

University of Delaware

Department of Civil and Environmental Engineering

Graduate Program Policies and Requirements

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Introduction

The University's most current Undergraduate and Graduate Catalog is the basic document describing overall requirements for all degrees, course offerings, and library, laboratory and computer facilities. It includes the general requirements for graduate degrees in the Department of Civil and Environmental Engineering as well.

The present document provides more specific requirements of the Department of Civil and Environmental Engineering for its graduate degrees and additional academic and procedural information. The department also issues a **Graduate Student Handbook** that offers supplemental information to help graduate students with the day-to-day logistics of graduate student life in the department.

I. Degrees Offered

The Department of Civil and Environmental Engineering offers five graduate degrees. These include three Master's degrees—the Master of Civil Engineering, the Master of Applied Science, and the Master of Ocean Engineering—and Ph.D. degrees in Civil Engineering and Ocean Engineering.

Master of Civil Engineering

The Master of Civil Engineering (MCE) degree is awarded only to individuals who, upon admission, have an undergraduate degree in engineering, preferably in civil or environmental engineering. The student pursuing the MCE degree may choose a traditional thesis program or a non-thesis option. The courses for the non-thesis option correspond to the course requirements for the traditional thesis master's degree program. The core requirements for both master's degrees are the same.

Master of Applied Science

Students who, upon admission, have a non-engineering degree are awarded the Master of Applied Science (MAS) degree. The MAS degree is also an option for students who choose to utilize the elective graduate courses in the degree program to study other engineering or physical science disciplines (even if they were admitted with an undergraduate degree in engineering). The student pursuing the MAS degree may choose a traditional thesis program or a non-thesis option. The courses for the non-thesis option correspond to the course requirements for the traditional master's degree program.

Master of Ocean Engineering

The Master in Ocean Engineering is offered jointly with the Physical Ocean Science and Engineering Program (POSE) in the College of Marine and Earth Studies. Students may matriculate through either the College of Engineering or the College of Marine and Earth Studies and may choose a thesis advisor from either program. Degree requirements are the same for either College and are given in Section III.

Non-thesis Options

Within the MCE and MAS degree programs, non-thesis options are available for students concentrating their studies in the areas of Civil Infrastructure Systems, Coastal Engineering, Environmental Engineering, Structural Engineering, Geotechnical Engineering, Transportation Engineering, and Water Resources Engineering. The objective of the non-thesis master's programs is to provide an opportunity for students who do not have the need to develop research skills to obtain a non-thesis degree with a quality and depth of study comparable to the master's degree with thesis. Through coursework (minimum of 30 credits), students develop their engineering skills and obtain a state-of-the-art background within the chosen area of study. The non-thesis programs are designed for students with relevant experience in industry, whose employment precludes them from doing a thesis master's degree. Students originally enrolled in the thesis master's degree program may not transfer to the non-thesis option except under special conditions and with the approval of the faculty (thesis) advisor and the Graduate Committee. Students selecting the non-thesis option are not eligible for financial support from the University.

Ph.D. in Civil Engineering

This degree is offered in the major areas of Civil Infrastructure Systems, Coastal Engineering, Environmental Engineering, Structural Engineering, Geotechnical Engineering, Transportation Engineering, and Water Resources Engineering.

Ph.D. in Ocean Engineering

The Ph.D. in Ocean Engineering is offered jointly with the Physical Ocean Science and Engineering Program (POSE) in the College of Marine and Earth Studies. Students may matriculate through either the College of Engineering or the College of Marine and Earth Studies and may choose a thesis advisor from either program.

Concentrations

The Department of Civil & Environmental Engineering offers the following areas of graduate study concentration (also referred to as Concentrations):

- **Civil Infrastructure Systems**—asset management, natural disaster risk analysis, and infrastructure vulnerability
- **Coastal Engineering**—coastal engineering, wave mechanics and fluid mechanics.
- **Environmental Engineering**—water and wastewater treatment, environmental chemistry and remediation, solid and hazardous waste management.
- **Geotechnical Engineering**—computational geomechanics, soil mechanics, foundation engineering, earth structures engineering.
- **Structural Engineering**—structural mechanics, dynamics and design, analysis of structures, matrix and finite element methods, computational mechanics, and structural engineering materials.
- **Transportation Engineering**—urban transportation, traffic engineering, systems engineering, logistics engineering, and engineering management.
- **Water Resources Engineering**—groundwater hydraulics, groundwater contamination, watershed management, hydrology, and water quality control.

Students in all departmental graduate degree programs may elect to choose a concentration; however, concentrations are voluntary, and students selecting

multidisciplinary or other specialized studies need not declare a concentration. Study in two or more related concentrations is allowed. Students selecting a concentration must meet the concentration requirements detailed in Section X in addition to meeting their general degree requirements. The concentration will be denoted on the student's transcript if one is selected.

II. Admission Requirements

The minimum requirements for admission to a master's or doctoral program in the Department of Civil & Environmental Engineering are an undergraduate grade point average of at least 3.0 (out of a possible 4.0) for master's applicants or 3.5 (out of a possible 4.0) for Ph.D. applicants; GRE scores (verbal and quantitative combined) of at least 1050; and a TOEFL score (for international students) of at least 550.

Although it is possible for students to study toward a Ph.D. directly upon entering graduate school, most students choose to obtain the MCE or MAS first. Students considering doctoral study typically must have completed any previous graduate study with at least a 3.5 grade point average and have clearly demonstrated a capacity for independent work. If an M.S. thesis or other comprehensive work was written at another institution, a copy must be provided to the advisor soon after the student enrolls at the University of Delaware.

The minimum requirements for admission to a master's or doctoral program for a Master of Science and Doctor of Philosophy in Ocean Engineering are as follows: a Bachelor of Science in Engineering, an undergraduate grade point average of at least 3.0 (out of a possible 4.0) for Masters applicants or 3.5 (out of a possible 4.0) for Ph.D. applicants, GRE scores (verbal and quantitative combined) of at least 1200, and a TOEFL score (for international students) of at least 600. The POSE Graduate committee may increase these minimum requirements.

