Physics Graduate Program Handbook

This document presents the rules and requirements governing the Graduate Program in the Department of Physics at Carnegie Mellon University.
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1 Overview

This document presents the rules and requirements governing the Graduate Program in the Department of Physics at Carnegie Mellon University (CMU). It shall be updated to reflect new rules and requirements that are approved by the Physics Faculty in the future. Additional requirements may apply as outlined in the “Carnegie Mellon University Faculty Handbook” and the “Mellon College of Science Faculty Handbook”. The operation of the Physics Graduate Program is handled by the Director of the Graduate Program (DGP) together with the Department Head. In the following, the requirements for Admission to Graduate Studies at CMU, the Graduate Degree Requirements and the operation of the Graduate Program, are described.

In general, candidates for the degree of Ph.D. (Doctor of Philosophy) in Physics should expect to spend at least four years of full-time graduate study, including a minimum of one year of full-time course work at Carnegie Mellon. The first three semesters are devoted to concentrated study of fundamental topics. During their second year, students typically take the written and oral part of the Qualifying Examination. Following successful completion of this examination, students have to seek affiliation with one of the department’s research groups and identify a supervisor and subject area for their thesis research. Formal admission to candidacy for the Ph.D. depends on acceptable performance in teaching, research and course work, as well as the Qualifying Examinations. The affiliation with a research group is encouraged before admission to Ph.D. candidacy and can take place as early as the first semester. After a student is passed to Ph.D. candidacy, a committee of faculty conducts annual reviews of the students research progress until the student’s thesis defense and graduation.

2 Graduate Admission

To be admitted to graduate study in the Department of Physics, an applicant must have graduated from a recognized four-year college, university or institute of technology, or must have earned equivalent credentials. Students who are finishing a B.S. or B.A. degree in physics or a closely related subject will be considered for admission to graduate study in physics. Applications should be complete and submitted by the application deadline of January 1 for admission to begin study in the Fall semester of that year. All applicants are required to take the Graduate Record Examination GRE General Test and the GRE Subject Test in Physics, which are used together with the other application material in selecting students. Only complete applications will receive full consideration. There is no application fee in Physics at CMU.

A complete application package consists of the following:

- A completed (online) application form.
- Official copies of transcripts from all college-level institutions that the applicant attended, independent of whether a degree was received.
- Three letters of recommendation from professional references. At least one letter should be from the institution that the applicant currently attends or attended most recently.
The reference writers will receive instructions by email on how to submit the letter of recommendation after the applicant completes the online application forms.

- An official report of the GRE General Test and the GRE Subject Test in Physics. To ensure that the scores reach CMU in time for the review of applications, the GRE tests should be taken no later than November. The GRE Institution code for Carnegie Mellon University is 2074 and the GRE department code for physics is 0808.

- International applicants whose native language is not English must submit an official report of the Test of English as a Foreign Language (TOEFL). It is recommended that applicants take the internet based test TOEFL iBT but the paper based test TOEFL PBT is also acceptable. The TOEFL Institution code for Carnegie Mellon University is 2074 and the TOEFL department code for physics is 76.

After enrolling at Carnegie Mellon, students whose native language is not English are expected to take the International Teaching Assistant (ITA) test administered by the Intercultural Communications Center (ICC) at CMU. Students are required to take this test in order to be certified as teaching assistants.

2.1 Undergraduate Preparation

The following course work is considered to be part of a regular undergraduate preparation. Textbooks are given in brackets to indicate the general level expected from a suitable undergraduate education:

- Intermediate Mechanics (Thornton and Marion)
- Electricity and Magnetism (Griffiths)
- Thermodynamics and Statistical Physics (Callen, Guenalt)
- Atomic Physics (Eisberg and Resnick)
- Elementary Quantum Mechanics (Griffiths)
- Modern Physics Laboratory
- Electronics
- Advanced Calculus

3 Graduate Degree Requirements

The requirements for advanced degrees for students entering the Physics Graduate Program at Carnegie Mellon University are described in this section. Additional requirements may apply as outlined in the “Carnegie Mellon University Faculty Handbook” and the “Mellon College of Science Faculty Handbook”.

