

# Physics

Department Website: <http://physics.uchicago.edu>

## Program of Study

Physics is concerned with the study of matter, energy, forces, and their interaction in the world and universe around us. The undergraduate curriculum in the Department of Physics leading to the BA in physics includes a strong emphasis on experiment and covers the broad fundamentals necessary for graduate study in theoretical physics, experimental physics, or astronomy and astrophysics, as well as some fields of engineering and many interdisciplinary specialties requiring a strong technical background (e.g., biophysics, medical physics, atmospheric and environmental sciences).

Students who are majoring in other fields of study may also complete a minor in physics. Information follows the description of the major.

## Program Requirements

### Courses

The curriculum leading to the BA degree in physics is designed for maximum flexibility consistent with a thorough coverage of the essential principles of physics. Degree requirements include introductory and advanced physics and mathematics courses, as well as physics electives that allow students to pursue specific interests. Students intending to pursue graduate work in astrophysics should consider the program leading to a BA in physics with a specialization in astrophysics, which is described later.

Students who plan to major in physics are encouraged to start course work in their first year. However, the program can be completed in three years, so one could start physics in the second year without delaying graduation. Two of the physics and two of the mathematics courses can be designated as general education courses, with sixteen courses remaining to fulfill the major.

In general, students should take the most advanced courses for which they have the appropriate prerequisites. Entering students will be given a placement for either PHYS 13100 Mechanics or PHYS 14100 Honors Mechanics based on their mathematics and physics background. Either course is appropriate for students planning to major (or minor) in physics.

### Mathematics

The mathematics requirement is a calculus sequence (MATH 15100-MATH 15200-MATH 15300 or MATH 16100-MATH 16200-MATH 16300) followed by PHYS 22100. As an alternative to PHYS 22100, students taking an Analysis sequence (MATH 20300-MATH 20400-MATH 20500 or MATH 20700-MATH 20800-MATH 20900) may substitute MATH 20500 or MATH 20900 for PHYS 22100, though they will subsequently need to acquire certain math tools, as needed, on their own. However, students interested in pursuing further study in physics and mathematics should consider taking both PHYS 22100 and an Analysis sequence.

But please note that for students starting their program with the PHYS 13100-PHYS 13200-PHYS 13300 sequence, the MATH 15300/MATH 16300 requirement is replaced by PHYS 22000. This course in mathematical methods introduces tools typically used in the PHYS 14100-PHYS 14200-PHYS 14300 sequence, and ensures that a student taking PHYS 13100-PHYS 13200-PHYS 13300 will possess the mathematical background needed for subsequent physics course work.

Finally, entering students placing into MATH 13100 should consult the undergraduate program chair to plan a program of study.

## Summary of Requirements

### GENERAL EDUCATION

One of the following sequences:		200
PHYS 13100-13200	Mechanics; Electricity and Magnetism	
PHYS 14100-14200	Honors Mechanics; Honors Electricity and Magnetism *	
One of the following sequences:		200
MATH 15100-15200	Calculus I-II *	
MATH 16100-16200	Honors Calculus I-II	

Total Units 400

### MAJOR

One of the following:		100
PHYS 13300	Waves, Optics, and Heat	
PHYS 14300	Honors Waves, Optics, and Heat *	
One of the following:		100
MATH 15300	Calculus III *	
MATH 16300	Honors Calculus III	

PHYS 22000	Introduction to Mathematical Methods in Physics	
Note: students in PHYS 13300 must take PHYS 22000.		
One of the following:		100
PHYS 22100	Mathematical Methods in Physics	
MATH 20500	Analysis in Rn III	
MATH 20900	Honors Analysis in Rn III	
PHYS 15400	Modern Physics	100
PHYS 18500	Intermediate Mechanics	100
PHYS 23400-23500	Quantum Mechanics I-II	200
PHYS 21101-21102-21103	Experimental Physics I-II-III	300
PHYS 22500-22700	Intermediate Electricity and Magnetism I-II	200
PHYS 19700	Statistical and Thermal Physics	100
Three electives (to be selected from list of approved courses)		300
Total Units		1600

\* Credit may be granted by examination.

