EME QUALIFYING EXAMINATION PROCEDURE

OVERVIEW

Policy GCAC-604, adopted by the Graduate Council, requires the successful completion of the qualifying exam as part of Doctoral degree at Penn State. The full policy can be viewed here. Accordingly, acceptance into the Ph.D. degree program in Energy and Mineral Engineering (EME) will be based on the student's performance in the Ph.D. Qualifying Examination. This examination is offered twice a year at the beginning of the Fall and Spring semesters (August/September and January/February). It consists of Knowledge- and Research-based components, administered by an examination committee consisting of at least three Graduate Faculty in the EME Department. The EME Graduate Office supervises the exam application with the support of members of the Qualifying Examination committee.

OBJECTIVE

As described in GCAC-604, the primary purpose of the Qualifying Examination is to provide an early assessment of whether the student has the potential to develop the knowledge, skills, and attributes the program has defined in its formal Learning Objectives, including evidence of critical thinking skills, necessary for a successful researcher in the disciplinary field.

a) The qualifying examination is conducted early in a student's program to ensure that the considerable investment of time, resources, and effort required by the student has a high likelihood of leading to completion of the Ph.D.

b) Additionally, the qualifying examination may assess if the student is well-grounded in the fundamental knowledge of the discipline.

ACADEMIC INTEGRITY

All Penn State Academic Integrity policies (see Senate Policies 49-20 and G-9) apply to the Qualifying Examination in general and the research proposal in particular. Academic Integrity violations will result in the maximum penalty of failure in the Qualifying Examination.

CONFLICTS OF INTEREST

As described in GCAC-604, conflict of interest in administering the Qualifying Examination must be avoided or effectively managed. The research advisers of students participating in the exam during that semester may serve on that semester's exam committee as a member or chair however, research advisers may not evaluate the research component (written or oral) of the student(s) they advise, and they may only write and/or evaluate half of the questions for any topic area selected by their students for the knowledge-based component.

SCHEDULING

All students must take the Qualifying Examination within *three semesters* (not counting the summer semester) of entry into the doctoral program.

a) Failure to schedule the exam before the start of the fourth semester of the doctoral program will be treated equivalently to the students having taken the qualifying exam and failed.
b) Students who have been identified as master's-along-the-way upon admission into the graduate program may be allowed an extension such that the three-semester time limit will begin upon completion of the master's degree.
c) Students pursuing dual-title degrees must take the Qualifying Examination within four semesters (not counting the summer semester) of entry into the doctoral program.

To be eligible to take the Qualifying Examination the student must:

a) Have earned at least **18 credits** in courses eligible to be counted toward the graduate degree (these may be graduate credits earned previously at other recognized institutions from which transfer credits would be accepted) or the equivalent as determined and documented by the program. Credits from courses taken during graduate studies, such as M.Sc. degrees, from recognized institutions are counted toward the 18 credits threshold. Research credits such as EME 600 also count towards the 18-credit threshold.
b) Have a grade-point average of 3.00 or greater for work done at Penn State University while a graduate student. Accordingly, have completed *at least one semester* at Penn State to establish a Penn State GPA.
c) Have no incomplete or deferred grades.
d) Be in good academic standing and must be registered as a full-time or part-time graduate degree student for the semester (excluding the summer session) in which the qualifying examination is taken.

EME students are allowed a *maximum of two attempts* to pass the qualifying exam. Students are permitted to retake the qualifying exam within the following *two semesters* of a failure verdict.

CONTENT

Knowledge-based Component

Objective: Demonstrate fundamental knowledge and critical thinking in two topic areas related to EME core competencies and courses.

Each student must choose ***two*** of the following topic areas and notify the EME Graduate Program Coordinator at least *two months* in advance:

1) Mathematics,
2) Optimization and Stochastic Simulation,
3) Thermodynamics,
4) Chemistry and Interfacial Phenomena,
5) Transport Phenomena.

Four questions from each of the selected specialty areas will be given to students. In general, questions are at upper-level undergraduate and introductory graduate courses. Students must answer a TOTAL of *five questions* drawn from the *two selected specialty areas* in *four hours*. The first five questions will be graded if more than five questions are answered.

The written examination (knowledge-based component) is closed books and notes, though the exam committee may permit students to bring a 1-page (front and back) reference sheet to the exam. The only calculator models acceptable during the knowledge-based exam are the NCEES approved ones:

- **Casio:** All fx-115 and fx-991 models (Any Casio calculator must have "fx-115" or "fx-991" in its model name).
- **Hewlett Packard:** The HP 33s and HP 35s models, but no others
- **Texas Instruments:** All TI-30X and TI-36X models (Any Texas Instruments calculator must have "TI-30X" or "TI-36X" in its model name).

