



BROWN
Department of Physics

**HANDBOOK ON
THE DOCTORAL PROGRAM
IN PHYSICS AT BROWN**

These notes are addressed to all current and incoming PhD students in Physics, to be used as a planning guide in the first year and as a progress checklist and reference resource throughout the PhD years. The Graduate School and pertinent University web resources should be regarded as the primary references for degree requirements and options.

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A. INTRODUCTION

The aim of the Doctoral Program in Physics is to train professional physicists grounded in the fundamental principles, facts and methods of the discipline who are able to plan and execute original investigations leading to new and useful knowledge. The program is not career-oriented or slanted toward specific fields of specialization. The temporary specialization demanded by a student's research is conceived as a part of the academic experience and, in many cases, will be abandoned upon graduation, entailing neither loss nor waste. Similarly the Doctoral Degree in Physics imposes no career commitment. It certifies a command of certain intellectual tools of broad validity and physics' modes of thought as well as a facility in attacking the unknown. Of course, it enables one to practice research and/or teaching in Physics.

These aims underlie the two broad phases of the graduate program: courses and research. The intent is to retain the maximum of individual freedom which is consistent with attainment and demonstration of a professional level of competence in both phases. The system of grades, examinations and associated requirements has three functions: to certify achievement of the program objectives, to monitor progress toward them, and to identify students of highest promise and accomplishment in a systematic way. They are meant to protect the University against devaluation of its degrees, the student against an unprofitable investment of time and effort, and both against the ineffective distribution of limited resources for financial support.

Faculty members are willing and able to give information, advice and assistance at all stages of graduate work. They have a real interest in the individual student, a stake in his/her present progress and future career, and respect for his/her privacy and dignity as a person. The student/faculty ratio has remained low, contact is meant to be informal and unconstrained, and each student should come to know and be known by a number of faculty members in a short time. The number and effectiveness of these interpersonal contacts depends largely on the student's own initiative. In general, faculty members will not seek a student out but will welcome him/her.

B. ADVISING & COMMUNICATION

The Department has a tradition of relaxed and informal interaction among its faculty members and graduate students. We count this tradition as one of our assets and consciously seek to preserve it, to do so we rely on student initiative and participation. In-course contact, seminars, and colloquia are natural occasions for students to become acquainted with faculty members.

Equally important is the communication among graduate students at various levels of advancement. The grapevine is a unique and important source of information which should not be neglected. Students should not hesitate to ask other students questions and to utilize the many student resources available, including mentoring and graduate student coffee hour.

Formal mechanisms for faculty advising are as follows: one faculty member is designated Director of Graduate Studies (DGS), who chairs a Graduate Advising Committee. The responsibilities of the DGS and this committee include:

- maintaining an open line of communication with the faculty as a whole on matters of general or individual concern
- providing individual advising (available at all stages but of particular importance in the period before a research affiliation is established)
- ensuring an awareness of each student's progress within the graduate program
- serves as a liaison with the Graduate School (GS)

One member of the Graduate Advising Committee will discuss with each incoming student the choice of the first year course program. This member will continue to advise the student on his/her progress throughout the initial stage of study. This advising will include four scheduled meetings during the first year in the program. Once an association with a research supervisor has been established by the student (usually at the end of the first year), the principal advising responsibility shifts to the research advisor.

A member of the department administrative staff, the Student Affairs & Programs Manager, is available to assist students with all graduate matters. S/he is the first point of contact for most academic matters. All communications/forms should be cc'd to the Student Affairs & Program Manager to ensure an accurate student file. The Student Affairs & Program Manager regularly sends out information pertinent to the student's academic progress including

- fellowship opportunities and available travel funding as they arise
- professional development opportunities and sessions as scheduled

Grievances

It is our hope that a student does not encounter difficulties with members of the department or university. When a difficulty does arise it is important to know how it is handled. See the webpage describing the process for [Grievances](#) in detail on the Graduate School's website. A synopsis is included here - all students do have the right to a fair and prompt hearing of grievances after the following steps have been followed:

- The first step is always try to resolve an issue directly with the person(s) involved.
- Talk with the Chair of the department and/or the Director of Graduate Study (DGS)
 - The DGS can put a student in contact with other resources within the department, e.g. the Diversity Officer.

