# The Graduate Program in Physics at Montana State University

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# 1 Synopsis

The Department of Physics grants the degrees Master of Science (M.S.) and Doctor of Philosophy (Ph.D.). The general requirements and policies for these degrees as outlined at the Graduate School's webpage here. Every student should examine this site and be familiar with its requirements.

The main components of graduate study in Physics are:

1. *Graduate coursework in fundamental physics:* classical mechanics, quantum mechanics, electrodynamics, statistical mechanics. A list of Physics and Astronomy graduate courses is given in §A. Course descriptions in physics are here, and in astronomy, here. See §§2-7 for details on program requirements.
2. *Qualifying Exam:* a written exam that assess proficiency in physics at the undergraduate level and preparedness for graduate study. The exam has two parts covering four subject areas and students have two chances to pass each subject area. See §13.1.
3. *Comprehensive Exam.* For the Ph.D., the Comprehensive Exam is a written research proposal and an oral exam that assesses preparedness for graduate Ph.D. research (§13.2). For the M.S., the Comprehensive Exam is an assessment of the student's mastery of their discipline (§13.3).
4. *Written dissertation and oral defense (Ph.D. and Plan A M.S.):* assessment of original and substantive contributions to an area of research. See §14.

The M.S. is typically obtained *en route* to the Ph.D., if a student decides to finish the program with the M.S., or if the student not allowed to continue in the Ph.D. program.

# 2 Ph.D. Degree Requirements

1. Course Requirements – Ph.D.

| | | |
|---|---|---|
| PHSX 594 | Teaching Seminar | 1 cr |
| PHSX 594 | Research Introduction Seminar | 1 cr |
| PHSX 501 | Math Methods and Applications in Classical Mechanics | 3 cr |
| PHSX 506 | Quantum Mechanics I | 3 cr |
| PHSX 519 | Math Methods and Applications in Electromagnetic Theory | 3 cr |
| PHSX 520 | Electromagnetic Theory II | 3 cr |
| **or** ASTR 550 | Radiative processes in Astrophysics | |
| PHSX 535 | Statistical Mechanics | 3 cr |
| Electives | see conditions in §4 | 17 cr |
| PHSX 690 | Doctoral Reading & Research | $\geq$ 26 cr |
| | | $\geq$ 60 cr |

2. dissertation Requirement – An acceptable dissertation is required.

3. Examinations – Qualifying and Comprehensive Examinations are required. An oral defense of the dissertation is also required.

   *Students accepted into the Ph.D. program are encouraged to apply for and be awarded an M.S. degree (under Plan B) while in the Ph.D. program.*

# 3 M.S. Degree Requirements

The Department of Physics grants the Master of Science Degree (M.S.) under two options:

Plan A (dissertation option)

1. *Course Requirements* – A minimum of 20 cr of acceptable course work including:

| | | |
|---|---|---|
| PHSX 594 | Teaching Seminar | 1 cr |
| PHSX 594 | Research Introduction Seminar | 1 cr |
| PHSX 501 | Math Methods and Applications in Classical Mechanics | 3 cr |
| PHSX 506 | Quantum Mechanics I | 3 cr |
| PHSX 519 | Math Methods and Applications in Electromagnetic Theory | 3 cr |
| PHSX 535 | Statistical Mechanics | 3 cr |
| Electives | see conditions in §4 | 6 cr |
| PHSX 590 | M.S. dissertation | $\geq$ 10 cr |
| | | $\geq$ 30 cr |

2. dissertation Requirements – An acceptable dissertation is required.

3. Examinations – The Qualifying Exam and the Comprehensive Exam are required. An oral defense of the dissertation is also required. The Comprehensive Exam and the dissertation defense may be combined and offered simultaneously.

