

University of Delaware
Department of Electrical and Computer Engineering
Graduate Program Policy Statement
2025 Revision (December 2025)

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The following graduate studies policies are in addition to those established by the University.

I. Graduate Degrees Offered

Master of Science in Electrical and Computer Engineering (M.S.E.C.E.)

Authorized: 2002 (Permanent)

(Replaces Master of Electrical Engineering (M.E.E.), Authorized: 1941)

Doctor of Philosophy in Electrical and Computer Engineering (Ph.D.)

Authorized: 2002 (Permanent)

(Replaces Doctor of Philosophy in Electrical Engineering (Ph.D.), Authorized: 1986, which replaced Doctor of Philosophy in Applied Science [Ph.D.], Authorized: 1960)

Stackable Certificates towards M.S.E.C.E. degree

Authorized: 2021 (Permanent)

II. Graduate Admission Criteria

Admission is selective and meeting the minimum requirements of the Department does not guarantee admission. The number and quality of other applicants as well as the availability of faculty supervision and laboratory space affect the number of students offered admission. The Department may find it appropriate to consider admitting an applicant who does not meet all of the admission requirements as stated if it is clear that other strengths identified in the applicant's admission information outweigh the stated minimum requirements for admission.

Master and Doctoral Programs

The requirements for admission to the master's and/or doctoral program in electrical and computer engineering are:

- (1) Applicants normally will have a B.S. in electrical or computer engineering. However, admission may be granted to applicants with good training in other engineering or related fields, such as math, physics, or computer science. Students without a B.S. in electrical or computer engineering may be admitted with provisional status and may be required to complete prerequisite courses that are deemed necessary for the appropriate preparation for courses in the program.
- (2) GRE scores are not required but will be considered if provided.
- (3) Applicants are expected to have a “B” or better undergraduate record, which is based on the last two years of undergraduate schooling, plus the applicant's record in advanced engineering, mathematics, and science courses.
- (4) International applicants from countries that do not have English as the primary language must submit TOEFL scores. The Department requires a minimum IBT TOEFL of 79, with a minimum speaking score of 18. This is equivalent to a paper-based TOEFL score of 550 PBT and 61 PDT, with a separate evaluation for Speaking Proficiency required. Alternatively, the minimum IELTS score is 6.5 overall with no individual Speaking sub-

score below 6.0. Applicants must score 100 or higher on the TOEFL or the equivalent on the IELTS to be considered as a Teaching Assistant.

Stackable Graduate Certificates towards Master's Degree

Students enrolled in a Graduate Certificate may apply for admission to the MSECE program upon completion of their Certificate. Provided that the Certificate is successfully completed (the overall GPA across the three (3) graduate courses applied to the Certificate must be no lower than 3.0 and a cumulative GPA of 3.0 must be achieved even if a course is repeated or an additional course is completed), the student will be admitted to the MSECE program using a "Change of Classification" form. In order to get admission into the MSECE thesis program, a letter from the prospective research advisor is required. No formal application or GRE will be required.

4+1 Accelerated MS in ECE

The department offers special 4+1 BEE/MSECE, 4+1 BCpE/MSECE, 4+1 BSCyE/MSECE and 4+1 BSAIE/MSECE programs for highly-qualified undergraduate students. This program allows the student to earn both the BEE/BCpE/BSCyE/BSAIE and the MSECE degree in 5 years of full-time study in Electrical and Computer Engineering at the University of Delaware. Students would normally apply in the spring of their junior year by submitting the abbreviated 4+1 application form. Applicants are expected to have a "B" or better undergraduate record.

III. Academic

III.A. Degree Requirements

Rules Applicable to All Degree Programs

The following rules are applicable to all the degree programs:

- A grade of B- or better is required for a course to count toward a degree requirement. A student who receives a grade less than B- must either take the course over to raise the grade, or take another course approved by his/her advisor to replace it in meeting the degree requirement.
- Graduate students must maintain an overall grade point average of 3.0 or higher for all graduate work. Students with an overall grade point average below 3.0 are not eligible for any form of University financial aid in the following semester.
- No course used to meet degree requirements may be taken Pass/Fail.
- Credit transfers from another institution must be approved by the Graduate Committee and University's Graduate College.
- At most six (6) credits of independent study and/or special problems may be used to meet degree requirements.
- Research credits may not be used to meet degree requirements. Research credit grades are, however, included in the cumulative grade point average calculations.

- All students in residence who have not been given sustaining status must enroll, each regular term, in at least one advanced technical course (for credit) and the department research seminar.