### Electives

In addition to specified course work, the physics major requires three electives. These electives may be selected from the following courses:

All 20000-level physics courses (except PHYS 29100-29200-29300, and PHYS 29700)

Any of the following courses:		
ASTR 24100	The Physics of Stars <sup>†</sup>	
ASTR 23900	The Physics of Galaxies	
or ASTR 24200	The Physics of Galaxies and the Universe	
ASTR 24300	Cosmological Physics	
ASTR 25400	Radiation Processes in Astrophysics	
BIOS 29326	Introduction to Medical Physics and Medical Imaging	
CHEM 26300	Chemical Kinetics and Dynamics	
CHEM 26800	Computational Chemistry and Biology	
CMSC 23710	Scientific Visualization	
CMSC 28510	Introduction to Scientific Computing	
GEOS 21200	Physics of the Earth	
GEOS 23200	Climate Dynamics of the Earth and Other Planets	
GEOS 24220	Climate Foundations	
GEOS 24230	Geophysical Fluid Dynamics: Foundations	
GEOS 24240	Geophysical Fluid Dynamics: Rotation and Stratification	
GEOS 24250	Geophysical Fluid Dynamics: Understanding the Motions of the Atmosphere and Oceans	
MATH 23500	Markov Chains, Martingales, and Brownian Motion	
MATH 27000	Basic Complex Variables	
MATH 27200	Basic Functional Analysis	
MATH 27300	Basic Theory of Ordinary Differential Equations	
MATH 27400	Introduction to Differentiable Manifolds and Integration on Manifolds	
MATH 27500	Basic Theory of Partial Differential Equations	
MENG 23700	Quantum Computation	
MENG 26020	Engineering Electrodynamics	
MENG 26101	Transport Phenomena I: Forces and Flows	
MENG 26102	Transport Phenomena II	
STAT 23400	Statistical Models and Methods	
or STAT 24400	Statistical Theory and Methods I	
or STAT 24410	Statistical Theory and Methods Ia	
STAT 24500	Statistical Theory and Methods II	
or STAT 24510	Statistical Theory and Methods IIa	

Or other courses approved by the program chair for physics

† Cannot be counted toward electives if used to satisfy requirements for the specialization in astrophysics.

### Sample Programs

The sample programs below illustrate different paths for fulfilling requirements for the physics major.

In the first example, the Honors physics sequence PHYS 14100-14200-14300 is taken concurrently with calculus:

First Year	Units	Winter Quarter	Units	Spring Quarter	Units
Autumn Quarter					
PHYS 14100	100	PHYS 14200	100	PHYS 14300	100
MATH 15100 or 16100	100	MATH 15200 or 16200	100	MATH 15300 or 16300	100
	200		200		200

Total Units: 600

The next example shows a PHYS 13100-13200-13300 pathway. Here, the required PHYS 22000 course replaces the third quarter of calculus.

First Year	Units	Winter Quarter	Units	Spring Quarter	Units
Autumn Quarter					
PHYS 13100	100	PHYS 13200	100	PHYS 13300	100
MATH 15100 or 16100	100	MATH 15200 or 16200	100	PHYS 22000	100
	200		200		200

Total Units: 600

The remaining required courses are typically distributed over the next three years, like so:

Second Year	Units	Winter Quarter	Units	Spring Quarter	Units
Autumn Quarter					
PHYS 15400	100	PHYS 18500	100	PHYS 23400	100
PHYS 22100	100				
	200		100		100
Third Year					
Autumn Quarter	Units	Winter Quarter	Units	Spring Quarter	Units
PHYS 23500	100	PHYS 22500	100	PHYS 22700	100
PHYS 21101	100	PHYS 21102	100	PHYS 21103	100
	200		200		200
Fourth Year					
Autumn Quarter	Units				
PHYS 19700	100				
	100				

Total Units: 1100

In addition, three electives (selected from a list of approved courses) must be taken. In deciding when to take electives, students should be mindful of any course prerequisites.

The required laboratory sequence PHYS 21101-21102-21103 is a year-long study of experimental physics. It is recommended, but not required, that Experimental Physics be taken in the third year, concurrent with PHYS 23500.