*Plan B (no dissertation)*

1. *Course Requirements* – A minimum of 30 crs of acceptable course work, including:

| | | |
|---|---|---|
| PHSX 594 | Teaching Seminar | 1 cr |
| PHSX 594 | Research Introduction Seminar | 1 cr |
| PHSX 501 | Math Methods and Applications in Classical Mechanics | 3 cr |
| PHSX 506 | Quantum Mechanics I | 3 cr |
| PHSX 519 | Math Methods and Applications in Electromagnetic Theory | 3 cr |
| PHSX 520 | Electromagnetic Theory II | 3 cr |
| **or** ASTR 550 | Radiative processes in Astrophysics | |
| PHSX 535 | Statistical Mechanics | 3 cr |
| Electives | see conditions in §4 | 13 cr |
| | | 30 cr |

2. DISSERTATION REQUIREMENTS — None.

3. EXAMINATIONS – The Qualifying Exam and the Comprehensive Exam are required.

# 4 Electives

A. Electives will include lecture courses in Physics and Astronomy, and supporting fields (e.g., Math, Computer Science, Engineering) at the 400 level and 500 level. At least half of the elective credits must be in Physics or Astronomy.

   (a) For Ph.D. students, at least 9 credits of electives must be 500-level lecture courses, and at least 6 of them must be lecture courses in the Physics Department.

   (b) For M.S., Plan A students (dissertation option), the 6 credits of electives must all be 500-level lecture courses.

   (c) For M.S., Plan B students (no dissertation), at least 9 credits of electives must be 500-level lecture courses. No more than 4 elective credits requirements may be at the 400 level.

B. The following courses do not count toward electives: PHSX 320, 423, 425, 446, 461, 462, 490, 492, 494, 589, 590, 689, 690.

C. Physics 591 (Special Topics) is allowed as an elective to a maximum of 6 credits.

D. Physics 592 (Independent Study) is allowed as an elective to a maximum of 3 credits for an M.S. Program and 6 credits for a Ph.D. Program. These credits must be letter graded. They are not considered lecture courses.

E. No more than 2 credits of non-required, pass/fail seminar courses are applicable as electives.

F. Only 4 course-work credits must be taken beyond a M.S. *en route* to the Ph.D.

All elective courses must be approved by the student's Doctoral Committee and the Physics Department Head. This approval will ensure that the electives represent a coherent block of study that give the student a broad education in graduate-level Physics.

# 5 Coursework in the First Year

The following schedule of coursework is typical in the first year. Students with admission provisions or graduate credit from another program might be on a different schedule.

| Fall | Spring |
|---|---|
| PHSX 501 (3 cr) | PHSX 519 (3 cr) |
| PHSX 506 (3 cr) | PHSX 535 (3 cr) |
| PHSX 594 (Teaching Sem., 1 cr) | PHSX 594 (Res. Intro. Sem., 1 cr) |

A student should expect to spend 3 hours/week/cr fulfilling lecture course requirements - 18 hours/week for the above schedule.

# 6 Research Course Credit

Course credit for research is recorded in PHSX 592 (Independent Study), 689 (Doctoral Reading and Research), and 690 (Doctoral dissertation). "Doctoral standing" is achieved when a student passes the Ph.D Comprehensive Exam. The following conditions apply to elective courses:

A. Students can take PHSX 689 (Doctoral Reading and Research) only after passing the Qualifying Exam and before passing the Comprehensive Exam; *6 credits of PHSX 689 can be counted towards 26 dissertation credits.*

B. Students can take Physics 690 (Doctoral Thesis) only after passing the Ph.D. Comprehensive Exam. This course is intended for students performing doctoral research.

# 7 Other Requirements and Expectations

First year graduate students are required to register for:

1. A one-credit teaching seminar (PHSX 594-01, fall semester).
2. A one-credit research seminar (PHSX 594-15, spring semester) designed to acquaint the students with the various research areas in the department. These seminars will be presented by persons active in those areas and are designed to aid a student in identifying the particular area or areas they would like to pursue.