Master's Degree (Thesis Program)

The thesis master's degree program is designed for individuals who want to broaden their electrical and computer engineering foundation knowledge while also conducting an in-depth research project. All master's degree students receiving financial support from the University/Department, at any point in their program, must take the thesis option. This requirement may be waived with the approval of the Graduate Committee.

Credit Requirements

The master's program requires 30 credit hours including at least 24 graduate course credits and at least 6 credits for master's thesis (ELEG 869).

The 24-credit course program of each student must include:

- Six (6) credits of electrical and computer engineering Foundation courses. (A list of currently offered Foundation courses is attached in Appendix I.)
- Eighteen (18) credits of advanced technical courses (level 600 or above) related to the student's area of interest. At most twelve (12) credits of these can bear non-ELEG/CPEG numbers and at least three (3) credits must be of 800 level electrical and computer engineering courses. Substitution of 800 level courses may be approved by the Graduate Committee.

Thesis Requirement

All students in the thesis master's degree program will carry out original publishable research in collaboration with their advisor and, possibly, other collaborators. Masters's candidates must write a thesis describing their contributions to this research. Theses must follow the University's rules and those accepted in the profession for the presentation of original work. Master's theses will have two faculty readers, the advisor and one additional reader approved by the faculty advisor and Graduate Committee. The Department Chairperson, upon recommendation of the readers, approves theses.

Non-Thesis Master's Degree

This program is intended to satisfy the continuing education needs of working engineers and recent graduates who want to broaden their electrical and computer engineering foundation before starting an industrial career. University financial aid is not available to students taking this program. Students receiving financial support from the University/Department, at any point in their program, must enroll in the thesis master's degree program. This requirement may be waived with the approval of the Graduate Committee.

Credit Requirements

The non-thesis master's program requires 30 credit hours of course work.

The 30-credit course program of each student must include:

- Six (6) credits of electrical and computer engineering Foundation courses. (See the attached appendix for a list of currently offered Foundation courses.)
- Twenty-four (24) credits of advanced technical courses (level 600 or above) related to the student's area of interest. At least six (6) credits of these must be 800 level electrical and computer engineering courses and at most twelve (12) credits can bear non-ELEG/CPEG number. Substitution of 800 level courses may be approved by the Graduate Committee.

Stackable Graduate Certificates towards Master's Degree

Students admitted to the MSECE program upon successful completion of one or more Graduate Certificates will be able to apply the graduate courses of up to three (3) successfully completed Certificates¹ towards the non-Thesis or Thesis MSECE degree requirements. Upon admission to the MSECE program, a student will not be able to earn additional Graduate Certificates.

The remaining courses required to complete the Non-Thesis MSECE degree (a minimum of one (1) course if a student has successfully completed three (3) Graduate Certificates, a minimum of four (4) courses if a student has successfully completed two (2) Graduate Certificates, or a minimum of seven (7) courses if a student has successfully completed one (1) Graduate Certificate) must be satisfied within three years of the completion of the first Certificate. A student has flexibility to choose these remaining courses provided that the ten (10) courses applied to the non-Thesis MSECE (the ones from the Certificate(s) plus the courses completed after admission to the MSECE program) satisfy all the credit requirements for the Non-Thesis Master's Degree as stated in the previous section. A student may need to take additional courses in order to satisfy all the credit requirements for the Non-Thesis Master's Degree.

The remaining credits required to complete the Thesis MSECE degree (a minimum of six (6) Master's Thesis credits if a student has successfully completed three (3) Graduate Certificates, a minimum of six (6) Master's Thesis credits and two (2) courses if a student has successfully completed two (2) Graduate Certificates, or a minimum of six (6) Master's Thesis credits and five (5) courses if a student has successfully completed one (1) Graduate Certificate) must be satisfied within three years of the completion of the first Certificate. A student has flexibility to choose these remaining courses provided that the eight (8) courses applied to the Thesis MSECE (the ones from the Certificate(s) plus the courses completed after admission to the MSECE program) satisfy all the credit requirements for the Thesis Master's Degree as stated in the previous section. A student may need to take additional courses in order to satisfy all the credit requirements for the Thesis Master's Degree. The Master Thesis has to be filed within three years of the completion of the first Certificate and must satisfy the requirement specified in the previous section.

4+1 Accelerated MS in ECE

Students admitted to the 4+1 BEE/MSECE, 4+1 BCpE/MSECE, 4+1 BSCyE/MSECE, or 4+1 BSAIE/MSECE programs are required to meet all the requirements listed for the MSECE degree, and they can choose either the thesis or non-thesis option (the thesis option may take more than five

¹A Graduate Certificate is completed successfully if the overall GPA across the three (3) graduate courses of the Certificate is not lower than 3.0 and a cumulative GPA of 3.0 is achieved, even if a course is repeated or an additional course is completed.

years to complete). A maximum of three (3) courses (nine credits) that are acceptable for the MSECE degree (600-level or higher technical courses), taken while enrolled in the Bachelor's program, may be "dual-counted" toward both the Bachelor's and Master's degrees; a grade of B- or better must be received in order for these courses to count toward the graduate degree.