3.1 Orientation Program

Entering graduate students will attend an orientation program during the week preceding the beginning of classes which is typically at the end of August. During that week students attend talks introducing them to the department, take a placement test, discuss the responsibilities of teaching assistants, and enjoy informal social events. International students need to
<table>
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<td><strong>Spring Semester, First Year</strong></td>
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Table 1: Typical graduate course program indicating required and suggested courses in the first year. The course units indicate the expected number of hours spent by a student on a particular course per week.

arrive one week earlier, as they will receive additional orientation organized by the Office of International Education (OIE).

### 3.1.1 Placement Process

To determine the preparedness for graduate studies, every student takes a placement test on basic undergraduate physics. The results of which are used to identify suitable courses for the first year of graduate studies. The placement test will consist of questions on Quantum Mechanics, Electrodynamics, Mathematical Physics and Statistical Mechanics, which are the standard courses for first year graduate students. The results of the test together with student interviews are used to determine the optimum choice of courses in the first and second semesters. The placement test does not affect the student’s grades in any way. The responsibility for advising incoming graduate students is handled by the DGP who also serves as academic advisor for all first year graduate students. Following the placement test, students meet with the DGP to plan their course work for the first and second semesters.

### 3.2 Course Requirements

Students must successfully complete a series of courses before being admitted to Ph.D. candidacy. The typical pre-qualifying course program is shown in Table 1.

By the end of the second year of graduate studies, students should complete the breadth requirement consisting of two courses out of the following list:

- 33-758 Quantum Computation and Quantum Information Theory
- 33-767 Biophysics: From Basic Concepts to Current Research
- 33-777 Introductory Astrophysics
- 33-779 Introduction to Nuclear and Particle Physics
- 33-783 Solid State Physics
With special permission of the DGP, other physics courses can also be permitted as substitutes to satisfy the breadth requirement.

In addition, individual research groups may impose further course requirements on their students.

3.3 Academic Performance

Students must pass all required courses with a grade of B- (B-minus) or higher before being admitted to Ph.D. candidacy. Exceptions can be made only if a student demonstrates proficiency in the subject matter of a particular course and receives prior approval by the DGP. Students are also required to maintain a satisfactory academic record in order to continue in the Graduate Program. This means students cannot have a grade-point average (GPA) of less than 3.0 in each of two consecutive semesters.

3.4 Qualifying Exams

Two qualifying exams have to be passed for a student to be admitted to Ph.D. candidacy: The General Written Qualifying Exam and the Special Oral Qualifying Exam. Students take these exams during their second year of graduate studies. If both examinations are not passed on the level required for the Ph.D. program, candidates are still eligible to pass the Written Qualifying Examination on the Master’s level to receive a M.S. degree in Physics.

3.4.1 General Written Qualifying Exam

To qualify for Ph.D. candidacy, students have to pass the General Written Qualifying Exam which covers the course material of the first year graduate courses plus Classical Mechanics. The exam is offered twice a year: in August and again in late January or early February. The exam is administered over two days: Day 1 tests Classical Mechanics, Electrodynamics as well as Mathematical Physics. Day 2 tests Quantum Mechanics, Statistical Mechanics and “integrated” problem-solving ability. The problems will be at the level of the first year graduate material or the advanced undergraduate level in the case of Classical Mechanics.

Graduate students must take both days of the Written Qualifying Exam in August after their first year of graduate study or earlier. The last opportunity for a student to pass the Written Qualifying Exam is in August before the student’s third year of graduate study.

The exam committee will either pass or fail a student on each day of the exam separately. Passage of each day’s exam will be based on the score from all problems for that day. That is, insufficient performance on a single physics area will not necessarily lead to failure of the whole exam. Failure to pass one of the two days results in the requirement to retake only that day’s exam. If a student fails one or both days, the student is expected to retake the failed portion(s) again at the next offered opportunity. The exam committee will decide whether the exam is been passed at the Master’s level consisting of a lower level of performance.

