**Montana University System Collaborative**

**Materials Science Ph.D. Program**

**Student Guidebook**

**Fall 2023 Revision**

**(*work in progress*)**

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## Introduction

### Objective

This guidebook describes the academic degree requirements, policies and practices for graduate students in the Montana University System Materials Science Ph.D. Program (MatSci Ph.D. Program). The general program degree requirements are presented, along with the milestones, rules and policies, and standards of performance and integrity expected of graduate students.

The graduate student is responsible for understanding and adhering to the policies and procedures outlined in this guidebook as well as the policies in effect at the university in which the student is enrolled. Inconsistencies may arise between the contents of this guidebook and the specific policies of Montana State University and Montana Technological University. In such instances, the policies of the university in which the student is enrolled take precedence.

### Program Overview

Montana State University (MSU) and Montana Technological University (MTU) participate in the Materials Science Ph.D. program. The program is a collaborative effort of the two campuses, and involves multiple departments, faculty, courses, and research infrastructure.

Research specialties are focused in five areas:

1. biomaterials
2. electronic, photonic, and magnetic materials
3. materials for energy storage, conversion, and conservation
4. materials synthesis, processing, and fabrication
5. environmental materials

The curriculum integrates a broad range of physical science and engineering disciplines with an even broader range of applications: from health and medicine to nanotechnology to energy, environment, and natural resources. Courses are coordinated and shared by the two campuses, taking advantage of on-line instructional technologies where appropriate. Each student must complete original, independent research culminating in a dissertation. The program offers optional, employer-based internships, in which the student tackles a current problem important to the employer.

Program requirements include the qualifying exam, the candidacy exam, the dissertation, participation in the program’s annual summer symposium, annual meetings with a student’s advisory committee, and an optional internship. These requirements and their timing are summarized in Table I and described in greater detail in the sections that follow.

Table I. Typical Schedule for MatSci Ph.D. Program of Study

|  |  |
| --- | --- |
| **Year 1 Fall Term** | **Year 1 Spring Term** |
| MTSI 500 Survey of Materials Science & Eng. (1) | MTSI 500 Survey of Materials Science & Eng. (1) |
| MTSI 501 Advanced Materials Science I (3) | MTSI 502 Advanced Materials Science II (3) |
| MTSI 511 Thermodynamics of Materials (3) | MTSI 503 Optical, Electrical and Magnetic Properties (3)(3)3)Kinetics and Phase Transformations (3) |
| MTSI 551 Materials Characterization I (3) | MTSI 512 Kinetics and Phase Transformations (3) |
| *Total Credits: 10* | *Total credits: 10* |
| *Choose Research Advisor by the end of Year 1 Spring Term* | |
| *Participate in Spring Materials Science Symposium (March/April)* | |
| *Qualifying Examination in mid-August* | |
|  | |
| **Year 2 Fall Term** | **Year 2 Spring Term** |
| Electives (6-9) | Electives (6-9) |
| Research (0-6) | Research (0-6) |
| *Total Credits: 9-12* | *Total Credits: 9-12* |
| *Late Spring: Candidacy proposal and oral exam; March/April Materials Science Symposium* | |
| *Summer: If needed, repeat Qualifying Exam* | *Sept-Dec: Assemble dissertation committee* |
|  | |
| **Year 3 Fall Term** | **Year 3 Spring Term** |
| Electives (0-6) | Electives (0-6) |
| Research (3-9) | Research (6-9) |
| *Total Credits: 9-12* | *Total Credits: 9-12* |
| *June/July: Summer Symposium* | |
|  | |
| **Year 4 *et seq.*** | |
| Research (6-9 credits each semester) | |
| *Every Year in June/July: Summer Symposium* | |
| *Final Term: Submission and Oral Defense of Ph.D. Dissertation* | |

### Mission, Vision, and Core Values

The MatSci Ph.D. program mission is to advance knowledge and techniques while preparing the next generation of leaders in materials research, application, and education. The program’s vision is to become a top-ranked program, sought after by students, sponsoring agencies, and industry, with high student demand, placement success, and positive impact on Montana’s economy. This mission and vision align directly with those of the participating campuses and the MUS, as described in detail in Section 4D of the Level II proposal. Noteworthy contributions are expected to Montana’s workforce and economic development, research and development, graduate education capacity and opportunities, and efficiency and effectiveness. In addition, through this program Montanans will have affordable access to the highest level of educational opportunity in materials science and closely related fields.