If it is an issue outside of the department, the Dean of the Graduate School will be consulted.

C. DIGEST OF PROGRAM AND REQUIREMENTS

In brief, the requirement for a PhD degree in Physics consists of successfully completing the list below. See Appendix B for details.

- Six prescribed core courses
- Four advanced courses, including a 'breadth' course - one course outside of a student's main research area
- Comprehensive examination
- Preliminary examination (oral), and
- an original investigation under the sponsorship of a particular faculty member (research supervisor) leading to a final thesis and a thesis defense examination.

Normally, **the first year** is spent wholly on the prescribed core courses. It is highly desirable that a research field be chosen and, if possible, an understanding reached with a research supervisor before the end of that year.

In **the second year**, students must take the Comprehensive exam, the core courses should be concluded, one or two advanced courses taken in the chosen specialty area, an online ethics tutorial must be completed, and active work begun with a research group.

In **the third year**, formal course work usually ends with two more advanced courses. An independent research project gets underway, thereafter absorbing the student's full effort until it is completed and embodied in the formal thesis. The preliminary examination is taken in the third year; once passed the student advances to candidacy.

Students can earn a **Transitional Master's Degree (ScM)** prior to the PhD. This *transitional* degree recognizes a significant level of academic achievement beyond an undergraduate degree. The ScM degree requires eight courses which usually includes the six core courses (PHYS 2010, 2030, 2040, 2050, 2060, 2140) and two other 2000 level courses, No more than two courses can be research courses. Courses outside the Department may be substituted by permission of the DGS. At least half of the grades in the core courses must be B's or better under the ABC/NC option, or must represent performance of equivalent quality under the S/NC option. (A written recommendation from the instructor will be required in this case.) Ordinarily, a thesis is not required for the ScM but the Department reserves the right to require a thesis in special cases. Such a decision is made no later than one semester after the student announces to the Department Chair his/her candidacy for a Master's Degree in Physics.

Students are required to take a Comprehensive Examination soon after successfully completing each of the core graduate courses. This examination consists of questions from all of the core areas. It provides students with the opportunity to demonstrate a comprehensive understanding of the core areas of physics. Students normally take it at the start of their second year in the program after taking some time to review the core areas. It may be deferred in the case of a first-year program that did not include the normal complement of core courses. See Appendix A for more details.

The **Preliminary Examination**, which should be taken during the third year, evaluates a student's ability to understand and orally convey a physics research topic of current interest. Successful completion of this exam marks a student's formal [Advancement to Candidacy](#).

PROCEDURES FOR THE PRELIMINARY EXAMINATION

- Students are to identify, in consultation with their research advisor by the end of the **second year**, a three person faculty committee, who will serve as their Preliminary Exam Committee. This committee, which will guide and inform the research work of the student over the graduate career and, in most instances, will also serve as the Thesis Defense Committee, should include the research advisor and two other members of the Department. Other members outside the Department can serve on the committee subject to the prior approval of the Director of Graduate Studies, but at least two members of the committee must have appointments in Physics, with one having his/her primary appointment in the Department.
- At least two weeks prior to taking the Preliminary Exam, a student submits an abstract to his/her committee. The abstract provides a brief description (approximately one typed 8-1/2 x 11 page in length) of the topics that the student will present and in which they are willing to be tested during the exam. The topic may be in the area of the student's research or may represent a specific research paper, provided its subject is dealt with in sufficient generality, perhaps preceded by an appropriate introduction formulated by the student.
- The first forty minutes of the exam is devoted to a prepared presentation by the student. He/She should expect questions, based upon his/her graduate coursework and relevant to the topic under discussion.
- A two-thirds favorable vote is necessary to pass. The exam may be retaken as needed.

After the PhD thesis is completed and approved, there is a [Final \(Oral\) Examination](#) – often called **defense of the thesis**. Rules of the Graduate School require that this Final Examination take place within five years after the Preliminary Examination, unless special circumstances justify an extension. The Preliminary and Final Examinations mark the formal beginning and completion of the independent research work. Ideally, the Thesis Defense Committee for the Final Examination will consist of the same faculty who served on the student's Preliminary Exam, though changes can be made in consultation with the research advisor and the Director of Graduate Studies. These faculty members also serve as research and career mentors to the student over the course of his/her thesis work.

