

# PHYSICS, PHD

## Admission Requirements

To obtain admission, a student is expected to submit evidence that they have a good chance to succeed.

### A complete application will include:

- Statement of purpose. We look for a thoughtful, well-written statement that shows the ability to overcome challenges, dedication to attain chosen goals, a capacity for creativity, an understanding of physics and/or astronomy, and any other indication of potential for research.
- Three letters of recommendation. Recommendation letters should help us evaluate your capacity for research, the most important criterion for admission.
- Transcripts of all previous work. Transcripts submitted with the application may be unofficial transcripts. Successful applicants who accept the offer of admission must supply an official transcript before they can begin the PhD program at JHU. In the case of students in the final year of their bachelor's program, the official transcript must show completion of all coursework required for the degree.
- TOEFL or IELTS for international students. A reproduction is acceptable. Johns Hopkins prefers a minimum score of 600 (paper-based) or 250 (computer-based) or 100 (Internet-based) on the Test of English as a Foreign Language (TOEFL).
- \$75 non-refundable application fee. The application fee may be waived (<http://krieger.jhu.edu/graduate-admissions/apply/how-to-apply/#fees>).

*Note: submission of General GRE and Physics GRE scores is optional.*

Successful applicants applying in the last year of their Bachelor's program will need to demonstrate the completion of their bachelor's degree program before they can begin the PhD program at JHU.

## Program Requirements

The PhD program has a strong emphasis on early and active involvement in graduate research. Thus, students are required to have a research advisor and file a research summary every semester they are enrolled in the program, starting with the first one. Furthermore, students must complete the required courses with a grade of B- or better; the coursework is typically done over the first two years.

In the beginning of the second year, students complete the research examination. In the beginning of the third year, students take the University's Graduate Board Oral examination. Both the research and oral exams are based on completed or proposed research.

During the first two years, students are typically involved in introductory research projects, which may or may not be related to their thesis work. Although students may work with several different advisors throughout this time, they must identify (and have an agreement with) a thesis advisor no later than the beginning of their third year in the program. After this point, students focus on their thesis research. The thesis must be completed no later than the end of the sixth year and concludes with an oral presentation of the thesis to a faculty committee.

## Course Requirements

### Ph.D. in Physics

Students must complete the following courses:

Code	Title	Credits
AS.171.603	Electromagnetic Theory	3
AS.171.605 & AS.171.606	Quantum Mechanics I and Quantum Mechanics	3
AS.171.703	Advanced Statistical Mechanics	3

### Ph.D. in Astronomy and Astrophysics

Students must complete the following courses:

Code	Title	Credits
AS.171.611	Stellar Structure and Evolution	3
AS.171.612	Interstellar Medium and Astrophysical Fluid Dynamics	3
AS.171.613	Radiative Astrophysics	3
AS.171.627	Astrophysical Dynamics	3
AS.172.633	Language Of Astrophysics	1

Students in both programs must receive at least a B- in each required course, or they will be required to retake the specific course once more and pass it. Graduate courses may only be retaken once.

The department offers a wide range of graduate physics, astrophysics, mathematical methods and statistics classes. While only five are required, students are encouraged to use the flexibility of the graduate program and the available classes to design programs of study that best prepare them for their chosen area of research. In addition to the required courses listed above, below is the list of the graduate courses that have been taught in recent years:

Code	Title	Credits
AS.171.610	Numerical Methods for Physicists	4
AS.171.618	Observational Astronomy	3
AS.171.621	Condensed Matter Physics	3
AS.171.625	Experimental Particle Physics	3
AS.171.632	Atomic and Optical Physics I	3
AS.171.639	Group Theory in Physics	3
AS.171.644	Exoplanets and Planet Formation	3
AS.171.646	General Relativity	3
AS.171.648	Physics of Cell Biology: From Mechanics to Information	3
AS.171.649	Astrophysical Plasmas	3
AS.171.701	Quantum Field Theory	3
AS.171.708	Gravitational Waves	3
AS.171.732	Elementary Particle Physics	3
AS.171.750	Cosmology	3
AS.171.752	Black Hole Astrophysics	3
AS.171.755	Fourier Optics and Interferometry in Astronomy	3
AS.171.785	Advanced Particle Theory: Dark Matter	3
AS.171.671	Advanced Topics in Astrobiology	3
AS.171.638	Fundamentals of Radio Astronomy	3
AS.171.749	Machine Learning for Physicists	3

AS.171.764 Experimental Techniques in Condensed Matter Physics

## Research and Advising

The principal goal of graduate study is to train the student to conduct original research. Therefore, physics and astronomy graduate students at Johns Hopkins are involved in research starting in their first semester in the program.

