.
- Initiate recommendations for awarding the degree.

### Ph.D. Plan of Study

The student's planned program of study, documented on the GS-2 form, must be submitted no later than the beginning of the fourth semester of the program. Please note that as of Fall 2015, all GS-2 forms are submitted electronically. If circumstances necessitate later changes to the plan a revised GS-2 form must be completed and given to the ECE Graduate Student Services Coordinator for submission to the Graduate School.

### Summary of Ph.D. Requirements

The requirements of the ECE Ph.D. Program are as follows:

- Satisfy any undergraduate course deficiencies specified at the time of admission.
- Pass the Ph.D. Qualifying Examination.
- Pass the Ph.D. Comprehensive Examination.
- Complete the graduate course-work requirements.
- Complete a written Ph.D. dissertation.
- Pass the final examination.

Each student's program of study, as specified by the GS-2 form, must satisfy one of the following two program options.

#### Entry to the Ph.D. Program with a Prior Master's Degree

The student must pass the Ph.D. Qualifying Examination, pass the Ph.D. Comprehensive Examination, and write a dissertation that is approved by the student's advisory committee and the Graduate School.

The GS-2 form for the Ph.D. degree with a prior M.S. degree must include a minimum of 42 credit hours of graduate-level course work at the 6000-level, 8000-level, or 9000-level, including the following:

- Exactly 18 credit hours of ECE 9910 (Ph.D. Dissertation Research)
- A minimum of 24 credit hours of letter-graded course work.
  - No credit for course work at the 7000-level can be applied towards the degree requirements.

No credit for MTHSC 6000 can be applied towards the degree requirements.

The student must pass a final examination administered by his/her advisory committee, which includes at a minimum an oral defense of the student's dissertation. The advisory committee has the option of administering an additional written and/or oral exam on coursework, however.

#### Direct Entry to the Ph.D. Program after the Bachelor's Degree

The student must pass the Ph.D. Qualifying Examination, pass the Ph.D. Comprehensive Examination, and write a dissertation that is approved by the student's advisory committee and the Graduate School.

The GS-2 form for the Ph.D. degree without a prior M.S. degree must include a minimum of 60 credit hours of graduate-level course work at the 6000-level, 8000-level, or 9000-level, including the following:

- Exactly 18 credit hours of ECE 991 (Ph.D. Dissertation Research)
- A minimum of 42 credit hours of letter-graded course work.
  - At least nine (9) credit hours of the letter-graded course work must be for non-ECE courses.
  - No more than nine (9) credit hours of the letter-graded course work can be at the 6000-level.
    - No credit for course work at the 7000-level can be applied towards the degree requirements.

No credit for MTHSC 6000 can be applied towards the degree requirements.

The student must pass a final examination administered by his/her advisory committee, which includes at a minimum an oral defense of the student's dissertation. The advisory committee has the option of administering an additional written and/or oral exam on coursework, however.

## Earning an M.S. Degree While Enrolled in the Ph.D. Program

A student who has entered the Ph.D. program directly after the Bachelor's Degree may earn an M.S. degree in the same major en route to the Ph.D. The student must satisfy all the requirements of the M.S. degree with the thesis option (including 6 credits research). A special form, the GS2-14 (Master's En Route to Ph.D. Degree Curriculum) form must be submitted before receipt of the en route M.S. degree. (A separate GS-2 form is required for the Ph.D. degree following receipt of the M.S. Degree.) If a direct-entry Ph.D. student receives an en route M.S. degree, the remaining requirements for the Ph.D. program (beyond the requirements for the M.S. degree) are the normal direct-entry Ph.D. degree requirements minus the 24 hours of letter-graded course work used to satisfy the M.S. degree requirements. Ph.D. students interested in earning an M.S. degree en route should discuss the option with their academic advisor and the ECE Graduate Student Services Coordinator.

A student who has entered the Ph.D. program directly after the Bachelor's Degree and wishes to earn an M.S. degree with the non-thesis option must request a change of program to the M.S. degree program in the major. If the student later wishes to re-enter the Ph.D. program, he or she must submit a new application for admission into the program. If the student is admitted into the Ph.D. program again after having received an M.S. degree in the major, the remaining requirements for the Ph.D. program are the requirements for a student entering the program with a prior M.S. degree.

## Ph.D. Candidacy Requirements

A student in the Ph.D. program is classified as a "candidate for the doctorate" (or is "admitted to candidacy") upon successful completion of the Comprehensive Examination for the degree and acceptance of the GS5-D (Doctoral Candidacy) form by the Graduate School. Once admitted to candidacy, the student has five years to complete all the requirements for the doctorate.

## Ph.D. Qualifying Examination

Part of the outcome of earning a Ph.D. degree is acquisition of sufficient depth and breadth in the core areas of the major to enable the graduate to teach courses in these areas. Each student in the Ph.D. program must demonstrate mastery of the material at this level by passing the written Ph.D. Qualifying Examination, which tests the student's preparation in undergraduate ECE material.

The Ph.D. Qualifying Examination is given once each year; it is currently scheduled during the Fall break each year. Each student who enters the Ph.D. program with a prior M.S. degree in the major must take the exam at the first opportunity. Each student entering the Ph.D. program with only a prior B.S. degree (i.e., direct-entry Ph.D.

students) may take the exam at the first opportunity or may defer the exam until the second opportunity.

