Boston University Physics Requirements for the PhD Degree

Satisfactory Academic Progress

The Graduate School of Arts and Sciences (GRS) and the Physics Department guarantee five full years (12 months each) of financial support for students who maintain Satisfactory Academic Progress. This support will be in the form of Teaching Fellowships, Research Fellowships, and/or Graduate Fellowships. Funding beyond five years is generally provided (but not guaranteed) to students who are working productively toward their PhD. The time limit to complete the PhD is seven years (exceptions require a petition to GRS).

Course requirements

Sixteen 4-credit courses are required with grades of B- or higher. These include the *core courses*: Quantum Mechanics I & II (PY 511-512), Electrodynamics I (PY 521), Mathematical Physics (PY 501), and Statistical Physics & Thermodynamics (PY 541). Additionally, all first-year students must take the Scholarly Methods course, PY 961, in their first semester. An average grade of B or better must be achieved in the five core courses in order to qualify for the PhD program, with no grade lower than B-.

While not a core course, Advanced Laboratory (PY 581) is a required course that must be completed prior to advancing to candidacy. Additionally, at least two additional lecture courses (numbered between 500 and 899) must be taken, with at least one *distribution course* from outside your research specialty. The distribution requirement may be satisfied by taking an approved graduate-level course in other science and engineering departments. You must obtain approval from the Director of Graduate Studies (DGS) prior to taking courses outside of the Physics department to ensure that they will count towards the distribution requirement.

Up to eight non-lecture courses may be applied to the 16-course requirement, including research in physics courses (PY901/902), but no more than two directed study courses (PY909/910) and no more than two seminar courses.

Transfer Credits versus Course Waivers

Transfer Credits: Credits may be transferred from other universities to count towards a PhD, as long as they have not been used previously toward any other degree. Only courses that obtained a letter grade (not Pass/Fail) may be considered for a transfer. Courses taken before the senior year of college will not be accepted. Of these, a maximum of eight (8) credits can be used towards a Master's degree, a maximum of sixteen (16) credits can be used towards a Master's and PhD, and a maximum of 32 credits can be used towards a PhD. Transferring credits could have an effect on obtaining a Master's degree during your course of study, so please consult the GRS website for guidance. Additional details may be found at http://www.bu.edu/academics/grs/policies/transfer-of-credits/. Students who enter the program with a Master's degree from another College or University could also be eligible for transfer credits; decisions are reviewed on a case-by-case basis, so please reach out to the Graduate Program Administrator as soon as possible to determine eligibility.

Course Waivers: PY501, 511, 512, 521, 541 and an elective lecture course are normally taken during the first year of graduate study. A student who has either taken an advanced undergraduate lab course or has had significant experimental research experience may petition the DGS or DUS (Director of Undergraduate Studies), with input from the teaching faculty for PY 581 when necessary, to be excused from this course (i.e.: course waiver). If the petition is approved, PY 581 must be replaced with another 4-credit lecture course. The *Graduate Program Waiver Request form* and the *AdLab Supplemental Questionnaire* are both required to request a course waiver for PY 581. Please contact the Graduate Program Administrator to obtain copies of the two forms. Please remember that course waivers are different from transferring credits. Approved waivers still require students to replace the course with another 4-credit lecture course.

Demonstration of Proficiency in Physics
Students are required to demonstrate proficiency through course work by maintaining an average grade of at least B in the five core Physics courses, with no grade lower than B-.

Anyone who fails to achieve the qualification standard during the first year may be asked to re-take the course, for credit or audit, and to re-take the final examination in the second year. Anyone who is unable to achieve the qualification standard at the end of the second year will be terminated from the program.

A student who has failed to achieve the qualification standard may file a petition to the DGS to appeal termination from the program because of exceptional extenuating circumstances. Please contact the DGS directly to determine next steps.

Selection of Research Project
Students are strongly encouraged to begin research with a BU faculty member, typically in the Physics department, as early as possible. In order to demonstrate Satisfactory Academic Progress, a student should identify a faculty research advisor between their second and third year in the program. The advisor and student jointly formulate a research project of about one semester in duration.