An aggregate of three years of full-time study while in residence at Brown is required and is automatically satisfied in the normal program of classroom and research courses. It may be possible to meet part of this requirement by transfer of credit from another institution.

It is the individual student's responsibility to make sure, before appearing for the Final Examination, that all of his/her Departmental and University requirements have been met.

Academic Standing

Every student admitted to the graduate Physics program enters in Good Standing, and it is the expectation and desire of the Physics Faculty that all Physics graduate students will remain in *Good Standing*, completing a PhD

degree. An academic standing of *Satisfactory* indicates the student has encountered some difficulty in the program. A student may be placed on *Warning* due to a serious and/or persistent difficulty. In all cases, the student will be given written notification of academic standing with clear criteria for regaining good standing and the consequences of not correcting the deficiencies. *Termination* indicates problems that can not be resolved. The following criteria define Good Standing and also conform to the standard progress of a Physics PhD graduate student's career at Brown.

Students appointed as Teaching Assistants or Research Assistants are required to take three full courses per semester. Students holding Brown University or U.S. Government sponsored scholarships or Fellowships are required to take four full courses per semester. Reading and research courses may only be taken by first year students either as a fourth course or under special circumstances with permission of the Director of Graduate Studies. Note: Students cannot drop a course without consulting with the Director of Graduate Studies first.

To be in good standing, a student::

- Passes three approved courses each semester if a Teaching Assistant, or four courses if holding a Fellowship, after two semesters of graduate study at Brown; then passes or is excused from taking the remainder of the "core" courses by the end of four semesters of graduate study at Brown and achieves the following core course grade record: no NC's and at least 50% B's or better by the end of two semesters and no remaining NC's or I's and 50% B's or better by the end of four semesters.
- Successfully passes the Comprehensive Examination and receives faculty approval to continue a graduate career in Physics by the end of his or her fourth semester of graduate study at Brown.
- Establishes a plan for financial support with a research advisor who can guide his/her PhD research effort within two semesters of successfully passing the Comprehensive Examination or by the start of his/ her fifth semester of graduate study, whichever comes first. The relationship with the research advisor is expected to remain through the student's PhD study. This relationship and the associated plan of support must be endorsed by the department chair.
- Passes the Preliminary Oral Exam by the end of the sixth semester of graduate study at Brown.
- Satisfactorily performs any teaching and/or research duties.

A student failing to meet at least one of these criteria is not in Good Standing unless a prior exception has been made by the Department Chair in consultation with the Director of Graduate Studies. Examples of exceptional circumstances include illness, inadequate preparation for some graduate courses and/or postponement of the Comprehensive Exam, or personal problems. The Student Affairs and Program Manager will maintain a student's record to include any exception and the relevant reasons given by the Chair and/or the Director of Graduate Studies, a student's course grades, Comprehensive Exam and Preliminary Exam results and current standing.

It is expected that all core courses will be taught and taken ABC/NC. For any Physics graduate student who passes a core course with an S, the instructor will prepare an evaluation form for the Chair. The evaluation will include an equivalent ABC letter grade for use in establishing standing.

It is anticipated that students in Good Standing will continue. It is also anticipated that in addition to the requirements in Section A. above, students will perform satisfactorily in all courses. Records of course grades will be kept by the Director of Graduate Studies, who will inform the faculty if an advanced graduate student (third year or beyond) is not doing satisfactorily in courses. At an appropriate meeting, the Physics Faculty will discuss the performance of graduate students. Those fulfilling the above criteria are assured automatic Good Standing. The standing of those students who do not meet these criteria will then be discussed by the Faculty.

In addition, if a student is not in Good Standing, then either:

- the Department Chair, after consultation with the Director of Graduate Studies and the student's research supervisor, may discontinue the student's support as a teaching assistantship or research assistant
- or the research supervisor, after consultation with the Department Chair and the Director of Graduate Studies, may discontinue the student's research assistantship.

These decisions will be communicated to the student and the Physics faculty in writing as soon as possible.