Students are required to complete the [Qualifying Examination Signup Form](#) and turn it in to the Student Services Program Coordinator for the Graduate Program. The signup deadline and the dates and times of the next exam can be found on the [ECE website](#).

On the signup form, the student must select three topics.

Electrical engineering majors must choose their topics from the following list:

Electrical Engineering Exam Topics
Circuits
Controls
Electronics
Electromagnetics
Power & Energy Systems
Probability and Random Variables
Signals and Systems

Computer engineering majors must choose their topics from the following list:

Computer Engineering Exam Topics
Circuits
Controls
Computer Hardware and Architecture
Computer System Structures
Probability and Random Variables
Programming Systems and Software Engineering
Signals and Systems

The examination takes place over two days. On each day the duration of the exam is three hours. The first part of the examination is on the afternoon of the first day, and the second part is on the morning of the second day. The first day of the examination is closed book, and the second day is open book.

The examination consists of 12 questions, four from each exam topic the student has selected. The student must answer all 12 questions. On each day, the student answers two questions from each topic. The questions are handed out and collected two at a

time (topic by topic) each hour. The student may not go back to questions given in an earlier hour.

Test solutions are identified only with a two-digit code given to each student by the proctor prior to the start of the examination. Students should not put their names on their exams, but should only use the two-digit code.

A committee of at least two faculty members writes the questions for a given topic. The same committee evaluates each student's performance on the four questions from this topic and assigns a single score that is one of the following:

- 10: Exceptional competence
- 8: Reasonable competence
- 6: Minimum competence
- 4: Some knowledge, but not enough to declare competence
- 2: Rudimentary knowledge
- 0: No knowledge

Scores between these values are not given. Note that the score measures overall competence on the topic. It is not a measure of the percentage correct. A cumulative score of 24 or higher for the three topic areas constitutes a passing exam attempt, whereas a cumulative score of 22 or below constitutes a failed exam attempt. Students will be informed in writing of their scores on each topic after grading of all exams is completed.

A Ph.D. student who fails the Ph.D. Qualifying Examination in the first attempt must retake and pass the exam at the next available opportunity (with the exception of those students eligible for the remediation option described below). If a student fails the second attempt at the exam, the Department will request that the Graduate School dismiss the student from the Ph.D. program.

To sign up for the test as a retake, the student must complete the [Qualifying Examination Retake Signup Form](#) and turn it in to the Student Services Program Coordinator for the Graduate Program. The deadline for submitting this form is given at [this link](#). For the retake, the student may again choose any three topics. However, for a topic that was also taken in the first attempt, the *maximum* of the scores of that topic from both attempts will be used. For a topic that was not taken the first attempt, only the score from the second attempt is used. For the retake, a student may choose to retake less than three topics, accepting scores from the first attempt on the remaining topics. This must be decided in advance and is entered on the signup form. For the retake, passing again requires a total score of at least 24.

A student who fails the Ph.D. Qualifying Examination during the first attempt may be eligible for *remediation* as an alternative to taking the exam a second time. A student is eligible for remediation if the student's first attempt at the exam results in a score of 8 or 10 on each of two (2) topics and a score of 4 or 6 on the third (3<sup>rd</sup>) topic. Each

student who meets this requirement for eligibility will be given the option to remediate the third topic by taking a course, for credit, during the subsequent spring semester. If the student chooses the remediation option, a remediation course will be assigned by the Ph.D. Qualifying Exam topic committee for the topic area requiring remediation. The student must earn the letter grade specified by the topic committee in the course (either an "A" or a "B" as determined by the committee). If the student passes the course with the required grade, the student is considered to have passed the Ph.D. Qualifying Examination. If the student attempts the remediation course but does not earn the grade specified, then the student is required to retake the Ph.D. Qualifying Examination at the next opportunity (as if the remediation option had not been chosen). A student who fails the first attempt but is not eligible for the remediation option or declines the remediation option must retake the exam at the next opportunity.

A student enrolled in the M.S. program can elect to take the Ph.D. Qualifying Examination, though it is not a requirement of the M.S. program. If an M.S. student takes and passes the exam and is later admitted into the Ph.D. program, it is not necessary for the student to take and pass the exam again once entering the Ph.D. program. If an M.S. student takes and fails the exam and is later admitted into the Ph.D. program, however, the failed attempt is treated as a failed first attempt in the Ph.D. program. In that instance, the required date of the student's retake of the exam (or remediation if that option applies) is determined relative to the student's date of entry into the Ph.D. program (as if the failed first attempt had occurred at the first opportunity after entering the Ph.D. program).

A Qualifying Examination Study Guide is available to help you prepare for this exam. This document specifies what should be studied for each topic and is found in Appendix B of this handbook. No other review material is provided by the department for this exam. Good practice in preparing for the exam includes outlining the designated textbooks specified in the Study Guide, solving all problems at the end of textbook chapters, and preparing lecture notes as if the student were teaching the topic material himself or herself.

Any student petition regarding the results of the Ph.D. Qualifying Examination must be submitted in writing to the Chair of the ECE Graduate Committee within 30 days of the date on the letter informing the student of the results of the Examination.

## Ph.D. Comprehensive Examination

The student's advisory committee administers this exam. The content and scope of the exam are at the discretion of the committee. The exam may be written or a combination of written and oral. This exam must be completed at least six months before the student is eligible to graduate. The GS5-D (Doctoral Candidacy) form is required for documentation of the completion of the requirement. Further details may be found in the [Graduate School Announcements](#).