## 7.1 Graduate Student Teaching

Teaching experience is an important component of graduate students' education and their preparation for future careers. Typically, graduate students are supported as Graduate Teaching Assistants (GTAs) during their first two years. GTAs are generally assigned 19 hours per week of work for duties such as leading lab sections, grading, and meeting with students in the help center. GTAs are not expected to be "instructors of record", i.e., to have the responsibility for preparing an entire course, syllabus, lectures, course materials, etc. However, in exceptional circumstances, students in advanced standing may request this opportunity. The Graduate School has more information to help you be a successful GTA.

### 7.2 Graduate Student Research

In addition to taking formal courses, a student in their first two years of study is expected to be making progress in a research project under the supervision of a research advisor.

The training of Ph.D. candidates in physics goes beyond formal coursework and the doctoral research project. The department runs several informal activities that are aimed at giving students experience with giving professional talks and reading the scientific literature. Graduate students are urged to enroll in seminars of their choice to obtain more in-depth knowledge of particular areas.

Graduate students are also required to attend department colloquia and should take advantage of opportunities to meet with colloquium speakers.

Students in the Ph.D. program are expected to attend regional, national and/or international conferences during their tenure as graduate students. Students are especially encouraged to attend conferences at which they will make research presentations.

The doctoral degree in physics requires students to write and defend a dissertation that presents the results of independent research. To progress to that point, each student must first pass the Comprehensive Examination (§13.2) to become a Doctoral Candidate.

After passing the Comprehensive Examination, students should typically enroll each semester in 6 credits of PHSX 690 – Doctoral dissertation and spend a minimum of 18 hours per week (3 hours/credit x 6 credits) on their research based on MSU recommendations for study time, plus an additional 19 hours per week for their work as a Graduate Research Assistant (GRA).

## 8 Doctoral Committee

The Doctoral Committee advises the student on academic matters and is the examining committee for the Comprehensive Exam and the Dissertation Defense.

Committee Appointment Deadline – The doctoral committee composition must be submitted to The Graduate School **by the end of the student's first year in the graduate program**. For a research Master's degree (i.e. those with a dissertation or a research paper), the same rule applies.

Committee Chair – A tenured or tenure-track faculty member serves as the chair of the student's Doctoral Committee and acts as a channel of communication between the student and the Physics Department. A student may instead elect to have two co-chairs, with at least one being tenured/tenure-track faculty. In the event that the student does not select a chair of their Doctoral Committee within the first term of attendance as a graduate student, the Department Head will appoint a temporary advisor by the end of the student's first semester in the program. This advisor will advise the student until a tenured or tenure-track faculty member is selected as chair of the Doctoral Committee. The student must find their doctoral advisor by the end of their first year.

Committee Composition – Committees should be formed in the best interest of the student. A research doctoral committee is composed of a minimum of four members. For a research master's (i.e. those with a dissertation or a research paper), a master's committee is composed of a minimum of three members. The majority of the committee and the committee chair should be from the degree-granting academic unit or be affiliated with the academic unit. The chair must hold a doctoral degree. The Doctoral Committee chair and the academic unit head recommend the committee composition to The Graduate School. Final approval of committee composition rests with The Graduate School.

Non-tenure Track Committee Members – Committee members not holding tenure or tenure-track faculty status at MSU, including people from outside MSU, must be approved by the Department Head. In some cases, these committee members may act as co-chair of a student's committee.

Changes to the Committee – The student may make changes to their committee, using the Doctoral Committee Revision form. Committee makeup should not be changed simply to accommodate short term scheduling issues.

Mandatory Annual Meetings – Each graduate student is required to hold annual meetings with the student's Doctoral Committee to discuss progress and plans for completion of the dissertation. The meetings will also serve as a regular source of input from other members of the committee. The student is responsible for scheduling the committee meeting.

The annual meetings are encouraged once a student joins a research group and has formed a Doctoral Committee, but become mandatory beginning with the spring term of the student's second year in the program, that is, prior to the student starting their third year.