Progress through the physics program can be accelerated by "doubling up" on some of the required courses. For example, PHYS 23500 and PHYS 19700 may be taken concurrently in the third year, and PHYS 22500/PHYS 22700 may be concurrent with PHYS 18500/PHYS 23400 in the second year. This provides more options in the third and fourth years for electives, as well as research or graduate course work. Note that it is possible to complete all program requirements in three years.

The specialization in astrophysics might be pursued by taking ASTR 24100, ASTR 24200, and ASTR 28200 in either the third or fourth year.

Finally, the sample programs shown here are only meant to be illustrative. Students are encouraged to speak with the departmental counselors in planning individual programs, especially regarding selection of mathematics courses and program electives.

### Introductory Course

The introductory course for students in the physical sciences is divided into two variants—PHYS 13100-PHYS 13200-PHYS 13300 and PHYS 14100-PHYS 14200-PHYS 14300—so students may learn with others who have comparable physics and mathematics backgrounds. The co-requisite for both is a first-year calculus sequence: MATH 15100-MATH 15200-MATH 15300 or MATH 16100-MATH 16200-MATH 16300 (or completion of MATH 13100-MATH 13200-MATH 13300). The essential physics content of these two sequences is the same, but the 140s sequence covers material at a higher mathematical level. Both PHYS 130s and PHYS 140s prepare students for further courses in the physics major or minor.

First-year students are assigned to either PHYS 13100 or PHYS 14100 based on Advanced Placement test scores. In addition, physics placement may be adjusted by consulting the undergraduate program chair (KPTC 205) during Orientation week. Transfer students who have satisfactorily completed calculus-based introductory physics courses at another university may be granted appropriate transfer credit upon petition to, and approval by, the program chair.

Another introductory sequence, PHYS 12100-PHYS 12200-PHYS 12300, is intended for students pursuing studies in biology or medicine. The prerequisite is two quarters of calculus and completion of general chemistry. While topics are similar to the 130s and 140s sequences, PHYS 120s cannot serve as a prerequisite for further courses in physics, and thus cannot be used for the physics major or minor.

A student who completes PHYS 14100 or PHYS 14200 with a grade below C is normally required to move to PHYS 13200 or PHYS 13300 the following quarter. Petitions for a waiver of this requirement must be presented to the undergraduate program chair before the second day of the succeeding course. A student who receives an A or A- in PHYS 13100 may petition the undergraduate program chair to move to PHYS 14200.

### Advanced Placement

Students who took the Physics C Advanced Placement examinations prior to matriculation in the College may receive credit for some or all of PHYS 12100-PHYS 12200-PHYS 12300. Consult the section on Advanced Placement Credit in this catalog for more information.

### Accreditation

Accreditation examinations are administered for the content of PHYS 12100-PHYS 12200-PHYS 12300 and PHYS 14100-PHYS 14200-PHYS 14300. The first examination may be taken by incoming students only at the time of matriculation in the College. Students who pass the first examination (for PHYS 12100 or PHYS 14100) will receive credit for the lecture part of the course only and will then be invited to try the next examination of the sequence. All students who receive advanced standing on the basis of a physics accreditation examination are interviewed by the undergraduate program chair to determine the extent of their lab experience. Additional laboratory work may be required.

### Grading

All regular (nonresearch) physics courses must be taken for quality grades. All courses used to satisfy prerequisites must be taken for quality grades. The Department of Physics requires students to pass PHYS 13100-PHYS 13200-PHYS 13300-PHYS 14100-PHYS 14200-PHYS 14300, PHYS 15400, PHYS 18500, and PHYS 23400 with an average of 2.0 or higher to continue in the program.

### Opportunities for Participation in Research

The physics program offers unique opportunities for College students to become actively involved in the research being conducted by faculty of the department. Interested students are welcome to consult with the departmental counselors. The focus of much of the undergraduate research is structured around the Bachelor's Thesis (PHYS 29100-PHYS 29200-PHYS 29300). Alternatively, third- or fourth-year students majoring in physics may register for research for academic credit (PHYS 29700). In addition to these formal arrangements, students at any level may become involved in research by working in a faculty member's lab or research group on an extracurricular basis.