The Master of Ocean Engineering is not available in a non-thesis option.

III. Academic Requirements

A. Master's Degree Requirements (Civil Engineering)

Master's Degrees with Thesis total of 30 credits:

The master's program with thesis requires 30 credit hours including 24 graduate course credits and at least 6 credits for the master's thesis. The Department Graduate Committee must approve each student's program.

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

- At least one course each in mathematics and in engineering sciences.
- At least 3 credits at the 800 level.
- At least 9 credits of courses in the chosen concentration (a list of required courses for each concentration area is attached).

The student should consult his/her advisor in selecting courses to fit these requirements. Petitions for required course substitutions may be made via the advisor to the Department

Graduate Committee. A maximum of 9 credits is transferable to the University of Delaware toward any master's degree.

Master's Degrees Non-Thesis Option

The non-thesis master's degree options require 30 credits of courses comprising a core of studies, together with elective courses selected with the approval of a faculty advisor. (The courses for the non-thesis options correspond to the course requirements for the traditional master's degree programs with thesis.) Petitions for core course substitutions (e.g., in the case of cross-disciplinary programs of study) may be made via the advisor to the Department Graduate Committee. A maximum of 9 credits is transferable to the University of Delaware toward any master's degree.

B. Master's Degree Requirements (Ocean Engineering)

The Master of Ocean Engineering degree program requires a minimum of 30 credit hours. This includes a thesis describing independent research. Students may earn up to six credits for the thesis.

Required courses are as follows:

- MAST691/CIEG639 (Ocean Fluid Dynamics)
- MAST882 (Physical Ocean Science and Engineering Seminar) or CIEG865 (Civil Engineering Seminar)
- MEEG690 (Intermediate Engineering Mathematics)
- MAST693 (Waves in the Marine Environment) or CIEG672 (Water Wave Mechanics)

Additional courses typically include at least 6 credits at the 800 level and at least 9 credits of graduate courses. The student's advisor approves the course curriculum. Petitions for required course substitutions may be made via the advisor to the program director. A maximum of 9 graduate course credits from other universities may be applied toward the Master's degree.

C. Ph.D. Degree Requirements (Civil Engineering)

The Ph.D. program is aimed at training the graduate student to achieve the highest degree in research within a chosen topic. Mathematics, fundamental sciences, and engineering sciences are combined to provide a personalized program of study and research. All graduate students work in close cooperation with the faculty in the chosen area. Although it is possible for students to study toward a Ph.D. directly upon entering graduate school, most students choose to obtain the MCE or MAS first.

Residency Requirement

The student must meet a campus residency requirement of at least one continuous academic year devoted exclusively to full-time study in the major field at the University of Delaware. The residency requirement may be fulfilled in the fall and spring semesters but not in the summer or winter sessions. If a student has earned a master's degree at the University of Delaware, this can be used to fulfill the residency requirement.

Course Requirements

A student's doctoral program, comprising 72 credits beyond the bachelor's degree (including doctoral dissertation), is planned around a central objective in applied science and mathematics. If a student who already holds a master's degree in the specific field of study

is accepted directly into the Ph.D. program, the coursework from the master's degree will be taken into account in the design of the doctoral program. All courses in the program are selected with the approval of the student's dissertation advisor. The program requirements are shown in the following table.

Beyond the Bachelor of Science Degree:

TOTAL COURSE REQUIREMENTS	CREDITS
Graduate Program Courses	36
Ph.D. DISSERTATION	9
RESEARCH (minimum)	9
TOTAL Ph.D. PROGRAM	72

Beyond the Master's Degree

TOTAL COURSE REQUIREMENTS	CREDITS
Graduate Program Courses	12
MASTER'S DEGREE	30
Ph.D. DISSERTATION	9
RESEARCH (MINIMUM)	9
TOTAL Ph.D. PROGRAM	72

Mathematics and Engineering Sciences: The purpose is to provide an adequate basis for original work in the field of study and, within the limits of available time, to extend the student's knowledge outside that field. Typically one course must be taken from each of the Mathematics and Engineering Sciences course lists.

Seminars

All full-time graduate students are required to attend departmental or college seminars in their fields of study (CIEG865 or MAST882), registering as a "Listener" in subsequent semesters. Students will also make presentations at these seminars.

Resume and Dissertation Proposal

A student who has completed about 30 credits of coursework should consult his/her advisor for assistance in the preparation of a written resume that is to include the dissertation proposal. The resume should provide information about the student's background: publications authored; the concentration contemplated; and a proposal describing the doctoral research to be undertaken. The resume can enable the advisor and the committee to assess progress and plans for the future. It is also useful to advisor and student in determining the composition of the student's Doctoral Committee and the most appropriate character for the Qualifying Exam. The student will provide a copy of the resume to each committee member and the Department Chairperson for approval.

Doctoral Committee

The selection of prospective members of the Doctoral Committee is discussed by the student and his advisor, who then forwards a recommendation for the composition of the committee via the Department Chairperson to the University Coordinator of Graduate Studies. At least three, but not more than five, members (in addition to the advisor) will be appointed to the committee by the Department Chairperson. At least two committee

members, one of whom is the committee chairperson, represent the major field of interest. At least one committee member shall be an external examiner from a different academic unit or from outside the University. Changes in the composition of the committee to reflect the student's interests may be made following the same procedure, i.e., consultation with the faculty advisor, who forwards the recommendation via the Department Chairperson to the University Coordinator of Graduate Studies.

It is the student's responsibility to consult each member of the Doctoral Committee at least six weeks before the Qualifying Exam for advice on any specific preparation that the committee members suggest. Any committee member who is not fully satisfied with a student's preparation for the formal exam will advise the Doctoral Committee chairperson promptly.

