# MATERIALS SCIENCE AND ENGINEERING

## UNIVERSITY OF DELAWARE

## Policy Statement Summary for

## MASTER OF MATERIALS SCIENCE AND ENGINEERING

## And

## DOCTOR OF PHILOSOPHY

## IN MATERIALS SCIENCE AND ENGINEERING

**(Effective September 2007)**

Graduate degrees (M.M.S.E. and Ph.D.) in Materials Science and Engineering are offered by the interdisciplinary Department of Materials Science and Engineering of the College of Engineering.

The requirements for the M.M.S.E. and Ph.D. are described in the following document "Academic Requirements for Advanced Degrees in Materials".

A student entering the Materials Science and Engineering Graduate Program normally possesses a bachelor's (or higher) degree in a physical science or engineering discipline. A successful candidate for admission would minimally have taken courses to the following levels: mathematics, through partial differential equations: physics, including mechanics, heat, electricity, magnetism and introductory modern physics: chemistry, through physical chemistry; and introduction to materials science. In addition, courses in thermodynamics, field concepts, phase transformations, and structure and mechanical properties of materials are considered very useful.

Admission requirements are normally (1) completion of a bachelor's program with a GPI of at least 3.2, (2) excellent letters of recommendation from faculty or scholars, and (3) a GRE total score (verbal plus quantitative) of at least 1150. (Deleted One of the above norms may be waived inexceptional cases) Admission decisions are made by the Materials Science and Engineering Faculty on the advice of its Chairperson and/or Graduate student Recruitment Coordinator.

Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths).

The Master's thesis must be accepted by both the research advisor and the Chairperson of the Materials Science and Engineering Faculty. A formal defense of the Master's thesis before the committee may be required. The Ph.D. dissertation must be defended before the student's advisory committee. That committee consists of the student's research advisor and at least three other faculty, at least one of whom is not a member of the Materials Science and Engineering Faculty. The Ph.D. Committee will be set up at the time of the student's Ph.D. Qualifier/Dissertation Committee within the student's first five semesters and will meet with the student annually. In addition to a criterion of scholarly excellence, there must be no barriers to publication of the thesis or dissertation.

Stipend and tuition support is awarded to meritorious students. The authorization of such support resides with the Chairperson of the Department.

# Academic Requirements for Advanced Degrees

# In

# DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

In order to receive an advanced degree, a student must satisfy both the University's basic requirements and the programmatic requirements given below. Deviations from the program outlined below may be authorized in writing by the faculty advisor to the chairperson and to the Graduate Office in exceptional circumstances such as may apply for transfer students or students entering the Department in the Spring.

**A. Degree of Master of Materials Science and Engineering**

Two options are available, one with a thesis and the other by lecture course credit only. The first is available to all students, the second is only available to Outreach or part-time students and does not require a thesis. Transfer is not permitted from the first to the second option, although transfer is acceptable from the second to the first.

**Master of Materials Science and Engineering with Thesis**

**1.** 24 credit hours of course work and 6 credit hours of thesis research are necessary for the thesis-option Master's degree.

**2.** The following 3 credit courses totaling 15 credits, or their equivalent as approved by the faculty advisor and Chairperson, are required:

| | |
|---|---|
| MSEG 803 | Equilibria in Materials Systems |
| MSEG 804 | Kinetics in Materials Systems |
| MSEG 602 | Structure of Materials |
| MSEG 607 | Physical Properties of Materials I |
| MSEG 630 | Introduction to the Science and Engineering of Polymer Systems |

**3.** Six credit hours of thesis work must be completed, and the thesis must be accepted by the student's advisory and the chairperson of the Department.

**4.** The remaining 9 credits of elective courses will be chosen after discussion with the faculty advisor, and will usually be related to the student's area of research interest. Courses in various areas of specialization are listed at the end of this document.

**Master of Materials Science and Engineering without Thesis**

**1.** 30 credit hours of lecture course work are necessary for the Master's degree without thesis.

**2.** The following 3 credit courses totaling 15 credits, or their equivalent as approved by the faculty advisor and Chairperson, are required:

| | |
|---|---|
| MSEG 803 | Equilibria in Materials Systems |
| MSEG 804 | Kinetics in Materials Systems |
| MSEG 602 | Structure of Materials |
| MSEG 607 | Physical Properties of Materials I |
| MSEG 630 | Introduction to the Science and Engineering of Polymer Systems |

**3.** The remaining 15 credits of elective courses will be chosen after discussion with the advisor, and will usually be related to the student's area of interests. Courses in various areas of specialization are listed at the end of this document.

**B. Ph.D. Degree in Materials Science and Engineering**

**1.** Direct entry to the Ph.D. Program without prior completion of a Master's Degree is available for suitably qualified candidates.

**2.** 12 credits of course work beyond those required for the Master's Degree with thesis, are necessary for the Ph.D. degree.