The proposed program’s core values are:

• High standards of academic quality, research originality, and significance

• Integrity

• Interdisciplinarity and collaboration, with administrative processes transparent to the students

• Service and value to Montana, the nation, and world

• Efficiency and effectiveness

This two-campus collaborative Ph.D. program is designed specifically to ensure that the curriculum, courses, mentors, research teams, infrastructure, funding, and governance will sustain its interdisciplinary and collaborative nature; with educational experiences and original research of the highest quality, integrity, significance, and value to Montana; thereby achieving high efficiency and effectiveness while preparing graduates for the workforce and fostering economic development in Montana.

1.4 Program Goals and Objectives

Given its goals, the MatSci Ph.D. program will contribute significantly to the intellectual climate and research environment on the participating campuses. Furthermore, the program aspires to become a top-ranked program in its fields and to serve students superbly by achieving high student retention, timely degree completion, and direct pathways to careers. In terms of value to the campuses and more broadly to the MUS, the program’s objectives are to:

* Attract the highest caliber of tenure-track and visiting faculty to Montana, further enriching the environment for students at all levels;
* Foster and increase grant activity and research collaborations within Montana, regionally, nationally, and internationally;
* Enrich the research opportunities and infrastructure on each campus, including those available to undergraduate and master’s students in related fields;
* Accelerate implementation of the cost-effective and collaborative graduate-education model being pursued by the Montana University Graduate System (MUGS), and potentially become a cost-effective model nationally, where campuses with complementary strengths collaborate to offer shared degree programs that transcend what would be possible on any one campus alone;
* Bring national recognition to the materials science research enterprise in Montana and the MUS;
* Nucleate start-up companies and attract other firms to relocate or expand to Montana. These entrepreneurial ventures will not only enhance local and state economies, they will increase internship and employment opportunities for students and graduates in Montana;
* Be highly cost-effective, with courses and curriculum coordinated across the two campuses, thereby maximizing course enrollments (including those in existing courses serving graduate programs in the many science and engineering disciplines important to MatSci); and
* “...make more efficient uses of resources and …reach critical masses of faculty and students that cannot be readily attained by individual campuses” (AAAS, August 2012, p. 3).

The MUS MatSci Ph.D. curriculum is designed to be flexible, but still provide students with an exceptionally strong and broad understanding of the theory, experimental techniques, current challenges, and societal/economic impacts of materials science and engineering. The program’s learning goals for all students—regardless of specialty—are to understand materials and the full suite of characterization and analysis tools commonly used in materials research. Specific learning goals are for students to understand how classes of materials derive their properties from the atomic to the macroscopic level; be familiar with the growing set of materials fabrication, assembly, processing, and characterization tools and techniques; be aware of and committed to the professional and ethical standards of the field; be knowledgeable about the economic, societal, and other broader impacts of materials and materials research; and to demonstrate through their dissertation research, that they can conceive, plan, design, conduct, analyze, defend, publish, and communicate original and creative research that advances understanding in an area important to MatSci.

## Admissions

To be eligible for admission to the Ph.D. program, the student must have earned a B.S. degree or equivalent in materials science, materials engineering, physics, chemistry, metallurgy, or a related science or engineering field. The student’s academic record must provide evidence of a strong background in the fundamentals of science and/or engineering principles. A student with such a background who has not passed certain undergraduate courses that are prerequisites for their required or elective graduate courses must remedy this gap as expeditiously as possible, either by taking the prerequisite undergraduate course or through independent study and “credit by examination.”

Students may apply to the MatSci Ph.D. program through the graduate admissions office of the campus where they prefer to enroll:

Admission information can be accessed through the following links:

Montana State University: <http://www.montana.edu/wwwdg/apply.html>

Montana Tech: <http://www.mtech.edu/academics/gradschool/>

The Ph.D. Program Admissions Committee reviews the applicants, including the match between the applicant’s interest and preferred campus. Admissions recommendations will consider the applicant’s quality, the availability of financial support, and the availability of willing mentor(s)/advisor(s). The admitted students will be extraordinary applicants with interests spanning the research themes. The Program’s recommendation on each applicant is forwarded for action to the graduate admissions office on the campus where the student is recommended or waitlisted for admission. In the case of students not recommended for admission, the recommendation is returned to the graduate admissions office of the campus where the student applied.

