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

September 2020

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.

Students who have not yet completed their bachelor's degree may only be admitted under a special program, such as the 4+1 program for qualified UD undergraduates or in another joint program (e.g. 3+2) for schools with which an articulation agreement is in effect. The admissions requirements for these programs are otherwise the same as for other applicants as delineated below.

Admission requirements are normally (1) completion of a bachelor's program with a GPA of at least 3.2, (2) three excellent letters of recommendation from faculty or scholars. (3) A TOEFL score of 79 or higher with a minimum speaking of 18. The GRE is NOT required by our Department. Admission decisions are made by the Materials Science and Engineering Graduate Admissions Committee.

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 members, at least one of whom must be from outside 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, within the student's first five semesters, and will meet with the student annually. The thesis or dissertation must meet the criterion of scholarly excellence and there must be no barriers to its publication.

Stipend and tuition support are 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 intended for outreach or part-time students and does not require a thesis. Transfer between options is permitted only upon the recommendation of the student's research advisor and with the approval of the Department Chairperson and the Chair of the graduate committee.

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 (30 total credits required).

2. The following courses, totaling 9 credits, are required of all students. Equivalent courses may be substituted as approved by the faculty advisor and Chairperson:

MSEG 608	Structure and Properties of Materials I (3 credits)
MSEG 803	Equilibria in Materials Systems (3 credits)
MSEG 804	Kinetics in Materials Systems (3 credits)

3. Students may choose two courses from the following four courses with their advisor (6 credits total required). Any students taking more than the required two courses may count those additional courses as technical electives.

MSEG 640	Applied Quantum Mechanics I (3 credits)
MSEG 841	Solid State Materials I (3 credits)
MSEG 832	Principles of Polymer Synthesis (3 credits)
MSEG 835	Polymer Physics (3 credits)
MSEG817	Composite Materials (3 credits)

4. Technical Electives (three courses – 9 credits total required). These courses should be chosen with student's advisor, and will usually be related to the student's area of research. MSEG 868 – Research may not be taken as Technical Electives.

5. Six credit hours of thesis work, MSEG869, must be completed and the thesis must be accepted by the student's advisory committee and the Department Chairperson.

6. Students must earn a grade of B- or higher in all courses counting towards the degree requirement. The University requires graduate students have a GPA of 3.00 or higher to earn their degree.

7. All graduate students are expected to attend departmental seminars.

8. Master's Thesis: A thesis containing original results of the student's research effort must be presented and approved by the student's research advisor and the Department Chairperson.

Master of Materials Science and Engineering without Thesis

1. 30 credit hours of course work are required for the Master's degree without a thesis.

2. The following courses, totaling 9 credits, are required of all students. Equivalent courses may be substituted as approved by the faculty advisor and Department Chairperson:

MSEG 608	Structure and Properties of Materials I (3 credits)
MSEG 803	Equilibria in Materials Systems (3 credits)
MSEG 804	Kinetics in Materials Systems (3 credits)

3. Students may choose two courses from the following four courses with their advisor (6 credits total required). Any students taking more than the required two courses may count those additional courses as technical electives.

MSEG 640	Applied Quantum Mechanics I (3 credits)
MSEG 841	Solid State Materials I (3 credits)
MSEG 832	Principles of Polymer Synthesis (3 credits)
MSEG 835	Polymer Physics (3 credits)
MSEG817	Composite Materials (3 credits)

4. Technical Electives (five courses – 15 credits total required). These courses should be chosen with student's advisor, and will usually be related to the student's area of research. MSEG 868 – Research may not be taken as Technical Electives.

5. Students must earn a grade of B- or higher in all courses counting towards the degree requirement. The University requires graduate students have a GPA of 3.00 or higher to earn their degree.

6. All graduate students are expected to attend departmental seminars.

7. Candidates for the Master's Degree without thesis may be asked to demonstrate their comprehensive knowledge of materials science by successfully completing a final project. If so, the project consists of a written analysis and research project proposal on a topic chosen by the candidate and his/her advisor. The written report should contain **no more than 15 pages single-spaced (12-pt. Font)** not including the bibliography. The written report should cover at least 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 a feasible Experimental/Theoretical Approach
    f. Anticipated Results
    g. Potential Impact (scientific or technological)

    The written report must be approved by the student's faculty advisor and the Department Chairperson.

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

1. 24 credit hours of course work and 9 credit hours of dissertation research are required for the Ph.D. Degree (33 total credits required). The distribution of required credits is described below.