Ph.D. Degree

The Ph.D. degree program is designed for individuals interested in fundamental research on novel aspects of electrical and computer engineering. The degree is intended for individuals planning to pursue academic research and/or industrial research and development careers. All students pursuing the Ph.D. degree are initially entered in pre-candidacy. Formal entry into the Ph.D. program, or candidacy, is granted following the successful completion of the Ph.D. Qualifying Examination and approval by the Graduate Committee of the student's Research and Study Program. The specific Ph.D. degree requirements are detailed below.

Admission to Candidacy

To be formally admitted into Ph.D. candidacy, in addition to satisfying the University requirements, students must successfully complete the Ph.D. Qualifying Examination and have a Research and Study Program approved by the student's advisor and the Department Graduate Committee.

- *Qualifying Examination.* Candidates who started the Ph.D. in the ECE program without an M.S. degree in ECE must have completed at least four Foundation courses with a GPA of at least 3.50 to sit for the Qualifying Examination. If more than four Foundation courses have been completed, only the four ones with the highest grade will count to compute the GPA. Candidates who started the Ph.D. in the ECE program with an M.S. degree in ECE will have a coursework approved by the Graduate Committee, and they should have a GPA of at least 3.50 in the approved coursework to sit for the Qualifying Examination. The Qualifying Examination consists of a research report and oral examination.
 - *Research report*, reflecting the research progress of the student. The report should provide sufficient background materials to convey the big picture to a non-expert, the expected impact of the research, as well as a summary of the contributions of the student to date, and possible research approaches. It should be an original document produced wholly by the doctoral student.
 - *Oral examination*, consisting of a short oral presentation followed by a period of discussion. The oral presentation will be based on the research report. The discussion period will revolve around foundational aspects of the problem presented and of the corresponding research area. The discussion period will also provide constructive feedback. The oral examination should also assess the student's ability to creatively think about the research problem presented.

The Qualifying Examination is administered twice a year, must be completed within two years of admission, and can be taken at most twice.

- *Research and Study Program.* Students must submit a Research and Study Program (RSP) prior to taking the Qualifying Examination. The RSP details: (1) all courses

taken by the student, (2) all future courses planned to be taken in fulfillment of the degree requirements, (3) an abstract of the research to be undertaken in fulfillment of the degree requirements, and (4) a list of the individuals that have agreed to serve on the student's dissertation committee.

- *Ph.D. Committee.* The Ph.D. committee must consist of at least four individuals. The committee is chaired by the student's faculty research advisor and must include at least two additional faculty members from the Department. Moreover, the committee must have at least one faculty member from a different academic unit, or an equivalently qualified individual from outside the University.

Research Program and Dissertation

Following formal admission to candidacy, students must complete: (1) Pre-Dissertation Examination, (2) Ph.D. Dissertation, and (3) Final Oral Examination.

- *Pre-Dissertation Examination.* The pre-dissertation examination is an in-depth written document and presentation of the student's thesis proposal to members of his/her committee. The proposal must present sufficient evidence to justify accepting the proposal as a dissertation topic. The proposal must include, therefore, the need for the proposed research, existing methods and techniques, the proposed new methods and techniques, and the expected benefits. Candidates must complete the pre-dissertation examination within one and a half (1.5) years of passing the Ph.D. Qualifying Examination and having an approved RSP. The written proposal must be distributed to the committee members for review no less than two weeks prior to the scheduled proposal presentation.
- *Ph.D. Dissertation.* Candidates must carry out a program of substantial original research on a topic agreed upon by his/her committee and the Departmental Graduate Committee. This research forms the basis of a written dissertation that must be read and approved by the student's committee as adequate for the Ph.D. degree. The dissertation must be prepared in accordance with the rules of the Graduate College. The dissertation research should form the basis of several research papers in refereed professional journals.
- *Final Oral Examination.* The written dissertation must be distributed to the committee members for review no less than two weeks prior to the scheduled final oral examination. In the final oral examination, the student presents the results of his/her dissertation research to members of the faculty. The format of the presentation is that of a seminar in which questions from the audience take the place of formal exam questions. The student's committee meets afterwards, in closed session, to decide if sufficient research progress has been made to warrant the granting of the Ph.D.