Once the program’s admission recommendation is made, the remainder of the admissions process follows the normal graduate admissions process on the campus where the student is admitted, waitlisted, or applied. Admissions offers are made by the campus where the student will matriculate, in the same manner and by the same official as for other graduate students at that campus.

## Doctor of Philosophy Degree

The Montana University System Materials Science Ph.D. Program is designed to be flexible but still provide students with an exceptionally broad and strong understanding of the theory, experimental techniques, current challenges, and socioeconomic impacts of materials science and engineering. All students in the program – regardless of specialty – will understand how classes of materials derive their properties from the atomic to the macroscopic level and be familiar with the growing set of materials fabrication, assembly, processing and characterization tools and techniques. Further, students will be aware of and committed to the professional and ethical standards of the field. Students are also expected to become aware of the economic, societal, and broader impacts of materials and materials research. Through their dissertation research, students will demonstrate that they can conceive, plan, design, conduct, analyze, defend, publish, and communicate original and creative research that advances understanding in an area important to materials science.

### Research Advisor, Research Topic, and Committee Selection

Incoming students who do not enter the program as Graduate Research Assistants under the guidance of a faculty member are classified as “unplaced.” During the initial year, unplaced students are expected to meet MatSci faculty, discuss mutual research interests, and learn about available projects. As part of MTSI 500 Survey of Material Science and Engineering, each campus will host a one-day forum/exposition each academic year to provide students with the opportunity to meet the MatSci faculty, learn about their research interests, and discuss potential research projects. The format may include seminars, tours, equipment demonstrations, etc.

Once a student and advisor agree to work together on a specific research project, they must notify the MatSci Ph.D. Program Leadership Council of their decision, and the student will be classified as “placed”. Consequently, that specific research project will not be advertised or available to the unplaced students. Before the mid-semester break in the first semester of the second year, all unplaced students specify their project preferences and are then placed by agreement of the MatSci Ph.D. Program faculty and the Leadership Council.

Not later than the first semester of the second year, the student will form a faculty advisory committee with at least five members, of which at least one is from a non-home campus, and another is the Graduate School Representative. The advisor and committee monitors the student’s progress, helps the student tailor elective course choices to his/her interests, and provides feedback and guidance to keep the student on track to completing all program requirements in a timely manner. Students meet with their committees annually during every year they remain in the program following their candidacy exam. An additional “outside examiner” from outside the Montana University System may be added to the Advisory Committee prior to the time the dissertation is submitted. The outside examiner reviews the dissertation, participates in the oral defense, and makes a formal recommendation to the Committee about the quality and originality of the dissertation. Selection and appointment of the outside examiner follows the standard practice on the campus where the student is enrolled.

### Credit Requirement

The MUS MatSci Ph.D. requires a minimum of 60 semester credits beyond the bachelor’s degree. Of the 60 credits, at least 18 credits must be obtained for dissertation research, and at least 32 credits must be earned for coursework. Up to 24 semester-credits from a master’s degree may be accepted toward the minimum degree requirements, but they must be applicable to the MatSci curriculum, and their acceptance is subject to the review and approval of the student’s committee and the MatSci program’s Leadership Council. No more than 9 credits may be from 400-level courses. To ensure that students benefit from the collaborative, three-campus nature of the program, at least 9 credits must be earned from courses offered away from the home campus. Full-time students are expected to complete the 20-credit core curriculum and pass the qualifying examination within the first year.

In addition to the core curriculum, each student must earn at least 12 credits of electives within or related to the chosen specialty. Typically, this coursework is completed by the end of the student’s second year. Additional elective courses intended to provide a student with specialized expertise and/or skills relevant to their dissertation research may be recommended by the individual student’s advisor and committee.

### Core Course Requirements

#### MTSC 500 – Survey of Materials Science and Engineering (2 credits: 1 credit/semester)

This course is offered to benefit students contemplating a career in scientific or engineering research and technical management. It offers information that many research professionals wish that they had received at the outset of their graduate educations, both to facilitate their studies and to prepare them for career success following graduation. The course will feature: 1) experimental design and project management; 2) guidance on conducting thorough literature and patent searches, properly documenting experimental data, data reduction and critical analysis, and effective presentation; 3) proposal and grant writing, publications, contracts, intellectual property, professional societies and conferences; and 4) information on potential career paths and opportunities, as well as expectations from research supervisors in universities, corporations, national laboratories, and government agencies.