Advancement to Candidacy and the Advancement to Candidacy Examination
In order to advance to candidacy, students must meet the course qualification standard, pass the Advancement to Candidacy Examination (ACE), and complete PY 581 (or receive a course waiver). Please note that PhD students, who matriculated in Fall 2021 or earlier, have the option to take either the ACE or the old Preliminary Oral Exam (POE). Detailed information regarding the POE and its requirements can be found at https://www.bu.edu/physics/previous-grad-degree-requirements/.

Purpose of the Advancement to Candidacy Examination:
The purpose of the ACE (Advancement to Candidacy Exam) is to assess a student's research potential and to test the student's depth and breadth of knowledge in physics.

A committee of four faculty members (the DGS plus three additional faculty members) will conduct the ACE, which will involve an oral presentation followed by questions from the committee. Interested parties, including the student's research advisor, may attend the oral presentation, but only the student and their ACE committee members can be present for the exam questioning. The Director of Graduate Studies (DGS), who may consult with the student's advisor if the student has an advisor, will appoint the ACE committee member. A student's advisor cannot serve on their student's ACE committee.

Conduct of the Examination:
Format: The examination consists of a concise oral presentation of approximately 20 minutes on a research paper chosen by the student in consultation with their research advisor, which is subject to approval by the DGS. If the student does not have an advisor at the time of ACE preparation, a student can choose a paper in their field of interest, again subject to approval by the DGS. The committee will ask questions about the content of the research paper following the presentation. Some questions will encourage the student to place the discussed paper within a broader physics context.

Duration: The entire examination should last about 60 minutes, which includes the 20 minutes for the oral presentation.

Schedule: The ACE should be held by the end of the students' *second year*, with a time table as follows: (i) select the paper/topic by February 15 of the spring semester of the second year; (ii) conduct the oral exam before the end of that spring semester or at the beginning of the following fall semester but in no case later than September 30 at the start of the students' third year.

Grading of the examination: Following the examination, the committee assigns a Pass or Fail grade and submits their assessment to the DGS. The committee must determine the P/F grade and notify the student immediately following the exam. (Ties and requests for further information are not possible outcomes.)

- A *Pass* grade permits the student to advance to PhD Candidacy.
- In the case of a *Fail* grade, the DGS will consider the committee's assessment and the student's other academic progress indicators to decide whether the student will be allowed a second exam attempt. If granted, the additional exam attempt must be conducted before the end of the following spring. If an additional attempt is not permitted, the student will be terminated from the program. A second ACE failure will also result in the student's termination. While students cannot appeal their ACE grade, they can appeal a termination decision to the Department Chair.

Guidelines for Faculty:
The faculty trust in the judgment of their faculty colleagues to ask reasonable questions.

The exam committee will fill out a form with a grading rubric to facilitate the discussion among its members. The proposed form is analogous to the forms already used for the Departmental Seminars and PhD Final Examinations. Comments on the assigned score in each of the areas outlined in the grading rubric must be included in the form. If the committee assigns a Fail grade, they must submit a recommendation to the DGS detailing any proposed remedial action, such as whether the student can retake the ACE or whether the student should take additional courses.

Guidelines for students:
Students should start preparing for the ACE during their second year in the PhD program and in advance of the February 15 paper selection deadline.

1) The student chooses a research paper (usually in their planned research area), as the topic of their oral exam presentation. The chosen paper is subject to approval by the DGS. If the student has a research advisor, the paper should be chosen in consultation with the advisor.
2) The student's presentation should not be about any specific research that they have conducted, which will be showcased at the Departmental Seminar, but rather on the research described in the selected paper.
    a) Selection of a research article or paper that has been published in a peer-reviewed journal within the last decade or on the arXiv is recommended. A seminal paper in the field may also be chosen. The DGS, in consultation with the committee, approves the paper. Ideally, the selected paper could be a letter or short article, or a section of a review article.
    b) The oral presentation on the selected paper should last no more than 20 minutes. It should cover the background physics, as well as describe the results and the main conclusion, and include a perspective on the impact of the selected article. A suggested template is provided at the end of this document.
3) At the end of the presentation, the exam committee will ask the student questions about the paper they described.
4) The exam will continue with additional questions encouraging the student to place their presentation in a broader physics context.

Suggested Template for the Oral Presentations:
For the presentation part of the ACE, students may prepare slides (including any supporting media) or a blackboard chalk talk. While the committees may accept a wide range of formats, the 20-minute time limit will be enforced.