Qualifying Exam

The Qualifying Examination is usually taken near the completion of 36 credits of course work beyond the bachelor's degree. After the resume has been prepared and a Doctoral Committee selected, the committee chairperson shall schedule the Qualifying Exam. The Qualifying Exam is a comprehensive written and oral exam. It is usually administered in two sections, a week or so apart, to test the student's preparation and the aptness of the proposed research. It is not open to the public. The advisor, as Exam Committee Chairperson, administers the written exam and chairs the oral. Upon successful completion of the Qualifying Exam, the student is certified as a candidate for the doctorate. The student must then register for each semester until the thesis is completed. At the conclusion of the Qualifying Exam, the Committee members signify agreement by signing the appropriate Graduate Office form.

The Qualifying Exam (written and oral) may result in one of the following actions for a student:

- a. Passed; candidacy form signed by all committee members.
- b. Passed, but additional work required (self study or formal course); form signed by all committee members. If the Qualifying Exam Committee recommends passing but with additional study or course work, the Committee Chairperson will ensure that the student meets these recommendations promptly.
- c. Failed, but to be offered a second complete exam after, in most cases, one semester of additional preparation; memo of record from advisor via the Department Chairperson to the Office of Graduate Studies. If unsuccessful a second time, the student will not be permitted a third attempt, and matriculation in the program will be ended. The form signed by all committee members
- d. Failed, no re-examination; form signed by all committee members and matriculation in the program will be ended.

Dissertation Defense

The procedure for departmental presentation of the Ph.D. dissertation is as follows: After the student has obtained the approval of the advisor regarding the contents of the dissertation, it must be typed or printed with all figures and charts completed. Copies of the dissertation are provided in binders to every member of the Doctoral Committee. The committee members evaluate the dissertation (allow at least two or three weeks). If their decision is favorable, the dissertation advisor, who is Chairperson of the Doctoral Committee, will schedule the public Final Oral Examination. University policy requires that "all Ph.D.

dissertation defenses be open and that an announcement of the time, place, subject, candidate's name, and the title of the dissertation be made available to the University community at least one week prior to the defense. A copy of the dissertation will be made available in the department office at the time the public announcement is made."

In the Department of Civil & Environmental Engineering, the procedure for the Final Oral Examination is as follows:

- a. The candidate gives a presentation of approximately 30 minutes on the dissertation research and findings.
- b. An intensive questioning by the Doctoral Committee and all others present takes place after the presentation. The examination is not merely a defense by the student of the dissertation but may also include a review of the student's competence and comprehension in related fields. After the questioning is completed, the meeting is closed to everyone except the committee members, who render their vote.
- c. Upon successful completion of this examination and compliance with any necessary revisions of the dissertation, the candidate will be certified by the Doctoral Committee for conferral of the degree by completion of the appropriate form.
- d. In the case where the Final Oral Examination is not passed by the student, the applicant will be allowed to appear for a second trial after the lapse of at least six months. If unsuccessful in a second trial, the student will not be permitted to take a further examination and will be terminated from the program.

D. Ph.D. Degree Requirements (Ocean Engineering)

The Ph.D. in Ocean Engineering program is aimed at training graduate students to achieve the highest level of proficiency in research. Mathematics, fundamental sciences, ocean sciences and engineering sciences are combined to provide a personalized program of study and research. All graduate students work in close cooperation with the faculty on their dissertation area.

Residency Requirement

The student must meet a campus residency requirement of at least one continuous academic year. If a student has earned a master's degree at the University of Delaware, this can be used to fulfill the residency requirement.

Course Requirements

A student's doctoral program, comprising 72 credits (including doctoral dissertation) beyond the bachelor's degree, is planned around a central engineering objective. For students holding a master's degree in an appropriate field of study, the coursework from the master's degree will be taken into account in the design of the doctoral program. All courses in the program are selected with the approval of the student's advisor.

The program requirements are shown in the following table.

TOTAL COURSE REQUIREMENTS	CREDITS
Graduate Courses Beyond the Bachelor of Science Degree	36

The purpose of the course work is to provide a solid foundation for original research in the field of study and, within the limits of available time, to extend the student's knowledge outside that field. At least 6 of the required credits should be taken outside of the Program of Ocean Science and Engineering and may include significant components from other departments.

Ph.D. DISSERTATION	9
RESEARCH (minimum)	9
MASTER'S THESIS (if applicable)	6
TOTAL Ph.D. PROGRAM	72

Required courses include courses in mathematics and engineering sciences designed to insure that Ph.D. candidates have the basic skills in Physical Ocean Science and Engineering needed to conduct dissertation research.

Required courses beyond the Bachelor of Science:

- CIEG639/MAST691 Ocean Fluid Dynamics
- CIEG672 Water Wave Mechanics
- MEEG690 Intermediate Engineering Mathematics
- MEEG691 Advanced Engineering Mathematics
- MAST693 Waves in the Marine Environment
- MAST882 Physical Ocean Science and Engineering Seminar
- CIEG865 Civil Engineering Seminar

Students matriculating from other universities may petition to have these courses waived if their course of study included equivalent courses.

Doctoral Committee

Each Doctoral Committee shall consist of no fewer than four or more than six members. The selection of members of the Doctoral Committee is made by the student and advisor. This is forwarded via the Department Chairperson or a program director and respective college deans to the University Coordinator of Graduate Studies. A Doctoral Committee in the Ocean Engineering program is required to have at least four members. This is composed of the student's advisor, who is also the chair of the committee, at least one member each from CMES and CIEG faculties, and one member from an outside academic unit. At least two committee members, one of whom is the committee chairperson, represent the major field of interest.

Qualifying Exam

Doctoral students must demonstrate to their advisory committee that they have acquired a comprehensive grasp of their field of study through a Qualifying Examination (written and oral) before they are admitted to formal candidacy.

The examination process begins when the student submits a dissertation proposal to his/her committee at least six weeks before the written and oral examination. Then the student consults each member of the Doctoral Committee for advice on any specific preparation that the committee members suggest. Any committee member who is not fully satisfied with a student's preparation for the formal exam will advise the Doctoral Committee chairperson promptly.