#### Advanced Materials Science I and II

##### Semester 1: MTSI 501 – Bonding, Structure and Defects (3 credits)

The goals of MTSI 501 are to establish how bonding, structure, symmetry, and defects at the microscopic level lead to macroscopic material properties. Detailed treatment of these fundamental materials science concepts will provide the foundation to understanding the function and application of advanced materials, with particular attention to structural and thermal properties, symmetry and diffraction, as well as chemical and structural defects.

##### Semester 2: MTSI 502 – Function and Application (3 credits)

How are materials designed and synthesized to achieve specific functional applications? Instead of looking at each material system, this course will attempt to provide some fundamental tools for studying how to model and simulate materials development and application.

##### Semester 2: MTSI 503 – Function and Application (3 credits)

The goal of MTSI 503 is to establish how the functional properties of materials (primarily optical, electrical, vibrational, and magnetic) emerge from the fundamental interactions between the atoms.

##### MTSI 511 – Thermodynamics of Materials (3 credits)

Advanced thermodynamic principles are presented in the context of materials science and engineering. The course focuses on the application of thermodynamic principles to materials structure, properties and processing. Subject matter includes elements of solution thermodynamics and application to equilibrium diagrams.

##### MTSI 512 – Kinetics and Phase Transformations (3 credits)

This course covers the fundamentals of kinetic processes in Materials Science such as diffusion, adsorption, chemical reactions and phase transformations.

##### MTSI 551/552 – Advanced Materials Characterization Techniques I (3 credits)

The course will provide an overview of fundamental principles of widely used, advanced surface and structural characterization techniques in the context of academic and industrial research.

### Waiver of a Core Course

Students can petition to waive any core course if the student has taken an equivalent course at another accredited university and achieved a grade of B or better at the graduate level. The student must provide proof in the form of transcripts and a syllabus of that course. A petition should be submitted to the graduate program chair via the graduate advisor who reviews requests for waivers or substitutions of the core courses. The student must take an approved technical elective in the place of the waived core course. Students will be responsible for material from waived courses during the qualifying exam.

### Technical Electives

Elective courses are available to allow students to deepen their understanding and research skills in the program’s focus areas in biomaterials; materials for energy storage, conversion, and conservation; electronic, magnetic, and photonic materials; and materials synthesis, processing, and fabrication. Courses in mathematics, statistics, and numerical modeling are recommended for students with special interests in theory and simulation.

Many graduate-level electives applicable to the MatSci Ph.D. program are available. Most are graduate courses from other related graduate programs. As examples, applicable electives are offered in the following departments:

**Montana State University:** Chemistry, Biological Sciences, Physics, Chemical and Biological Engineering, Earth Sciences, Electrical and Computer Engineering, Mechanical and Industrial Engineering, Mathematics, and Computer Science.

**Montana Tech:** Biological Sciences, Chemistry and Geochemistry, Computer Science Electrical Engineering, Environmental Engineering, Geological Engineering, Mathematics, Mechanical Engineering, Petroleum Engineering, and Metallurgical and Materials Engineering.

### Summer Symposium

Every student is expected to attend and participate in the doctoral program’s annual summer symposium. Every student who has advanced to candidacy is expected to present either a poster or a talk.

### Deficiency Course Requirements for non-Materials Students

Students who do not possess an undergraduate materials science degree may be required to complete additional coursework in order to remediate deficiencies before they enroll in certain graduate level courses. Deficiencies will be identified by the Admissions Committee and will be stated on the student’s admission letter. Deficiencies in the courses listed hereunder must be remedied in addition to the required graduate coursework. Students who do not enter the program in possession of an undergraduate materials science degree are required to complete additional coursework to remediate deficiencies before they may enroll in certain graduate level courses. Deficiencies identified by the Admissions Committee will be stated on the student’s admission letter.

## Qualifying Exam

Every student must take and pass a comprehensive, written qualifying examination at the end of the first year. Qualifying exams will be offered at a specified time during the summer and prior to the start of fall classes. The outcome of the exam will be “pass,” “conditional pass,” or “fail.” A conditional pass indicates that a student has significant deficiencies in one of the areas tested. This student would be required to take and pass (B or better) designated course(s) in the following year to “pass” the qualifying exam. Students who fail on the first attempt may retake the exam at the next scheduled date. Students who fail twice are released from the Ph.D. program. By passing the qualifying exam, the students demonstrate that they understand materials and their properties from the atomic to the macroscopic levels and have familiarity with the growing set of materials fabrication, assembly, processing, characterization, and modeling tools and techniques.