3.4.2 Special Oral Qualifying Exam

The purpose of the Special Oral Qualifying Exam is to evaluate the candidate’s ability to learn new material and apply knowledge from course work to a new topic, present a coherent
talk on a large topic as well as answer questions on various aspects of a given topic. Particular emphasis is placed on conceptual understanding.

Students are required to take the Special Oral Qualifying Exam in their second year of graduate studies. The exam is given annually in January in the week prior to the start of the spring semester classes. If the Special Oral Qualifying Exam is not passed on the first attempt, it must be taken a second time the following year.

The chair of the Special Oral Qualifying Exam Committee meets with all students taking the exam at the beginning of December. At this meeting the topic of the exam is announced and references as well as the suggested reading material will be made available to students. The students have about 3-4 weeks to prepare for the exam. After reviewing the suggested material, each student prepares a 20 minute talk exposing what the student considers the most important and interesting aspects of the subject. The presentation will be given without notes, using only the blackboard. After the talk the Exam Committee will ask a series of questions based on the talk or other aspects of the given subject. The question period will last typically from 30 minutes to one hour. Candidates should prepare their talk completely on their own; there should be no discussion between the candidates concerning any aspect of the exam or topic.

3.5 Admission to Ph.D. Candidacy

After a student has fulfilled all course requirements and successfully passed both of the Qualifying Exams, a meeting of the faculty is held to review the academic record and exam results of the student. Progress toward research, finding a research advisor, the expected research aptitude of a student, as well as completing the teaching requirement, which is required for graduation, are part of this discussion. After a positive vote by the faculty the student is passed on to Ph.D. candidacy and begins full-time thesis research.

3.6 Thesis Research and Annual Research Reviews

It is generally expected that students will find a thesis research supervisor before the end of their second year of graduate studies. A student must find a suitable advisor for full-time research no later than one year after admission to Ph.D. candidacy.

Starting no later than one year after being passed to Ph.D. candidacy, a student must hold a first annual review by the end of the spring semester. For example, students who were admitted to Ph.D. candidacy in the spring of 2011 must complete their 2011-2012 annual review before the end of the Spring’12 semester. The annual research review is repeated each academic year with the review meeting held before the end of each spring semester.

At the start of each spring semester, students who must complete a review by the end of that semester will be individually notified, together with their advisors. By March 1 each student, with the help of their advisor, must have submitted a list of tentative thesis committee members, including the outside member if possible. Information on forming a thesis committee can be found in the “Mellon College of Science Faculty Handbook”. In the exceptional case that students are not able to complete the annual review for the current academic year, the students need to indicate that they have taken steps to schedule their review and provide the proposed date for the review.
The annual review needs to include:

- the presence of at least 3 of the tentative thesis committee members
- a presentation by the student which includes a discussion of research progress over the past year
- a discussion between the student and committee members on the progress and a plan for continuation of the student’s research toward a Ph.D. thesis
- documentation of the annual review by the advisor, through the completion of a form which can be obtained from the Graduate Student Program Coordinator or the departmental website. The completed and signed form needs to be returned to the Graduate Student Program Coordinator. It is at the discretion of the thesis advisor to forward a copy of the annual review form to the student.
- the submitted form can be accompanied by a 1-2 page progress report prepared by the student or a copy of the student presentation

If a student graduates by the end of the spring semester, the thesis defense can replace the annual review. The registration for summer and fall classes can be put on hold for the student until the annual review is completed. Progress toward this goal will be monitored by the DGP.

### 3.7 Teaching and Language Requirement

All graduate students are required to perform classroom or laboratory teaching for at least one semester before receiving a Ph.D. in Physics. Students will benefit from the practice gained by explaining complex physics concepts in an understandable way and by responding to questions.

If a student’s native language is not English, a certification of proficiency in spoken English is necessary before the student will be allowed to perform the required classroom teaching. To obtain certification, non-native English speakers must pass an International Teaching Assistant (ITA) Test administered by the Intercultural Communication Center (ICC) at CMU. A student must reach as a minimum an ITA test score of “Restricted II” (former Category 3) which allows for restricted TA assignments such as teaching in a laboratory course. A variety of support facilities are available at the ICC to improve the student’s command of the English language. Any student who is assigned as Teaching Assistant but has not reached the top ITA test score of “Pass” (former Category 1), must participate in the ITA Support Program for a minimum of 15 hours of language and cultural work at the ICC per semester.