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

3. The department may waive the requirement for up to 15 credit hours of course work for students entering the Ph.D. program with a Master's Degree or credits for graduate course work performed at another recognized/accredited graduate school. The primary purpose of these waivers is to provide students the opportunity to take courses that extend their depth and breadth of knowledge. Because these courses are waived, not transferred, a student must still meet the department's required number of total credits (33) by taking other courses as determined in collaboration with his/her advisor. Waivers will only be granted for courses that cover subjects eligible for credit toward a Ph.D. in Materials Science and Engineering from the University of Delaware, and all waivers are at the discretion of the Graduate Committee in consultation with other faculty members. Typically, waivers are only available for MSEG "Required Courses" (i.e. not technical electives). In order to request a waiver, students should submit an MSEG Course Waiver Form, syllabi, course description, and grades received for the courses that the student considers a substitute. The student must initiate requests for a course waiver before the beginning of their second semester at UD. The waiver must be approved by the Graduate Program Director (in consultation with the Graduate Program Committee) and will be

contingent on the student's demonstration of satisfactory performance in course work taken at UD.

4. The following courses, totaling 9 credits, are required. Equivalent courses may be substituted when approved by the faculty advisor and Department Chairperson:

   MSEG 608 Structure and Properties of Materials I (3 credits)
   MSEG 803 Equilibria in Materials Systems (3 credits)
   MSEG 804 Kinetics in Materials Systems (3 credits)

5. Students may choose two courses from the following four courses with their advisor (6 credits total required). Any students taking more than the required two courses may count those additional courses as technical electives.

   MSEG 640 Applied Quantum Mechanics I (3 credits)
   MSEG 841 Solid State Materials I (3 credits)
   MSEG 832 Principles of Polymer Synthesis (3 credits)
   MSEG 835 Polymer Physics (3 credits)

6. Technical Electives (three courses – 9 credits total required). These courses should be chosen with student's advisor, and will usually be related to the student's area of research. MSEG 868 – Research may not be taken as Technical Electives.

7. Students must earn a grade of B- or higher in all courses counting towards the degree requirement. The University requires graduate students have a GPA of 3.00 or higher to earn their degree.

8. A student can take 9 credits of MSEG964 – Pre-Candidacy in the semester they plan to take their Ph.D. Qualifying Exam. If they pass, and are admitted to Doctoral Candidacy, these 9 credits can be switched to 9 of the required MSEG969. If they do not take Pre-Candidacy credits, after admission to Doctoral Candidacy, the student must complete 9 credit hours of Dissertation MSEG 969.

9. All graduate students are expected to attend departmental seminars.

10. <u>MSEG Ph.D. Qualifying Exam -</u>

<u>Purpose</u>

MSEG Ph.D. students follow a curriculum that includes both required "core" courses and technical electives. Student mastery of the content presented in these courses is assessed through the course exams and grades, enforced by the minimum GPA (3.0) requirement for continuation in the Ph.D. program. The purpose of the qualifying exam is to assess students' ability to 1) synthesize the knowledge gained from separate courses and 2) apply that knowledge to a) understand the background of the research problem they will pursue and b) propose an informed and feasible approach to addressing open scientific questions. In so doing, students will demonstrate that they have mastered the scientific foundations of

their dissertation research topic and that they are prepared for increasingly independent research. The qualifying exam therefore serves dual purposes: it both determines whether a student is prepared to conduct PhD-level research and also allows the committee to review the proposed work.

Format

The MSEG Qualifying Exam has two parts: a written paper and an oral presentation. Both are evaluated by the student's exam committee.

Exam committee composition: The dissertation committee is chaired by the student's primary advisor and must include at least two (three if the advisor does not have a primary appointment) other professors with primary appointments in MSEG (i.e. at least three professors with primary appointments in MSEG in total) and at least one external member, who should be a professor from another department or other Ph-D scientist/engineer who is not primarily appointed in the MSEG department. External committee members are expected to respect the dual role of the examination as a proposal defense (in which they are expected to take an active role) and as the exam for qualification to doctoral candidacy, which should be based on departmental standards and expectations. Additional members, for example Ph.D.-level technical staff, corporate collaborators, and professors from other institutions, are welcome. Students are expected to work with their advisor to identify potential members of the dissertation committee who are familiar with the research topics to be considered and thus able to provide maximally-useful feedback. The examination committee for the qualifier is intended to be the same as the dissertation committee, but the membership of the committee can change between the qualifier and the conclusion of the PhD if such a change is warranted.

Students contact these potential members of the committee with a tentative timeline for the qualifying exam and ask if they are willing to serve on the committee. Once the membership of the committee is confirmed, students circulate potential dates and times to secure an exam time that will work for the entire committee. Students then request assistance from the MSEG department office to secure a conference room for the exam time. Reservations should be made for two hours.