### Honors

There are two routes to receiving a BA with honors. Both require a minimum GPA of 3.0 in the courses listed under Major in the preceding Summary of Requirements section. In the first route, the student must register for PHYS 29100-PHYS 29200-PHYS 29300 and earn a grade of B or higher based on a bachelor's thesis describing an approved research project completed during the year. The second route to receiving a BA with honors is to pass an approved set of three graduate courses, with a grade of B or higher in each. One such set of courses is PHYS 34100-PHYS 34200 and PHYS 35200; however, other 30000-level courses may be used with approval from the program chair.

### Degree Program in Physics with Specialization in Astrophysics

The program leading to a BA in physics with a specialization in astrophysics is a variant of the BA in physics. The degree is in physics, with the designation "with specialization in astrophysics" included on the final transcript. Candidates are required to complete all requirements for the BA degree in physics, plus three courses in astrophysics (selected from ASTR 23900 The Physics of Galaxies, ASTR 24100 The Physics of Stars, ASTR 24300 Cosmological Physics, ASTR 25400 Radiation Processes in Astrophysics, ASTR 28200 Current Topics in Astrophysics), or two courses in astrophysics plus a senior thesis project in physics (PHYS 29100-29200-29300 Bachelor's Thesis) on a topic in astrophysics. If the latter option is chosen, the thesis topic must be approved by the program chair. (This thesis may simultaneously fulfill part of the requirements for honors in physics.) A grade of at least C- must be obtained in each course.

### Minor Program in Physics

The minor in physics is designed to present a coherent program of study to students with a strong interest in physics but insufficient time to pursue the major. The courses required for the minor are:

One of the following:		100
PHYS 13300	Waves, Optics, and Heat	
PHYS 14300	Honors Waves, Optics, and Heat	
One of the following:		100

MATH 15300	Calculus III	
MATH 16300	Honors Calculus III	
PHYS 22000	Introduction to Mathematical Methods in Physics	
Note: students in PHYS 13300 must take PHYS 22000.		
PHYS 15400	Modern Physics	100
PHYS 18500	Intermediate Mechanics	100
PHYS 22100	Mathematical Methods in Physics	100
PHYS 23400	Quantum Mechanics I	100
Two electives, at least one of which is:		200
PHYS 19700	Statistical and Thermal Physics	
PHYS 22500	Intermediate Electricity and Magnetism I	
PHYS 23500	Quantum Mechanics II	
The second elective may be any course that is required by the major or can be used as an elective for the major.		
Total Units		800

The mathematics requirement for the minor is identical to the requirement for the major; please consult the description of the major for more information, particularly regarding PHYS 22000 and PHYS 22100. Note that PHYS 22000 and PHYS 22100 may be replaced by equivalent courses, as approved by the undergraduate program chair. Note also that the PHYS 13300/PHYS 14300, PHYS 22100, and MATH 15300/MATH 16300/PHYS 22000 requirements will be waived for those who must take these courses to satisfy the requirements of a major or another minor. Consequently, the number of courses needed for the minor will vary between five and eight.

Students who elect the minor program in physics must meet with the physics undergraduate program chair before the end of Spring Quarter of their third year to declare their intention to complete the minor. The approval of the program chair for the minor program should be submitted to a student's College adviser by the deadline above on a form obtained from the College adviser. Courses for the minor are chosen in consultation with the program chair.

Courses in the minor (1) may not be double counted with the student's major(s) or with other minors and (2) may not be counted toward general education requirements. Courses in the minor must be taken for quality grades, and students must have a GPA of 2.0 or higher in the minor. More than half of the requirements for the minor must be met by registering for courses bearing University of Chicago course numbers.





### Font Notice

This document should contain certain fonts with restrictive licenses. For this draft, substitutions were made using less legally restrictive fonts. Specifically:

Times was used instead of Trajan.

Times was used instead of Palatino.

The editor may contact Leepfrog for a draft with the correct fonts in place.