## Ph.D. Dissertation

The Ph.D. dissertation must constitute an original, unique, substantive contribution to scholarship in the major field of the candidate.

## Transferring Coursework

A maximum of one third (1/3) of the required graded coursework may be transferred to an ECE graduate program. All transfer coursework must be approved by the student's advisor and advisory committee prior to being included on the GS-2. Coursework eligible for transfer must be: from a regionally accredited institution, graded with a B or higher, and is subject to the Graduate School's six year time limit for validity. Please note all limitations for transfer work set forth by the Graduate School apply. Coursework applied towards the requirements of a prior degree earned by the student cannot be used for transfer credit. (If requested by the Department, the student must be able to provide verification of eligibility for each course in which transfer credit is requested.)

## **Applied Electromagnetics**

Courses in this focus area can be used to satisfy the focus-area requirements for the M.S. in electrical engineering. There are four (4) course requirements:

1. ECE 8300 Electromagnetics
2. ECE 8290 Special Functions in Engineering
3. One (1) of the following:
  - ECE 6360 Transmission Lines and Microwave Circuits
  - ECE 8270 Finite Difference Time Domain Method
  - ECE 8310 Advanced Electromagnetic Theory
  - ECE 8340 Asymptotic Methods and Diffraction Theory
  - ECE 8350 Finite Element Method in Electromagnetics
  - ECE 8390 Integral Equations in Electromagnetics
4. One (1) of the following, unless taken as an undergraduate:
  - ECE 6350 Grounding and Shielding
  - ECE 6460 Antennas and Propagation
  - ECE 8930 Special Topics (CMOS RFIC Design)

## **Communication Systems and Networks**

Courses in this focus area can be used to satisfy the focus-area requirements for either the M.S. in computer engineering or the M.S. in electrical engineering. There are three separate tracks; one for computer engineering majors and two for electrical engineering majors.

### **Computer Engineering Track**

There are three (3) course requirements:

1. ECE 6380 Computer Communications
2. ECE 8480 Telecommunication Network Modeling and Analysis
3. One (1) of the following:
  - ECE 6400 Performance Analysis of Local Computer Networks
  - ECE 8410 Distributed Computing and Networks
  - ECE 8450 Computer System Design and Operation
  - ECE 8500 Computation and Simulation

### **Electrical Engineering Communication Networks Track**

There are three (3) course requirements:

1. ECE 6380 Computer Communications
2. ECE 8480 Telecommunications Network Modeling and Analysis
3. One (1) of the following:
  - ECE 8180 Random Process Applications in Engineering
  - ECE 6300 Digital Communications (previously ECE 8200)
  - ECE 8570 Coding Theory

### **Electrical Engineering Digital Communication Systems Track**

There are four (4) course requirements:

1. ECE 8180 Random Process Applications in Engineering
2. ECE 6300 Digital Communications (previously ECE 8200)
3. ECE 8210 Digital Communication Systems II
4. ECE 8570 Coding Theory

## **Computer Systems Architecture**

Courses in this focus area can be used to satisfy the focus-area requirements for the M.S. in computer engineering. Students must take at least one (1) course from each of the following three areas:

### **Software**

- ECE 6170 - Elements of Software Engineering
- ECE 8520 - Software Engineering
- ECE 8550 - Artificial Intelligence
- ECE 8730 - Parallel and Distributed Systems

### **Architecture**

- ECE 6290 - Organization of Computers
- ECE 6680 - Embedded Computing
- ECE 8420 - Computer Architecture
- ECE 8510 - Advanced Topics in Computer Architecture

### **Networks**

- ECE 6400 - Performance Analysis of Local Computer Networks
- ECE 6490 - Computer Network Security
- ECE 8480 - Telecommunication Networks Modeling and Analysis
- ECE 8490 - Advanced Topics in Computer Communications

## Digital Signal Processing

Courses in this focus area can be used to satisfy the focus-area requirements for either the M.S. in computer engineering or the M.S. in electrical engineering. There are two separate tracks; one for computer engineering majors and one for electrical engineering majors.

### Computer Engineering

There are three (3) course requirements:

1. ECE 6670 Introduction to Digital Signal Processing
2. ECE 8440 Digital Signal Processing
3. Three (3) of the following:
  - ECE 6420 Knowledge Engineering
  - ECE 8460 Digital Processing of Speech Signals
  - ECE 8470 Digital Image Processing
  - ECE 8550 Artificial Intelligence
  - ECE 8560 Pattern Recognition
  - ECE 8720 Artificial Neural Networks
  - ECE 8770 Computer Vision

### Electrical Engineering

There are three (3) course requirements:

1. ECE 6670 Introduction to Digital Signal Processing
2. ECE 8440 Digital Signal Processing
3. Three (3) of the following:
  - ECE 8180 Random Process Application in Engineering
  - ECE 8190 Detection and Estimation Theory
  - ECE 6300 Digital Communications (previously ECE 8200)
  - ECE 8460 Digital Processing of Speech Signals
  - ECE 8470 Digital Image Processing
  - ECE 8560 Pattern Recognition
  - ECE 8720 Artificial Neural Networks
  - ECE 8770 Computer Vision

## Electronics

Courses in this focus area can be used to satisfy the requirements for the M.S. in Electrical Engineering—*Electronics*. Four (4) courses must be selected from the list of acceptable courses below:

1. ECE 6040 Semiconductor Devices
2. ECE 6060 Introduction to Microelectronics Processing
3. ECE 6320 Instrumentation
4. ECE 6590 Integrated Circuit Design (When Available)
5. ECE 8230 Integrated Circuit Technology
6. ECE 8400 Physics of Semiconductor Devices

### Additional Course Options

Subject to enrollment, Electronics faculty offer ECE 8930 Selected Topics courses dealing with advanced topics in solid-state energy conversion devices and systems, micro- and nano-electronics, IC design, and photonics. In special cases, the student's advisory committee may approve one of these ECE-8930 courses to satisfy one of the focus-area requirements.