D. COURSES

The six prescribed **core courses** are:

Physics 2010	Techniques in Experimental Physics
Physics 2030, 2040	Classical Theoretical Physics I & II
Physics 2050, 2060	Quantum Mechanics
Physics 2140	Statistical Mechanics

No student should be asked to repeat work already done, and those who believe they have substantially covered the content of any of the core courses should ask (at their first advising meeting, or of the Director of Graduate Studies at any time) to be excused from taking the corresponding course(s) in the list above. Conversely, significant gaps in undergraduate preparation are sometimes filled by taking one or more 1000-level courses in the first year. Such courses may carry full graduate credit if the grade is B or better, in consultation with the DGS.

Students who have taken graduate courses prior to coming to Brown that are similar to those offered in our curriculum may request transfer credit and/or waiver of associated course requirements.

- A course waiver excuses a student from one of the Department's required courses but does not reduce the total number of courses that must be completed for the degree.
- A course transfer reduces the total number of courses that must be completed for the degree.

To request a course transfer/waiver(s), a student submits to the DGS:

- A written request (email is fine)
- A transcript that shows completion of the course(s)
- Syllabus for each course that includes information about the textbook, scope of course and information about the types of work performed in the course. Examples of a student's work can also be helpful.

Students who enter the PhD program at Brown after having successfully completed the Masters program at Brown may transfer all 8 courses toward their PhD course requirements.

Beyond the core courses, PhD candidates are expected to pass **four advanced courses**, in addition to research courses, to strengthen and update their knowledge of their chosen research fields. At least one of the four courses must fall outside a student's main research area (breadth requirement). See Appendix C for course chart for breadth requirement. The remaining courses required help students along their research path. The student's own taste and the supervisor's recommendations are both vital guides in their selection and it should be possible to accommodate both, these courses are expected to be from the 2000 level. The remaining courses can be courses offered by other departments - subject to the approval of the Director of Graduate Studies. The Department's offerings at this level vary from year to year. The student should consult the Department's annual listing of course announcements. Special courses can sometimes be arranged in response to student requests,

given sufficient numbers and sufficient lead time. Reading courses may be counted towards the advanced course requirement only with approval by the Director of Graduate Studies. However, a generic research course cannot be used to satisfy the advanced course requirement.

The sequence of advanced courses in the various fields of specialization shades almost imperceptibly into the various weekly series of topical seminars and departmental colloquia. These are a major constituent of the graduate program, and regular attendance and occasional participation are expected of each student. They provide not only contact with the current literature but also a first-hand experience in professional Physics research. (It is possible to learn from less exciting visiting speakers as well as the most stimulating ones.)

The normal full-time course load for Teaching or Research Assistants is three courses at a time, and four for others. After the first year, fewer classroom courses are taken and a full-time registration is maintained by the assignment of course credits for research activity (designated PHYS2980/2981). If all core and advanced courses have been taken, registration should be for Research (PHYS2980/2981) at triple credit each semester until 24 tuition credits have accrued. After 24 tuition credits have been accumulated, Thesis Preparation (PHYS2990/2991) is usually the appropriate course to take. A similar adjustment is occasionally made in the first year, e.g., in the cases of foreign students for whom special work in English is recommended (See also: H. FOR INTERNATIONAL STUDENTS). The concept of full-time load is a federally defined prerequisite for the tenure of federal fellowships.

Individual course registrations are submitted online via the University's Banner registration system.

E. THE RESEARCH COMPONENT IN GRADUATE STUDY

Many students enter graduate school without a clear preconception of which specific research field attracts them most strongly. It is an important function of the first year to evoke such a preference through courses, colloquia and seminars, and informal discussions with faculty and other graduate students. The primary aim should be to establish a choice of field before the end of the first year, so that active association with a research group can begin during the first summer at Brown. It is not intended to force a premature choice; changes of direction are possible, but the sooner a reasoned choice can be made and acted upon, the smoother will be the transition from coursework to research. (See also: H. FINANCIAL SUPPORT).

Establishment of a research connection obviously requires not only concentrated thought but substantial initiative on the part of the individual concerned. Three steps are involved:

- learning what kinds of work are going on and, hence, what is available
- estimating what opportunities, duties and daily life might be in those groups of interest
- establishing a personal connection

Colloquia and seminars (especially those specifically related to current departmental activities), and discussions with the Director of Graduate Studies or any faculty member with whom a student has become acquainted will help in the first stage. Students should talk at length with other graduate students and supervisors in the groups that are of interest. The last, of course, is accomplished by a direct approach to the faculty member with whom students would like to work, an expression of their interest, and a request to be accepted as a research student. Students should begin this process well before the end of Semester II of their first year in the program.