The Qualifying Exam is a comprehensive written and oral exam. It is administered in two sections approximately a week apart. This examination is designed to test the student's preparation and the aptness of the proposed research. It measures the student's preparation, including knowledge about the area of Physical Ocean Science and Engineering, the student's capability to apply knowledge gained in courses, and the student's qualifications in written and oral communication. Qualifying exams are not open to the public. The advisor, as Exam Committee Chairperson, administers the written exam and chairs the oral. The written exam usually consists of one independent exam of at least two hours duration set by each of the committee members and administered over two or more consecutive days. At the oral exam, the student gives a brief review of the research plan and then answers questions from each committee member related to the dissertation proposal or to the student's coursework. In general, the Doctoral Committee should strive to achieve consensus concerning the student's performance and quality of work. In the case of dissenting votes, the majority opinion rules and a majority vote in favor is needed for a successful defense. Upon successful completion of the Qualifying Exam, the committee members signify agreement by signing the appropriate graduate office form.

- a. Passed; candidacy form signed by all committee members.
- b. Passed, but additional work required (self-study or formal course); form signed. If the Qualifying Exam Committee recommends passing but with additional study or course work, the Committee Chairperson will ensure that the student meets these recommendations promptly.
- c. Failed, but to be offered a second complete exam after, in most cases, one semester of additional preparation; memo of record from advisor via the Department Chairperson or College Dean to the Office of Graduate Studies. If unsuccessful a second time, the student will not be permitted a third attempt, and matriculation in the program will be terminated. The form signed by all committee members.
- d. Failed, no re-examination; form signed by all committee members and matriculation in the program will be ended.

Dissertation Defense

Upon completion of the dissertation, a final oral examination must be passed, consisting of a defense of the dissertation and a test of the candidate's mastery of the fields covered in the program. The final oral examination is open. It is conducted by the student's Doctoral Committee and chaired by the student's advisor. To permit adequate time for the committee to review the dissertation, all copies of the tentatively completed dissertation (subject to revisions required by the examining committee) must be deposited with the program director and the respective college offices at least two weeks before the date of the final oral examination. The advisor shall submit certification of a successful defense to the Office of Graduate Studies through the respective college deans.

Seminars

All full-time graduate students are required to attend departmental or college seminars in their fields of study (CIEG865 or MAST882), registering as a "Listener" in subsequent semesters. Students will also make presentations at these seminars. Students are also encouraged to attend other University seminars that may be of interest to them.

IV. Statutes of Limitation

A Ph.D. student entering with a master's degree must finish within 5 years. A Ph.D. student entering without a master's degree must finish within 7 years. Expiration of the limit without an extension results in automatic dismissal from the Graduate Program. Requests for extensions must be made in writing by the student and be approved by the student's advisor and the Chair of the Department before they are sent to the Office of Graduate Studies for approval.

V. Academic Load

Fall and Spring Semesters

Credits to be taken per semester depend upon the student's needs, the nature of employment or appointment, and his/her past performance. Incoming international students may find it necessary to begin with 3 to 6 fewer credits than normal for the first one or two semesters. Any courses prescribed to correct deficiencies in academic or language backgrounds will be taken into account by the student and advisor in establishing maximum academic load for any term. Credits shown in the following table are graduate semester credits, taken for grade.

Status	Fall or Spring Term Minimum Requirement	Normal
Graduate Students		
Part-time	3	3-6
Full-time	9	9-12
Teaching Assistants	6	9
Research Assistants	6	9
Graduate Assistants	6	9
Fellows	9	9-12

Required minimum figures include only courses for which graduate credit is given. Additional credits, up to the maximum, may be used for courses in which enrollment is required to remove a deficiency or to achieve competence in English and other appropriate languages. Additional courses may be audited; however, if the student wishes to audit two courses, these should be considered as about three credits in figuring the course load for the semester. Registration for ongoing students must be completed during early registration period.

Fellows and Assistants must be full-time graduate students during the period of their contract and, therefore, must register for the minimum graduate credits shown in the preceding table or register in sustaining status

Winter and Summer Sessions

During winter session, no registration is required. At the present time, registration for one 3-credit course (may be research) during the first summer session is required of all funded students, with the tuition being paid by the University. Unfunded students must register for summer session if they will be awarded their degrees at the conclusion of the Summer Session, although the University will not pay their tuition. Registration for any other course is optional, with the fee dependent upon the number of credits taken. Tuition coverage for winter or summer (except for the aforementioned 3-credit course) is not part of a student's

contract. All students may use the laboratories, library, and computers for study and research without registration and without paying for such use.

Registration Prior to Doctoral Candidacy (G1 Status)

Once a student has registered for all course requirements in a program of study but has not yet met all of the stipulations for passing into candidacy, the student must maintain registration during the fall and spring semesters in course(s) or in 3-12 credits of Pre-Candidacy Study, CIEG964, which is graded pass/fail. If the student registered in Pre-Candidacy Study is admitted to candidacy before the end of the free drop/add period of the next semester, the registration in Pre-Candidacy Study for the preceding semester may be changed to the course Doctoral Dissertation, CIEG969. (Students classified as G1 and holding graduate assistantships or tuition scholarships must register for a minimum of six graduate credits, and those holding fellowships must register for a minimum of nine graduate credits.)

Registration

Sustaining Status University policy states that students may not register for Doctoral Dissertation (CIEG060) until admitted to candidacy (G2 status). In addition, once a graduate student who is completing a thesis or dissertation option has completed all required course credits needed for the degree (including six credits of Master's Thesis (CIEG869) or nine credits of Dissertation (CIEG969)), except the submission of thesis or dissertation, the student is required to maintain his/her matriculation in the degree program during the fall and spring semesters by registering for either Master's Sustaining Thesis (UNIV 899) or Doctoral Sustaining (UNIV 999). All students, including sustaining students, are required to be registered in the semester in which the degree is officially awarded. (Sustaining registration is not required for summer session unless the degree is to be awarded at the conclusion of the summer session. Sustaining registration is never required for winter session, as graduate degrees are not awarded at the conclusion of winter session.)

