PHYSICS - BACHELOR OF SCIENCE (BS)

The undergraduate Bachelor of Science (BS) degree in physics emphasizes knowledge and awareness of:

- The basic subfields of physics (classical mechanics, electricity and magnetism, quantum mechanics, statistical mechanics and thermodynamics), as well as at least one specialty area of application (e.g., condensed matter physics, plasma physics);
- The major principles of physics, their historical development and the roles they play in the various subfields of physics;
- The interrelations between theory and observation, the role of systematic and random experimental errors, and methods used to analyze experimental uncertainty and compare experiment with theory;
- Physical phenomena and experience in the use of basic experimental apparatus and measuring instruments;
- Mathematics sufficient to facilitate the acquisition and application of physical principles; and
- The importance of physics in other fields such as chemistry, biology, engineering, medicine and in society at large.

In addition, students completing the BS degree in physics are expected to acquire the ability and skills to:

- Apply physical principles to new situations;
- Construct and assemble experimental apparatus, conduct and analyze measurements of physical phenomena, analyze experimental uncertainty and make meaningful comparisons between experiment and theory; and
- Communicate results of scientific inquiries verbally and in writing.

Plans of Study

Two different plans are available to students for the BS in Physics. Because there is some flexibility within each plan, the department encourages students to pursue their own interests in setting up their curriculum. The final responsibility for fulfilling the requirements for the degree rests with the student.

Note: Students may not earn both a BS degree in physics from the College of Arts & Sciences and a either a BS degree in engineering physics from the College of Engineering & Applied Science or a BA degree in physics from the College of Arts & Sciences. Furthermore, the physics minor may not be earned with any of these baccalaureate programs.

Plan I

This plan is primarily for students planning graduate work in physics or planning a career in industry.

Plan II

This plan is for students desiring an interdisciplinary physics program.

The interdisciplinary program includes a combination of a physics major with a focus in another area such as astrophysics, atmospheric sciences, applied mathematics, biophysics, biotechnology, chemical physics, computer science, electronic devices, environmental sciences, geophysics, optics, philosophy and history of science, and pre-medicine.

Requirements

Program Requirements

Students who have declared physics as a major are required to consult with a physics faculty mentor at least once per semester. First-year students considering physics as a major, are strongly encouraged to visit the physics academic advisor and discuss the situation. Because most of the advanced physics courses have various prerequisites, failure to settle on an appropriate plan of study early in the college career can result in delay and complications later. Students must receive a "C-" or better in all major courses, as well as in ancillary courses. These courses cannot be taken pass/fail. If a course is a pre-requisite for another course, the student may not register for the subsequent course until the grade in the pre-requisite is a "C-" or better. Students must have a grade point average of at least 2.000 in the major in order to graduate, and no more than 66 credits in PHYS may be applied to overall graduation requirements.

Students must complete the general requirements of the College of Arts and Sciences and the required courses listed below.

Plans of Study

Plan I

This plan includes 45 credit hours of physics courses.

Required Courses and Credits

Code	Title	Credit Hours
Required Physics Courses		
PHYS 1115	General Physics 1 for Majors	4
or PHYS 1110	General Physics 1	
PHYS 1125	General Physics 2 for Majors	4
or PHYS 1120	General Physics 2	
PHYS 1140	Experimental Physics 1	1
PHYS 2150	Experimental Physics 2	2
PHYS 2170	Foundations of Modern Physics	3
PHYS 2210	Classical Mechanics and Mathematical Methods 1	3
PHYS 3210	Classical Mechanics and Mathematical Methods 2	3
PHYS 3220	Quantum Mechanics 1	3
PHYS 3310	Principles of Electricity and Magnetism 1	3
PHYS 3320	Principles of Electricity and Magnetism 2	3
PHYS 3330	Electronics for the Physical Sciences	3
PHYS 4230	Thermodynamics and Statistical Mechanics	3
PHYS 4410	Quantum Mechanics 2	3
Physics Electives		
Complete at least 9 credits Physics Electives taking at least 3 credits from Research Activity list and at least 3 credit from Theory Electives list.		9
Research Activity - see details below		
PHYS 4430	Advanced Laboratory	
PHYS 4610	Physics Honors	
PHYS 4620	Physics Honors	
PHYS 4630	Physics Honors	
PHYS 4700	Quantum Forge I	
PHYS 4710	Quantum Forge II	