### 3.8 Thesis Committee and Thesis Defense

The formation of a valid thesis committee and the execution of a thesis defense are governed by the MCS Doctoral Degree Policies as found in the “Mellon College of Science Faculty Handbook”. These are repeated here in excerpts.

The purpose of a doctoral thesis committee is to judge the validity, originality, significance, and proper presentation of the candidate’s doctoral thesis. To that end, the committee
shall examine the thesis submitted by the candidate, conduct the public oral final examination on the thesis, prescribe corrections or revisions to the thesis before or at the time of the examination, and certify to the Dean its finding on the acceptability of the thesis in its final form.

Normally, the members of the thesis committee shall be nominated by the thesis advisor with the agreement of the candidate, and their appointment approved by the Department Head or the faculty member designated to supervise the Department’s doctoral programs. Ultimate responsibility for the appointment of a thesis committee rests with the Department.

The doctoral thesis committee shall consist of no fewer than four members, and shall include the thesis advisor, as well as the departmental sponsor if the thesis advisor is not a faculty member in the Department conferring the degree. At least half of the members of the committee shall be regular or research faculty members in the Department in which the degree is to be conferred; one of these, who must be a regular faculty member with the rank of Assistant Professor or higher, shall chair the committee. If qualified under the preceding provision, the thesis advisor will ordinarily chair the committee; the same is applicable to the departmental sponsor if there is one.

At least one member of the committee shall be a “visitor”, i.e., a person not affiliated with the Department in which the degree is to be conferred nor with any Department participating in the candidate’s thesis research; the thesis advisor may not serve as “visitor”. To be eligible to be a “visitor”, a person should be familiar with academic standards and procedures and be especially qualified to judge some aspect of the thesis. A “visitor” may come from another Department at Carnegie Mellon, from some other university, or from outside academic institutions altogether.

When the thesis advisor is satisfied that the thesis is ready, it shall be submitted to the committee. The final examination shall be scheduled so as to provide the committee with at least two weeks to study the thesis between its submission and the date of the examination.

3.9 Academic Probation

If a student does not maintain adequate academic performance, such as falling below a GPA of 3.0 for one semester, fails qualifying exams or does not meet the requirements for the annual reviews, the student can be put on academic probation. In this case, the student will meet with the Graduate Program Director and Department Head to discuss the situation and receive a letter from the Department Head stating a list of steps plus a time-line required to be taken off academic probation. If the student fails to follow these requirements, the faculty will discuss the given case, vote and decide whether the student is allowed to continue in the graduate program in physics.

3.10 The Ph.D. in Applied Physics

Besides the conventional Ph.D. program, Carnegie Mellon offers a degree in Applied Physics. Ph.D. thesis research that may appropriately be characterized as applied physics can be carried out either within the Physics Department or in conjunction with other branches of the University such as the Robotics Institute, the Data Storage Systems Center, the Materials Science and Engineering Department or the Electrical and Computer Engineering
Department. Students in the applied physics program may find it necessary to prepare themselves in a technical area through courses in another department or through independent study. The Ph.D. Qualifying Examinations and the program of basic graduate courses in physics are required as outlined above but also flexible enough to accommodate the various options in applied physics.

3.11 The M.S. in Physics

The Master's of Science (M.S.) degree in Physics is awarded to students enrolled in the Ph.D. program typically after 2 years of course work. Note, the Physics Department does not offer an M.S. only program, and the M.S. degree is usually offered only to students enrolled in the Ph.D. degree program. However, in exceptional circumstances applicants can be considered who intend to obtain only a M.S. degree, but in this case for admission without financial aid.

Candidates for the degree of M.S. in Physics must satisfactorily complete at least 96 units of courses with a B average (3.0) or better including the following:

1. At least 48 units of courses at the graduate level (700 level courses) in the Department of Physics.

2. At least 24 units of graduate or advanced undergraduate courses in physics or closely affiliated fields.

3. Six to 12 units of advanced physics laboratory (at the level of 33-340, Modern Physics Laboratory) or research in form of 33-776, Introduction to Research 1 or 33-997, Graduate Laboratory.

