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Requirements for the Ph.D. degree in Environmental Engineering

The Ph.D. degree requires completion of 72 hours of graduate credit, a minimum of which must be 30 hours of didactic graduate coursework with a minimum of 24 course credit hours to be completed at Vanderbilt (6 hours in environmental engineering graduate level courses). The remaining credit hours can be fulfilled with courses or research hours. In addition, all Ph.D. students must pass the Environmental Engineering Graduate Program preliminary exam, must complete the university-required qualifying exam, and must write and defend a dissertation. The specifics of the requirements for the environmental engineering program are listed below.

1. **Courses.** As part of the required 30 hours of didactic graduate coursework, students must demonstrate competency in four areas – (i) *quantitative mechanisms and theory*; (ii) *experimental methods;* (iii) *data analysis techniques;* and (iv) *computation, simulation, and applied mathematics* – by taking at least one course in each of the four areas selected from the following approved list.

   Quantitative mechanisms and theory: ENVE 5605 Environmental Thermodynamics, Kinetics and Mass Transfer; ENVE 5625 Environmental Separations Processes; ENVE 5705. Physical Hydrology; CHBE 5200. Phase Equilibria and Stage-based Separations; CHBE 5300. Fluid Mechanics and Heat Transfer; CHBE 6200. Transport Phenomena; CHBE 6220. Surfaces and Adsorption; EES 5550. Transport Processes in Earth and Environmental Systems; EES 5650. Physics of the Climate System.

   Experimental methods: ENVE 5620 Environmental Characterization and Analysis; CHEM 5040. Nanoparticles; EES 5250. Earth Materials; EES 5600. Geochemistry; EES 7300. Isotopes and the Environment; MSE 6343. Intro. To Electron Microscopy; PHYS 8159. Experimental Nanoscale Fabrications and Characterization.

   Data analysis techniques: CE 6300. Probabilistic Methods in Engineering Design; CE 6310. Uncertainty Quantification;

   Computation, simulation, and applied mathematics. CE 6210. Finite Element Analysis; CE 6212. Adv. Computational Mechanics; CE 6313. Multiscale Modeling; CHBE 6100. Applied Mathematics in Chemical Eng; CHEM 5410. Molecular Modeling Techniques; EES 5760. Agent- and Individual-Based Computational Modeling; ME 5263. Computational Fluid Dynamics & Multiphys. Modeling.

2. **Preliminary examination**. The preliminary examination is to be completed at the end of the spring semester of the first year[1]. Success will require preparation throughout the

[1] The preliminary exam is offered only once per year, following final exams in the spring semester. The topics for the required review/proposal are announced only once per year, around November 1. Because there will be only one student per topic, a lottery will be established to decide on the order in which students choose available topics. Students beginning off cycle (i.e., not starting in fall semester of the first year) will wait and go on to the "normal" cycle in the following fall semester.

year. During the fall semester, entering graduate students are required to take a 1-hour, zero credit seminar to orient them to how critical review of a topic is conducted and how research proposals are prepared. By November 1, students will select a topic (one student per topic) from a list provided by the ENVE Oversight and Management Policy Committee. The students will be required to write a paper that critically reviews the literature on the selected topic, identifies research gaps, and proposes research to fill a gap. The paper will be submitted to the DGS by the end of the spring semester classes. On an assigned day after the end of the final exams, each student will do a 15-minute presentation of her or his research proposal followed by a 10-minute question period by the Environmental Engineering Graduate Faculty. The faculty will vote on whether the student has demonstrated adequate preparation to proceed to the PhD. qualifying exam. Students with an "unsatisfactory" rating may submit a written request to retake the examination before the start of the fall semester. The student may then retake the either the written exam or the oral exam or both before the start of the fall semester if the request is approved by the Oversight and Management Policy Committee and the DGS. Two preliminary examinations receiving an "unsatisfactory" rating would result in failure.