The graduate student will discuss the planned timeline and progress on the dissertation at the meeting. After the meeting, the dissertation advisor will submit a summary letter to the Department Head, with copies to the student and other members of the committee, prior to the end of that spring semester. Failure to do this will delay initiation of the GTA or GRA appointment for the following fall term. Questions regarding this policy should be brought to the Department Head.

# 9 Program of Study

The program of study acts as a contract between the student, the Department, the College, the Graduate School, and the University. The program of study defines the minimum requirements for the degree. Approval of a program of study is a two-step process. The first step is the submission to The Graduate School and the second step is a review by the Office of Degree Programs and Certificates.

The student's Doctoral Committee work together to develop the Graduate Program of Study. **Once a listed course is taken and graded, it cannot be removed from a program of study.** Courses applied toward one degree may not be used for another. Exception: the graduate committee may recommend that up to 30 credits obtained from a Master's degree can be applied to a doctoral degree.

Students may take classes beyond those listed on their program of study. Other requirements as determined by the student's Ph.D. committee may also be listed.

Program Approval — The program of study must be recommended by the Doctoral Committee Chair and Department Head. Final approval rests with The Graduate School.

Filing Deadlines — The program of study must be submitted on an official Program of Study form to the Graduate School by the end of the student's second semester of graduate attendance. A one-time fee is associated with the filing of this form. See here for more information.

A student must have an approved program of study and committee form on file with the Graduate School prior to sitting for any portion of the Comprehensive Examination or Dissertation Defense.

Changes to the Program of Study — The program of study may be amended through the course of the student's graduate study. Changes to a student's program of study must be made through the Program of Study Revision form and recommended by the Doctoral Committee Chair and Department Head. Final approval rests with The Graduate School. No fee is associated with this form.

# 10 Second-year Review

In spring of student's second year, the student's Doctoral Committee will convene to assess progress toward degree. **This meeting is mandatory**. The committee will consider: 1) course grades, 2) performance on the Qualifying Exam, and, 3) research. By this time, it is expected that the student will have:

- maintained a GPA of at least 3.0 in coursework with passing grades (B-) in core graduate courses, i.e., PHSX 501, PHSX 506, PHSX 519, PHSX 520 or ASTR 550, PHSX 535. A B- or higher is expected in any courses taken as electives.
- passed all Qualifying Exam subject areas.
- made a satisfactory start in research.

The student will give a 20-minute presentation describing progress in research.

The committee makes recommendations and can impose requirements for the student to proceed in the program; see §12. No later than the following annual review, the committee will determine if the student has fulfilled requirements put in place in the Second-year Review. A student who is not making satisfactory progress toward degree (as determined in the second-year and subsequent reviews) could be dismissed from the program. The second-year review could take place as the student's annual meeting or a separate meeting.

Exceptions – Exceptions to the timelines for the Qualifying Exam and Second-year Review might be permitted if the student has unusual circumstances (e.g., medical problems, a family emergency, or other hardship) upon petition by the student to their Doctoral Committee.

Grade Requirements – Graduate coursework for all graduate degree-seeking students will assess proficiency in advanced topics, techniques, and concepts in Physics. Graduate students are required to receive a minimum grade of B- in all courses that are listed on the Program of Study and maintain a minimum average GPA of 3.0 to fulfill the coursework requirement for their degrees. Note that the Physics Department minimum grade requirement is more stringent than the requirement set by the Graduate School.

# 11 Second-year Review Checklist

The following checklist will be filled out by the student's Doctoral Committee during the mandatory second-year review. For purposes of this checklist, "graduate core" refers to PHSX 501, 506, 519, 535, and 520 **or** ASTR 550.

