

Environmental Engineering Preliminary Exam Procedures (Revised 11/28/23)

Overview. The preliminary exam is a two-part examination to test a student's potential to be successful as a Ph.D. student. The preliminary exam has the following objectives:

1. Assess the ability of the student to propose an interesting problem relevant to environmental engineering for Ph.D. research;
2. Assess the student's understanding the breadth of knowledge in the proposed area of research, and the ability to identify knowledge gaps;
3. Test the student's grasp of appropriate methods to assess the research question(s) or hypothesis(es) that they pose for the research problem being evaluated; and
4. Evaluate written and oral communication skills, quality of presentation, and the ability to respond to questions.

Exams are held biannually, typically in the first week of January and the second and third weeks of May. The preliminary exam is an oral exam lasting for 90 minutes that includes a 20-minute slide presentation of a short research proposal, submitted two weeks prior to the exam. The presentation is followed by a question-and-answer session with four faculty members, one of whom is the student's dissertation advisor. At the conclusion of the question-and-answer session, the student will be excused, and the faculty committee members will deliberate and vote on the outcome of the exam.

Eligibility. There is no time requirement for taking the preliminary exam. Students should register for the exam when they judge themselves to be ready to take the exam and after consultation with their dissertation advisors. Students should understand there is an assumption that they will be familiar with the content of the core graduate courses CEE 581, CEE 582, and CEE 591, whether these courses were taken by the student at the University of Michigan or as equivalent courses elsewhere. Students should also expect a free-ranging discussion to ensue during the question-and-answer period with the exam committee, with follow-up questions that may be posed to evaluate the student's understanding of environmental engineering knowledge in program subjects related to the student's research proposal. A list of the seven program subjects, and the core knowledge associated with each, is appended to this document. Lastly, students should be aware that the faculty members for their committee will be drawn from the entire EWRE group, and not just from the faculty most closely aligned to their proposed research areas. Students should therefore prepare their proposals and their exam presentations for an audience of environmental engineering faculty who are not specialists in their intended dissertation research area.

Registration and Preparation. Eligible students must register their intent to take the preliminary exam to the CEE department's Student Services Office. The online registration form is announced to students via email in the first two weeks of each Fall

and Winter term. The deadline to register is the last day of September for the January prelim exam, and the last day of January for the May prelim exam. Student attendance at a prelim exam information session hosted by the EWRE Program Director in October (for January prelims) or February (for May prelims) is also mandatory.

At least two weeks prior to the scheduled exam date, students are responsible for submitting an electronic document to the Student Services Office with the following:

1. A two-page biosketch using an amended version of the standard NSF format. A template for the biosketch is appended to this document.
2. A research proposal that includes the following elements:
 - a. the purpose and significance of the research;
 - b. key-related research, summarized from a review of relevant literature, with identified knowledge gaps;
 - c. a research question or hypothesis to be investigated;
 - d. a general research methodology; and
 - e. an explanation of how the proposed research is relevant to environmental engineering.

The research proposal should be formatted in 11-point Arial or Times Roman font, with single spacing, one-inch margins on all sides, and a maximum length of five pages, including citations or bibliography. Figures may be included.

The research proposal should be original work prepared by the student following their arrival at UM. The student may develop the topic of the proposal in consultation with their advisor but the work should be substantially their own. At the information session, the student should state what their intended proposal topic will be (i.e., a working title for their proposal), and certify that their topic is original and has not been appropriated from a prior proposal submission of their own, or of another member of their advisor's research group. Students should consult the EWRE Program Director with any questions regarding the suitability of their research proposal topic.

Schedule. The schedule for students to complete the requirements for preliminary exams to be taken in January and May, and for faculty to administer the exams during those same periods, is shown in the table below.