## Intelligent Systems

Courses in this focus area can be used to satisfy the focus-area requirements for either the M.S. in computer engineering or the M.S. in electrical engineering.

### Electrical Engineering

There are four (4) course requirements:

1. ECE 8010 Analysis of Linear Systems
2. ECE 8470 Image Processing
3. One (1) of the following:
  - ECE 6420 Knowledge Engineering
  - ECE 6550 Robot Manipulators
  - ECE 6680 Embedded Computing
4. One (1) of the following:
  - ECE 8540 Analysis of Robot Systems
  - ECE 8550 Artificial Intelligence
  - ECE 8560 Pattern Recognition
  - ECE 8590 Intelligent Robotic Systems
  - ECE 8690 Advanced Robot Kinematics
  - ECE 8720 Neural Networks
  - ECE 8740 Nonlinear Control Systems
  - ECE 8770 Computer Vision

### Computer Engineering

There are four (4) course requirements:

1. ECE 8010 Analysis of Linear Systems
2. ECE 8470 Image Processing
3. One (1) of the following:
  - ECE 6420 Knowledge Engineering
  - ECE 6490 Computer Network Security
  - ECE 6680 Embedded Computing
4. One (1) of the following:
  - ECE 8540 Analysis of Robot Systems
  - ECE 8550 Artificial Intelligence
  - ECE 8560 Pattern Recognition
  - ECE 8590 Intelligent Robotic Systems
  - ECE 8690 Advanced Robot Kinematics
  - ECE 8720 Neural Networks
  - ECE 8770 Computer Vision

## **Power & Energy Systems**

Courses in this focus area can be used to satisfy the focus-area requirements for the M.S. in electrical engineering. The thesis option and the non-thesis option have slightly different requirements.

### **Thesis Option**

Four (4) courses must be selected from the list of acceptable courses below.

### **Non-thesis Option**

Six (6) courses must be selected from the list of acceptable courses below. A final project report is also required.

#### *List of acceptable courses:*

- ECE 8020 Electric Motor Control
- ECE 8070 Computer Methods for Power Systems Analysis
- ECE 8160 Electric Power Distribution System Engineering
- ECE 8170 Power Systems Transients
- ECE 8240 Power System Protection
- ECE 8620 Real Time Computer Applications in Power Systems
- ECE 8630 Power Systems Dynamics and Stability
- ECE 8930 Advanced Power Electronics
- ECE 8930 Special Topics in Power Systems

## Circuits

Courses at Clemson covering Ph. D. qualifier exam material for this subject area:

ECE 2020, ECE 2110 (lab)

ECE 2620, ECE 2120 (lab)

Textbook:

Electric Circuits, 6th - 9th editions, by Nilsson and Riedel

Chapters 1-14, 18, except 5. All these editions are suitable for review purposes

Topics covered:

- Power, energy, voltage, current, charge concepts
- Independent and dependent voltage and current sources
- Circuit elements and circuit topologies
- DC steady-state and transient analysis
- AC steady-state analysis, phasor analysis, single and balanced three-phase systems
- Sinusoidal steady-state power computations in single and balanced three-phase circuits.
- Mutual Inductance, ideal transformers
- Laplace transforms and applications in circuit analysis
- Frequency selective circuits and resonance
- Two-port circuits and transfer functions

## Computer Hardware/Architecture

Courses at Clemson covering exam material:

ECE 2010  
ECE 2720  
ECE 3270  
ECE 3710

Textbooks:

Mano, Logic and Computer Design Fundamentals, 4<sup>th</sup>, Prentice Hall, ISBN 013198926x

Tanenbaum, Structured Computer Organization, 5<sup>th</sup>, Pearson, ISBN 0131485210

Brown, Fundamentals of Digital Logic w/ WHDL Design, 3<sup>rd</sup>, McGraw Hill, ISBN 0077221435

Barrett, Embedded Systems: Design and Applications 68HC12 and HCs12, 2005, Pearson, ISBN 0131401416

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Topics of coverage:

- Boolean algebra
- Combinational logic
- Synchronous sequential logic
- Asynchronous sequential logic
- Computer organization
- Microprogramming
- Machine language
- Assembly language
- Addressing and addressing modes
- I/O
- Hardware definition languages (HDLs)
- Simulation of digital systems

## Computer Systems Structures

Courses at Clemson covering exam material:

ECE 2230

CPSC/ECE 3220

Textbooks:

Standish, Data Structure Algorithms Software Principles in C, 1995, Addison-Wesley, ISBN 0201591189

Tanenbaum, Modern Operating Systems, 3<sup>rd</sup>, Prentice Hall, ISBN 0136019196

Topics of coverage:

- Stacks
- Queues
- Lists
- Trees
- Heaps
- Tables
- Data structures applications
- Processor management
- Processes, threads, execution frames, and scheduling
- Signals, inter-process communication
- Concurrency (deadlock, monitors, semaphores, locks, etc.)
- Memory management
- Paging
- Segmentation
- Address translation
- Virtual I/O
- Device drivers
- File systems
- Computer communications
- Classic problems (dining philosophers, smokers, readers/writers, etc.)