PHYS 4840	Independent Study
Theory Electives	
PHYS 2600	Introduction to Programming and Scientific Computing
PHYS 3090	Introduction to Quantum Computing
PHYS 4150	Plasma Physics
PHYS 4340	Introduction to Solid State Physics
PHYS 4420	Nuclear and Particle Physics
PHYS 4450	History and Philosophy of Physics
PHYS 4460	Teaching and Learning Physics
PHYS 4510	Optics
PHYS 4550	Cells, Molecules and Tissues: A Biophysical Approach
PHYS 4560	Introduction to Biophysics
PHYS 4810	Special Topics in Physics
PHYS 5030	Intermediate Mathematical Physics 1
PHYS 5040	Intermediate Mathematical Physics 2
PHYS 5770	Gravitational Theory (Theory of General Relativity)
Other PHYS or ASTR upper-division courses as approved in advance by advisor.	
Total Credit Hours	**47**

Ancillary Mathematics & Chemistry Coursework

Code	Title	Credit Hours
Ancillary Mathematics Courses		
MATH 1300	Calculus 1	4-5
or APPM 1350	Calculus 1 for Engineers	
MATH 2300	Calculus 2	4-5
or APPM 1360	Calculus 2 for Engineers	
MATH 2400	Calculus 3	4-5
or APPM 2350	Calculus 3 for Engineers	
Select one of the following Linear Algebra and Differential Equations options:		4-6
Option 1		
APPM 2360	Introduction to Differential Equations with Linear Algebra	
Option 2		
MATH 2130 & MATH 3430	Introduction to Linear Algebra for Non-Mathematics Majors and Ordinary Differential Equations	
Ancillary Chemistry Course		
CHEM 1113 & CHEM 1114	General Chemistry 1 and Laboratory in General Chemistry 1	5
Total Credit Hours		**21-26**

Ancillary Programming Requirement

The programming requirement may be completed in one of the following ways:

1. Complete PHYS 2600, ASTR 2600, CSCI 1300 or APPM 1650. (PHYS 2600 will count toward the 45 required PHYS credit hours while the other programming courses will not.)
2. By documentation of programming experience (i.e., a letter from a job or internship, or evidence of substantial contributions to an open-source code base). Approval by a physics department faculty mentor is required for this option and no academic credit is earned under this option.

Research Activity Requirement

The research activity may be completed in one of the following ways:

1. Between 3 and 6 credit hours may be earned from: PHYS 4430, PHYS 4610/PHYS 4620/PHYS 4630, PHYS 4700, PHYS 4710 or PHYS 4840.
2. By documentation of your accomplishments as an intern with a research activity within the physics department or a suitable cognate department, institute or external entity such as NCAR, NIST, NOAA, etc.
   - Approval by a physics department advisor is required for option (2) and should be obtained in advance.
   - No academic credit is earned under the internship option (2), so if an internship is taken, students must still earn 9 credit hours of physics electives.

Plan II

For the interdisciplinary program, 33 credit hours of physics courses, plus 12 credit hours of interdisciplinary courses are required. Courses in the interdisciplinary subjects may not be double-counted with the required 33 credit hours of physics courses. Students may not double-major in Astrophysics (though the APS department) and Physics Plan 2 with an astrophysics concentration.

Interdisciplinary courses must be approved by the physics department, either by the pre-approved list of courses in each discipline or by a physics department mentor on a course-by-course basis. It is therefore imperative that students in Plan II be in close contact with the physics department advisor.