General Requirements

In addition to the specific requirements noted above, the following General Requirements must be satisfied by all candidates:

- Candidates are required to complete one continuous academic year of full-time study as a residency requirement.
- Candidates must complete the course requirements for the thesis master's degree, or have been awarded a master's degree in electrical or computer engineering or closely related field.
- Candidates must take at least 9 credits of Doctoral Dissertation (ELEG 969).

Embedded Master's Degree

Students who are directly admitted to the Ph.D. program without holding a Master's degree are required to fulfill the course requirements for the thesis Master's degree. In addition to these coursework requirements, M.S.E.C.E. students in the thesis program must complete a Master's thesis to obtain their degree, whereas Ph.D. students are required to complete a doctoral dissertation and successfully pass the final oral examination. To formally acknowledge that students admitted to the Ph.D. program without an M.S. degree have satisfied the requirements of the M.S.E.C.E program when they complete their Ph.D. —given that a Ph.D. dissertation exceeds the scope of an M.S.E.C.E. thesis—such students will be awarded the M.S.E.C.E. degree concurrently with the Ph.D. without requiring a separate Master's thesis.

This section does not restrict doctoral students from receiving an M.S.E.C.E. if they do not complete their Ph.D. If a Ph.D. student meets the M.S.E.C.E. degree requirements on their way to the Ph.D., the student has the option to get a Master's degree when the Master's requirements are met: i) if they use the thesis Master's option, they should have an independent Master's thesis prepared that is not allowed to be also used in their Ph.D.; and ii) if they choose the non-thesis Master's option, they need to take all required courses for the non-thesis M.S.E.C.E. program.

Concentrations

Students in the Ph.D. and M.S.E.C.E. programs may elect to choose a concentration area of study. Concentrations are available in *Computer Systems & Networking*, *Signal Processing*, *Communications*, *and Controls*, *Materials and Devices*, *Electromagnetics and Photonics*, and *Biomedical Engineering*. Students selecting a concentration must meet the concentration requirements detailed Appendix III, in addition to meeting their general degree requirements. Students admitted to the MSECE program upon successful completion of one or more Graduate Certificates will be able to apply the graduate courses of up to three (3) successfully completed Certificates towards the concentration requirements. Concentrations are voluntary, and students selecting multidisciplinary or other specialized studies need not declare a concentration.

III. B. Administration of the Graduate Program and Expectations

Electrical and Computer Engineering Graduate Committee

The graduate program in Electrical and Computer Engineering is administered by the faculty in Electrical and Computer Engineering through its Graduate Committee. This committee is to have representation from each of the major research concentration areas within the Department, including cybersecurity. The chairperson of the Departmental Graduate Committee is responsible for day-to-day administration of graduate programs in Electrical and Computer Engineering.

Faculty Advisors

Each graduate student must have a faculty advisor. For beginning students, the faculty advisor works with the student in planning his/her program, monitors student progress, and is available to advise and help the student. Once students begin their thesis and/or dissertation research, the faculty advisor becomes their research advisor.

Each student in the thesis M.S.E.C.E. and Ph.D. programs must select, by mutual agreement and shared research interests, a faculty advisor during the first year of study. Students that have not secured a faculty advisor after a year of study will be assigned an advisor by the Graduate Committee. With the approval of the Graduate Committee, a student may select a qualified individual from outside the Department as his/her research supervisor. Students with a research supervisor outside the Department must also have a co-advisor within the Department. Students in the non-thesis M.S.E.C.E. program must select an advisor within the Department.

Publications and Research Results

The thesis master's and Ph.D. degrees in electrical and computer engineering are research degrees. Each student is required to participate in publishable research in one of the areas of departmental concentration, or in some other area with the prior approval of their research advisor and the Graduate Committee.

Publication of research is an important requirement for graduate thesis and dissertation research. Each candidate shall prepare one or more papers with his/her advisor describing his/her research and submit these papers to appropriate refereed journals. These papers will provide the basis for the student's thesis and/or dissertation. Each student is also expected to present the results of his/her research at research day and at appropriate professional meetings, if feasible.

Evaluation of Progress

Candidates for graduate degrees must maintain a cumulative average of 3.0 or better to remain in good standing. The Graduate Committee will review the progress of all master and Ph.D. students at the end of each term. Only students in good standing, and who are making adequate progress on their research, are eligible for financial aid.

Faculty—/Student— Initiated Dismissal

If a student or research advisor wishes to terminate the advisee/advisor relationship, there should be mutual agreement and/or sufficient advance notice.