Student action (deadline)	January prelim exam	May prelim exam
Student registers for exam	September 30	January 31
Student attends prelim exam information session and submits working title for preliminary proposal	October 16-31 (TBD)	February 15-28 (TBD)
Student submits research proposal and biosketch	December 15	April 15
Student presentation and Q&A with exam committee	January 3-7 (TBD) ** subject to Rackham candidacy deadline **	May 8-21 (TBD)
Student notified of exam outcome	Within three days after exam was taken	Within three days after exam was taken

Faculty action (deadline)	January prelim exam	May prelim exam
EWRE Program Director hosts information session and confirms suitability of students' proposal topics	October 16-31 (TBD)	February 15-28 (TBD)
EWRE Program Director presents draft committee assignments to faculty at EWRE group meeting	November 1-15	March 1-15
Faculty confirm participation as prelim examiners	November 30	March 31
Faculty examiners review submitted research proposals	December 16 – January 2	April 16 - May 7
Faculty examiners attend prelim exams and evaluate students	January 3-7 (TBD) ** subject to Rackham candidacy deadline **	May 8-21 (TBD)
Faculty examiners report outcomes to Graduate Chair and Student Services Office	Within three days after exam was taken	Within three days after exam was taken

Examiners. Three Environmental and Water Resources Engineering (EWRE) faculty members are selected by the EWRE Program Director, in consultation with the EWRE faculty, to act as examiners for each student. These three faculty members, along with the student's dissertation advisor, will serve as the student's prelim exam committee. For students who are co-advised by two faculty members, one co-advisor may serve interactively on the committee. The other co-advisor may attend as an observer.

Eligible examiners for the environmental engineering prelim are faculty holding at least a 50% CEE appointment and primary affiliation in the EWRE group. This includes tenure-system faculty (i.e., tenured and tenure-track), professors of practice, and research professors and lecturers of any rank. EWRE faculty are expected to equally serve on committees regardless of appointment fraction, except when on sabbatical.

The Student Services Office will notify students whom their faculty examiners will be in the month prior to the scheduled exam. *There is an expectation that any EWRE faculty member can serve as an examiner on the committee of any environmental engineering Ph.D. student. Students should prepare their research proposals and their slide deck presentations with this expectation in mind. Students should be prepared to explain their research proposal at a level that any EWRE faculty member can follow, including faculty who are outside of the student's anticipated area of research specialization.*

It is expected, and strongly encouraged, that most preliminary examinations will be attended by all participants in-person, with the student and the faculty examiners meeting in a GGB or EWRE conference room for the student's presentation and oral examination. However, accommodation will be made for remote participation if any of the faculty examiners, or the student, is unable to attend the exam in-person, due to scheduling constraints or other unavoidable circumstances.

Grading. Students are evaluated on a four-point scale ranging from strongly agree (4) to strongly disagree (0) in each of the following areas:

1. Student is well versed in the proposed area of study and its knowledge gaps.
2. Student has made a convincing argument for the importance of the research.
3. Student has proposed a sound methodology for conduct of the research.
4. Student has prepared a high-quality proposal and presentation to committee.
5. Student has good communication skills and effectively answers questions.

A grading rubric for faculty examiners is appended to this document. The scores of the three faculty examiners (excluding the student's advisor) are summed and averaged to yield a score ranging from 0 to 20. A score of 15 or higher is generally considered a passing grade for the student to immediately advance to Ph.D. candidacy. After discussion of the student's exam performance among the prelim committee members, the three non-advisor faculty examiners will vote on whether the

outcome is pass or fail, with the majority vote prevailing. These three examiners will produce a written report to the CEE Graduate Chair (with copy to the CEE Student Services Office), indicating if the student has passed or failed the preliminary exam, with specific reasons for the decision and feedback to be shared with the examinee.

Communication of Results. The student's dissertation advisor will inform the student of the prelim outcome immediately following the exam. The Student Services Office will subsequently email the exam result, with the committee's feedback, to the student, copying the student's advisor, the EWRE Program Director, and the CEE Graduate Chair.

Retaking the Prelim. If the student fails the exam, one retake is permitted. Students must re-register within the aforementioned deadlines for a future available exam date with a different group of faculty examiners; i.e., there is no requirement that the same group of examiners be seated for the exam retake. The student may prepare and present a research proposal that is substantively similar to the previous submission. However, it is strongly recommended that the student carefully consider the feedback provided from the faculty committee that was seated for the student's prior exam, and address all concerns that were identified that prevented the student from advancing to candidacy on the first attempt.

Environmental Engineering Program Subjects

A recommended list of topics is presented below for examinees to review, in preparation for a preliminary examination on a research proposal presented by the student that is thematically aligned with one or more the following program subjects.

