I: Written Part

1. The MSE Ph. D students are required to take the written qualifying exam one academic year (4 semesters) after they are enrolled in the Materials Science & Engineering program at University of Cincinnati with a M.S. prior to enrollment or within 7 semesters with a B.S. prior to enrollment in the Ph. D program.

2. The written exam consists of two main fields in materials science, namely: Polymer Science and Metals/Ceramics. Students may choose either Polymer Science or Metals/Ceramics for the written part of the qualifying exam. Regardless of the main field chosen, relevant thermodynamics must be included as a portion of the written exam.

   Specifically, for Polymer Science, the exam topics include: thermodynamics, polymer characterization, polymer physics and properties, and polymer chemistry and synthesis, a total of 4 topical areas.
   For Metals/Ceramics, the exam topics include thermodynamics, physical metallurgy, mechanical metallurgy, and Ceramics, a total of 4 topical areas.

3. The written exam committee is composed of The Chair and 3 other primary MSE faculty members.

4. Each faculty on the committee develops a set of problems in each field, Metals/Ceramics for example: thermodynamics, structures of metals/ceramics, mechanical/physical properties, and materials processing. These exam problems should be constructed at the levels of the first year graduate and senior year of undergraduate courses in materials science. Each topical area is worth 100 points; 400 points for the entire written exam.

5. The committee chair compiles these problems for the written exam. The committee chair proctors the exam at a designated location. The exam is open book. The maximum exam time is 6 hours within 1 day.

6. After the exam, the committee chair distributes the worked problems to the faculty members who have developed them for grading individually. The committee members must complete grading within one week.

7. A Pass is awarded if at least a 60% average overall in the chosen field is earned.

8. Anonymities of students and their supervisors are kept for the entire qualifying exam (including grading). Therefore, students only provide their assigned Qualifying Exam Number on the test.

9. Students who fail the Written Part are required to retake the Written Part during the next offered exam. A maximum of two times to take the Written Part is allowed.

II: Oral Part:

The oral part of the exam is titled as the Comprehensive Exam which is to be given by the Comprehensive Committee within one year of a student passing the Written Part. The Comprehensive Exam committee is essentially the dissertation committee, chaired by the student’s dissertation advisor. It should include at least two other primary MSE faculty members along with the dissertation advisor. The student submits a written report, called: Research Proposal based on his/her current research data with a 20 page limit. The report should be submitted to all committee members two weeks prior to the Oral Exam in both electronic and printed forms. In this report, the student proposes his/her research with rigorous literature review of the field and justifies the proposed topic (~1/3 of the report). The student also presents his/her current research data and provides in-depth analysis (~2/3 of the report) in the Research Proposal. The format of the Research Proposal should follow that of Advanced Materials.

The student will take the Comprehensive Exam in the same semester as the written exam (two weeks following successful passing of the written part). In the oral exam, the student will give a 40 min PPT presentation of his/her Research Proposal. The committee members will ask questions related to the literature review and critique student’s experimental results and analysis. The oral exam is to be completed within two hours. The committee discusses the outcome of the oral exam and gives a pass/fail grade. The result will be submitted to the UC Graduate School.

Students who fail the Oral Part are required to reschedule the Oral Part with their Comprehensive Committee by the following semester. A maximum of two times to take the Oral Part is allowed.
Qualifying Exam Fields
Metals/Ceramics
Polymer Science

Topical Areas

Metals/Ceramics
1. Thermodynamics
2. Physical Metallurgy
3. Mechanical Metallurgy
4. Ceramic Engineering

Polymers Science
1. Thermodynamics
2. Polymer Physics and Properties
3. Polymer Characterization
4. Polymer Synthesis and Chemistry

Note: Suggested subtopics of each field can be found below. These subtopics listed below are the major topics under the fields indicated but the actual qualifier problems may not be exclusively confined to these subtopics. The Written Part is open book.

Subtopics

Ceramics:
Structure of ceramics
Point defects
Kroger-Vink Notation
Grain growth
Synthesis and processing of ceramic powders
Binders, dispersion, hot pressing, Sol Gel, vapor deposition
Weight-out and calcination
Sintering of ceramics
Microstructure features of fracture in ceramics and composites
Fracture mechanics
Weibull statics for failure strength analysis

Textbooks Recommended for Ceramics
Physical Ceramics (Chiang)
Fundamentals of Ceramics (Barsoum)
**Physical Metallurgy**
Lattice, basis, unit cells, and crystal structures
Points, directions, and planes in the unit cell
XRD for crystal structure analysis
SEM, TEM, Electron diffraction, EDS
Phases and phase diagrams
Nucleation and growth
Diffusion Mechanisms
Thermally activated processes (Arrhenius expressions)

**Mechanical Metallurgy**
Dislocations, slip systems, Schmid’s Law
Elasticity and elastic properties
Plastic deformation of single crystals, polycrystals, order-disorder/superlattices
Strain hardening and annealing
Precipitation hardening
Dispersion strengthening
Heat treatment and TTT diagram
The stress-strain diagram
Fatigue test
Creep, stress rupture, and stress corrosion

**Textbooks Recommended for Metallurgy and Ceramics**
Physical Metallurgical Principles (Reed-Hill)
Fundamentals of Physical Metallurgy (Verhoeven)

**Polymer Physics and Properties**
Transitions: melting, crystallization kinetics, glass transition, viscosity, diffusion
Bulk properties: rubber elasticity, strength and fracture, dynamic mechanical properties
Solution properties: methods of determining molecular weights, Theta temperature and excluded volume effect, solution thermodynamics

**Polymer Characterization**
Spectroscopy (ESCA, XPS, XRD, Auger, IR, light, etc.) small angle diffraction, Thermal analysis, Mechanical properties
**Polymer Synthesis and Chemistry**
- Addition polymerization
- Step reaction polymerization
- Ionic polymerization
- Living polymerization
- Radical chain growth copolymerization
- Molecular weight averages and distributions
- Crosslinking and gelation

**Textbooks Recommended for Polymer Science**
- The Physics of Polymers (Strobl)
- Fundamental Principles of Polymeric Materials (Brazel and Rosen)
- Principles of Polymer Systems (Rodriguez)
- Polymer Science and Technology (Freid)
- Polymers: Chemistry and Physics of Modern Materials (Cowie)

**Thermodynamics**
- Basic principles governing phase equilibria
- The regular solution model for liquid and solid alloy phases
- Calculations of enthalpy and entropy balances

**Textbook Recommended for Thermodynamics**
- Thermodynamics of Materials (Ragone)