Below is a suggested outline for presentations with prepared slides. As a rule, for a 20-minute talk there should be no more than 12 slides, not counting acknowledgements and any additional references. It is good practice to include slide numbers and citations on each presentation slide. It is also prudent to rehearse the talk in front of members of the student's research group or friends and colleagues.

1) Title slide with student's name (1 slide)
2) Outline of talk and the paper to be presented (1 slide)
3) Motivation and background physics (1 – 2 slides)
4) Description of the main results and conclusions in the paper (no more than 6 slides)
5) Critique/perspective on the impact of the paper (1 – 2 slides)
6) Acknowledgement and references
7) Backup slides to answer anticipated questions (*Optional*)

Eligible students who are ready to schedule their ACE should reach out to the Graduate Program Administrator so that a day/time and location can be reserved. You will need to provide a Title and Abstract for your talk so that the event can be advertised on the Department calendar. There are two forms that must be completed and returned to the Department immediately after the exam.

Selection of PhD Dissertation Committee

PhD research is normally carried out under the guidance of a faculty member who is a full-time or affiliated member of the Boston University Physics Department. A student may choose to continue his/her association with the faculty advisor for the Advancement to Candidacy Exam. The student's advisor becomes the First Reader for the PhD dissertation. The PhD Dissertation Committee consists of five members: (1) First Reader, (2) Second Reader, (3) Committee Chair, and (4/5) two other members. The five-committee members should include one who works in the opposite technical discipline of the student (theory versus experiment) and one who works in a different field. The Committee Chair is responsible for completing and returning the necessary forms for the student's thesis defense. A student wishing to work with a faculty member outside the Physics Department must first consult with the DGS. GRS policy requires at least two committee members, including the Committee Chair, to be from the Physics Department. By special appointment that is approved by the Dean of GRS, up to two committee members may be from outside Boston University. The membership of the PhD Committee must be approved by the DGS. The selection of the advisor and PhD Committee must be made no later than the end of the fall semester of the student's fourth year at Boston University.

Interim Progress Report

The student must submit an Interim Progress Report to the DGS by the end of spring semester of the student's fourth year at Boston University. This report is a three- to five-page (single spaced, 12-point font) description of the student's PhD research activities. It should include the anticipated research scope, research accomplishments, and time scale for completion of the PhD. The report should be prepared in consultation with, and approved by, all members of the PhD Dissertation Committee.

Dissertation Prospectus

The Dissertation Prospectus is prepared in consultation with the student's PhD Dissertation Committee. It should be submitted to GRS, after approval by the Readers, the DGS and Physics Department Chair, approximately *seven months* before the Final Oral Exam, and *no later than the fall semester of the student's seventh year*. This document must be four- to six-pages long (single spaced, 12-point font), and must provide a clear statement of the problem being studied and a self-contained discussion of the research techniques. It should also include an outline of the dissertation, with a bullet-style listing of its sections and subsections. These section and subsection headings should be augmented with one or two explanatory sentences.

Departmental Seminar

The student is required to give a generally accessible seminar related to the dissertation project as part of a *Graduate Seminar Series*. All five members of the PhD Dissertation Committee must attend the seminar; other faculty and students are encouraged to attend. The seminar should be presented shortly after the Dissertation prospectus is prepared, and no later than *six months before* the Final Oral Exam.

At the conclusion of the seminar, the PhD Dissertation Committee will meet privately with the student to discuss the quality, quantity and schedule of research required for the completion of a satisfactory PhD dissertation.

Eligible students who are ready to schedule their Departmental Seminar should reach out to the Graduate Program Administrator so that a day/time and location can be reserved. You will need to provide a Title and Abstract for your talk so that the event can be advertised on the Department calendar. You will be given one form that must be completed and returned to the Department by your research advisor immediately after your seminar.

Dissertation and Final Oral Exam

The PhD Dissertation must contain an account of original research and results conducted by the candidate. It should contain a critical evaluation of prior research, place the results of the PhD research in perspective, and discuss future research directions. It must be a cohesive document, rather than a compilation of reports or publications. The writing of the dissertation should begin no later than the time of the Departmental Seminar. The First and Second readers should be informed of progress and provide feedback as required. The student should provide a first draft of the dissertation to the First and Second Readers no later than *two months before* the Final Oral Exam. A properly formatted draft of the thesis must be submitted to the Readers and GRS at least *three weeks* prior to the Final Oral Exam.