Environmental Chemistry

(expectation for typical courses taken: CEE 581 and CEE 580 or CEE 597)

- understanding of reaction kinetics
- ability to apply organic chemical partitioning principles between phases (air, water, organic solvents, natural organic matter, mineral surfaces), including an understanding of the molecular interactions that govern partitioning, to determine chemical fate
- understanding of linear free energy relationships (single parameter and multi-parameter)
- awareness of direct and indirect photolysis reactions
- familiarity with acid/base chemistry
- ability to apply complexation and speciation principles to determine the distribution of a chemical species
- awareness of mineral precipitation and dissolution strategies for the control of metals in the environment
- understanding of redox chemistry
- ability to carry out gas-water equilibrium calculations for open systems

Environmental Biotechnology and Microbiology

(expectation: CEE 582 and 592)

- knowledge of microbial diversity, physiology and phylogeny
- understanding of basic biochemistry and cell composition
- understanding of microbial bioenergetics
- ability to model microbial processes, including enzyme kinetics, growth kinetics, and microbial interactions
- ability to characterize microbial communities
- understanding of molecular biology and microbial genetics
- understanding of how to interrogate/manipulate the genomes of unusual prokaryotes
- ability to use molecular biological techniques for the enumeration and characterization of natural microbial communities
- knowledge of microbial metabolisms

Air Quality

(expectation: CEE 563 and CEE 564)

- knowledge of the principal sources responsible for outdoor air pollutants and their precursor species
- understanding of pollutant formation mechanisms and how they are used to reduce emissions
- ability to design processes using catalysis, two-fluid contactors, adsorption, absorption, or membranes for gas separations and air pollution control
- awareness of the physical principles governing aerosol dynamics
- ability to design particle filtration processes using filtering media, cyclonic separation, or electrostatic precipitation
- knowledge of the principal sources of indoor air pollutants and their control strategies
- knowledge of the principal sources of greenhouse gas emissions
- ability to quantify greenhouse gas radiative forcing effects on global climate
- ability to use physical property data and thermodynamic principles to calculate the energy requirements for the separation of carbon dioxide from gas mixtures

Sustainable Energy Systems

(expectation: CEE 567 and CEE 564)

- general understanding of the energy source, hardware components, efficiency / capacity limits, and emissions associated with the following generation technologies: coal-steam turbines; gas combustion turbines; natural gas combined cycle power plants; co-generation for combined heat and power; nuclear fission reactors; wind turbines; concentrating solar thermal plants; photovoltaic modules; hydroelectric / pumped hydro stations; geothermal plants; tidal power; wave energy; and ocean thermal energy conversion
- ability to apply First and Second Law principles from thermodynamics to analysis of heat engine cycles (Carnot, Rankine, Brayton) for electric power generation
- strategies for improving the thermal efficiency of coal- and gas-fired power plants (reheat, regeneration) and for reducing combustion emissions from these plants
- ability to calculate electricity generation from wind resources, taking into account rotor size, tower height, generator capacity, and site wind speed distribution
- ability to determine the amount of insolation available for solar energy utilization, based on location and orientation of a collector array and calendar date and time
- awareness of strategies to minimize losses in power transmission and distribution using power factor correction
- ability to do integrated resource planning analysis of fixed and variable costs to identify amount and type of generation capacity needed to meet consumer demand
- ability to conduct net present value economic analysis, considering discounting and fuel escalation, to evaluate energy efficiency or distributed generation projects

Ecohydrology and Environmental Fluid Mechanics

(expectation: CEE 591 and CEE 521 or CEE 428)

- understanding of hydrologic fluxes and mass budgets for surface and subsurface media and interfaces
- understanding of energy fluxes and budgets for surface and below-ground media and interfaces
- comprehension of steady vs. unsteady phenomena in surface and subsurface media: flows and transport; mass and momentum
- comprehension of energy and phase change phenomena
- understanding of the role of biological elements in physical dynamics and their interactions
- use of dimensional analysis to describe fundamental physical processes

Water Quality Process Engineering

(expectation: CEE 480 and CEE 580 or CEE 592)

- ability to apply concepts of aquatic chemistry and fluid mechanics
- basic understanding of organic chemistry, microbiology, and biochemistry
- awareness of constituents of concern in water streams, and appropriate levels to protect public health and the environment
- awareness of water system management (centralized and decentralized) approaches to protect public health and the environment
- ability to evaluate, and use when appropriate, physical, chemical and biochemical unit processes
- ability to model energy and mass flows across process engineering systems
- ability to model water quality process dynamic drivers (chemical reactivity, biological metabolism, and mass transfer)
- ability to combine physical, chemical, and biochemical unit processes into treatment systems to process water of various qualities and produce product water of various qualities
- understanding of approaches used to manage treatment residuals
- familiarity with tools used to support decision-making around water quality process engineered systems