3. **Qualifying examination**. The Ph.D. qualifying examination must be scheduled and completed by the end of the third year (6 semesters) of graduate training, at the latest. Successful qualification represents the final checkpoint for admission into candidacy for a Ph.D. degree. The purpose of the qualifying examination is to test the student's familiarity with published research related to their dissertation project, and to determine whether the student possesses and can communicate the appropriate analytical abilities needed to complete the dissertation. The qualifying exam is administered by the student's dissertation committee, which is appointed upon formal recommendation to the Graduate School by the DGS. The dissertation committee is comprised of at least five members, four of which must be Vanderbilt faculty members. The committee must include at least two tenured faculty members from the graduate faculty of the Department (one of whom may be the advisor), and one tenured member of the Vanderbilt faculty from outside the Department. An appropriate person from outside Vanderbilt must be approved by the Graduate School upon request by the DGS in order to be appointed to the dissertation committee. The dissertation committee serves as a working team to help the student in a number of ways including offering suggestions about the research design and providing continual encouragement to be innovative. Therefore, it is important that the dissertation committee be carefully selected, with consideration of the scientific training, intellectual interests, and research activities of each committee member. The qualifying exam consists of presentation of a

written proposal and an oral defense of such proposal. The written proposal should demonstrate the ability to propose a novel project that is worthy of a PhD. The student should demonstrate command of the topic to be studied including related published research and of the methods to tackle the problem, as well as present an adequate appraisal of possible results and implications. The proposal also should include a detailed plan towards completing of the dissertation, including planned journal publications and a realistic schedule for completion. The proposal should be no longer than 15 pages (no less than single-spaced, margins no smaller than 1 inch in every direction, font no smaller than 12-point Times New Roman), including figures and tables; references may appear in additional pages. The exam consists of a public presentation of the key aspects of the research proposal, followed by a closed-door meeting with the advising committee. In the oral presentation, the student should clearly and briefly present the project, as well as answer questions from the faculty members participating in the exam. The exam needs to be officially scheduled with the Graduate School at least two weeks in advance. The dissertation committee should receive the proposal no later than a week before the exam. Students approved in the qualifying exam are recommended for promotion to candidacy, at which time they officially become PhD candidates.

4. **The dissertation**. A written dissertation is required to obtain the PhD degree. In general, a student is expected to complete the dissertation within 4 or 5 years of initiating graduate study at Vanderbilt." The dissertation has to follow the guidelines provided by the Graduate School (http://gradschool.vanderbilt.edu/academics/theses/). For Environmental Engineering the dissertation is to be prepared with a minimum of three substantive chapters, in addition to the introduction and conclusion chapters, each in the form of a paper for a peer-reviewed archival journal.

5. **The final examination (the dissertation defense)**. The candidate should send a complete draft of the dissertation to the committee no later than 2 weeks before the defense. The Committee Chair (student's advisor) should have reviewed and discussed the complete draft dissertation with the candidate, and allowing the candidate time for revisions, prior to submission to the Committee. The candidate should plan accordingly and provide her or his advisor(s) with sufficient time for an in-depth review and discussion of the complete draft dissertation. Committee members will read the document in detail prior to the defense. At the time of the defense there are minimum requirements related to publication in peer-reviewed journals: at least one paper (chapter) has to be in press or in print and at least one other paper (chapter) must have been submitted to a peer-reviewed journal. Note that these are minimum

requirements; in general Ph.D. students are expected to have multiple manuscripts in-review or in-press in high quality peer-reviewed journals by the time of the dissertation defense. The dissertation defense has to be officially scheduled with the Graduate School at least 2 weeks in advance, and the advising committee has to be appointed upon the request and recommendation of the DGS or chair. The defense consists of a public presentation of the key aspects of the research conducted and presented in the dissertation, followed by a closed-door meeting with the advising committee. In the oral presentation, the candidate should be able to explain to a broad audience the main findings as well as important implications and significance of the work. The oral presentation is immediately followed by questions from the audience (other than members of the advising committee). The committee then meets with the student and asks questions related to the dissertation; the student should be able to answer the questions posed by the committee members satisfactorily. At the end of the meeting, the committee makes a determination of whether the student has passed the examination. When students pass the oral defense, most typically, the committee will request that the student make changes to the written dissertation to reflect suggestions made during the examination; in general, it is the responsibility of the advisor to ascertain that such changes have been satisfactorily made prior to submission of the dissertation, but committee members can request to review the final draft. The dissertation must be submitted to and approved by the Graduate School following acceptance by the dissertation committee. Students should be aware that deadlines for submission of the dissertation to the Graduate School occur relatively early in each term (mid-March for spring graduation; mid-July for summer graduation)