VI. Petition

Exceptional circumstances may justify petition for relief of certain requirements. A student may petition the Departmental Graduate Committee through the advisor, who will attach an appropriate recommendation. The Departmental Graduate Committee may act upon certain petitions. In other matters, it may be necessary to refer such a petition, along with a committee recommendation, to the Department Chairperson and possibly to the Dean of the Engineering College or to the Office of Graduate Studies.

VII. Grade Requirements and Evaluation of Progress

The Department has the following requirements in addition to those of the Office of Graduate Studies, stated in the University Graduate Catalog. Failure to meet the standards listed below may result in termination of funding.

English Proficiency

While admission is based upon GRE Verbal (and TOEFL for international students) scores, there may still be need for further improvement. Where deficiencies exist, oral or written, the advisor may recommend additional training by the student and may place a "communication condition" on the student's record. The "communication condition" is removed by successfully completing a noncredit, individualized instruction program at the University Writing Center.

Academic Progress: Grades

The academic records of students are reviewed at the end of each semester. Special attention is given to students who earn less than a B (3.0) average in any semester or those whose cumulative average is less than B. Graduate student's overall grade point average must be at least B (3.0) in order to be eligible for the degree. A student who receives a grade below B (3.0) in a core course is required to retake the course. Credit hours and courses for which the grade is below C- do not count toward the degree, even though the grade is applied to the cumulative grade point average.

Thesis/Dissertation Progress

During the first year, students should select a thesis/dissertation topic and an advisor. During the second year, students should have their research underway.

VIII. Thesis/Dissertation Preparation

The thesis or dissertation must show that the candidate has technical mastery and is capable of independent research. It must enlarge or modify what was previously known or present a significant interpretation of its subject. A number of drafts may be required. Appropriate time must be anticipated for these rewrites. A two-week review period is typical. If more than three weeks are required, a student may contact the Department Chairperson for assistance in expediting the review. A Ph.D. dissertation must be provided to all members of the student's committee in accord with Graduate Office requirements and deadlines.

Typing and reproduction of theses and dissertations will be at student expense. When a thesis or dissertation also serves as a research report under a contract, and if facilities and time permit, the student may arrange for additional copies and will pay only a prorated cost for those copies required for personal or graduate office use. A copy of *The Thesis Manual* may be purchased at the University bookstore and is also available electronically on UDiscover!

IX. Graduate Assistantships

Graduate Assistantships requiring various types of duties, including teaching, are offered by the Department Graduate Coordinator based upon the recommendation of individual faculty members. Decisions on offers to be made for the fall and spring semesters generally are made in March and April of the previous spring. Selections among new students are based on all data received with the application for graduate study. Selections among continuing students are based on graduate academic and work performance to date. For master's degree candidates, no more than two years financial support will be provided from graduate

assistantships. (Students selecting a non-thesis master's degree option are not eligible for financial support. Students originally enrolled in the thesis master's degree program may not transfer to the non-thesis option except under special conditions and with the approval of the faculty (thesis) advisor and the Graduate Committee.) For Ph.D. candidates, a maximum of three years support by graduate assistantship will be provided beyond the master's level.

Graduate Assistantships not requiring teaching are normally offered to outstanding new graduate applicants to attract such students to the graduate programs. In allocating teaching Graduate Assistantships for upcoming semesters, first consideration is generally given to those students currently receiving aid. It is recommended that Ph.D. candidates serve at least one semester as teaching assistants.

Master's and Ph.D. candidates are also both eligible for Research Assistantships (excluding non-thesis master's students). Research Assistantships are offered by the Department Graduate Coordinator on the recommendation of individual faculty having research funds. No long-term support is assured for any graduate student; awards are typically committed on a semester or yearly basis with further support based on the student's satisfactory performance and the availability of research funding.

Students who hold appointments in the Department of Civil & Environmental Engineering are not permitted to accept other employment (inside or outside the University) during the period of appointment. This is necessary to ensure that a student does not undertake so much work that the academic progress suffers and also to ensure that the student does not lose his FICA tax-exempt status. Students who do not hold appointments, but who accept employment elsewhere are requested to keep the advisor informed of these circumstances. The Civil & Environmental Engineering Chairperson must sign any contract issued by another department for a graduate student in this department. Students who need part-time employment to supplement their resources during a school term should inquire whether a position is available in this department for their skills. Advisors and other faculty members may also be of assistance in suggesting possible sources of employment, as may the University Placement Office. In any case, no international graduate student may work for more than 20 hours a week and still be considered a full-time graduate student (thus entitled to FICA tax-exempt status) by the IRS.

The following types of support are available:

Type	Expected Weekly Performance
Graduate Assistantships: Teaching*	20 hours (maximum): paper grading, proctoring, teaching, running labs, etc.
Graduate Assistantships: Non-teaching	20 hours (maximum): assisting a faculty member
Research Assistantships	20 hours (maximum): research: assisting a faculty member

*International graduate students who have been offered a Teaching Graduate Assistantship and whose native language is not English must participate (prior to the teaching assignment) in the International Teaching Assistant Training Course offered by the English Language Institute, University of Delaware.

X. Concentrations

Students in all departmental graduate degree programs may elect to choose a concentration area of study. Concentrations are available in Civil Infrastructure Systems, Coastal Engineering, Environmental Engineering, Geotechnical Engineering, Structural Engineering, Transportation Engineering, and Water Resources Engineering. Students must meet the concentration requirements detailed in the following sections, in addition to meeting their general degree requirements. Study in two or more related concentrations is allowed. Concentrations are voluntary, and students selecting multidisciplinary or other specialized studies need not declare a concentration.

Civil Infrastructure Systems

Civil infrastructure systems involves the design, analysis, and management of infrastructure supporting human activities, including, for example, electric power, oil and gas, water and wastewater, communications, transportation, and the collections of buildings that make up urban and rural communities. These networks deliver essential services, provide shelter, and support social interactions and economic development. They are society's lifelines.