- If there is mutual agreement between the current student and research advisor to change research advisor, the student should complete a Change of Advisor form, which will make the change effective at the time of submission to the ECE Graduate Coordinator.
- If a student wishes to seek a new research advisor and the current research advisor is not supportive of a transition, the student should discuss the situation with the Associate Chair for Graduate Studies three months prior to a proposed transition, and prior to securing a new research advisor.
- If a faculty member seeks to discontinue serving as a research advisor due to performance, fit to research group, and/or ability to support the research due to issues such as funding

support, the research advisor must provide three months advance notice to the student and the Associate Chair for Graduate Studies. The Graduate Committee will provide feedback to the student on a path forward, which may include an interim remedial plan or assistance in identifying a new research advisor. The student may join another research group, switch programs, or leave the program.

- The student and faculty member should both contribute to a smooth transition, maintaining productivity on planned research activities and funded work until the transition. Unless there is agreement between the student, the current research advisor, and the new research advisor, the change of advisor will occur three months after the advisor or the student provides a written notice to the other party.

Following a change in research advisors, both the student and the former research advisor will have access to all products resulting from their joint research. Unless an exception is granted by the Department Chair, if the student wishes to utilize research performed under the supervision of the former advisor in his/her Master's thesis or Doctoral dissertation, the former research advisor will have the option to serve on the thesis or dissertation committee as a co-advisor. The thesis/dissertation committee members will be chosen by mutual agreement between the student, the new research advisor and the former research advisor serving now as co-advisor.

IV. Educational Goals

Non-Thesis Master's Degree

A graduate of the ECE Non-Thesis MS program will be able to:

1. Apply advanced knowledge to analyze ECE engineering problems.
2. Learn ECE subject matters independently, showing an ability to lifelong learning.
3. Understand the technical literature.
4. Communicate effectively.
5. Demonstrate professional development and maturity in preparation for a successful professional career in an ECE related field.

Thesis Master's Degree

A graduate of the ECE Thesis MS program will be able to:

1. Apply advanced knowledge to formulate hypotheses for, analyze, and synthesize solutions to ECE engineering problems.
2. Learn ECE subject matters independently, showing an ability to lifelong learning.
3. Work in interdisciplinary teams, while at the same time showing initiative and ability to make independent contributions.
4. Understand the technical and research literature and communicate effectively.
5. Demonstrate professional development and maturity in preparation for a successful professional career in an ECE related field.

Ph.D. Degree

A graduate of the ECE Ph.D. program will be able to:

1. Define ECE engineering problems and apply advanced knowledge to formulate hypotheses for, analyze, and synthesize solutions to these problems generating new knowledge.
2. Learn ECE subject matters independently, showing an ability to lifelong learning
3. Lead interdisciplinary teams, showing initiative and ability to make independent contributions and synthesize contributions from the team members.
4. Communicate effectively, both orally and in writing, so as to contribute to the technical and research literature expanding existing knowledge.
5. Demonstrate professional development and maturity in preparation for a successful professional career in an ECE related field, either in industry or academy.

V. Financial Aid

A number of fellowships, research assistantships, and teaching assistantships are awarded on a competitive basis each year to full-time graduate students in the Department. In addition, the University awards various competitive fellowships each year to particularly outstanding students. Both entering and continuing graduate students are eligible for financial aid. If awarded financial aid, students entering with a bachelor's degree are typically supported for a maximum of two years for a master's degree, or a maximum of five years total if they continue for the Ph.D. degree. Students entering with a master's degree are typically supported for a maximum of four years for the Ph.D. degree.

Appendix I. Foundation Courses

*The ECE Department offers the following Foundation courses:

CPEG 621: Compiler Design
CPEG 624 Analog Integrated Circuit Design
CPEG/ELEG 651: Computer Networks II
CPEG/ELEG 652: Principles of Parallel Computer Architectures
CPEG 657: Search and Data Mining
CPEG 660: Introduction to VLSI Systems
CPEG 672 Applied Cryptography
CPEG/ELEG 694 System Hardening and Protection
ELEG 622: Electronic Materials Processing
ELEG 630: Information Theory
ELEG 631: Digital Signal Processing
ELEG 635: Digital Communication
ELEG 646: Nanoelectronic Device Principles
ELEG 648: Advanced Engineering Electromagnetics
ELEG 671: Mathematical Physiology
ELEG 679: Introduction to Medical Imaging Systems
or ELEG 604: Imaging and Deep Learning
ELEG 682: Optics & Photonics
ELEG 815: Analytics I – Statistical Learning

*Other Foundation courses may be approved by the ECE Faculty.