| | | |
|---|---|---|
| Graduate GPA $\geq 3.0$? | ☐ yes ☐ no | |
| B- or higher in graduate core | ☐ yes ☐ no | |
| Course grades: | | |
| | PHSX 501 | ____ |
| | PHSX 506 | ____ |
| | PHSX 519 | ____ |
| | PHSX 535 | ____ |
| | PHSX 520 or ASTR 550 | ____ |
| All Qualifying Exam subject areas passed? | ☐ yes ☐ no | |
| Scores in Qualfying Exam subject areas (P/F): | | |
| | Classical Mechanics | ____ |
| | Quantum Mechanics | ____ |
| | Electricity & Magnetism | ____ |
| | Thermal & Statistical Physics | ____ |
| Is the initiation of research satisfactory? | ☐ yes ☐ no | |

# 12 Remediation

In the mandatory second-year review (see §10), the student's performance on the Qualifying Exam, in graduate coursework, and in research are all assessed by the student's Doctoral Committee. If major deficiencies are identified, the Doctoral Committee will recommend: i) dismissal from the program or, ii) a process of *remediation*.

If the student is found to be deficient in coursework, the Doctoral Committee should recommend a course of action for the student to improve their grades, which may consist of retaking courses.

If there is lack of progress in research, the committee should define a course of action to address the problem.

If more than one qualifier subject area remain unpassed, the student will ordinarily be dismissed from the Ph.D. program. Special consideration might be given in unusual situations, for example those that require change to the exam timeline, or if the student has exceptional performance in both graduate coursework and research. Any unpassed qualifier subject area should be remediated, ordinarily by taking an appropriate undergraduate course from the following list, and obtaining a grade of B+ or higher:

- PHSX 320 (classical mechanics), offered every fall.
- PHSX 462 (quantum mechanics II), offered every spring.
- PHSX 425 (electricity and magnetism II), offered every fall.
- PHSX 446 (thermodynamics & statistical mechanics), offered every spring.

Classes taken prior to exhausting all Qualifier attempts cannot be used as a substitute for taking the exam and cannot be used as remediation retroactively. If the corresponding class has already been taken, the Doctoral Committee will administer an additional oral exam in the unpassed subject area(s), which might also have a written component. A member of the Qualifying Exam committee is required to be present at

this exam to offer advice to the committee. In no case will the student be allowed to retake the Qualifying Exam a third time. Independent study coursework may not be used for remediation.

It is the responsibility of the Doctoral Committee to define and implement a remediation plan, if any, including goals and timeline. A recommendation to remediate must be justified in writing, signed by all members of the committee, and approved by the Department Head. The Department reserves the right to suspend GTA support for students that do not meet the standard expectations in basic physics knowledge.

# 13 Graduate Examinations

## 13.1 Qualifying Examination

All M.S. and Ph.D students are required to demonstrate competence in fundamental physics at the advanced-undergraduate level, by passing the Qualifying Exam. The Qualifying Exam provides a student an opportunity to solidify their command of fundamental physics.

The Exam – The Qualifying Exam is at the upper-division undergraduate level. The exam tests four subjects: 1) classical mechanics, 2) quantum mechanics, 3) electricity and magnetism, and, 4) statistical/thermal physics. Each subject must be passed for M.S. and Ph.D. students.

The Qualifying Exam is in two parts:

- Part A: classical mechanics and quantum mechanics, given in August.
- Part B: electricity and magnetism, and statistical/thermal physics, given in January.

Grading – Three problems are given in each subject area, of which two must be passed. Subject areas can be passed separately, and need not be repeated when passed.

Timeline – A student will have two opportunities to take each part of the Qualifying Exam before spring semester of the student's second year.

Study Recommendations – Students should review classical mechanics and elementary quantum mechanics before arriving at MSU to prepare for Part A of the Qualifying Exam.

More information about the Qualifying Exam, including specific topics and previous exams, can be found at here.