**3.** The following 3 credit courses totaling 15 credits, or their equivalent as approved by the faculty advisor and Chairperson, are required:

| | |
|---|---|
| MSEG 803 | Equilibria in Materials Systems |
| MSEG 804 | Kinetics in Materials Systems |
| MSEG 602 | Structure of Materials |
| MSEG 607 | Physical Properties of Materials I |
| MSEG 630 | Introduction to the Science & Engineering of Polymer Systems |

**4.** The remaining 21 credits of elective courses will be chosen after discussion with the advisor, and will usually be related to the student's area of research interest. Up to a maximum of 6 credits (out of 21) of research (MSEG 868) may be taken prior to the admission to Candidacy. Additional courses in various areas of specialization are listed at the end of this document.

**5.** After admission to Candidacy, the student must complete 9 credit hours of Dissertation MSEG 969.

**6.** Qualifying examination

Candidates for the Ph.D. degree are required to demonstrate proficiency in the knowledge of materials science by passing the qualifying examination. This is administered (Feb. 1 – Oct. 31) at the request of the student/advisor and consists of a comprehensive research project (written/oral) review on a topic chosen by the candidate and his/her advisor. The written part should contain **no more than 15 pages single-spaced (12-pt. Font)** not including the bibliography. Both the written and oral (not more than 30 minutes) should include but would not be limited to discussion on the following topics/issues:

a. Motivation and Significance of the Research
b. Definition of the Critical Issues
c. Literature Search/Bibliography
d. Research Objectives
e. Outline of the Experimental/Theoretical Approach
f. Anticipated Results
g. Timeline (sequence of accomplishment and milestones)
h. Metrics to Determine the Successful Outcome of the Research
i. Relevant Supporting Preliminary Data
j. Potential Impact (scientific or technological)

This oral exam is designed to evaluate *comprehensive knowledge* in materials science and engineering, "soft" skills, e.g., communication, awareness of market-driven technology, etc., and the ability to organize and plan a project. Thus questions during the oral exam will not only be directed towards the research topic but can also be directed toward peripheral materials issues related to the proposed research. Full time students entering the Ph.D. program with a Masters Degree are expected to take the qualifying examination and set up a Qualifier/Dissertation Committee in their first five semesters. Under certain circumstances, an extension is possible upon request to and approval of the research advisor and department chair. The Qualifier/Dissertation Committee will contain the student's advisor(s) and at least three other faculty, at least one of whom is not a member of the Materials Science and Engineering Faculty. Within the first two years, students will be admitted to candidacy based on three criteria:

a. Results of Qualifying Examination

b. Successful completion of the required courses with a GPA of 3.25 or higher.

c. Satisfactory research progress as determined by the candidate's Qualifier/Dissertation Committee.

Admission to candidacy decisions will be made by the Departmental Graduate Committee.

For those who enter the program with a M.S. or equivalent or those

exceptionally well qualified students (with a B. S. degree or equivalent) wishing to directly enter the Ph.D. program, they will have until the end of January of their second year (a second and final chance by June 1 in the same year if performance on first exam is unsatisfactory) to take the Qualifying examination.

Part-time students entering with a B.S. degree take the qualifying examination no later than the sixth semester, and will then follow the above procedure with the expectation that admission to candidacy requirements be satisfied by two years after the qualifying exam is taken.

**7.** Specialization
In addition to the materials science core leading to the Ph.D. qualifying examination, students engage in the study of an area of specialization. Current areas of specialization are polymers, electronic and magnetic materials, materials chemistry, biomolecular/bioinspired materials, metals and composite materials. Students are required to complete satisfactorily at least five courses in an area of specialization. The course of study is developed by the student and his/her research advisor and is approved by the Materials Science and Engineering Faculty. Course lists for the areas of specialization are found in item C below. The lists are subject to change.

**8.** Dissertation
A dissertation containing original results of the student's research effort must be presented and approved by the Ph.D. Committee and the Chairperson of the Department.

**9.** Final Oral Examination
After an oral presentation open to all interested persons, the student will be examined on the dissertation by the Ph.D. Qualifier/Dissertation Committee. In addition to examining the results of the original research contained in the dissertation, the committee will pay particular attention that suggestions for future work shall constitute a well-formulated and coherent plan to extend the research significantly.