The field of civil infrastructure systems builds on and extends traditional civil engineering areas. Rather than focus on individual structural components or structures, civil infrastructure systems emphasizes how different structures behave together as a system that serves a community's needs. Problems in this field typically involve a great deal of uncertainty, multiple and competing objectives, and sometimes numerous and conflicting constituencies. They are often spatial and dynamic. The technical aspects of infrastructure engineering must be understood in the social, economic, political, and cultural context in which they exist, and must be considered over a long-time horizon that includes not just design and construction, but maintenance, operations, performance in natural disasters and other extreme events, and destruction as well.

MS Course Requirements

The Master's degree in Civil Engineering or Applied Science in the field of Civil Infrastructure Systems requires three core course and five electives taken from a variety of fields. Electives should be selected based on discussions with your advisor.

Core Courses

- CIEG645 Civil Infrastructure Systems
- CIEG667 Risk Analysis
- ORES601 Survey of Operations Research I or CIEG667 Modeling Engineering Systems

Suggested Electives

- CIEG650 Urban Transportation Systems
- CIEG661 Structural Dynamics Design
- CIEG667 Resilience Engineering
- CIEG667 Pavement Analysis and Design
- CIEG667 Sensors
- CIEG811 Advanced Structural Dynamics Design Modeling

- MAST663 Decision Tools for Policy Analysis
- BUAD836 Problem Structuring and Analysis for Decision Making
- GEOG667 Geographic Information Systems
- GEOG671 Advanced Geographic Information Systems
- GEOG677 Spatial Analysis
- ORES602 Survey of Operations Research II
- ORES603 Simulation
- STAT601 Probability Theory for Operations Research and Statistics
- STAT602 Mathematical Statistics
- STAT608 Statistical Research Methods
- STAT609 Regression and Experimental Design
- SOCIO 640 Social Issues in Disaster Research
- SOCIO 643 Society and Risk
- MAST672 Applied Policy Analysis
- UAPP827 Program and Project Evaluation
- ECON801 Microeconomics
- ECON802 Macroeconomics

Students with no computer programming or computer science background should take CISC106, CISC181 or CISC220.

General Requirements

Students must also complete the general degree requirements as detailed in the Civil and Environmental Engineering Graduate Policies and Requirements and University Catalog. These requirements include credit requirements and, for Ph.D. and thesis option MS students, the carrying out of research and completion of dissertation/thesis.

Coastal Engineering

A broad engineering knowledge is required for the construction, protection, and maintenance of coastal communities and harbors, the development of offshore resources, and the preservation of estuarine and coastal areas. Generic engineering knowledge is crucial, despite the fact that construction of coastal and offshore facilities is highly dependent upon unique site-specific characteristics, such as local bathymetry, coastal topography and the offshore wave climate. Coastal engineers who work on the nearshore region face a wide variety of problems, including the following:

- Prediction of long-term shoreline changes due to beach nourishment or presence of structures;
- Prediction of the forces a marine structure, including a levee, experiences over its lifetime;
- Prediction of wave-induced forces and currents on sediment redistribution and morphological change.
- Determination of the influence of sea level rise on coastal erosion and infrastructure;
- Determination of shallow water directional spectra and storm surge;
- Determination of correct breakwater design, including composition, shape, and orientation;
- Calculation of estuarine and harbor hydrodynamics and pollution transport;

- Wave breaking and air bubbles.

Because of shoreline erosion from major storms and increasing sea level rise, pollution of estuaries, and the high cost of constructing and maintaining navigable channels and harbors, the demand for coastal research expertise is strong. The Center for Applied Coastal Research (www.coastal.udel.edu) is responding to this demand through the development of science and engineering methodologies to support design strategies for the coastal and offshore industry.

MS Course Requirements

The Master's degree in Civil Engineering or Applied Science in the field of Coastal Engineering requires three core course and five electives taken from a variety of fields. Electives should be selected based on discussions with your advisor.

Core Courses

- CIEG639 Ocean Fluid Dynamics
- CIEG672 Water Wave Mechanics
- MEEG690 Intermediate Engineering Mathematics

Suggested Electives

- CIEG675 MATLAB for Engineering Analysis
- CIEG678 Transport and Mixing Processes
- CIEG679 Sediment Transport Mechanics
- CIEG680 Littoral Processes
- CIEG681 Water Wave Spectra
- CIEG682 Nearshore Hydrodynamics
- CIEG684 Numerical Methods for Coastal Modeling
- CIEG865 Civil Engineering Seminar (Ocean)
- CIEG870 Offshore Design
- CIEG871 Coastal Structures
- CIEG872 Advanced Water Wave Mechanics
- MAST681 Remote Sensing of Environment
- MAST693 Waves in Marine Environment
- MAST806 Geophysical Fluid Dynamics
- MAST808 Coastal/Estuarine Physical Dynamics

General Requirements

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

Environmental Engineering

The field of environmental engineering deals with environmental issues from the nanoscale to the global scale. Contamination caused by the activities and waste products of our modern society affect the water, air, soil, and ecosystems around us in complex ways that

must be clearly understood if we are to successfully address these problems. In recognition of the interdisciplinary nature of these issues, our program provides students with a broad foundation in the fundamentals of physical, chemical, and biological processes. Advanced coursework and research in our graduate program is focused on the following areas:

- Contaminant Fate and Treatment in Soil and Groundwater
- Environmental Biotechnology
- Environmental Chemistry and Nanotechnology
- Green, Sustainable, and Global Environmental Technologies
- Solid Waste and Hazardous Waste Management
- Water Quality and Wastewater Engineering

The environmental engineering program is designed not only for those with undergraduate degrees in Civil and Environmental Engineering, and other engineering disciplines, but also related non-engineering fields such as Chemistry, Environmental Science, Geology, and many others.

MS Course Requirements

The Master's degree in Civil Engineering or Applied Science in the field of Environmental Engineering requires three core courses and five electives taken from a variety of fields. Electives should be selected based on discussions with your advisor.

