

## **Comprehensive Exam Guidelines**

### **Department of Chemical and Biomolecular Engineering, Ohio University**

#### **Purpose**

In the Comprehensive Exam, the student prepares an oral and a written research proposal. The Comprehensive Exam tests and develops the Ph.D. student's ability to plan an independent research project. The ability to familiarize oneself with a new area of inquiry, identify a key knowledge gap, formulate a research objective, and plan research to meet the objective is essential to Ph.D.-level work and beyond. An M.S. degree may be earned for successful independent execution of a research project in which the research objective and plan were largely defined by the advisor. The Ph.D. student must go beyond independent execution, to independently define research objectives and strategies.

This document describing the Comprehensive Exam supplements (and does NOT replace) the guidelines in section II.E.7 of the "Requirements and Procedures for Graduate Degrees in Chemical Engineering at Ohio University," revised September 2007.

#### **Procedure**

Early in the quarter in which the exam is required, the student will request a topic for the comprehensive exam from the department graduate chair. The graduate chair will assign a member of the graduate committee to be the "Exam Supervisor." The Exam Supervisor will meet with the student's research advisor to define a topic for the comprehensive exam. The assigned topic should be in an area related to the student's research, but not directly related to the student's dissertation topic. (See below.) When the graduate committee has approved the topic, it will be presented to the student.

The student will have two weeks to become familiar with the topic, identify a specific research objective, and prepare an oral research proposal related to the assigned topic. The graduate chair will schedule the oral presentation, reserving a conference room, a laptop computer and a projector for at least 1 hour on that day. The student and the majority of the graduate committee must be present. The student should check all equipment and be prepared to begin on time. The student should prepare a 20 - 25 minute presentation of the research proposal. (As a rule of thumb, that means 20 - 25 slides.) With questions and discussion, the complete presentation should take 40 - 50 minutes.

The department graduate committee will evaluate the oral research proposal and convey its decision and comments to the student by the end of the next workday. If the oral presentation is satisfactory, a more detailed written research proposal will be due two weeks later. The department graduate committee will evaluate the written research proposal, endeavoring to convey its decision to the student within one week. If both oral and written proposals are satisfactory, the student will have passed. If either the oral or the written proposal is unsatisfactory, the student will have failed. Each student has two chances to pass the exam. The second attempt will consist of a new topic, and will begin with two weeks to prepare an oral proposal.

## **Topic Selection**

The topic selected should be in broadly the same field as the student's research, but not directly related to the dissertation topic or a simple derivation thereof. The student is expected to know and apply terminology and fundamental principles common to the core chemical engineering curriculum, and to stretch beyond his/her dissertation research. The student should not be expected to learn a large amount of specialized terminology or new subject matter specifically for the comprehensive exam. The comprehensive exam should draw from specialized knowledge already familiar to the student.

For example, a student whose dissertation subject is the chemistry of nitrogen oxides on fly ash particles should *not* receive a comprehensive topic such as the chemistry of nitrogen oxides on soot particles, or the chemistry of ozone on fly ash particles, or some similar simple derivative of the dissertation research. A topic in heterogeneous catalysis would be a reasonable choice for this student, because it would take advantage of his/her experience in kinetics and mass transfer at the solid-fluid interface, and use fundamental chemical engineering principles. Topics involving corrosion, batteries, or fuel cells might also involve kinetics and mass transfer at an interface, but these topics require specialized knowledge of electrochemistry that would present a major barrier to this student and would probably be inappropriate. Similarly, living cells taking up and transforming chemicals from their culture medium involves kinetics and mass transfer at an interface, but the student could not write a credible proposal without knowing the vocabulary and fundamentals of cell biology.