Research-based Component

Objective: Demonstrate the student's ability to think critically, plan a research project, and write, discuss, and defend a research proposal.

i) Research Proposal: The proposal should be single-spaced, font size 12, 1" margins, and five pages in length (letter size), including graphics and tables, but excluding bibliography. The proposal comprises a title, student name, and the following sections:

- *Introduction and Problem Statement*: Start with defining the research topic understandable to a non-expert, public audience. Describe the research problem, research question/objective, and the research importance.
- *Literature Review*: Write a critical assessment of the topic by (a) describing the current knowledge, the applicable fundamental laws, and operative assumptions; (b) discussing the related analysis methods, models, and experimental techniques, (c) identifying the gaps in knowledge, and (d) citing relevant references.
- *Research Plan*: Describe the broad design of activities to be undertaken and provide a clear description of experimental/theoretical methods and procedures. Describe how the results/outcomes answer the question or test the hypothesis.
- *Intellectual Merit and Impact*: Describe the potential to advance knowledge. Describe the benefits accrued if the proposed research is successful.
- *Bibliography*: List the references that are cited in the proposal in a standard format.

ii) Proposal Discussion: The discussion takes place within a week after submission of the proposal. Students must defend their proposals by answering questions from the committee members during a formally scheduled oral discussion meeting. The oral discussion may not exceed one hour, and it comprises a maximum of 10 minutes presentation of the proposal by each student, followed by a Q&A period. Students may use audio-visual aids during their presentations.

GRADING

Knowledge-based Component: Maximum 50 points

- Each student must answer five questions in four hours. Each question will be scored 0-10 (10 is best).
- The written examination will be graded anonymously (each student is assigned a confidential letter code).

Research-based Component: Maximum 50 points

i) Research Proposal: Maximum 25 points – Written proposal completed in advance and submitted to the EME Graduate Program Coordinator before its deadline

- Each proposal will be graded anonymously and scored independently by at least three faculty using the enclosed rubric. Faculty scores will be averaged.

ii) Proposal Discussion: Maximum 25 points – Q&A oral discussion

- The discussion part will be scored independently by at least three faculty using the enclosed rubric. Faculty scores will be averaged.

Total Score: Maximum 100 points

- The sum of scores on written exam questions (Knowledge-based component) and the score on the research proposal and related discussion (Research-based component).

PASS: Requires a total score of 70 or higher

- If based on the total score, the outcome is FAIL on the first attempt, the student must retake ALL parts of the exam on the second attempt.
- If based on the total score, the outcome is FAIL on the second attempt, the student may not continue in the EME Ph.D. program.

ENGLISH COMPETENCY

Policy GCAC-605, adopted by the Graduate Council, requires every graduate program shall have a formal mechanism for assessing and improving the English language competence of both domestic and international students. Programs must document the outcome of the assessment of English competence, including any areas requiring improvement and remedial steps, at the time of reporting the outcome of the Qualifying Examination. The evaluation includes the student's ability to read and comprehend technical literature, write well, and participate in scientific and technical discussions.

Accordingly, the English competency assessment will be based on the student's performance on the Knowledge- and Research-based components. The research proposal will be used to assess the student's *written English competency*. The student's *oral English competency* will be evaluated during the oral discussion meeting. Unless the committee identifies areas requiring improvement, the Qualifying Examination (PASS/FAIL) outcome will be reported for English competency.

TOPIC AREA 1: Mathematics

Relevant Courses:

- EME 521: Mathematical Modeling of EME Systems
- EMCH 524: Mathematical Methods in Engineering

Potential Problem Types:

- Solving ODEs
- Solving PDEs
- Vector calculus
- Transforms
- Linear algebra

Suggested Text(s):

Advanced Engineering Mathematics, Erwin Kreyszig, 9th Edition

- Chapter 1: First-Order ODEs
- Chapter 2: Second-Order ODEs
- Chapter 3: Higher Order ODEs
- Chapter 5: Series Solutions of ODEs
- Chapter 6: Laplace Transforms
- Chapter 9: Gradient, Divergence, Curl
- Chapter 10: Integral Theorems
- Chapter 11: Fourier Analysis
- Chapter 12: Partial Differential Equations

Introduction to Linear Algebra, Gilbert Strang, 4th Edition

- Chapter 2: Solving Linear Equations
- Chapter 3: Vector Spaces and Subspaces
- Chapter 6: Eigenvalues and Eigenvectors

TOPIC AREA 2: Optimization and Stochastic Simulation

Relevant Courses:

- EME 501: Design Under Uncertainty in EME Systems
- IE 505: Linear Programming
- STAT 500: Applied Statistics
- STAT 501: Regression Methods

Potential Problem Types:

- Linear programming
- Dynamic programming
- Applied probability
- Descriptive statistics
- Linear regression

Suggested Text(s):

Mathematical Statistics and Data Analysis, John Rice, 3rd Edition

- Chapter 1: Probability
- Chapter 2: Random Variables
- Chapter 3: Joint Distributions
- Chapter 4: Expected Values
- Chapter 5: Limit Theorems
- Chapter 6: Distributions Derived from the Normal Distribution
- Chapter 8: Estimation of Parameters and Fitting of Probability Distributions
- Chapter 9: Testing Hypotheses and Assessing Goodness of Fit
- Chapter 10: Summarizing Data
- Chapter 11: Comparing Two Samples

Introduction to Operations Research, Frederick Hillier and Gerald Lieberman, 10th Edition

- Chapter 3: Introduction to Linear Programming
- Chapter 4: Solving Linear Programming Problems: The Simplex Method
- Chapter 6: Duality Theory and Sensitivity Analysis
- Chapter 11: Dynamic Programming
- Chapter 12: Integer Programming
- Chapter 13: Nonlinear Programming (includes KKT conditions)

TOPIC AREA 3: Thermodynamics

Relevant Courses:

EME 531: Thermodynamics in EME Systems
PNG 520: Thermodynamics of Hydrocarbon Fluids

Potential Problem Types:

Conservation of mass and energy
Entropy and enthalpy balances for reversible and irreversible processes
Single- and multi-component phase behavior

Suggested Text(s):

Modern Thermodynamics: From Heat Engines to Dissipative Structures, Dilip Kondepudi and Ilya Prigogoine, 2nd Edition

Chapter 1: Basic Concepts and the Laws of Gases
Chapter 2: The First Law of Thermodynamics
Chapter 3: The Second Law of Thermodynamics and the Arrow of Time
Chapter 6: Basic Thermodynamics of Gases, Liquids and Solids
Chapter 7: Thermodynamics of Phase Change

Chemical, Biochemical, and Engineering Thermodynamics, Stanley Sandler, 5th Edition

Chapter 2: Conservation of Mass
Chapter 4: Entropy: An Additional Balance Equation
Chapter 7: Equilibrium and Stability in One-Component Systems
Chapter 8: The Thermodynamics of Multicomponent Mixtures

TOPIC AREA 4: Chemistry and Interfacial Phenomena

Relevant Courses:

EME 511: Interfacial Phenomena in EME Systems
CE 570: Environmental Aquatic Chemistry

Potential Problem Types:

Acids and bases interactions
Complexation
Dissolution and precipitation
Oxidation and reduction
Interface between phases
Catalysis and reactions

Suggested Text(s):

Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters, Werner Stumm and James Morgan, 3rd Edition

Chapter 3: Acid and Bases
Chapter 6: Metal Ions in Aqueous Solution: Aspects of Coordination Chemistry
Chapter 7: Precipitation and Dissolution
Chapter 8: Oxidation and Reduction (Not Microbial Mediation)
Chapter 9: The Solid-Solution Interface
Chapter 11: Kinetics of Redox Processes
Chapter 13: Kinetics at the Solid-Water Interface: Adsorption, Dissolution of Minerals (Not Nucleation, and Crystal Growth)

Interfacial Science: An Introduction, Geoffrey Barnes and Ian Gentle, 2nd Edition

Chapter 2: Capillarity and the Mechanics of Surfaces
Chapter 4: The Gas-Liquid Interface: Adsorption, Films and Foams, Aerosols
Chapter 6: The Liquid-Liquid Interface: Emulsions and Membranes
Chapter 8: The Gas-Solid Interface: Adsorption and Catalysis

TOPIC AREA 5: Transport Phenomena

Relevant Courses:

EME 521: Mathematical Modeling of EME Systems
PNG 501: Flow in Porous Media
CHE 544: General Transport Phenomena

Potential Problem Types:

Momentum, heat, and mass transport
Velocity, temperature, and concentration distribution in solids and laminar flow
Flow in porous media

Suggested Text(s):

Transport Phenomena, Byron Bird, Warren Stewart, and Edwin Lightfoot, 2nd Edition

Chapter 1: Viscosity and the Mechanisms of Momentum Transport
Chapter 2: Shell Momentum Balances and Velocity Distributions in Laminar Flow
Chapter 9: Thermal Conductivity and the Mechanisms of Energy Transport
Chapter 10: Shell Energy Balances & Temperature Distributions in Solids and Laminar Flow
Chapter 17: Mass Transport
Chapter 18: Concentration Distributions in Solids and Laminar Flow