Appendix II. Policy Statement for the Electrical and Computer Engineering (ECE) Graduate Certificates

I. Program History

The field of Electrical and Computer Engineering comprises numerous areas of specialization. Full-time workers who wish to expand their knowledge, and even prospective graduate students, may not be able or ready to begin graduate studies on a full-time basis. The proposed certificates will allow them to begin to acquire skills by focusing on specific areas of interest in ECE. Specific educational and business goals of the proposed certificates are:

- Enhance the knowledge of professionals working in the field of Electrical and Computer Engineering.
- Support industry desire to provide their employees with incremental and meaningful continuing education in specific fields of Electrical and Computer Engineering.
- Attract prospective graduate students, not yet ready to begin full-time graduate studies, to the field of Electrical and Computer Engineering.

II. Admission Requirements

The ECE Graduate Certificates program has the following admission requirements for each one of the offered certificates:

- Applicants must hold a bachelor's degree from an accredited four-year College or University with a minimum grade point average of 3.0 on a 4.0 system.
- Applicants must have undergraduate degrees in Electrical and Computer Engineering or related disciplines. Applicants with degrees in other disciplines may be admitted depending on their experience in the relevant disciplines. Although it is expected that most applicants will be non-current UD students, applications are open to current UD graduate students.
- International applicants must demonstrate a satisfactory level of proficiency in the English language if English is not their first language. The University requires an official TOEFL score of at least 550 on paper-based or 79 on Internet-based tests. TOEFL scores more than two years old cannot be considered official. Alternatively, IELTS can be accepted in the place of the TOEFL. The minimum IELTS score is 6.5 overall with no individual sub-score below 6.0.

Applications for the Fall semester must be received by August 15, while the application deadline for the Spring semester is January 25. Admission to the ECE Graduate Certificate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

III. Academic Requirements

The following Certificates are offered: (a) Embedded Systems and Integrated Circuits, (b) Computer Hardware and Software Design and Optimization, (c) Smart Grid and Energy Systems, (d) Large-Scale Data Analytics, (e) Machine Learning Foundations, (f) Signal Processing and Imaging Systems, (g) Communication Systems, (h) Semiconductor Device Fabrication, and (i) RF Engineering. Applicants must select one of these nine Certificates when they apply to the program. All courses will be offered as regular on campus courses.

Each Certificate requires satisfactory completion of three (3) graduate-level courses (9 credits) from within the list of ECE graduate courses corresponding to each Certificate. Each course must be

completed with a grade no lower than B-. If the grade in one of the courses is below B-, the student may either retake the course or take another course from the same Certificate. The overall GPA across the three (3) graduate courses applied to the selected Certificate must be no lower than 3.0 and a cumulative GPA of 3.0 must be achieved even if a course is repeated or an additional course is completed to be eligible for the certificate to be awarded. Any particular course can only be applied towards a single certificate.

Students may apply the graduate courses of up to three (3) successfully completed certificates towards the degree requirements for a Master of Science in Electrical and Computer Engineering (M.S.E.C.E.). All the M.S.E.C.E. requirements must be satisfied within three years of the completion of the first certificate.

The course requirements for each Certificate are listed below.

(a) For the Embedded Systems and Integrated Circuits Certificate, applicants must select three (3) courses from the following:

- ELEG 622 Electronic Materials Processing
- ELEG 646 Nanoelectronic Device Principles
- CPEG 622 Embedded Systems Hardware/Software Co-Design
- CPEG 624 Analog Integrated Circuit Design
- CPEG 660 Introduction to VLSI Systems
- CPEG 853 Computer System Reliability

(b) For the Computer Hardware and Software Design and Organization Certificate, applicants must select three (3) courses from the following:

- CPEG 621 Compiler Design
- CPEG 622 Embedded Systems Hardware/Software Co-Design
- CPEG 652 Principles of Parallel Computer Architectures
- CPEG 655 High-Performance Computing with Commodity Hardware
- CPEG 853 Computer System Reliability

(c) For the Smart Grid and Energy Systems Certificate, applicants must select three (3) courses from the following:

- ELEG 617 Smart Grids
- ELEG 628 Solar Energy Tech and Applications
- ELEG 637 Energy Systems
- ELEG 657 Microgrids
- ELEG 684 Electric Vehicles

(d) For the Large-Scale Data Analytics Certificate, applicants must select three (3) courses from the following:

- CPEG 655 High-Performance Computing with Commodity Hardware
- CPEG 657 Search and Data Mining
- ELEG 815 Analytics I - Statistical Learning
- ELEG 817 Large-Scale Machine Learning

(e) For the Machine Learning Foundations Certificate, applicants must select three (3) courses from the following:

- ELEG 601 Convex Optimization
- ELEG 602 Advanced Machine Learning
- ELEG 815 Analytics I - Statistical Learning
- ELEG 817 Large Scale Machine Learning
- ELEG 845 Modern Machine Learning
- CPEG 657 Search and Data Mining

(f) For the Signal Processing and Imaging Systems Certificate, applicants must select three (3) courses from the following:

- ELEG 604 Digital Imaging and Photography
- ELEG 631 Digital Signal Processing
- ELEG 679 Introduction to Medical Imaging Systems
- ELEG 815 Analytics I - Statistical Learning

(g) For the Communication Systems Certificate, applicants must select three (3) courses from the following:

- ELEG 630 Information Theory
- ELEG 635 Digital Communications
- ELEG 642 RF Systems for Wireless Communications
- ELEG 811 Channel Coding Theory and Practice
- ELEG 812 Wireless Digital Communications

(h) For the Semiconductor Device Fabrication Certificate, applicants must select three (3) courses from the following:

- ELEG 622 Electronic Materials Processing
- ELEG 628 Solar Energy Technology and Applications
- ELEG 640 Opto-Electronics
- ELEG 646 Nanoelectronic Device Principles
- ELEG 650 Semiconductor Device Design and Fabrication
- ELEG 682 Optics and Photonics

(i) For the RF Engineering Certificate, applicants must select three (3) courses from the following:

- ELEG 641 Antenna Theory and Design
- ELEG 642 RF Systems for Wireless Communications
- ELEG 692 Radar Systems and Technology
- ELEG 842 Radio Frequency and Microwave Technology
- CPEG 624 Analog Integrated Circuit Design

IV. Assessment Plan

The ECE Graduate Certificates program will enable students to demonstrate their ability to understand and apply concepts in the areas of (a) Embedded Systems and Integrated Circuits, (b) Computer Hardware and Software Design and Optimization, (c) Smart Grid and Energy Systems, (d) Large-Scale Data Analytics, (e) Machine Learning Foundations, (f) Signal Processing and Imaging Systems, (g) Communication Systems, (h) Semiconductor Device Fabrication, and (i) RF Engineering. Student learning relative to this outcome can be directly assessed by the students' course grades in the selected three courses of their Certificate. In addition, the current and updated

employment listing of the students will serve as indirect evidence of student attainment of the learning goal.

V. Financial Aid

University financial aid is not available to students enrolled in the ECE Graduate Certificates program.

VI. Department Operations

This program will be administered by the ECE Department through its Graduate Committee. The ECE Associate Chair for Graduate Studies will oversee the administration of the program with the support of departmental graduate support staff, and can approve necessary adjustments to meet the needs of the parties involved.

Appendix III. Graduate Studies Concentrations

Computer Systems & Networking

Students in the Computer Systems & Networking (CSN) concentration focus on research and coursework in computer architecture and parallel systems, optimizing and parallelizing compilers, design and test of high-performance digital and analog VLSI circuits, wired and mobile wireless networking, computer program optimization, as well as emerging CSN theories and applications. The CSN concentration is available to students in the MSECE and Ph.D. degree programs. Students in the CSN concentration must complete the following:

Course Requirements

***Required Courses**

ELEG 651 – Computer Networks II	3 Credits
ELEG 652 – Principles of Parallel Computer Architectures	3 Credits
ELEG 662 – Digital System Seminar (each semester)	0 Credits

***A minimum of two courses from the following:**

CPEG 621 – Compiler Design	3 Credits
CPEG 622 – Embedded Systems Hardware/Software Co-Design	3 Credits
CPEG 624 – Analog Integrated Circuit Design	3 Credits
CPEG/ELEG 655 – High-Performance Computing w/ Commodity Hardware	3 Credits
CPEG 657 – Search Engine Technology	3 Credits
CPEG 660 – Introduction to VLSI Systems	4 Credits
CPEG 673 – Cloud Computing and Security	3 Credits
ELEG 852 – Advanced Topics in Computing Systems	3 Credits
ELEG 853 – Computer System Reliability	3 Credits

*Other courses may be approved by the Graduate Committee.

General Requirements

Students must also complete the general degree requirements as detailed in the Electrical and Computer Engineering Graduate Policy and University Catalog. These requirements include credit requirements and, for Ph.D. and thesis option MSECE students, the carrying out of research and completion of a dissertation/thesis.

Signal Processing, Communications, and Controls

Students in the Signal Processing, Communications, and Controls (SPCC) concentration focus on research and coursework in multimedia signal processing, statistical and nonlinear signal processing, image processing, time-frequency analysis, wireless communications, information theory, coding, as well as emerging SPCC theories and applications. The SPCC concentration is available to students in the MSECE and Ph.D. degree programs. Students in the SPCC concentration must complete the following:

Course Requirements

***A minimum of two courses from the following:**

ELEG 630 – Information Theory	3 Credits
ELEG 631 – Digital Signal Processing	3 Credits
ELEG 635 – Digital Communications	3 Credits
ELEG 815 – Statistical Learning	3 Credits

***A minimum of two courses from the following:**

ELEG 601 – Convex Optimization	3 Credits
ELEG 604 – Imaging and Deep Learning	3 Credits
ELEG 634 – Signals and Systems	3 Credits
ELEG 668 – Detection and Estimation	3 Credits
ELEG 811 – Channel Coding Theory and Practice	3 Credits
ELEG 812 – Wireless Digital Communications	3 Credits
ELEG 817 – Large Scale Machine Learning	3 Credits

***Required Courses**

ELEG 663 – Signal Processing Seminar (each semester)	0 Credits
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*Other courses may be approved by the Graduate Committee.