The Department aims at giving all possible freedom to every student in the choice of doctoral research, including the right to change fields for good reason. However, practical obstacles may arise, notably, that the preferred research group or groups cannot at that time handle any more students. It is very important that students explore a variety of research opportunities across several fields of physics.

Interdepartmental research projects carried out entirely in a related department are possible in connection with a PhD in Physics. Specific proposals should be discussed, in advance of any commitment, with the advisor as well as with the outside faculty members who may be involved. In such cases a Physics faculty member is associated with the program as liaison, the student is subject to the standard Physics Department requirements, and the final thesis must be approved by both departments involved.

The Department assumes proper PhD research to be of publishable quality, and thesis results are expected to be published in the professional literature. In all stages of the work, the supervisor has the primary role in evaluating the quality of the research. The research proposal may be considered by other faculty members in the student's Preliminary Examination, and the completed project should be approved by thesis readers representing the Department. A member of another department may also act in this role if his/her familiarity with the project is adequate. Usually, the thesis readers will be the same faculty who served on the student's Preliminary Exam Committee, though changes can be made in consultation with the research advisor. The members of the Preliminary Exam Committee can thus be drawn upon for informal counseling while the research is in progress.

F. TEACHING EXPERIENCE AND PROFESSIONAL DEVELOPMENT

Teaching experience is an integral part of graduate study in Physics at Brown, whether or not students serve as teaching assistants. Certainly such experience will be valuable to those who aim toward careers involving teaching, but it is also widely maintained that teaching experience has relevance comparable to that of research in graduate education.

Although more than half of doctoral students in Physics hold teaching assistantships for at least a year (usually the first), the Department will do its best to accommodate students who would choose to teach, either additionally or later in their program. Sessions dedicated to teaching are included in the departmental PhD Orientation at the start of each year. Because students may teach in later years, all first year students, regardless of mechanism of support, are required to attend these sessions.

The University provides a multitude of resources for teaching and [professional development](#), including:

- Sheridan Center for Advanced Teaching and Learning
- [CareerLab](#)
- [Writing Center](#)
- [Center for Language Studies](#)

Students are encouraged to participate in the programs offered, as suits their professional development.

G. STUDENT RESOURCES

In addition to the resources for teaching and professional development, there are many wellness and enrichment University resources available for graduate students. Faculty, deans, administrators, and even your cohorts are devoted to helping you during your graduate school experience. However, it is up to you to take the first step and reach out to these resources! It is especially important to reach out when your academic progress is in peril. Below is a listing of some of the resources available, a comprehensive listing can be found on the [Graduate School's resources](#) webpage.

- [Student and Employee Accessibility Services \(SEAS\)](#) - coordinates and facilitates services for students with physical, psychological, and learning disabilities.
- [Counseling and Psychological Services \(CAPS\)](#) - free, confidential counseling for Brown students is offered Mondays through Fridays during the academic year at the Counseling and Psychological Services office in J. Walter Wilson.

- [Associate Dean of Student Support, Maria Suarez](#) - handles all Graduate Student medical leave requests and any student support services for Graduate students. Office is located in 110 Horace Mann, 401-863-1802

A student should inform the DGS and the department if they have a disability or other condition that might require accommodations or modification of any of the program or course procedures. As part of this process a student should register with Student and Employee Accessibility Services (SEAS). SEAS will provide the students with an academic accommodation letter to be given to instructors.

Diversity and Inclusion Initiatives - The graduate school and the department are engaged in the work of creating a more diverse and inclusive academic community. The 4th floor of the Graduate Center can provide assistance with recording a lived or chosen name change into the University's systems.

The DGS can direct students to the department's representative of the Diversity and Inclusion Action Plan (DIAP) as a resource for questions or concerns

Leave of Absence - If a student feels a leave of absence is necessary during their course of study, the department follows the rule outlined in the graduate school's handbook. For a **medical leave** of absence, students should contact Student Support Services (Graduate Center, 4th floor), and Associate Dean for Student Support, Maria Suarez. All other leaves (**personal, professional development, family, childbirth, and academic - probationary**) require the student to fill out the Graduate School's leave of absence form, and have it signed by the Department chair and program director before sending it to the Graduate School. All forms should be cc'd to the Student Affairs and Program Manager to ensure it is included in the student's record.