The student must write and obtain approval of a Dissertation Abstract prior to scheduling the Final Oral Exam. The abstract cannot exceed 350 words, and must describe the research project, methods, results, and dissertation contents. It must be approved by the Readers, the DGS, and the Physics Chair, and must be submitted to GRS *at least three weeks before* the Final Oral Exam. The scheduling and approval form for the Final Oral Exam can be found through the GRS website: http://www.bu.edu/cas/files/2018/07/Schedule-and-Abstract.pdf.

Students are required by GRS to undergo a Final Oral Examination in which they defend their dissertations as valuable contributions to knowledge in their fields and demonstrate a mastery of their fields of specialization in relation to their dissertations. The Final Examining Committee is composed of five or more professorial faculty members including members of the PhD Dissertation Committee. The Final Oral Exam, which must be attended by all five members of the PhD Examining Committee, is formally scheduled by the Physics Department Office, which notifies GRS. The exam consists of two parts. The first is open to the public and consists of a presentation of the research that should last no more than 45 minutes. The talk should be accessible to a non-specialized audience, with emphasis on clarity of presentation. Interruptions should occur only for minor clarifications. The audience is excused for the second part, in which the PhD Examining Committee asks the candidate to defend the dissertation, including the background, scope, limitations of the work, completeness of data or calculations, and the validity of the conclusions. At the end of the second part, the PhD Examining Committee privately decides on a Pass or a Fail grade. In the case of a Pass grade, the title page of the PhD Dissertation is signed by the Readers and is submitted to GRS. In the case of a Fail grade, the PhD Examining Committee and the candidate formulate a plan for revisions, corrections, and/or additional work that will lead to an acceptable dissertation.

Eligible students, who are ready to begin the process of completing their PhD, should submit their Intent to Graduate through the GRS website: http://www.bu.edu/cas/current-students/phd-mfastudents/graduation-

information/intent-to-graduate-form-for-phd-students/. Please notify the Graduate Program Administrator prior to doing so in order to ensure that all required information is up-to-date. Students should also closely review the Graduation Checklists posted on the GRS website to better understand deadlines and criteria prior to and following your defense. Information can be found on the GRS Graduation Checklists website: https://www.bu.edu/cas/academics/phd-and-mfa-academics/graduation-information/. When you are ready to schedule your Final Oral Exam, please coordinate immediately with the Graduate Program administrator so that a day/time and location can be reserved. You will need to provide a Title and Abstract for your talk so that the event can be advertised on the Department calendar. You will be given two forms that must be completed and returned to the Department by your Committee Chair immediately after your exam.

PhD Timetable

Generally at the End of First Year

- Completion of the *core courses* PY501, PY511, PY512, PY521, and PY541, with an average of B with no single course grade lower than B-.
- Students who have completed the equivalent of these graduate level courses can satisfy the core course requirement by filing a petition immediately upon entering the graduate program, choosing one of three alternatives:
  i) retake one or more core physics courses at Boston University;
  ii) present evidence of prior satisfactory performance equivalent core course(s) to waive the requirement(s); or
  iii) opt for an oral proficiency examination to be administered by a faculty committee appointed by the DGS. Additional details are listed in Section 3.

No Later than End of Second Year

- Show evidence of competence by achieving at least an average grade of B in the core courses with no grade lower than B-.

No Later than End of Third Year

- Completion or waiver of the *Advanced Lab* requirement (PY581).
- Passing grade on the *Advancement to Candidacy Exam*.

No Later than End of Fourth Year

- Selection of the *PhD Dissertation Committee* by the end of the fall semester.
- *Interim Progress Report* submitted to the Director of Graduate Studies (DGS) by the end of the spring semester, to be prepared in consultation with, and approved by the members of the PhD Dissertation Committee.

Schedule Guidelines for Completion of PhD

- *Dissertation Prospectus* submitted to the DGS and GRS approximately *seven months* before the Final Oral Exam. Year-specific deadlines are available from GRS.
- *Departmental Seminar*, a presentation of PhD research to the PhD dissertation committee and an audience of departmental students and faculty. It must be held no later than *six months* before the Final Oral Exam.
- *Dissertation Abstract*, approved by the DGS and Physics chair, and submitted to GRS *three weeks* prior to Final Oral Exam.
- *Properly formatted draft of thesis* submitted to readers and GRS *three weeks* before Final Oral
- Exam.
- *Final Oral Exam.* Deadlines for specific graduation dates and detailed rules are available from GRS.
- For the most up-to-date deadlines and criteria, please review the GRS Graduation Checklists website at: http://www.bu.edu/cas/current-students/phd-mfa-students/graduation-information/.