In addition, students must satisfy the following requirements:

1. One year of residence as a full-time student is required and at least 72 of the units above have to be taken as student enrolled at CMU.

2. Candidates must pass Day 1 of the General Written Qualifying Exam on the Master’s level but do not need to take the Special Oral Qualifying Exam.

3. There are no research or language requirements for the M.S. degree.

3.12 General Requirements for Advanced Degrees

The service performed as a teaching or research assistant is part of the graduate training. Such service, or its equivalent, is required of all candidates for graduate degrees whether or not they receive stipends.
4 Operation of Graduate Program

The operation of the Physics Graduate Program is handled by the Director of the Graduate Program together with the Department Head ensuring a smooth running of the graduate program. The DGP oversees the various examinations (placement exam, written and oral qualifying exams), monitors the progress and success of pre-candidacy students, identifies student’s developing issues such as students challenged in the program who are put on academic probation, monitors post-candidacy students by following up on the annual graduate student reports. The DGP also oversees advising and takes care of any graduate program related issues such as course issues, social activities, day-to-day operational issues, etc. The DGP also assists the Department Head in teaching assignments for graduate courses and course curriculum related issues. The DGP reports to the faculty, informs about the status of the graduate program, discusses Ph.D. candidacy as well as issues with particular graduate students and with the graduate program itself.

In addition to the DGP and the Department Head, the other elements contributing to the operation of the Physics Graduate Program are the Graduate Admission Committee, the General Written Qualifying Exam Committee and the Special Oral Qualifying Exam Committee.

5 Financial Assistance

Nearly all graduate students in the Ph.D. programs receive financial support in the form of an assistantship (teaching or research) or fellowship. Teaching assistantships typically involve a work load of about 20 hours per week including classroom time, preparation and grading. Such teaching experience is considered a valuable part of a student’s graduate training. The hours required are such that the student may pursue a full-time graduate program. Teaching assistantships provide a full-tuition remission and a monthly stipend for the nine-month academic year.

Performing the duties of a teaching or research assistant is part of graduate training. Such service, or its equivalent, is required of all candidates for graduate degrees, whether or not they receive stipends.

To maintain support from the department, all students whose native language is not English must either pass the International Teaching Assistant test administered by the Intercultural Communications Center or must be satisfactorily participating in the English training program prescribed for them.

During their thesis research, candidates for the Ph.D. degree are, in most cases, supported as research assistants by the research group with which they become associated in the second year of residence. Sometimes, a first-year graduate student will be offered a research assistantship. The principal duty of a research assistantship is to aid in the program of one of the department’s research groups. The stipend and the time required are essentially the same as for a teaching assistantship.

Additional financial support is usually available for students wishing to participate in research projects or teaching during the summer months for which a student will receive the same monthly stipend.
Students accepting appointments with the Department of Physics may not accept an appointment elsewhere or engage in any occupation other than their program at the university, unless they receive written permission to do so from the Head of the Department of Physics.

6 Statement of Assurance

Carnegie Mellon University does not discriminate in admission, employment, or administration of its programs or activities on the basis of race, color, national origin, sex, handicap or disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Furthermore, Carnegie Mellon University does not discriminate and is required not to discriminate in violation of federal, state, or local laws or executive orders.

Inquiries concerning the application of and compliance with this statement should be directed to the vice president for campus affairs, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, telephone 1-412-268-2056.

Carnegie Mellon University publishes an annual campus security report describing the university’s security, alcohol and drug, and sexual assault policies and containing statistics about the number and type of crimes committed on the campus during the preceding three years. You can obtain a copy by contacting the Carnegie Mellon Police Department at 1-412-268-2323. The security report is available through the World Wide Web at http://www.cmu.edu/police/annualreports/index.html.

Carnegie Mellon University makes every effort to provide accessible facilities and programs for individuals with disabilities. For accommodations/services please contact the Equal Opportunity Services Office at 412-268-2012.