H. FINANCIAL SUPPORT

The Graduate School guarantees doctoral students five years of financial support, including a stipend, tuition remission, a health-services fee, and a health-insurance subsidy, contingent upon students maintaining satisfactory academic progress in their programs. This support may take the form of [a teaching assistantship, research assistantship, fellowship, or proctorship](#). All graduate student appointments are typically for the academic year only (September through May) or, in some instances, one semester only. Separate appointments are submitted for the summer. The nine-month, academic year stipend is set by the Graduate School annually and, by present Departmental policy, is the same for all categories of support. Summer funding is guaranteed for four summers, but in some departments, including Physics, the summer funding is provided, not by the Graduate School, but by the Department through departmental funds or faculty research funding. The summer stipend is set by the Department and is contingent upon a number of factors, the minimum summer support is 1/9th of the AY stipend (i.e. one month of support).

In addition to the support available through the University, applicants are encouraged to compete for national and foundation awards available for graduate study. These awards benefit the University, the department and especially the student - in addition to financial support they carry valuable prestige for the awarded student(s). External fellowships awarded in national competition require an application from the student. They are publicized via email communication. Additional information and links on [external funding](#), including the [Graduate School's Incentive Policy](#), can be found on the Graduate School's website. The Graduate School also provides [research travel support](#).

Because they are not yet fully prepared for research, most first-year students in Physics are supported as teaching assistants (TA's). As soon as possible thereafter, students should aim for research assistantships (RA's), which requires a combination of available funding and acceptance into a research project (see Section E above,) as well as external competitive fellowships. Support as a TA for a second year is not guaranteed. A TA's duties are typically in the laboratory component of either an undergraduate or a graduate course. An RA initially goes through the equivalent of on-the-job training, and as soon as possible, progresses to an individual topic expected to culminate in a PhD thesis. In either case, there is a specific faculty supervisor.

Holders of first year fellowships or the equivalent have no assigned duties other than continuation as full-time students taking four courses each semester. TA's and RA's are limited by the rules of the Graduate School to taking three courses each semester.

In keeping with a general aim for the fastest possible progress toward the PhD, consistent with good health and good work, graduate students are expected to work at Brown during the summer. The first summer can be a profitable period of assimilation, with some combination of preparation for the Comprehensive examination teaching experience, and research apprenticeship. In later summers, the uncommitted time is invaluable for research. Brown does not charge tuition in the summer.

Both the Graduate School and the Department invest substantial resources toward the training and professional development of doctoral students over the course of their graduate careers. As such, students are expected:

- to remain in good academic standing,
- to perform well the teaching and research duties associated with their support by demonstrating both ability and effort in those duties.
- to pass, in turn, the Comprehensive and Preliminary Examinations, and to complete the other milestones and benchmarks of the program in a timely manner.
- to engage in research during the summer term as well as the academic year.

I. FOR INTERNATIONAL STUDENTS

The following University offices and programs are devoted to supporting the unique needs of international students at Brown:

- [Office of International Student and Scholar Services \(OISSS\)](#)
- [Center for Language Studies](#)
- [English For International Teaching Assistants](#)

Fluency in English is an important skill for physicists and professionals. The department views participation in the appropriate English for International TA's (EINT) classes (as referred by evaluation) as not only important for professional development but as essential and mandatory while students are serving as teaching assistants. The Department encourages students whose native language is not English to take advantage of the opportunities and assistance provided by the above offices and organizations.

APPENDIX A: The Comprehensive Examination

Purpose of the Comprehensive Examination

To provide students with the learning opportunity afforded by studying for and demonstrating a comprehensive knowledge of the core areas of physics at the level necessary to commence original PhD research that advances physics. The exam also helps the department assess a student's level of physics knowledge and align their individual studies with the stated learning objectives of the PhD program in physics^(*).

Who can take the Comprehensive Examination

Students enrolled in the PhD program in the Department of Physics who have completed 2 semesters of study.