## Controls

Course at Clemson covering exam material:

ECE 4090

Textbook:

Dorf, Bishop, Modern Control Systems, 12<sup>th</sup>, Prentice Hall, ISBN 0136024580

Modern Control Engineering, K. Ogata

Chapters 1-9, 11-12

Topics of coverage:

- Laplace Transforms, transfer functions
- Block diagrams, signal flow graphs
- Physical system models, PD control
- Transient, steady-state error analyses
- Stability analysis
- Root locus techniques
- Frequency response analysis
- Compensation (lead-lag, PID)
- State space control analysis
- State space design

## Electromagnetics

Courses at Clemson covering exam material:

ECE 3800

ECE 3810

Textbook:

Sadiku, Elements of Electromagnetics, 5th, Oxford University, ISBN 0195387759

Chapters 1 through 12

Topics of coverage:

ECE 3800

- Vector calculus
- Electrostatic fields and potentials
- Work and energy storage (electrostatic)
- Boundary conditions and boundary value problems
- Capacitance
- Stationary currents and resistance
- Magnetostatic fields and vector potentials
- Work and energy storage (magnetostatic)
- Inductance

ECE 3810

- Time-varying fields and waves; Maxwell's equations
- Plane-wave propagation in unbounded medium
- Reflections at interfaces, power density
- Skin effect, resistance at AC
- Transmission lines (sinusoidal analysis)
- Transmission lines (transient analysis)
- Radiation concepts; basic antenna theory

## Electronics

Courses at Clemson covering exam material:

ECE 3200

ECE 3210

Textbook:

Microelectronics Circuit Analysis and Design, 4th. ed., McGraw Hill Publishing, 2010, by Donald A. Neamen. ISBN 0073380644.

All chapters

Topics of coverage:

ECE 3200

- Semiconductor materials
- Pn-junction operation and circuits
- Bipolar transistor operation and circuits
- Field effect transistor operation and circuits
- Design principles

ECE 3210

- Biasing and intermediate frequency design for BJT's and FET's
- Low and high frequency design of BJT and FET amplifiers
- Analysis and design of single ended and differential multi stage amplifiers
- Feedback and stability
- Operational amplifier basics and applications
- Non-ideal operational amplifiers
- Oscillator circuits
- Power amplification
- Integrated circuits and applications

## **Power & Energy Systems**

Courses at Clemson covering exam material:

ECE 3600

ECE 4180

Textbooks:

Electric Machinery and Power System Fundamentals, 4<sup>th</sup>, McGraw Hill, Chapman, ISBN 0072291354

Power System Analysis, 1994, McGraw Hill, Grainger and Stevenson, ISBN 0070612935

Note: These textbooks are only examples. Many other textbooks (for example, Elements of Power Systems, Stevenson, 3rd or 4th edition) cover the same material.

Topics of coverage:

- Power transformers(single phase and three phase)
- DC, induction, and synchronous machines
- Per unit system, system admittance and impedance matrices
- Load flow analysis
- Economic dispatch
- Fault analysis

## **Probability and Random Variables**

Courses at Clemson covering exam material:

ECE 3170

Textbooks:

Random Signal Analysis in Engineering Systems, John J. Komo, 1987,  
Academic Press, ISBN 012418660

Chapters 1-4, 6-7

Topics of coverage:

- Probability
- Random variables and vectors
- Functions of random variables
- Expectation
- Random processes

## Programming Systems/Software Engineering

Courses at Clemson covering exam material:

ECE 3520

ECE 4170

Textbooks:

R. J. Schalkoff, *Programming Languages and Methodologies*, 2007, Jones & Bartlett, ISBN 0763740594

S. McConnell, *Code Complete*, 2<sup>nd</sup> edition, 2004

Topics of coverage:

- Programming Languages
- Compilers and computing systems
- Programming paradigms
- Imperative (procedural) languages
- Object-based languages
- Functional languages
- Declarative (logic) languages
- Formal semantics
- Software engineering
- Software life cycles
- Object-oriented development (C++)
- Object-oriented modeling and design (UML)
- Programming tools (CVS / SVN, Visual Studio IDE and debugger, gdb)
- Pseudocode programming process, test-driven development
- Formal methods, systematic program development
- Requirements analysis and safety-critical systems
- Testing, verification and validation

## Signals and Systems

Courses at Clemson covering exam material:

ECE 3300

ECE 4670

Textbooks:

ECE 3300: Signals and Systems, 2nd Edition, Alan V. Oppenheim and Alan S. Willsky, 1997, Prentice Hall, ISBN 0138147574

Chapters 1-4, 5.1-5.3, 6, 7.1-7.3, 9, 10

Note: An entire course in DSP is not necessary. The relevant DSP material is taught in many Signals and Systems courses and is included in the chapters listed for the ECE 3300 textbook.