Environmental Finance

(expectation: CEE 504 and CEE 588)

- ability to differentiate risk and return assumptions between different asset classes
- understanding of processes, investment mandates and financial basics of traditional (stocks and bonds) and alternative asset classes (real assets, private equity, hedge funds, and structured products).
- knowledge of how structures and financial return characteristics inform capital allocations to environmental and sustainability objectives.
- ability to assess how digital investment strategies are starting to disrupt environmental finance.
- knowledge of the value of data streams in environmental investments
- ability to dissect project finance structures and place the different components in their context
- ability to quantify the effect of data uncertainty on risk and return expectations of an investment

Evaluation Category	Score	Comments
<p>Research Context: Student understands the state of the art – what is known and not known – and has identified a need for original knowledge to be developed.</p>	<ul style="list-style-type: none"> ○ 4 – strongly agree ○ 3 – somewhat agree ○ 2 – neither agree nor disagree ○ 1 – somewhat disagree ○ 0 - strongly disagree 	
<p>Research Significance: Student has convincingly explained why the research is important, and how it is related to the environmental engineering discipline.</p>	<ul style="list-style-type: none"> ○ 4 – strongly agree ○ 3 – somewhat agree ○ 2 – neither agree nor disagree ○ 1 – somewhat disagree ○ 0 - strongly disagree 	
<p>Research Methodology: Student has stated a hypothesis, outlined a research approach, and indicated how the environmental engineering body of knowledge applies to the research problem.</p>	<ul style="list-style-type: none"> ○ 4 – strongly agree ○ 3 – somewhat agree ○ 2 – neither agree nor disagree ○ 1 – somewhat disagree ○ 0 - strongly disagree 	
<p>Presentation: Student has crafted a well-organized proposal and slide deck, with polished content and thoughtfully chosen visuals to aid in following the presentation.</p>	<ul style="list-style-type: none"> ○ 4 – strongly agree ○ 3 – somewhat agree ○ 2 – neither agree nor disagree ○ 1 – somewhat disagree ○ 0 - strongly disagree 	
<p>Communication: Student demonstrates effective written and oral communication skills, and is able to acknowledge and answer questions insightfully.</p>	<ul style="list-style-type: none"> ○ 4 – strongly agree ○ 3 – somewhat agree ○ 2 – neither agree nor disagree ○ 1 – somewhat disagree ○ 0 - strongly disagree 	

Biosketch Template: Insert Name Here

Maximum of two pages. Use size 11 or 12 font throughout using one of the following typefaces: Arial, Courier New, Palatino Linotype, Times New Roman, or Computer Modern. Margins on all sides must be at least one inch. Remove all instructions in blue text prior to submission.

a. Professional Preparation. (listed in chronological order)

Institution	Major	Degree	Year
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b. Professional and Research Positions. (listed in reverse chronological order)

c. Publications.

PUBLICATIONS AUTHORED / CO-AUTHORED BY EXAMINEE (if applicable)

List up to 5 publications most closely related to the proposed project. Each publication identified must include the names of all authors, in the same sequence that they appear in the publication; the article title; journal name or book title; volume number; page range; and year of publication. If the document is available electronically, the website address also should be identified.

PUBLICATIONS RELATED TO PRELIMINARY EXAM NOT AUTHORED BY EXAMINEE

Use the same formatting guidelines as above. List up to 5 publications related to the research proposal to be presented by the student.

d. Synergistic activities.

Enter up to five activities that relate to furthering your skills as a graduate researcher and scholar. One of the activities can be a list of courses taken at the current and/or prior institutions that are relevant to the knowledge base and methodologies for the proposed research.

e. Collaborators and other affiliations.

1. **Collaborators.** List all persons in alphabetical order, including their current organizational affiliations, who are currently, or who have been collaborators or co-authors with the student, on a project, book, article, report, abstract, or paper during the 48 months preceding the submission of the proposal. Also include those individuals who are currently or have been co-editors of a journal, compendium, or conference proceedings during the 24 months preceding the submission of the proposal. If there are no collaborators or co-editors to report, this should be so indicated.

2. **Graduate advisor.** Name(s) of student's graduate advisor(s) and departmental affiliation(s).