## 13.2 Ph.D. Comprehensive Examination

After passing the Qualifying Exam, and making the first steps in research, Ph.D.-seeking students are required to pass the Ph.D. Comprehensive Exam. The goal of the exam is to establish the student's research direction as soon as possible, to establish a channel for assistance from the student's Doctoral Committee, and to ascertain that the student has the necessary background to proceed. The Ph.D. Comprehensive Exam has two components:

1. A brief written Research Proposal, describing the student's research progress, with a proposal for future work, submitted to the student's Doctoral Committee. The Research Proposal should give the relevance of the past and future work, with an appropriate bibliography. The Research Proposal

should convey the student's current research trajectory; it could be entirely based on an initial research project, and need not describe a dissertation topic. It is appropriate and expected that the Research Proposal will be developed collaboratively by the student and the student's advisor. As a guideline, the research proposal should be about 5 pages in length, 12 pt font, single-spaced.

2. An oral defense of the Research Proposal before the student's Doctoral Committee. After a 30-minute seminar, the student will be examined by the committee. The committee will probe the student's understanding of the fundamental physics and intellectual context of the research topic. The seminar portion of the oral defense can be open to the public, under the discretion of the student's advisor.

Timeline – The first attempt at the Comprehensive Exam must take place before the end of spring semester of the student's third year. If the exam is failed, the student may retake the exam 6 months later. The Comprehensive Exam can be taken only after the Qualifying Exam is passed. An extension to this timeline may be granted by petition to the student's Doctoral Committee and the Department Head.

Grading – Through the written research proposal and oral presentation of the research proposal, the graduate student must demonstrate a comprehensive knowledge base that is suitable to conduct the proposed research as judged by the Doctoral Committee. The student's performance will be graded pass/fail. Passing or failing grades are determined by the majority vote of the Doctoral Committee. The outcome of the Ph.D Comprehensive Exam will be communicated by the Doctoral Committee to the Department Head.

The passing of this Comprehensive Exam fulfills the Comprehensive Examination requirement of the Graduate School for a doctoral degree and is subject to all conditions and requirements set forth by the official policies of the Graduate School.

Deadline – The Comprehensive Exam can be scheduled any time after passing the Qualifying Exam, with the first attempt occurring **no later than end of spring semester of the student's third year**. Postponement of the Comprehensive Examination beyond this time is granted only in exceptional cases. Requests for postponement must be submitted to the student's Doctoral Committee by the student's advisor at least two months before the deadline. The Comprehensive Examination may be repeated once, six months after the first attempt.

Expiration – According to the Degree Requirements of the Graduate School, the results of any department's comprehensive examination "[are] valid for five (5)[1] years from the term of successful completion." When the successful results of a student's Physics comprehensive exam are deemed to have lapsed, the student's Doctoral Committee will administer an ad hoc re-examination. This will take the form of an oral exam by the entire committee and will serve to re-validate the results of the entire Physics comprehensive examination. The content of the exam will be set by the committee and may focus on topics relevant to the student's dissertation research. The oral exam may be counted as the annual meeting of the student's committee required by the Physics Department. If it occurs, it must occur before the student schedules a dissertation defense, and a passing result in the re-examination is required prior to scheduling the Dissertation Defense.

## 13.3 M.S. Comprehensive Examination

Plan A – Passing the Physics Comprehensive Examination covering the dissertation and related areas (as described above) fulfills the Comprehensive Examination requirement of the Graduate School for M.S. degree-seeking graduate students under Plan A.

Plan B – The Comprehensive Exam for M.S. degree-seeking graduate students under Plan B is based on the student's aggregate performance in the five core physics courses. Passing this Comprehensive Exam fulfills

[1]The Physics Department has an exception to this policy which allows validation for six (6) years from the term of successful completion (per Dr. Karlene Hoo, Graduate School, 2/13/15).

the Comprehensive Examination requirement of the Graduate School for a master's degree and is subject to all conditions and requirements set forth by the official policies of the Graduate School.

Format – The degree committee for the student will review that student's coursework performance in the five core physics courses: Math Methods and Their Applications in Classical Mechanics, Quantum Mechanics I, Math Methods and Their Applications in Electromagnetic Theory, Statistical Mechanics, Electromagnetic Theory II (or Radiative Processes in Astrophysics).

Timeline – Students must pass the Qualifying Exam at the Master's level before being considered for the Comprehensive Exam.