Topics of coverage:

- Signal representations
- System representations and properties
- LTI systems
- Discrete- and continuous-time Fourier series
- Discrete- and continuous-time Fourier transforms
- Sampling
- Laplace and Z-transforms
- Analysis of discrete- and continuous-time LTI systems via transform techniques

## Appendix C – ECE Department Assistantships

### Workload

The normal half-time graduate assistantship workload is 20 hours per week (average). Students are often hired for 25% (10 hours) or some other fraction of full-time work.

#### Affordable Care Act:

After you are on payroll, you will be asked to report paid service hours worked in a timely manner in the Time Capture System. Here is a link with more information about the ACA:

[http://www.clemson.edu/employment/benefits/aca/aca\\_updates.html](http://www.clemson.edu/employment/benefits/aca/aca_updates.html). Please contact the Office of Human Resources at [Ask-HR](#) with any questions related to ACA and the Time Capture System.

### Employment Schedule and Leave without Pay

Graduate students with 9-month and 12-month graduate teaching assistantship appointments work on the same calendar as faculty with 9-month and 12-month appointments, respectively. The duties over holiday periods for graduate research assistants should be agreed upon by the student and the immediate faculty advisor in charge of the research program. The policy concerning leave without pay is outlined in the financial section of the Graduate School Announcements.

### Termination of Pay

Pay for any session will end when the student leaves Clemson and/or is no longer available for work assignments, except for the 2-week Christmas vacation policy for continuing students, stated above. Normal termination dates for the spring and fall semesters for students not continuing into the next session will be Graduation Day. Any deviations from these dates must be approved by the student's research supervisor, or by his/her teaching supervisor, through the Graduate Program Coordinator.

### Reduction of Pay

Normally, 20 hours/week will be submitted on each payroll for each half-time graduate assistant. However, less than 20 hours may be submitted for a student, with the pay reduced accordingly if the amount of time worked by the student consistently deviates from the required 20-hours/week average. Due to the procedure currently used for time sheets, it may be necessary to implement any pay reductions in the pay period following the one in which the work deficiency actually occurred.

### Mechanisms for Funding Graduate Students

The ECE Department uses two different mechanisms for funding graduate students. One is the Department-offered assistantship that is normally offered at the beginning of

a student's enrollment at Clemson. The offer for this assistantship comes from the ECE Department Chair. This assistantship is subject to the four or six semester time limit as described below (depending upon the degree being pursued) and is contingent upon satisfactory performance and progress towards the degree by the student.

The other type of assistantship is a research assistantship offered directly by a faculty member. In this case, the funding commitment is from the faculty researcher, and the Department is not obligated to sustain the support if the faculty member withdraws support.

In some cases, an entering student is offered an assistantship both by the Department and by a faculty researcher. In this case, if the student elects to accept the research assistantship and the research funding ends, the Department's offer will still be available if the time limit of the original offer has not expired. Some students have a joint assistantship consisting of both a part-time teaching assistant position and a part-time research assistant appointment.

In addition to financial support from within the department, there are also various fellowships available from the College of Engineering and Science, the University, industry, philanthropic organizations, and from several U.S. government agencies. Information is available through the graduate program office in Riggs Hall or from the Graduate School office in Martin Hall. Many of these fellowships are restricted to U.S. citizens.

Note the following additional information:

- Assistantships for M.S. students will normally be awarded for a maximum of 4 regular (Fall/Spring) semesters. The same time limit applies to fellowships controlled by the Department.
- Assistantships for Ph.D. students will normally be awarded for a maximum of 6 regular (Fall/Spring) semesters beyond the M.S. degree. The same time limit applies to fellowships controlled by the Department.
- Some assistantships are available in the summer but are not guaranteed. Efforts will be made to distribute summer support equitably, based on needs of the Department and on the qualification and seniority of students.
- Continuation of assistantships and fellowships is contingent upon satisfactory academic performance, as well as satisfactory performance of assigned duties associated with the assistantship.

Students are encouraged to work with faculty on sponsored research projects. If a research project is terminated before a student has completed his/her degree program, the Department will endeavor (on an individual basis) to provide financial support to allow continuation of the student's program. This might involve a teaching assistant or grading assignment, if appropriate. The foregoing statement should not be construed as

an assurance of funding. The student is expected to complete his/her degree program in a timely fashion.

Each year, the Department establishes fixed rates for state-supported assistantships. The rates are a function of the type of assistantship, the number of hours per week assigned, and whether the student is a M.S. or Ph.D. candidate. Rates for externally funded assistantships are at the discretion of the individual faculty providing support. If the Department has committed an assistantship to a student at a particular biweekly rate, and a faculty researcher offers the student partial support, the Department reserves the right to reduce the level of support from state funds so as to maintain the same total biweekly or semester rate. (This reduction of state funding may be necessary due to overall budgetary constraints of the Department.)

Individual faculty members are not empowered to offer teaching assistantships or grading positions to graduate students.

The department maintains a list of all current students who have been awarded an assistantship by the department and of all non-supported students who have requested assistantship support. Faculty researchers will normally review this list and consult with the Graduate Program Coordinator before committing assistantship support to a student.

