University of Delaware
Department of Electrical and Computer Engineering
Graduate Program Policy Statement
2011 Revision

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)

II. Graduate Admission Criteria

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) All applicants are required to submit Graduate Record Examination (GRE) scores. The Department requires a combined score of the verbal and math sections in excess of 1050, with a mathematics score in excess of 600. (Foreign student applicants with low verbal scores will be considered if the applicant's TOEFL score is acceptable and if the applicant has a high quantitative GRE score.)

(3) International applicants from countries that do not have English as the primary language must submit TOEFL scorers. The Department requires a minimum TOEFL score of 550/213 (papers/computer examination) for admission and a minimum score of 600/250 for consideration as a Teaching Assistant (TA).

(4) 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. 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.

(5) The department offers special 4+1 BEE/MSECE and 4+1 BCpE/MSECE programs for highly-qualified undergraduate students. This program allows the student to earn both the BEE/BCpE 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 and GRE scores will be waived. For admission to this program the following <u>minimum</u> criteria will be applied:

- An undergraduate grade point average of at least 3.3 on a 4.0 scale.
- A minimum of two letters of strong support from former teachers at the University of Delaware.

III. Administration of the Graduate Program

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. The Department faculty elects members serving on the committee. 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.

IV. 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.

- No course used to meet degree requirements may be taken Pass/Fail.

- At most 9 credits approved for transfer from another institution may be used to meet degree requirements. Credit transfers must be approved by the Graduate Committee and University's Office of Graduate Studies.

- At most 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 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 research seminar in their area of concentration.

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 aid, at any point in their program, must take the thesis option.

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 Graduate Committee must approve each student's program.

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.)

- 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.

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 aid, at any point in their program, must enroll in the thesis master's degree program.

Credit Requirements

The non-thesis master's program requires 30 credit hours of course work. The Graduate Committee must approve each student's program.

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.

4+1 BEE/MSECE and 4+1 BCpE/MSECE Programs

Students admitted to the 4+1 BEE/MSECE or 4+1 BCpE/MSECE programs are required to meet all the above requirements for the MSECE degree, and they can choose either the thesis or non-thesis option (the thesis option can take more than five year to complete). These students are required to complete two of the courses acceptable for the MSECE degree during enrollment in the BEE/BCpE degree. These two courses can also be counted toward meeting the technical elective requirement of the BEE/BCpE 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 (G1 status). Formal entry into the Ph.D. program, or candidacy (G2 status), 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 (G2 status), 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 must have completed at least four ELEG/CPEG graduate courses and have a minimum 3.25 GPA to sit for the Qualifying Examination. The GPA requirement is based on all ELEG/CPEG graduate courses taken by the candidate, excluding special problems and

independent study courses. The qualifying examination is comprised of written and oral components.

- o *Written Component.* The written component assesses comprehensive knowledge of the material covered in Foundation courses. Foundation courses are offered in each of the major research areas within the Department. The examination is comprised of questions in each area. Students must successfully answer questions in: (1) his/her area of concentration and (2) at least one area outside his/her concentration.

- o *Oral Component.* The oral component consists of a closed question and answer session. Questions may cover foundation course material and current research topics in the student's area of concentration.

The Qualifying Examination is administered once 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.

- o *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 Office. 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 two foundation courses outside their area of concentration.

- Candidates must take at least 9 credits of Doctoral Dissertation (ELEG 969).

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.

VI. 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.

VII. Publication of 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 in the appropriate departmental research seminar and, where feasible, at appropriate professional meetings.

VIII Concentrations

Students in all departmental graduate degree 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 in the following appendices, in addition to meeting their general degree requirements. Concentrations are voluntary, and students selecting multidisciplinary or other specialized studies need not declare a concentration.

Department of Electrical & Computer Engineering

Graduate Studies Concentration in

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 Networking Communications	3 Credits
ELEG 652 – Principles of Parallel Computer Architecture	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 – Computer Systems Design II	3 Credits
CPEG 660 – Introduction to VLSI systems	3 Credits
ELEG 653 – Computer System Security	3 Credits
ELEG 654 – Sensor & Data Wireless Networks	3 Credits
CPEG/ELEG 655 – High-Performance Computing w/ Commodity Hardware	3 Credits
CPEG/ELEG 657 – Search Engine Technology	3 Credits
ELEG 819 – Topics in Networking I	3 Credits
ELEG 820 – Topics in Networking II	3 Credits

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.

Department of Electrical & Computer Engineering

Graduate Studies Concentration in

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 636 – Statistical Signal Processing	3 Credits

A minimum of two courses from the following:

ELEG 611 – Linear Systems Theory	3 Credits
ELEG 619 – Multimedia Communications	3 Credits
ELEG 633 – Image Processing	3 Credits
ELEG 654 – Sensor and Data Wireless Networks	3 Credits
ELEG 677 – Biosignal Processing	3 Credits
ELEG 675 – Image Processing With Biomedical Applications	3 Credits
ELEG 811 – Channel Coding Theory and Practice	3 Credits
ELEG 812 – Wireless Digital Communications	3 Credits
ELEG 832 – Wavelets and Filter Banks	3 Credits
ELEG 833 – Nonlinear Signal Processing	3 Credits

Required Courses

ELEG 663 – Signal Processing Seminar (each semester)	0 Credits

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.

Department of Electrical & Computer Engineering

Graduate Studies Concentration in

Materials 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:

ELEG 640 – Opto-Electronics	3 Credits
ELEG 648 – Advanced Engineering Electromagnetics	3 Credits
ELEG 639 – Magnetism & Spintronics	3 Credits
ELEG 627 – THz and MMW Light Generation and Detection	3 Credits
ELEG 647 – Optical Properties of Solids	3 Credits
ELEG 650 – Semiconductor Device Design and Fabrication	3 Credits

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.

Department of Electrical & Computer Engineering

Graduate Studies Concentration in

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:

ELEG 638 – Theory and Design of Diffractive Optics	3 Credits
ELEG 640 – Opto-Electronics	3 Credits
ELEG 641 – Antenna Theory and Design	3 Credits
ELEG 646 – Nanoelectronic Device Principles	3 Credits
ELEG 627 – THz and MMW Light Generation and Detection	3 Credits
ELEG 622 – Electronic Materials Processing	3 Credits
ELEG 842 – RF and Microwave Technology	3 Credits
ELEG 853 – Integrated Optics	3 Credits
ELEG 855 – Microwave and Millimeter-Wave Technology	3 Credits

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.

Department of Electrical & Computer Engineering

Graduate Studies Concentration in

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 – Introduction to Biomedical Engineering	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 670 – Biophysics of Excitable Membranes	3 Credits
ELEG 673 – Signal Processing in Neural Systems	3 Credits
ELEG 675 – Image Processing with Biomedical Applications	3 Credits
ELEG 676 – Bioinformatics and Biosystems Analysis I	3 Credits
ELEG 678 – Introduction to Nano and Biophotonics	3 Credits
ELEG 680 – Immunology for Engineers	3 Credits

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.