Students who enter the PhD program after successfully completing the Masters program in the Department of Physics at Brown have the option to take the exam at the beginning of their PhD studies, or after they have completed 2 semesters of study.

When is the Comprehensive Examination administered

The Comprehensive Examination is scheduled near the first week of classes each fall semester.

Composition and Duties of the Comprehensive Exam Committee

The Comprehensive Exam Committee (CEC) shall comprise five to six faculty members, including a Chair, appointed by the Department Chair to a one year term. The CEC:

- composes the Comprehensive Examination using questions submitted by physics faculty who usually are not committee members. Each question submitted includes a solution as well as a framework that the question submitter will employ in scoring (rubric).
- reviews all submitted questions, makes suggestions for improving the wording and/or grading rubric of each problem.
- reviews all submitted questions to maintain consistency through the years, and ensures the exam is at the appropriate difficulty level.
- reviews the exam procedures and submits recommendations for any changes to the faculty.

Guidelines Concerning the Comprehensive Examination

A copy of the following guidelines shall be made available to each graduate student of Physics upon entering the program.

When should a student take the Comprehensive Examination?

Under normal circumstances a student is expected to successfully pass the exam at the beginning of their third semester. In special cases a student may consult with the DGS to request a postponement. The decision on such requests will be made by the Department Chair after consultation with the DGS and the student's research supervisor if they have one.

In cases of emergencies the day before or the morning of the exam, the student should notify by email the Chair of the CEC, the Department Chair, and the DGS.

If a student does not successfully pass the exam at the first sitting, the student has the opportunity to attempt for a second time at the next sitting. In unusual circumstances, the Departmental Chair may allow postponement of this second sitting.

If a student does not successfully pass the exam after two attempts, the student will be withdrawn from the program, unless they successfully petition in writing to the Department Chair and DGS to take it for a third time. The decision on this petition will be made by vote of the Departmental faculty, acting upon a recommendation made by an ad hoc committee consisting of the Departmental Chair and the DGS. Factors to be considered in reaching this decision are the student's overall performance in courses, advice from the research advisor, and the previous performance in the Comprehensive Examination. A third unsuccessful attempt to pass the Exam will result in withdrawal from the PhD program in Physics.

Format of the Comprehensive Examination

The Comprehensive Examination is a written exam given on a single day. The exam is 6 hours long, that includes up to a 1 hour break in the middle. During the break, a student can have lunch, but may not interact in any way with other students, and/or use any electronic devices or other resources.

SAS accommodations of this format will be provided for students who need them. Students requiring SAS accommodations must inform the Chair of the CEC and the Student Affairs Coordinator at the time they apply to take the exam.

Each student taking it is given an identifier to make them anonymous. Graders do not have access to the student identification key which is generated and held by the Student Affairs Coordinator.

It consists of pairs of problems in Classical Mechanics, Classical Electrodynamics, Statistical Mechanics and Thermodynamics, and two pairs of problems in Quantum Mechanics. Students are expected to choose one problem to solve from each pair and thus should submit answers to a total of 5 problems. Each problem is graded out of 10. The questions are based on the physical principles discussed in the graduate core courses PHYS 2030, 2040, 2050, 2060, and 2140. The difficulty of the questions is similar to advanced undergraduate/early graduate level.

Preparing for the Comprehensive Examination

A good preparation includes a comprehensive review of the subject matter and problem-solving such as homework problems in the core courses, and problems from past exams (available on the departmental website). Students may find it helpful to form study groups, and the Department can provide space to facilitate such group meetings. The Student Affairs Coordinator can work with students for the necessary arrangements.

Notification of Examination Details

The CEC will set, prior to each exam, the specific timetable for the exam. This includes the grading schedule, the availability of booklets, the Department Faculty Meeting schedule, and the notification date. Students taking the exam will be notified well in advance of this timetable as well as of all other relevant details such as where and when the graded booklets will be available.

Availability of Examination Results

Exam booklets will be anonymously graded by the faculty members who wrote the problems based on the rubric submitted to the CEC and according to the timetable provided to students prior to the exam.

As soon as possible after tabulation of the results, students shall be notified of their grades on the individual written Examination questions. Individual students shall be afforded the opportunity to inspect their graded booklets and the associated grading rubrics in the company of a physics staff member (typically the student affairs coordinator).