### Enrollment Requirements for Students Receiving an ECE Assistantship

Each graduate student receiving an assistantship in ECE (whether a research assistantship, a teaching assistantship, or a grading assistantship) is required to maintain full-time enrollment status during the semester of the assistantship. The student is eligible for the (reduced) graduate assistant rate for tuition and fees only if he or she is employed as a graduate assistant for the full semester or through the time of completion of all degree requirements in the semester. Each graduate student receiving an assistantship in ECE during fall semester or spring semester must take nine credit hours of course work (including research credits), and each student receiving an assistantship during a summer semester must take three credit hours of course work (including research credits). Additional stipulations may be specified in the student's assistantship contract with the Department; thus, each graduate assistant should read the contract carefully.

### Description of Dept.-Offered Assistantships

There are two types of departmental-offered assistantships:

- Graduate Teaching Assistantship (GTA)
- Graduate Grading Assistantship (GGA)

A GTA assignment is made to a regular laboratory section that requires students to meet for a specified 2 or 3 hour time slot on a weekly basis. Recipients of GTAs are expected to prepare and present lab lecture and pre-lab materials, assist students in conducting the laboratory, and collect and grade lab reports. The GTA recipient is expected to be responsible for the portion of the student's grade related to that lab. Every regular laboratory section must have an official course number and be entered into the campus scheduling computer. Laboratories that do not have credit hours associated or do not meet on a regular basis should not be assigned course numbers and will not have a GTA automatically assigned.

A GGA assignment is made to a regular lecture section for the purpose of grading student homework and other assignments. The GGA is not expected to meet with students except as to explain the grading of a particular assignment when needed. Assignments are only made to lectures that have need of a GGA. The department does not have funds to provide a grader for every lecture section.

The Graduate Program Coordinator is the point of contact for faculty wishing to request graduate student positions. Note the following information:

- All regular laboratory sections will automatically have a GTA assigned. Each laboratory section carries a 5-hour assignment.
- Instructors must request a GGA to grade any regular lecture section. Hours assigned depend on enrollment as approved by the department chair.

### Award Policy for Dept.-Offered Assistantships

The Graduate Program Coordinator in charge of making assistantships assigns graduate students to departmental-offered assistantships. The following priority list is used in making assignments:

1. Students who have a financial commitment in writing from the department up to the amount of that commitment.
2. Students specifically requested for certain positions by the faculty member supervising that position.
3. Students with prior experience in a given position.
4. Students who have requested a given position.
5. Students whose focus area indicates a good match for a position.
6. Ph.D. students have priority over M.S. students.
7. Any qualified student.

At the beginning of each semester, students (whether they have an existing GTA/GGA or not) indicate TA and/or Grading preferences. This is done via a 'preference form' distributed from the Student Services Program Coordinator for the Graduate Program in 102C Riggs Hall.

Students need a total of 10 hours of support to receive a tuition reduction from the university. Thus, students who do not have an externally funded RA will be assigned at least 10 hours.

Effort is made to limit the number of different subjects a student must cover in a semester. If a student can be assigned to multiple sections of one lab, that is preferred. Two different subjects is considered a maximum, except in special cases. Of course, financial commitments must still be honored.

In making grader assignments, effort is made to have students grade as few different courses as possible, and to have faculty interacting with as few students as possible. Often this does not work out, but we try.

### Information for International Students

International students who wish to become graduate teaching assistants must first pass the ECE test of spoken English. It is given each fall and spring semester and can be arranged by signing up with the Student Services Coordinator for the Graduate Program.

The ECE exam lasts about 10 minutes and consists of a technical presentation of 5 minutes followed by a question and answer session. This exam is designed to assess a candidate's ability to present technical information orally to a typical group of undergraduates. The audience will consist of at least two faculty members from the ECE department. The presentation should be organized ahead of time by the candidate and be typical of what would be presented to an undergraduate laboratory class. For example, a suitable topic might be how a low-pass filter works and how the student will build and test this filter in the lab. [ECE Laboratory Manuals](#) are available on the ECE website. Computer presentations are not allowed due to the brief amount of time each student has to present.

### Appointment Procedure for New Appointments

New appointments for formal assistantships must be initiated, in writing, by the Graduate Coordinator or the Principal Investigator of the research project. Temporary appointments are made on a semester-by-semester basis as the need arises. Students must fill out tax forms either with the Office of International Affairs or the College of Engineering and Science Budget Center. Students are responsible for providing tax forms promptly. Delays in receiving these forms can cause delays in checks since they are only issued every two weeks.

## Appendix D – Combined BS/MS Program

### Application to the Combined BS/MS Program

A student must satisfy the following criteria in order to apply for the program:

1. Current enrollment in the B.S. program in CpE or EE at Clemson.
2. One to two semesters of course work remaining in the B.S. program.
3. Minimum overall GPR of 3.4 or higher at the end of the junior year of the program.

A student must take the following steps to apply for the program:

1. Complete and submit the GS6BSMS form (Request for Combined Bachelors/Masters Education Plan). The form is available on the Graduate School's website, and application details are available in the Academic Regulations section of the Graduate School Announcements.
2. Specify one of the following focus areas (areas of specialization) on the [GS6BSMS form](#). Indicate the focus area in parenthesis after the EE or CpE 'major.' The focus areas in the list below are the only options for the Combined BS/MS program.