Written paper: The written paper, which serves as a dissertation proposal, is prepared by the student. The student's advisor should review the paper to ensure that it conforms with these requirements and may offer constructive feedback to the student. After this review, the paper should be sent to the student's dissertation (exam) committee at least two weeks before the date of the qualifying exam. The paper should be no longer than 12 pages in length (single space, 12 pt font, Times New Roman or equivalent) including figures. Substantial references, demonstrating that students are familiar with the background literature in the field, should be included in the paper and are not included in the 12 page maximum. References should be in a standard format that complies with NSF guidelines (complete list of authors, title included, etc.)

The paper must include the following sections:

- Introduction and Motivation explaining the importance of the research problem
- Background summarizing the scientific foundations and important prior work in the field.

- Statement of the Research Problem that will be the focus of the student's dissertation research, including a statement of hypotheses to be tested.
- Proposed Approach describing the methods to be employed in conducting the research. This section should include citations to references that established the techniques to be employed and a description of why these techniques are appropriate for the proposed research.
- Timeline of the proposed research
- Progress to Date describing the student's efforts on the project thus far. Demonstration of substantial progress and/or results is not required.

Additional sections as appropriate to the proposed topic and field are welcome.

Oral Presentation: The student should prepare an oral presentation with slides. The slides should cover all of the required sections of the written paper and should include a final slide with a tentative project timeline. The presentation should be designed to be 30 minutes in length if delivered without interruption. Students should expect frequent interruptions to discuss the slide content and to probe the student's knowledge of the material presented and how it relates to underlying scientific principles. To ensure the examination adequately tests the student's ability to synthesize knowledge from courses and apply it to a research project, examiners are free to ask questions about any scientific topic related to the proposed project, including topics covered in either the written paper or oral presentation. All background knowledge probed should be germane to the proposed project. Exams typically take between 90 and 120 minutes. This should include a hard stop at least 10 minutes prior to the end of the examination to permit time for the faculty to deliberate without the student in the room.

Evaluation Criteria

Students will be evaluated according to the following criteria:

- Has the student demonstrated the ability to integrate foundational material and concepts in order to understand the scientific foundations of the research problem?
- Does the student understand the scientific underpinnings of the approaches to be employed?
- Has the student demonstrated knowledge of the important prior results in the field?
- Has a clear research problem or objective been identified and clearly explained?
- Does the proposed approach describe a feasible path to addressing this research problem?

Based on these evaluation criteria, the committee shall form a consensus on whether the student Passes, Passes Provisionally, or Fails the examination. Feedback should be provided to the student. A "Passes Provisionally" shall entail whatever provisions and timeline the committee deems necessary to address the shortcomings that resulted in that outcome. The advisor is responsible for ensuring these provisions are met and shall notify both the student's committee and the graduate program director in writing how the provisions were met. In the event a student fails the examination, s/he should be explained the reasons for the failure. The student shall, at the discretion of his/her advisor, be permitted to retake the exam one additional time within six months.

Timeframe

Students are expected to demonstrate the ability to understand the content of both core and technical elective courses and to apply this knowledge to the research problem of their dissertation. For this reason, qualifying exams should not be taken before students have completed the relevant courses. Moreover, students are often better able to synthesize

course and background material in the context of the research project after spending several months working on the problem. For this reason, qualifying exams are typically taken after the student's third semester in the Ph.D. program (e.g., no earlier than January of a student's second year in the Ph.D. program). Substantial research results are not required. The qualifying exam provides the opportunity to receive valuable feedback from the dissertation committee. For this reason, a student (with consent of his/her advisor) who wishes to delay the qualifying exam past the beginning of a student's third year in the Ph.D. program should submit a written explanation of the reason for the delay and the expected timeline for the exam to the graduate committee with at least two months' notice. After considering this request, the graduate committee, led by the graduate program director, will inform the student of their decision to approve/decline this request within two weeks.

Students should work with the graduate program coordinator to ensure that the timing selected meets constraints set by pre-candidacy credits. Students should register for MSEG 964 the semester in which they intend to complete the examination. Students who register for MSEG 964 within the fall semester have fall and winter to complete the examination. Students who register in spring semester will have spring and summer to complete the examination. The graduate program coordinator will ensure students have all the logistical information they need for the qualifier, including the forms below.

11. Pre-Defense/Data Defense Meeting: Candidates are required to present their research to their Ph.D. Qualifier/Dissertation Committee. This meeting should take place 3-6 months before the anticipated graduation date, before the student has engaged in formal job applications and before the written dissertation is complete. The purpose of this meeting is to get the committee's input about whether the scope and quality of research conducted is appropriate for graduation in the near future, to provide guidance on further work required, and to guide the writing of the dissertation.

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

13. Defense (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.