Selection of the comprehensive exam topic is a critical task that requires an investment of time and effort from Exam Supervisor and from the student's research advisor. Both individuals should keep in mind the purpose of the comprehensive exam (see above) and the interest of the department in maintaining a high quality graduate program. The department graduate chair will endeavor to rotate the Exam Supervisor task among members of the graduate committee. However, recognizing the potential for conflict with the student's advisor, untenured faculty will not be appointed Exam Supervisor.

## **Preparing the Proposal**

The student should spend a few days reviewing the literature to become familiar with the topic, identify a key question or knowledge gap, and then define a specific research objective and prepare a research proposal. The proposal should describe a research project that could be completed in 1 – 2 years.

A successful comprehensive exam solution has the following characteristics, most of which are common to any successful research proposal.

- It states a specific research objective.
- It explains the significance of the proposed research.
- It references and summarizes only literature directly related to the proposed research and its significance.
- It describes the methods and equipment to be used.
- It shows what variables will be tested, a reasonable range of values to be examined, and justification for the choices. A “test matrix” may or may not be appropriate.
- It includes methods for quantifying uncertainties.
- It explains how the results will be evaluated and how you will determine whether the objective has been met.
- It includes a schedule for completion of the project.
- It includes a rough budget ( $\pm 25\%$ ) for the project.
- The project description is not more than 15 pages long, 12 point font, double-spaced, with numbered pages.

The statement of the research objective is the most critical part of the proposal. In the examples below, the unacceptable objectives are too vague. They do not clearly identify the independent and dependent variables to be investigated. There is no way to tell when the objective has been met and the project is finished.

*Unacceptable:*

The objective of this research is . . .

- To study catalytic converters.
- To study how particle size affects catalytic converters.
- To test metal-supported catalytic converters.
- To model the operation of a catalytic converter.

*Acceptable:*

The objective of this research is . . .

- To determine the relationship, if any, between active particle size and susceptibility of a metal-supported catalytic converter to poisoning by sulfur in the fuel.
- To determine whether the choice of reactive element in the metal support affects the susceptibility of active metal particles in the catalytic converter to sintering.
- To model the changes in gas flow patterns and heat transfer in a commercial metal-supported catalytic converter as the aluminum oxide film grows on the metal surface during operation.

It is often appropriate to state the objective as a hypothesis.

- We hypothesize that the susceptibility of a metal-supported catalytic converter to poisoning by sulfur in the fuel is directly related to the surface area of the active particles, and, therefore, to the square of the average particle diameter.

The proposal must convey the significance of the research. How does this work differ from what has gone before? How will fulfilling the research objective benefit specialists in the field? How will it benefit humankind? What is the next step when this project is finished?

The research strategy, experimental plan, and plan for evaluating results should show a command of the fundamentals of experimental design and statistics. Even when the project focuses on modeling rather than experimentation, uncertainties are important. Consider the third of the acceptable example objectives. It would be important to quantify the sensitivity of the final model to changes in the thermal properties of the metal, the thermal properties of the gas, the flow rate of the gas, and the roughness of oxide the film.

The Ohio University Office of Research and Sponsored Programs (OUORSP) has budget aid examples online. (Students should not contact OUORSP staff directly for assistance in preparing a comprehensive exam solution.) Students should use an example for the National Science Foundation or the National Institutes of Health to prepare the budget. The committee will be satisfied with the right order-of-magnitude in each category (personnel, travel, materials and supplies, equipment, indirect costs, etc.).

The project description portion of the written proposal is not more than 15 pages long, 12 point font, double-spaced, with numbered pages. The 15 page limit does not include the cover page, abstract, budget, or list of references. The 15 page limit DOES include figures, tables, and appendices.

### **Acceptable Resources for Students to Use in Preparing Comprehensive Exam Solutions**

The student may consult the university writing center or the Ohio Program for Intensive English for assistance with language and grammar. No other students, staff, or faculty should review the student's proposal before it is evaluated by the graduate committee. The student is encouraged to consult a style guide or technical writing guide. The student may read proposals written by other students, staff, or faculty. The student may use any literature or other resource in the public domain, including the peer-reviewed (preferred) and popular literature and web-based resources. Citations should contain sufficient information to allow the reader to find the original source material. The student is encouraged to consult the checksheet at the end of this document to review his/her own work prior to submitting it.