General Requirements

Students must also complete the general degree requirements as detailed in the Electrical and Computer Engineering Graduate Policy and University Catalog. These requirements include credit requirements and, for Ph.D. and thesis option MSECE students, the carrying out of research and completion of a dissertation/thesis.

Material and Devices

Students in the Materials & Devices (MD) concentration focus on research and coursework in solid-state physics, semiconductor growth, device fabrication, and electro-magnetic measurement & characterization. The MD concentration is available to students in the MSECE and Ph.D. degree programs. Students in the MD concentration must complete the following:

Course Requirements

***Required Courses**

ELEG 646 – Nanoelectronic Device Principles	3 Credits
ELEG 622 – Electronic Materials Processing	3 Credits
ELEG 661 – Materials and Devices Seminar (each semester)	0 Credits

***A minimum of two courses from the following:**

CPEG 624 – Analog Integrated Circuit Design	4 Credits
ELEG 628 – Solar Energy Technology and Applications	3 Credits
ELEG 640 – Opto-Electronics	3 Credits
ELEG 647 – Optical Properties of Solids	3 Credits
ELEG 648 – Advanced Engineering Electromagnetics	3 Credits
ELEG 650 – Semiconductor Device Design and Fabrication	3 Credits

*Other courses may be approved by the Graduate Committee.

General Requirements

Students must also complete the general degree requirements as detailed in the Electrical and Computer Engineering Graduate Policy and University Catalog. These requirements include credit requirements and, for Ph.D. and thesis option MSECE students, the carrying out of research and completion of a dissertation/thesis.

Electromagnetics and Photonics

Students in the Electromagnetics & Photonics (EP) concentration focus on research and coursework in optics and electromagnetics; optoelectronic, microwave, millimeter-wave and terahertz devices and systems, device fabrication, and electro-magnetic measurement & characterization. The EP concentration is available to students in the MSECE and Ph.D. degree programs. Students in the EP concentration must complete the following:

Course Requirements

***Required Courses**

ELEG 648 – Advanced Engineering Electromagnetics	3 Credits
ELEG 682 – Optics and Photonics	3 Credits
ELEG 661 – Materials and Devices Seminar (each semester)	0 Credits

***A minimum of two courses from the following:**

CPEG 624 – Analog Integrated Circuit Design	4 Credits
ELEG 641 – Antenna Theory and Design	3 Credits
ELEG 642 – RF Systems Engineering for Wireless and Mobile Communications	3 Credits
ELEG 692 – Radar Systems and Technology	3 Credits
ELEG 843 – Fourier Optics	3 Credits
ELEG 853 – Integrated Optics	3 Credits

*Other courses may be approved by the Graduate Committee.

General Requirements

Students must also complete the general degree requirements as detailed in the Electrical and Computer Engineering Graduate Policy and University Catalog. These requirements include credit requirements and, for Ph.D. and thesis option MSECE students, the carrying out of research and completion of a dissertation/thesis.

Biomedical Engineering

Students in the Biomedical Engineering (BME) concentration focus on research and coursework in biomedical applications of signal and image processing, imaging systems, biophotonics, biochemical detection, cardiovascular and respiratory control, electrophysiology, computational biology, and bioinformatics. The BME concentration is available to students in the MSECE and Ph.D. degree programs. Students in the BME concentration must complete the following:

Course Requirements

***Required Courses**

ELEG 671 – Mathematical Physiology	3 Credits
ELEG 679 – Introduction to Medical Imaging Systems	3 Credits
ELEG 664 – Biomedical Engineering Seminar (each semester)	0 Credits

***A minimum of two courses from the following:**

ELEG 604 – Imaging and Deep Learning	3 Credits
ELEG 634 – Signals and Systems	3 Credits

*Other courses may be approved by the Graduate Committee.

General Requirements

Students must also complete the general degree requirements as detailed in the Electrical and Computer Engineering Graduate Policy and University Catalog. These requirements include credit requirements and, for Ph.D. and thesis option MSECE students, the carrying out of research and completion of a dissertation/thesis.