## C. List of Courses in the Areas of Specialization

A specialization requires satisfactory completion of at least three courses from the one of the following lists:

**a) Polymers**
**MSEG 601** Structure and Properties of Polymer Materials
**MSEG 604** Phase Transformations
**MSEG 614** Fracture of Materials
**MSEG 616** Chemistry and Physics of Surfaces and Interfaces
**MSEG 632** Principles of Polymerization
**MSEG 633** Polymer Synthesis and Characterization
**MSEG 635** Principles of Polymer Physics
**MSEG 821** Diffraction of Radiation by Matter
**MSEG 823** TEM in Materials Science

**MSEG 667** Biopolymeric Materials
**MSEG 667** Practical Electron Microscopy in Materials Science
**MSEG 667** Electron and Photonic Materials

**CHEM 620** Analytical Spectroscopy
**CHEM 624** Principles of Mass Spectroscopy
**CHEM 626** Instrumentation Methods in Mass Spectroscopy
**CHEM 627** Practical Mass Spectroscopy
**CHEM 673** Practical NMR Spectroscopy

**CHEG 601** Structure and Properties of Polymer Materials
**CHEG 602** Polymer Process Analysis and Design
**CHEG 603** Polymerization Reaction Engineering
**CHEG 606** Introduction to Catalysis
**CHEG 604** Intro. to Polymer Science and Engineering II
**CHEG 828** Statistical Thermodynamics

**MEEG 617** Composite Materials
**MEEG 813** Theory of Elasticity
**MEEG 817** Composite Materials
**MEEG 862** Advanced Engineering Analysis
**MEEG 863** Engineering Analysis 1

**b) Metals and Composites**

**MSEG 606** Corrosion and Protection
**MSEG 607** Physical Properties of Materials I
**MSEG 614** Fracture of Materials
**MSEG 616** Chemistry and Physics of Surfaces
**MSEG 806** Physical Properties of Solids
**MSEG 807** Physical Properties of Materials II
**MSEG 821** Diffraction of Radiation by Matter
**MSEG 823** TEM in Materials Science
**MSEG 667** Practical Electron Microscopy in Materials Science

**CHEG 601** Structure and Properties of Polymer Materials
**CHEG 602** Polymer Process Analysis and Design
**CHEG 606** Introduction to Catalysis
**CHEG 616** Chemistry and Physics of Surfaces and Interfaces

**MEEG 610** Experimental Mechanics for Composite Materials
**MEEG 617** Composite Materials
**MEEG 667** Composite Materials Design
**MEEG 667** High Temperature Composites
**MEEG 813** Theory of Elasticity
**MEEG 814** Theory of Plasticity
**MEEG 816** Advanced Continuum Mechanics
**MEEG 817** Composite Materials
**MEEG 818** Advanced Plates and Shells in Aerospace Structures I
**MEEG 819** Advanced Plates and Shells in Aerospace Structures II
**MEEG 855** Principle of Composite Manufacturing
**MEEG 856** Nanocrystalline and Nanocomposite Materials

**c) Electronic and Magnetic Materials**

**MSEG 616** Chemistry and Physics of Surfaces and Interfaces
**MSEG 623** Electrical Properties of Matter I
**MSEG 667** Introduction to Ceramic Materials
**MSEG 667** Practical Electron Microscopy in Materials Science
**MSEG 821** Diffraction of Radiation by Matter
**MSEG 822** Imperfections in Crystals
**MSEG 823** TEM in Materials Science
**MSEG 824** Advanced Carrier Transport in Solids

**ELEG 621** Solid State Electronics ll
**ELEG 622** Electronic Materials Processing
**ELEG 624** Fundamental Device Principles
**ELEG 626** Integrated Circuits
**ELEG 650** Semiconductor Device Design and Fabrication
**ELEC 640** Optoelectronics

**PHYS 645** Electronics for Scientist
**PHYS 646** Instrumentation for Scientists
**PHYS 803** Solid State Physics
**PHYS 624** Introduction to Solid State Physics
**PHYS 803** Solid State Physics

**MEEG 862** Advanced Engineering Analysis
**MEEG 863** Engineering Analysis 1

**CHEG 606** Introduction to Catalysis

d) **Biomolecular/Bioinspired Materials**

**MSEG 601** Structure and Properties of Polymer Materials
**MSEG 667** Polymer Physics
**MSEG 667** Issues at the Interface of Materials and Biology
**MSEG 667** Biopolymeric Materials
**MSEG 667** Practical Electron Microscopy in Materials Science
**MSEG 821** Diffraction of Radiation by Matter
**MSEG 823** TEM in Materials Science

**CHEG 620** Biochemical Engineering
**CHEG 650** Biomedical Engineeering

**MEEG 862** Advanced Engineering Analysis
**MEEG 863** Engineering Analysis 1

**CHEM 527** Introductory Biochemistry
**CHEM 641** Biochemistry
**CHEM 642** Biochemistry
**CHEM 643** Intermediary Metabolism

**CHEM 644** Mechanisms of Enzyme Catalysis
**CHEM 645** Protein Structure and Function
**CHEM 646** DNA-Protein Interactions
**CHEM 647** Biochemical Evolution
**CHEM 648** Membrane Biochemistry
**CHEM 649** Molecular Biophysics

d) **General**
**MSEG 811** Advanced Topics in Materials
**MSEG 620** Career Survival Outside the University
**MSEG 667** Entrepreneurship and Risk-Taking: How to Establish a Startup Enterprise
**MSEG 964** Pre-Candidacy Study