Grading – A student who has achieved a B average or higher in the standard first-year graduate courses, and no lower than a B- in any individual course, will be deemed to have passed the M.S. Comprehensive Examination.

Deadline – The conditions for a passing grade for the Comprehensive Exam for M.S. degrees must be met by the end of the second year of graduate studies.

# 14 Dissertation Defense

For both the Ph.D. and Plan A M.S. degrees, a final oral examination is conducted by the student's Doctoral Committee to assess the research contributions of the student. The passing of this dissertation Defense fulfills the Defense of dissertation requirement of the Graduate School for a doctoral or master's degree (as applicable) and is subject to all conditions and requirements set forth by the official policies of the Graduate School.

Format – The graduate student must present and defend the doctoral or master's dissertation to the committee in a manner that demonstrates the student's original contributions to the work and expertise in the area of research. The oral defense will consist of a public presentation that is followed by a closed-door examination that is conducted by the graduate student's Doctoral Committee. Graduate committee members must receive a draft of the dissertation or dissertation at least 14 business days before the scheduled defense.

Timeline – This examination takes place after the dissertation has been submitted.

Grading – Through the written dissertation and oral presentation, the graduate student must demonstrate original research contributions as judged by the Doctoral Committee. Passing or failing grades are determined by the majority vote of the Doctoral Committee.

# 15 Physics Departmental Financial Guidelines

Most students admitted to advanced degree programs in the Physics Department are awarded financial aid, in the form of research or teaching assistantships, fellowships, and fee waivers. To receive financial aid, a student must satisfy the requirements of the Graduate School as listed on their webpage, as well as requirements of the Physics Department given below. Satisfaction of these requirements does not guarantee financial aid, although it is the policy of the Physics Department to support as many qualified graduate students as permitted by the available resources. Limited financial assistance is offered in the summer. For foreign students, continuation of financial aid beyond the first year is contingent upon satisfactory performance in spoken English as well. Also see here.

Credit Requirements – Students receiving financial aid must be registered for a minimum of 9 credits during the academic year, unless instructed otherwise by the Department Head. Exception: during the year in which a student plans to establish residency, domestic students should register for 6 credits in order to earn state residency and reduce fees. This will typically occur during a student's 3rd or 4th academic year.

Grade Requirements – Financial aid may be revoked if a student's cumulative grade point average (GPA) falls below 3.0; graduate standing may also be removed in this case. See here.

The Department of Physics defines a passing grade for required graduate level classes to be a B- or better. A student receiving a C+ or lower is considered to have failed the required class and must retake the class when it is next offered. Questions regarding this policy should be brought to the Department Head.

M.S. Candidates – Candidates for the degree of M.S. in Physics will generally be granted a maximum of two years of financial aid including summers. Note that all specific course requirements for this degree can be satisfied in one year. Exception: students selecting the Plan A (dissertation) option may apply for research assistantships for up to one academic year beyond the second year of study; generally, teaching assistantships will not be awarded after the second year.

Ph.D. Candidates – Financial aid will be continued beyond three years only if the written Ph.D. Comprehensive Exam is passed by the second attempt.

Time Restriction for GTA Support – GTA support normally will not continue past a student's 7th year in the program. To request GTA support for semesters after the 7th year requires a letter from the sudent's graduate advisor to the Department Head describing the circumstances that justify the continued GTA support for the student.

Applying for Fellowships – Students are encouraged to talk to their advisors about applying for fellowships and scholarships from the Graduate School and external funding agencies.