#### Approved M.S. Focus Areas

Applied Electromagnetics  
Communications Systems and Networks  
Computer Systems Architecture  
Digital Signal Processing  
Electronics  
Intelligent Systems  
Power & Energy Systems

#### Admission into the Combined BS/MS Program and Provisional Admission into the M.S. Program.

Each application to the Combined BS/MS program will be evaluated by the ECE Department and the Graduate School to determine the applicant's suitability for the program. The applicant will be informed by the Graduate School of the resulting admission decision. (An applicant who is not accepted into the Combined BS/MS program can still submit an application in his or her senior year for standard admission into the M.S. or Ph.D. program upon graduation.) Students admitted to the Combined BS/MS program in ECE are considered to have gained *provisional* admission into the M.S. program in ECE.

## Appendix D – Combined BS/MS Program

### Additional Requirements to be met for Full Admission into the M.S. Program

1. Each student admitted into the Combined BS/MS program must provide the ECE Department with Graduate Record Examination (GRE) scores no later than the mid-term date of the semester in which the student will complete the requirements for the B.S. degree. (Earlier submission of the scores is encouraged so that the student will be considered for opportunities for financial support during in the M.S. program – see the ECE Department’s Web site for recommended dates for submission of graduate application material.)
2. Each student admitted into the Combined BS/MS program must complete the B.S. degree in ECE with a minimum GPR that depends on the student’s selected focus area. (The minimum GPR for each focus area is at least 3.4.)

### Graduate-Level Course Work taken Prior to Completion of the B.S. Degree

Each student admitted to the Combined BS/MS program in ECE is eligible to apply up to nine credit hours of 600-level and 800-level ECE course work towards the technical-elective requirements of the B.S. degree in CpE or EE. The same credit hours will also be applied towards the course requirements of the M.S. degree in CpE or EE. Several conditions and restrictions apply.

1. Only the 6000-level and 8000-level courses approved for the student’s specified M.S. focus area may be applied towards the B.S. degree requirements. (See the 6000-level and 8000-level courses listed below by M.S. focus area.)
2. Different 6000-level and 8000-level courses are applicable to the technical depth requirement of the B.S. program in different areas of concentration. (See the 6000-level and 8000-level courses listed below by the B.S. technical-depth concentration to which they may be applied.)
3. The student must submit a GS6 form (Request for Senior Enrollment in Graduate Course) to obtain the instructor’s approval for each 800-level course that is taken prior to completion of the B.S. degree.
4. Graduate-level course work taken prior to the completion of the B.S. degree can be applied only towards the requirements of the M.S. degree with the thesis option. It *cannot* be applied towards the requirements of the M.S. degree with the non-thesis option. (For details on the requirements of the M.S. thesis option, please refer to the M.S. thesis requirements in the ECE Graduate Student Handbook.)

## Appendix D – Combined BS/MS Program

### Other Policies Regarding the Combined BS/MS Program in ECE

1. In the event that a student participating in the Combined BS/MS program does not subsequently qualify for full admission into the graduate program, the 600-level and 800-level course credits earned by the student prior to completion of the B.S. degree are still applicable to the requirements of the B.S. degree.
2. If a student participating in the Combined BS/MS degree program is subsequently admitted to the Ph.D. program in ECE under the direct-entry option, the 6000- and 8000-level courses that were to be applied towards the requirements of the M.S. degree may be applied towards the requirements of the Ph.D. degree instead.
3. No student can hold a graduate assistantship prior to completion of the B.S. degree, including students enrolled in the Combined BS/MS program in ECE. Opportunities for financial support for Combined BS/MS students after completion of the B.S. degree depend on the availability of funds in alignment with ECE departmental policy.

Below please find a list of the participating focus areas for the graduate programs in ECE along with the courses that are eligible for use toward the graduate degree if also used toward the B.S. degree.

#### Applied Electromagnetics

ECE 6350, ECE 6360, ECE 6390, ECE 6460  
ECE 8270, ECE 8290, ECE 8300\*

\*Note that ECE 8300 is only eligible if ECE 8290 is taken as a pre-or co-requisite

#### Communications Systems and Networks

ECE 6300, ECE 6380, ECE 6400  
ECE 8180, ECE 8210, ECE 8480, ECE 8570

#### Computer Systems Architecture

ECE 6170, ECE 6290, ECE 6730, ECE 6680  
ECE 8420, ECE 8450, ECE 8510, ECE 8520, ECE 8730

#### Digital Signal Processing

Electrical Engineering  
ECE 6300, ECE 6670  
ECE 8180, ECE 8190, ECE 8440, ECE 8460, ECE 8470, ECE 8560, ECE 8720,  
ECE 8770

#### Computer Engineering

ECE 6420, ECE 6670

## Appendix D – Combined BS/MS Program

ECE 8440, ECE 8460, ECE 8470, ECE 8550, ECE 8560, ECE 8720, ECE 8770

### Electronics

ECE 6040, ECE 6060, ECE 6220, ECE 6320, ECE 6590  
ECE 8110, ECE 8230, ECE 8400

### Intelligent Systems

ECE 6420, ECE 6490, ECE 6550, ECE 6680  
ECE 8010, ECE 8470, ECE 8540, ECE 8550, ECE 8560, ECE 8590, ECE 8690,  
ECE 8720, ECE 8740, ECE 8770

### Power

ECE6180, 6190  
ECE 8020, ECE 8070, ECE 8160, ECE 8170, ECE 8240, ECE 8620, ECE 8630

For information about which of the above courses are applicable to each technical-elective subject area of the B.S. CpE and B.S. EE curricula, consult the information about the curricula on the ECE Department's Web site.