### First and Second-Year Research Requirement

By the end of September, the student chooses their first research advisor among the professorial faculty and starts working on the first-semester research project. If the proposed research advisor does not hold a primary appointment as a tenure-track or research faculty member in the Department of Physics and Astronomy, the form must be co-signed by a PHA faculty member, who will provide mentorship (relevant department faculty members list) (<https://physics-astronomy.jhu.edu/people/#filter=faculty>). This requirement holds for all semesters of research. The first-semester project continues through intersession in January. The spring-semester research project continues until the end of the spring semester. The summer semester lasts from June through August. Students may continue with one advisor through the entire first year, or they may choose to cycle through several different research advisors from one semester to the next.

This system of semester projects continues during the first two years of the program, when students also complete required coursework. The nature of these first- and second-year research projects varies from student to student, from advisor to advisor and from one sub-field of physics to another. Some may be self-contained research projects that lead to published scientific papers and may or may not be related to the thesis research in later years. Others may comprise reading or independent-study projects to develop background for subsequent research. In other cases, they may be first steps in a longer-term research project.

This system accommodates both the students who have chosen the direction of their thesis work before graduate school and those who would like to try a few different things before committing to a long-term project. As students get more familiar with the department and the research opportunities, they zero in on their thesis topic and find a thesis advisor. This may happen any time during the first two years, and students are required to find a thesis advisor by the beginning of the third year.

### Thesis Research and Defense

Securing a mutual agreement with a thesis advisor is one of the most important milestones of the graduate program. Students must find a thesis advisor and submit the thesis advisor form before the first day of their 3rd year. The form represents a long-term commitment and serious efforts in planning and communication between the student and the advisor. If the proposed thesis advisor does not hold a primary appointment as a tenure-track or research faculty member in the Department of Physics and Astronomy, the form must be co-signed by a PHA faculty member, who will serve as the departmental advisor of record (relevant department faculty members list) (<https://physics-astronomy.jhu.edu/people/#filter=faculty>).

After the student chooses a thesis advisor, the student forms their Thesis Committee consisting of three faculty members in the Department of Physics and Astronomy (PHA). At least two should be tenure-track faculty with primary appointments in PHA. An external advisor may be added

as the fourth member of the committee. These committees function as extended advisory bodies; students have the opportunity to discuss their progress and problems with several faculty. They also conduct one formal annual review of each student's progress.

Research leading to the dissertation can be carried out not only within the Department of Physics and Astronomy, but with appropriate arrangements, either partly or entirely at other locations if necessitated by the project goals. At the conclusion of thesis research, the student presents the written dissertation to the faculty committee and defends the thesis in an oral examination.

## Requirements for the MA Degree

Although the department does not admit students who intend to pursue the master's degree exclusively, students in the department's PhD program and students in other PhD programs at Johns Hopkins may apply to fulfill the requirements for the MA degree in the Department of Physics and Astronomy. Students from other JHU departments must seek approval from their home department and from the Department of Physics and Astronomy.

Before beginning their MA studies, students must have mastered the undergraduate physics material covered by the following courses:

Code	Title	Credits
AS.171.204	Classical Mechanics II	4
AS.171.303 & AS.171.304	Quantum Mechanics I and Quantum Mechanics II	8
AS.171.312	Statistical Physics/Thermodynamics	4

Students must receive at least a B- in each required course, or they will be required to retake the specific course once more and pass it. Graduate courses may only be retaken once.

Courses taken elsewhere may qualify at the discretion of the Graduate Program Committee (normally this requirement is satisfied by the PhD-track students before they arrive at JHU as they have completed a BA/BS in Physics at another institution).

To qualify for the MA degree in Physics, students must complete eight one-semester 3-credit graduate-level courses in the Department of Physics and Astronomy and pass the departmental research exam. The student must receive a grade of B- or above in each of the courses; graduate courses can be retaken once in case of failure.

Of the eight one-semester courses, four must be the core courses listed above in the PhD requirements and two must be Independent Graduate Research courses. The remaining two course requirements for the MA degree may be fulfilled either by 3-credit graduate electives or by additional Independent Graduate Research. The research courses must include an essay or a research report supervised and approved by a faculty member of the Department of Physics and Astronomy.

Under most circumstances students pursuing their PhD qualify for the MA degree by the end of their second year if they have taken all four core courses in their discipline at JHU, four semesters of Independent Graduate Research, and passed the research exam. Graduate courses taken at another institution or in another department at JHU in most cases do not count toward the MA requirements (therefore, students who are interested in the MA degree, but are planning to waive any graduate courses because they have passed a comparable graduate course at another institution, should discuss their eligibility for the MA degree with the Academic Program Administrator as soon as they arrive at JHU).

Students should expect that no MA requirements can be waived; that the minimal research requirement is two semesters; and that at most one of the core courses can be substituted by another (non-research) graduate course in exceptional circumstances. Any requests for MA course substitutions must be made to the Graduate Program Committee at least a year before the expected MA degree so that the committee can recommend an appropriate substitution.