## Candidacy Examination

After passing the qualifying exam and typically before the start of a student’s third year, the student will take a candidacy exam. By passing the candidacy exam, the student demonstrates that he/she can both: conceive, plan, and design an original and creative research project on a topic important to advancing understanding in MatSci; and communicate effectively both orally and in writing.

The candidacy exam will consist of two parts: (1) a written proposal describing the student’s intended dissertation research; and (2) an oral defense of the proposal to the student’s doctoral committee. The defense will include an open seminar followed by a closed interview/examination by the Committee that can cover a broad range of topics related to the proposed dissertation research.

The outcome of the candidacy exam will be either (1) full pass; (2) conditional pass; or (3) fail. Full pass enables the student to advance to candidacy with no further programrequirements remaining other than the dissertation and annual meetings with the committee. A conditional pass will be awarded if the committee feels that the student is lacking knowledge in a specific area that is vital to the proposed research.

The committee may recommend specific requirements for the student to fulfill in order to successfully advance to candidacy. These requirements may include taking (and passing) an additional course; preparing an appendix or response to questions that arose about the proposed research’s viability; and/or reconvening with the committee for a second oral examination.

## Dissertation

A written dissertation must be prepared, submitted, presented, and defended. The dissertation must be based on original and independent research conducted by the student under the guidance of the graduate supervisory committee. The dissertation must demonstrate the candidate’s ability to address a major intellectual problem and to propose meaningful questions and hypothesis through the mastery of research methods, theory, and tools of the discipline.

An oral, public defense of the dissertation is required and is scheduled for a minimum of 2 hours. A copy of the dissertation is given to the department and copies are placed in the three participating campus libraries.

### Graduate Faculty Supervisory Committee

With input from the student, the MatSci Leadership Council will recommend the committee composition for each student. The committee will have at least five members, including at least one faculty member from a collaborating campus and one member appointed by the graduate dean of the campus where the student is enrolled. The committee chair (the student’s advisor) must be a member of the graduate faculty that is approved to chair dissertation committee in the Materials Science program. A majority of the faculty committee must be MatSci faculty, however, academic professionals, research scientists, industrial professionals and other non-MatSci faculty may serve on doctoral supervisory committees with approval of the graduate director and the Graduate College of the home institution. Students should contact their graduate advisor for instructions for approval and assignment of such individuals to the committee.

## Registration Requirements and Financial Support

Financial support is reserved for students enrolled for 6 or more credits in an academic term and full-time students receiving financial support are expected to register for at least 6 credit hours per semester. In general, students will be eligible for no more than 12 semesters of financial support.

The Ph.D. program offers a standard total financial support package to students in the program. There may be variability based on whether the student has attained candidate status, but not based on the home institution or type of support. In accordance with BOR 940.31, Ph.D. students will be identified as GTA/GRA and be charged the in­state tuition rate. The tuition may be covered by each campus with some combination of waivers, grant funds, and other funds (institutional fellowships, endowment income, industrial funding, etc). Fees are the responsibility of the student and follow the policies and rates of the home institution.

Students in the program are eligible for financial support during the summer, without being enrolled, provided they were enrolled and eligible for financial support the previous spring term, have not yet completed the degree, and are working on their research.

### Optional Off-Campus Activities in Support of the Student’s Research

Students have the option to participate in a collaborative research activity at affiliated University Research Center, national laboratory, or industrial site. Students may complete one or more collaborative projects hosted by industrial partners, national laboratories, or Centers of Excellence, typically involving a project of at least 4 months duration (one semester). However, the dates of the residency at the host location need not align with the start and end dates of an academic semester.

Such projects will be reviewed by the student’s committee, which will determine—in consultation with the student and the sponsor/host—whether the project is suitable as the dissertation project or as a component of the dissertation. These opportunities are primarily considered a means to augment the student’s graduate education and research and, therefore, as stand-alone projects are unlikely to have the intellectual and scientific depth expected of a doctoral dissertation.

* Intellectual property and proprietary issues associated with such projects will be addressed by the host organization, the student, and the student’s campus, and will follow the process and policies on that campus related to intellectual property and proprietary work.
* Compensation from the project sponsor/host paid directly to the student will be counted as part of the student’s financial support “package.”
* The project must be summarized in a written report. This report may be the entire dissertation, a chapter in the dissertation, or a separate report.