The student may draw on many resources, but *must* produce an original research proposal. Plagiarism will not be tolerated. A student with *any* question about whether his/her work might constitute plagiarism should bring the source material and the proposal in progress to the Exam Supervisor for an opinion. International students in particular are cautioned that standards for plagiarism enforced in their home countries may be different from the prevalent standard in engineering and science research in the U.S. The graduate committee may review comprehensive exam solutions for plagiarism at any time. If the graduate committee rules that the solution includes plagiarized material, the student will automatically fail the comprehensive exam, even if a "pass" decision was previously rendered.

### Comprehensive Exam Assessment Guidelines

A successful comprehensive exam solution has the following characteristics, most of which are common to any successful research proposal.

- It states a specific research objective.
  - Objective is specific, not vague.
  - Objective clearly identifies the independent and dependent variables (factors and responses).
  - Objective reflects a higher motivation than simple data collection.
- It explains the significance of the proposed research.
  - It is clear how this work differs from what has gone before.
  - It is clear how meeting the objective will benefit specialists in the field and/or humankind.
- It references and summarizes only literature directly related to the proposed research and its significance.
  - Discussion of prior work is organized to show relationship to the proposed work.
  - Discussion of prior work shows relevant limitations or weaknesses as well as strengths.
- It describes the methods and equipment to be used.
  - Descriptions are understandable to engineers who are not experts in the particular techniques.
  - Descriptions focus on the type, precision, and accuracy of the information obtained.
- It shows what variables will be tested, a reasonable range of values to be examined, and justification for the choices. A “test matrix” may or may not be appropriate.
  - Independent variables (factors) are clearly identified.
  - Dependent variables (responses) are clearly identified.
  - The reasons for investigating each of the factors and responses are clearly described.
    - It is clear why or how each of the factors is expected to influence the responses.
    - It is clear that the factors and responses selected are sufficient to meet the objective.
    - It is clear that the factors and responses selected are reasonable for the resources allocated.
  - The range of values to be tested for each factor is stated.
  - The reason for selecting each range of values is clearly described.
    - Limits dependent on common industrial practice, equipment or instrument limitations, safety considerations, etc. are stated.
    - It is clear that the range investigated is sufficient to meet the objective.
    - It is clear that the range investigated is reasonable given the time and resources allocated.
- It includes methods for quantifying uncertainties.
  - Measurements or assumptions likely to make the largest contribution to the uncertainty are identified.
  - Specific methods or techniques for quantifying uncertainties are identified. A broad statement such as “replicate measurements will be made to check accuracy” is not sufficient.
  - It is clear that the data to be collected or the tests to be run or the model to be developed is consistent with the proposed methods or techniques for quantifying uncertainty.
- It explains how the results will be evaluated and how to determine whether the objective has been met.
  - Specific methods, techniques, or procedures for evaluating results are stated.
  - The data to be collected or the tests to be run or the model to be developed are consistent with the proposed methods or techniques for evaluating results.
  - The methods or techniques for evaluating results are clearly related to the objective.
  - The methods or techniques for evaluating results completely address the objective.
- It includes a schedule for completion of the project.
  - The schedule is consistent with the amount of work to be done, the time required to complete each task, and a typical 40-hour workweek.
- It includes a rough budget ( $\pm 25\%$ ) for the project.
  - The budget reasonably estimates personnel costs.
  - The budget reasonably estimates travel costs.
  - The budget reasonably estimates materials and supplies costs.
  - The budget reasonably estimates equipment costs.
  - The budget reasonably estimates indirect costs.
- The project description, including figures and tables and appendices, (excluding cover page, budget, and reference list) does not exceed 15 pages.