Core Courses

- CIEG632 Chemical Aspects of Environmental Engineering
- CIEG634 Contaminant Transport and Separation in Environmental Systems
- CIEG636 Biological Aspects of Environmental Engineering

Suggested Electives

- CIEG630 Water Quality Modeling
- CIEG633 Hazardous Waste Management
- CIEG635 Air Pollution and Control
- CIEG667 Industrial Ecology The Science of Environmental Sustainability
- CIEG668 Principles of Water Quality Criteria
- CIEG678 Transport and Mixing Processes
- CIEG679 Sediment Transport Mechanics
- CIEG698 Groundwater Flow and Contaminant Transport
- CIEG831 Theory of Water Treatment
- CIEG832 Theory of Wastewater Treatment
- CIEG833 Fate of Organic Pollutants in the Environment

In addition, classes from other departments can be selected in consultation with the advisor. These include graduate-level courses offered by Bioresources Engineering, Mathematics, Mechanical Engineering, Marine Studies, Geography, Urban Affairs and Public Policy, or Plant and Soil Sciences. Each semester students are also expected to register for CIEG865 Civil Engineering Seminar. Students register for credit one semester and as a "Listener" in the other semesters.

General Requirements

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

Geotechnical Engineering

Civil engineering is the professional engineering discipline that deals with the design, construction, and maintenance of public and private infrastructure within the natural environment. Geotechnical engineering is a discipline within Civil Engineering that focuses on the behavior of natural geological materials in engineered systems. Geotechnical engineers recognize that soil and rock are the cheapest and most abundant building materials on earth, and consequently play a major role in the construction and performance of every type of civil engineering structure.

To be successful in the field of geotechnical engineering, students should have a broad exposure to Civil Engineering, with advanced knowledge and coursework in geology, soil and rock mechanics, slope stability, foundation engineering, and computational mechanics.

The Geotechnical Engineering program at the University of Delaware offers opportunities for advanced study and research in the following areas:

- Soil and rock mechanics
- Soil-structure interaction
- Constitutive modeling
- Computational geomechanics
- Foundation and earth structures engineering
- Ground improvement
- Slope stability and landslide stabilization
- Liquefaction of soils and earthquake engineering
- Laboratory characterization of geomaterials and soil reinforcement
- Environmental geotechnics

Given the strong need for improvement to our nation's infrastructure, there is currently a high demand for geotechnical engineers within the civil engineering profession. Sustainable stewardship of our built environment is dependent on successful training of the future generation of civil engineers, both as researchers that are capable of advancing the state of the art, and as practitioners that have the ability to implement effective design solutions to real-world problems. A graduate degree in geotechnical engineering will give you the skills you need to succeed in both of these highly challenging environments.

MS Course Requirements

The Master's degree in Civil Engineering or Applied Science in the field of Geotechnical Engineering requires a total of three core course and five electives taken from a variety of fields. Electives should be selected based on discussions with your advisor.

Core Courses

- CIEG601 Introduction to the Finite Element Method
- CIEG622 Earth Structures Engineering
- CIEG626 Soil Behavior

Suggested CIEG Electives

- CIEG605 Intermediate Topics in Finite Element Analysis
- CIEG620 Soil Mechanics II
- CIEG621 Foundation Engineering
- CIEG623 Soil Mechanics Lab
- CIEG625 Geo-Environmental Engineering
- CIEG627 Deep Foundations
- CIEG628 Ground Improvement Methods
- CIEG667 Pavement Analysis and Design
- CIEG675 MATLAB for Engineering Analysis
- CIEG801 Advanced Topics in Finite Element Analysis
- CIEG820 Inelastic Behavior of Geomaterials

Other Suggested Courses

- CIEG606 Ocean and Atmosphere Remote Sensing (MAST606)
- GEOG667 Geographic Information Systems
- GEOG671 Advanced Geographic Information Systems
- GEOG677 Spatial Data Analysis
- MAST681 Remote Sensing of Environment
- MEEG690 Intermediate Engineering Mathematics
- STAT601 Probability Theory for Operations Research and Statistics
- STAT602 Mathematical Statistics
- STAT608 Statistical Research Methods
- STAT609 Regression and Experimental Design

In addition to the courses listed above, a variety of CIEG667 Seminar courses are frequently offered by the professors in the geotechnical engineering group, and will be accepted for elective credit. Each semester students are also expected to register for CIEG865 Section 010 Civil Engineering Seminar. Students register for credit one semester and as a "Listener" in the other semesters.

General Requirements

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

Structural Engineering

The structural engineering program offers opportunities for graduate study and research in many subject areas related to the analysis and design of civil structures. Emphasis areas of the program include bridge engineering, building engineering, structural mechanics, modern structural analysis, structural dynamics, and structural engineering materials.

MS Course Requirements

The Master's degrees in Civil Engineering and Applied Science in the field of Structural Engineering require three core courses and a minimum five electives taken from a variety of fields. Electives should be selected based on discussions with your advisor.

Core Courses

- CIEG601 Introduction to Finite Element Method
- CIEG611 Structural Dynamics Design
- CIEG612 Advanced Mechanics of Materials *or* CIEG817 Stability of Structures

Students are also expected to register for CIEG865 Section 010 Civil Engineering Structures Seminar each semester. Students register for credit one semester and as a "Listener" in the other semesters.