# 16 Important Milestones and Checklist for the Ph.D. and Dissertation-option M.S. Degrees

| Milestone | Deadline |
|---|---|
| 1. Find a research advisor | Spring of 1st year |
| 2. Submit M.S. Committee composition to Graduate School | End of spring semester, 1st year |
| 3. Submit M.S. Program of Study to Graduate School | End of spring semester, 1st year |
| 4. Submit Doctoral Committee composition to Graduate School | End of spring semester, 1st year |
| 5. Begin research project | Summer after 1st year |
| 6. Submit Ph.D. Program of Study to Graduate School | Before fall semester of 2nd year |
| 7. Complete Qualifying Exam | January of 2nd year |
| 8. Comprehensive Exam | Before end of spring semester, 3rd year |
| 9. Submit dissertation to Doctoral Committee | 14 business days prior to defense date |
| 10. Defend dissertation | 14 business days prior to end of term |

The candidate must file a graduation application form with the graduate school in the term of intended graduation. The application deadlines are September 20 for fall term, February 5 for spring term, and June 10 for summer term.

For the M.S., Plan A track, a comprehensive examination and dissertation defense are required. These may be combined and offered simultaneously.

# 17 Housing and Residency

A limited amount of on-campus graduate housing is available at affordable rates with month-to-month contracts. Interested incoming students should apply as soon as they are admitted to the program. For more information, see here.

Graduate students who are not Montana residents should take steps to become legal residents of the State of Montana, to avoid paying nonresident fees in subsequent years. These students should register for a maximum of 6 credits per semester in the year (probably, their 3rd or 4th year) that they plan to establish residency. More information can be found here.

# 18 University Policies & Procedures

For all other University Policies & Procedures, see here, where you will find MSU policies relating to everything from Academic Affairs to Technology Transfer. You are advised to pay particular attention to all policies listed under Student Affairs, and otherwise familiarize yourself with all other policies that are available to you here.

# 19 Code of Conduct

As professional scientists and educators, a safe, constructive, healthy, and supportive work and learning environment is essential to our success. In the MSU physics department, we have clear professional expectations for ourselves and our colleagues. Promoting a safe, constructive, healthy, and supportive work and learning environment is the responsibility of everyone within the department, including faculty, staff, graduate students, and undergraduate students.

- All students and university personnel are required to adhere to the Montana State University policies and procedures on Discrimination, Harassment and Retaliation.
- Both graduate and undergraduate students are required to adhere to Montana State University's Student Code of Conduct.
- Faculty, staff, graduate research assistants, graduate teaching assistants, and administrators are required to adhere to Montana State University's Ethical and Professional Standards.

The University policies are here.

# A Graduate Course Offerings

A list of graduate courses offering in physics and astronomy is given here for reference. See also the course catalog.

### Required Courses

PHSX 501 – Mathematical Methods and Their Applications in Classical Mechanics

PHSX 506 - Quantum Mechanics I

PHSX 535 - Statistical Mechanics

PHSX 519 - Mathematical Methods and Their Applications in Electromagnetic Theory

PHSX 520 - Electromagnetic Theory II†

ASTR 550 - Radiative Processes in Astrophysics†

†The student must take at least one. If the student chooses to take PHSX 520, ASTR 550 may serve as an elective, and vice versa.

### Electives

ASTR 560 - Stellar Astrophysics

ASTR 561 - Astrophysics of Galaxies

PHSX 507 - Quantum Mechanics II

PHSX 516 - Experimental Physics

PHSX 523 - Introduction to General Relativity

PHSX 524 - Advanced General Relativity

PHSX 525 - Gravitational Wave Astronomy

PHSX 531 - Nonlinear Optics/Laser Spectroscopy

PHSX 544 - Condensed Matter Physics I

PHSX 545 - Condensed Matter Physics II

PHSX 555 - Quantum Field Theory

PHSX 564 - Current Topics in Space Physics

PHSX 565 - Astrophysical Plasma Physics

PHSX 566 - Mathematical Methods for Theoretical Physics

PHSX 567 - Computational Physics

### Research Courses

PHSX 589 - Graduate Consultation

PHSX 590 - Master's dissertation

PHSX 591 - Special Topics

PHSX 592 - Independent Study

PHSX 594-01 Teaching Seminar

PHSX 594-15 Research Introduction Seminar

PHSX 689 - Doctoral Reading & Research

PHSX 690 - Doctoral dissertation