Modeling Phenomena of Flow and Transport in Porous Media, Jacob Bear, 1st Edition

Chapter 1: Porous Media
Chapter 3: Fundamental Balance Equations and Fluxes (Not Finite Volume Method)
Chapter 4: Momentum Balance and Motion Equation

EVALUATORS SHOULD NOT WRITE THEIR NAMES ANYWHERE ON THIS FORM

EME PhD Qualifying Examination: Research Proposal Scoring Rubric

Student Code: _____ Evaluator Code: _____ Date: _____

Category	1	2	3	4	5	Weight	Score
Introduction and Problem Statement	Not clear what the problem is to be solved, no justification for why the proposed research matters.		The main question or topic is somewhat clear; some attempt to provide context.		The proposed research question/objective is clearly stated; appropriate context provided for why this is important	× 1.0	0
Literature Review	References to specific work, focus on individual papers, lacking overall structure, intellectual gap unclear		Ample references to relevant literature, some coherence to the organization		Logical and thoughtful synthesis of relevant literature, clearly identifies the gap	× 1.5	0
Research Plan	Unclear what approach will be used or how the result from the approach would address the question posed		Some description of the proposed approach and methods to be used; description of the result to answer question not fully articulated		Clearly articulates proposed approach; clear description of how the result/outcome would answer the question or test the hypothesis	× 1.0	0
Intellectual Merit and Impact	Lacking description of the contribution or proposes a contribution that is minor or insignificant		Some attempt at describing the advancement in knowledge and contribution		Clearly identifies the potential to advance knowledge and contribution to be made	× 0.5	0
Presentation Style	Poorly written, difficult to read, numerous grammatical errors or typos		Writing is mostly clear, a few typos or clumsy formatting, close to the page limit		Well-written text, no typos, clear formatting, observed page limit	× 1.0	0
						Total Score: (maximum total of 25 points)	0

Comments

Assessment of Written English Competency

Clear Submit

☐ **Competent**

☐ **Requires Improvement** (indicate suggested improvement plan below)

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EME PhD Qualifying Examination: Research Presentation Scoring Rubric

Student Code: _____ Evaluator Code: _____ Date: _____

Category	1	2	3	4	5	Weight	Score
Ability to succinctly and clearly explain the research	Not clear what the problem is to be solved; no justification for why the proposed research matters		The main question or topic is somewhat clear; some attempt to provide context		The proposed research question/objective is clearly stated; communicates the novelty and importance effectively	× 1.0	0
Command of technical aspects of the field	Unable to answer one or more basic technical question correctly; demonstrates poor grasp of key concepts.		Adequate responses to technical questions; demonstrates knowledge of relevant methods		Responses indicate comfort with technical topics; demonstrates superior command of the material	× 1.5	0
Creativity; ability to apply concepts in new ways	Limited to specific research application and specific methods in the candidate's own research		Some demonstrated ability to think beyond the specific proposed research		Demonstrates ability to think beyond the specific proposed research; can apply concepts to new situations	× 1.0	0
Professionalism & English proficiency / fluency	Inappropriate, unprofessional, or too informal and unclear; Incorrect English usage; Difficult to understand at times		Somewhat informal at times; Nearly always fluent or clearly understandable		Clear, well-spoken, articulate, and professional; perfectly fluent, correct English at all times.	× 1.5	0
						Total Score: (maximum total of 25 points)	0

Comments

Assessment of Oral English Competency

Clear Submit

☐ **Competent**

☐ **Requires Improvement (indicate suggested improvement plan below)**

EVALUATORS SHOULD NOT WRITE THEIR NAMES ANYWHERE ON THIS FORM

EME PhD Qualifying Examination: Knowledge-Based Question Scoring Rubric

Student Code: _____ Evaluator Code: _____ Date: _____

Question Number	Question Score										
	0	1	2	3	4	5	6	7	8	9	10

Comments:

	0	1	2	3	4	5	6	7	8	9	10

Comments:

	0	1	2	3	4	5	6	7	8	9	10

Comments:

	0	1	2	3	4	5	6	7	8	9	10

Comments:

0	1	2	3	4	5	6	7	8	9	10
Nothing relevant to the question has been written		Some correct conceptual reasoning, but no part of the question has been correctly approached or solved.		Some correct approaches have been attempted, but no correct answers have been generated; multiple errors.		Some parts have been answered correctly, but multiple minor errors or one major error are present.		Most parts have been answered correctly, but some minor mathematical or conceptual errors are present.		All parts have been answered correctly and completely.

Clear Submit