Suggested Electives

- CIEG604 Prestressed Concrete Design
- CIEG605 Intermediate Topics in Finite Element Analysis
- CIEG608 Introduction to Bridge Design
- CIEG610 Experimental Mechanics of Composite Materials
- CIEG612 Advanced Mechanics of Materials
- CIEG619 Mechanical Behavior of Materials and Structures
- CIEG621 Foundation Engineering
- CIEG675 MATLAB for Engineering Analysis
- CIEG801 Advanced Topics in Finite Element Analysis
- CIEG802 Advanced Steel Design
- CIEG811 Advanced Structural Dynamics Design
- CIEG817 Stability of Structures
- MEEG618 Fracture of Solids
- MEEG690 Intermediate Engineering Math
- MEEG813 Theory of Elasticity
- MEEG814 Theory of Plasticity
- MEEG816 Advanced Continuum Mechanics
- MEEG817 Composite Materials

General Requirements

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

Transportation Engineering

The transportation engineering program offers opportunities for study and research in the planning, design, construction, operation, and management of transportation facilities and services. We emphasize systems approach to understand the interactions among transportation services, demand, mobility, socio-economic activities, environment, energy, and the quality of life in the region. We use a variety of techniques, from global positioning

and geographic information systems to artificial intelligence, to solve problems in the following areas:

- Transportation demand forecasting
- Traffic engineering and controls
- Construction methods and management
- Logistics and freight transportation
- Intermodal urban transportation systems

The education program maintains close links with the Delaware Center for Transportation and the University Transportation Center.

MS Course Requirements

The master's degrees in Civil Engineering and Applied Science in the field of Transportation require four core course and four electives taken from a variety of fields. Electives should be selected based on discussions with your advisor.

Core Courses

- CIEG650 Urban Transportation Systems (3 credits)
- 9 credits from one of the groups listed below (all courses are three credits unless otherwise noted)

Group 1 Transportation Planning:

- CIEG652 Transportation Facilities Design
- CIEG654 Urban Transportation Planning
- ORES601 or 602 Survey of Operations Research
- UAPP601 Measuring and Defining Planning Problems or
- UAPP827 Program and Project Evaluation

Group 2 ITS and Operations:

- CIEG652 Transportation Facilities Planning and Design
- CIEG667 Advanced Traffic Engineering (Workshop)
- CIEG667 Intelligent Transportation Systems
- MATH630 or 631 Probability Theory

Suggested Electives

- BUAD 836 Problem Structuring and Analysis for Decision Making
- ECON801 Microeconomics
- ECON802 Macroeconomics
- GEOG667 Geographic Information Systems
- GEOG671 Advanced Geographic Information Systems
- GEOG677 Spatial Analysis
- MAST663 Decision Tools for Policy Analysis
- MAST672 Applied Policy Analysis
- ORES603 Simulation
- STAT601 Probability Theory for Operations Research and Statistics

- STAT602 Mathematical Statistics
- STAT608 Statistical Research Methods
- STAT609 Regression and Experimental Design
- UAPP601 Measure and Define Planning Problems (1 credit)
- UAPP602 Introduction to Comprehensive Planning (1 credit)
- UAPP603 Introduction to Zoning and Land Use Controls (1 credit)

In addition, other CIEG667 seminar courses are frequently offered covering topics such as Geometric Design and Regional Analysis. Each semester, students are also expected to register for CIEG865 Section 013 Civil Engineering Seminar. Students register for credit one semester and as a "Listener" in the other semesters.

General Requirements

Students must also complete the general degree requirements as detailed in the Civil and Environmental Engineering Graduate Policy and University Catalog. These requirements include credit requirements and, for Ph.D. and thesis option MS students, the conduct of research and completion of dissertation/thesis.

Water Resources Engineering

Water resources engineering focuses on issues related to water quantity and quality. These include factors influencing water availability and supply; hazards associated with water, e.g., droughts and flooding; water movement in watersheds and implications for nutrient and contaminant transport; and the role of water in sustaining healthy ecosystems. Research at the University of Delaware ranges from the pore scale to the watershed scale, as we ask questions like "how do viruses attach to soil particles?" and "how do nutrients applied by farmers move through the watershed?" Because water pollution is often the primary driving force for the engineered control of water resources, graduate students typically take courses and conduct research within groups that also include environmental engineering students. Graduate course work and research in the water resources engineering program is focused on the following areas:

- Hydrology
- Watershed Hydrochemistry
- Water Quality Modeling
- Groundwater Hydrology
- Contaminant Movement in Soil and Groundwater

The water resources engineering program is designed not only for those with undergraduate degrees in Civil, Environmental, and other engineering disciplines, but also related non-engineering fields such as Geology, Geography and Environmental and Soil Sciences.

MS Requirements

The Master's degree in Civil Engineering or Applied Science in the field of Water Resources Engineering requires four core courses and four electives taken from a variety of fields for the thesis option. Students electing to receive the non-thesis degree must take a total of 30-credits of course work, which typically translates to six electives beyond the four core courses. Electives should be selected based on discussions with your advisor.

Core Courses

- BREG622 Watershed Modeling
- CIEG630 Water Quality Modeling
- CIEG698 Groundwater Flow and Contaminant Transport
- MATH/STAT (An approved 600-level course in Mathematics or Statistics)

Suggested Electives

- BREG621 Nonpoint Source Pollution
- CIEG632 Chemical Aspects of Environmental Engineering
- CIEG634 Contaminant Transport and Separation in Environmental Systems
- CIEG667 Industrial Ecology: The Science of Environmental Sustainability
- CIEG668 Principles of Water Quality Criteria
- CIEG678 Transport and Mixing Processes
- CIEG679 Sediment Transport Mechanics
- CIEG833 Fate of Organic Pollutants in the Environment
- FREC682 Spatial Analysis of Natural Resources
- GEOG657 Climate Dynamics
- PLSC603 Soil Physics
- UAPP611 Regional Watershed Management
- UAPP615 Urban, Regional & Environmental Planning
- UAPP628 Issues in Land Use & Environmental Planning

In addition, classes from other departments can be selected in consultation with your advisor. These include graduate-level courses offered by Bioresources Engineering, Mathematics, Mechanical Engineering, Marine Studies, Geography, Urban Affairs and Public Policy, or Plant and Soil Sciences. Each semester students are also expected to register for CIEG865 Civil Engineering Seminar. Students register for credit one semester and for "Listener" status in the other semesters.

General Requirements

Students must also complete the general degree requirements as detailed in the Civil and Environmental Engineering Graduate Policy and University Catalog. These requirements include credit requirements and, for Ph.D. and thesis option MS students, the conduct of research and completion of dissertation/thesis.