Students will have a window of opportunity to submit requests for regrades of specific problems to the CEC. The basis of a regrade request should be the identification of a discrepancy between the work shown and the application of the rubric. The CEC will forward regrade requests to the same faculty member who originally wrote and graded the problem. This process is anonymous. The timeline of such requests will be shared prior to the exam.

Faculty Evaluation of the Examination Results

Once results and regrades are completed, the CEC meets and discusses the outcome of the exam. The CEC also looks for question irregularities (e.g., if a problem was ill-defined) or any other problem that may have been identified during the grading of the exam. The CEC then produces a recommendation for the outcomes of the exam to the faculty.

Voting members of the physics faculty meet to review the exam results in order to render decisions on whether individual students successfully demonstrated a comprehensive knowledge of the core areas of physics. This meeting usually occurs within a week of the exam date.

During the meeting, faculty consider and discuss each student individually.

A student who obtains a grade of 6 or greater on every problem successfully passes the exam without further discussion.

If a student does not earn 6 or more points on one or more problems, the faculty reviews other evidence that demonstrates the student has shown sufficient command of the related material. The supporting evidence most often comes from performance in courses (with course instructor feedback). In addition, the faculty reviews past exam results (when applicable), and from work in a research group (with research advisor feedback). Note: not being part of a research group is never a reason to not successfully pass the exam.

This thorough review provides additional insight into whether a student has demonstrated the necessary comprehensive command of core physics in all 4 areas (Classical Mechanics, Statistical Mechanics, Classical Electrodynamics and Quantum Mechanics). Based on this review, a student may either successfully pass the exam, be asked to retake the exam, or conditionally

pass the exam by being asked to take a course on a topic that faculty may identify as beneficial to the student.

The Chair of the Department can provide a summary feedback of the faculty consensus on the rationale of a decision within a week of the faculty meeting.

Each student's graded booklets will be returned to them soon after the evaluation of the examination results.

Review of Procedures

These procedures will be reviewed annually and revised as needed. Written notice of all changes will be provided to all graduate students in the program.

(*) The Department of Physics is committed to fostering an environment of diversity, equity, and inclusion for every member of our department community, as we strive for excellence in research, teaching, and mentoring.

Learning Objectives

- Students will acquire a general foundational knowledge of physics at the graduate level and the necessary accompanying methodological aspects of mathematics, computing, and instrumentation.
- Students will learn to identify and solve problems at the frontier of physics knowledge, uphold standards of scientific integrity, and disseminate their research.
- Students will become educators and communicators with the ability to promote an understanding and appreciation of physics across the university, in academia, and in society.

(This appendix revised June 2022)

APPENDIX B: PhD Milestones and Guideposts

Year 1:

Guidepost:

- Work toward joining a research group

Milestones:

- Pass 3 courses per semester if a TA or 4 courses per semester if a Fellow with at least 50% B's or better
- Complete 6 core courses (PHYS 2010, 2030, 2040, 2050, 2060, 2140)

Year 2:

Guideposts:

- Begin research
- Complete PHYS2010 (or other core courses) if not taken during Year 1
- Complete at least 2 advanced courses

Milestones:

- Comprehensive examination
- Complete 2nd Year Ethics Training
- Identify prelim committee

Year 3:

Guideposts:

- Continue research
- Complete remaining advanced courses, including a 'breadth' course - outside of a student's main research interest.

Milestone:

- Pass preliminary exam and advance to candidacy

Year 4+:

Guidepost:

- Complete thesis research

Milestone:

- Write and defend thesis

APPENDIX C: Advanced Course Breadth Requirement –Doctoral Program in Physics

Condensed Matter Physics (CMP), including Biophysics	Particles & Fields/High Energy Physics (HEP)	Astronomy/Cosmology (Astro/Cosmo)
1610 / 2630 2340 2410 2420	2070 2170 2200 2300	2100 2280
<p>Beyond the core courses, Ph.D. candidates are expected to pass four advanced courses. At least one of the courses must fall outside a student’s research area (CMP, HEP, Astro/Cosmo). **Students can consult with the DGS about selecting a course that may not be listed above, as some advanced courses not listed may be approved for the breadth requirement.</p>		