MA Degree Requirements

Eight 4-credit courses are required with grades of B- or higher. These include the core courses Quantum Mechanics I & II (PY 511-512), Electrodynamics I (PY 521), Mathematical Physics (PY 501), and Statistical Physics & Thermodynamics (PY 541).

Advanced Lab (PY 581) is also required, as well as two additional courses numbered between 500 and 899. All first-year students must also take the Scholarly Methods course, PY 961.

A student with more than two grades below B in any of the 4-credit courses will be terminated from the program.

APPENDIX 1: PhD Distribution Requirement

A student with a research specialty in Category A subjects must take one (1) distribution course in Category B, and vice versa. Only one starred (*) item may count toward the distribution requirement. A student may also, *with prior permission from the DGS*, be allowed to satisfy the Distribution requirement by taking an approved graduate course in other science and engineering departments. Course listings and descriptions can be found in Appendix 2 (below). For the most accurate listing of course offerings, please review the Graduate Courses page at https://www.bu.edu/physics/academics/graduate-program/graduate/.

APPENDIX 2: Course Offerings

Category	Description
A	Courses in high energy (theory and experiment), nuclear, etc.
B	Courses in condensed matter (theory and experiment), statistical physics, biophysics, etc.
C	Core Course
W	Waiver
*	Indicates a course that can be counted towards a distribution requirement, but cannot be combined with another asterisked course to complete the distribution requirements of the PhD degree.
^	Courses will be offered upon sufficient demand.

Class	Name	Category
PY 501	Mathematical Physics	C
PY 502*	Computational Physics	A/B
PY 511	Quantum Mechanics I	C
PY 512	Quantum Mechanics II	C
PY 521	Electromagnetic Theory I	C
PY 522*	Electromagnetic Theory II	A/B
PY 536	Quantum Computing	A/B
PY 538	Econophysics	A/B
PY 541	Statistical Mechanics I	C
PY 542	Statistical Mechanics II	B
PY 543	Introduction to Solid State Physics	B
PY 551	Introduction to Particle Physics	A
PY 555	Cosmological Physics	A
PY 561^	Introduction to Nuclear Physics	A
PY 571	Introduction to Biophysics	B
PY 581	Advanced Laboratory	C/W
PY 621*	Advanced Scientific Computing in Physics	A/B
PY 677	An Introduction to Evidence-Based Undergraduate STEM Teaching	A/B
PY 681	Electronics for Scientists	A/B

PY 701^	Advanced Mathematical Physics I	A/B
PY 702^	Advanced Mathematical Physics II	A/B
PY 713	Quantum Field Theory I	A
PY 714^	Quantum Field Theory II	A
PY 731^	Theory of Relativity	A
PY 741	Solid-State Physics I	B
PY 742	Solid-State Physics II	B
PY 743	Low-Temperature Physics	B
PY 744	Polymer Physics	B
PY 745	Experimental Surface Physics and Chemistry	B
PY 747	Advanced Statistical Mechanics	B
PY 751	High-Energy Physics I	A
PY 752	High-Energy Physics II	A
PY 761^	Nuclear and Intermediate Energy Physics I	A
PY 762^	Nuclear and Intermediate Energy Physics II	A
PY 771	Systems Biology	B
PY 782	Advanced Materials Characterization	B
PY 811^	Advanced Quantum Field Theory	A
PY 841^	Symmetry in Condensed Matter Physics	B
PY 842^	Many-Body Topics in Solid State Physics	B
PY 895	Special Topics in Theoretical Physics	A/B
PY 896	Special Topics in Theoretical Physics	A/B
PY 897	Special Topics in Experimental Physics	A/B
PY 901	Research in Physics	n/a
PY 902	Research in Physics	n/a
PY 909	Directed Study in Physics	A/B
PY 910	Directed Study in Physics	A/B
PY 961	Scholarly Methods in Physics	C