Required Courses and Credits

Code	Title	Credit Hours
Required Physics Courses		
PHYS 1115	General Physics 1 for Majors	4
or PHYS 1110	General Physics 1	
PHYS 1125	General Physics 2 for Majors	4
or PHYS 1120	General Physics 2	
PHYS 1140	Experimental Physics 1	1
PHYS 2150	Experimental Physics 2	2
PHYS 2170	Foundations of Modern Physics	3
PHYS 2210	Classical Mechanics and Mathematical Methods 1	3
PHYS 3210	Classical Mechanics and Mathematical Methods 2	3
PHYS 3220	Quantum Mechanics 1	3
PHYS 3310	Principles of Electricity and Magnetism 1	3
PHYS 3320	Principles of Electricity and Magnetism 2	3
PHYS 3330	Electronics for the Physical Sciences	3
PHYS 4230	Thermodynamics and Statistical Mechanics	3
Interdisciplinary Program		
Select 12 credit hours from an interdisciplinary focus. [1]		12
Total Credit Hours		**47**

Ancillary Mathematics & Chemistry Coursework

Code	Title	Credit Hours
Ancillary Mathematics Courses		
MATH 1300	Calculus 1	4-5
or APPM 1350	Calculus 1 for Engineers	
MATH 2300	Calculus 2	4-5
or APPM 1360	Calculus 2 for Engineers	
MATH 2400	Calculus 3	4-5
or APPM 2350	Calculus 3 for Engineers	
Select one of the following Linear Algebra and Differential Equations options:		4-6
Option 1		
APPM 2360	Introduction to Differential Equations with Linear Algebra	
Option 2		
MATH 2130 & MATH 3430	Introduction to Linear Algebra for Non-Mathematics Majors and Ordinary Differential Equations	
Ancillary Chemistry Course		
CHEM 1113 & CHEM 1114	General Chemistry 1 and Laboratory in General Chemistry 1	5
Total Credit Hours		**21-26**

Ancillary Programming Requirement

The programming requirement may be completed in one of the following ways:

1. Complete PHYS 2600, ASTR 2600, CSCI 1300 or APPM 1650. (PHYS 2600 could count as the 3-credit PHYS elective in the interdisciplinary program.)
2. By documentation of programming experience (i.e., a letter from a job or internship, or evidence of substantial contributions to an open-source code base). Approval by a physics department faculty mentor is required for this option and no academic credit is earned under this option.

[1] Departmental lists of approved courses for the interdisciplinary plan are available in the advising guide on the Department of Physics website (http://www.colorado.edu/physics/).

Graduating in Four Years

Consult the Four-Year Guarantee Requirements for information on eligibility. The concept of "adequate progress" as it is used here only refers to maintaining eligibility for the four-year guarantee; it is not a requirement for the major. To maintain adequate progress in physics plans I and II, students should meet the following requirements:

- In the first semester, declare the physics major.
- By the end of the second semester, complete the following courses: PHYS 1110 or PHYS 1115; PHYS 1120 or PHYS 1125; PHYS 1140, MATH 1300 or APPM 1350, and MATH 2300 or APPM 1360.
- By the end of the fourth semester, complete the following courses: PHYS 2150, PHYS 2170, PHYS 2210, CHEM 1113, MATH 2400 or APPM 2350; and APPM 2360. MATH 2130 and MATH 3430 can substitute for APPM 2360.
- Before the fifth semester, meet with the physics advisor to get approval for completion plan (FSACP). In addition to completing PHYS 4230 and PHYS 4410, Plan I students must get approval to complete 9 credit hours in physics electives, with a research participation component. In addition to completing PHYS 4230, interdisciplinary Plan II students must complete 12 credit hours of interdisciplinary courses.
- By the end of the sixth semester, complete PHYS 3210, PHYS 3220, PHYS 3310, PHYS 3320 and PHYS 3330.
- Early in the seventh semester, meet with the physics advisor to have the statement of major status filled in. This includes a plan for completing the requirements of the major during the senior year and must be signed by the student and the advisor. Further details concerning the execution of the guarantee can be obtained from the department.

Sample Four-Year Plan of Study

Through the required coursework for the major, students will fulfill all 12 credits of the Natural Sciences area of the Gen Ed Distribution Requirement, including the Lab requirement, and the QRMS component of the Gen Ed Skills Requirement. See the department for Plan-specific Four-Year Plans of Study.

Year One		
Fall Semester		**Credit Hours**
PHYS 1115 or PHYS 1110	General Physics 1 for Majors or General Physics 1	4
MATH 1300 or APPM 1350	Calculus 1 or Calculus 1 for Engineers	5
Gen. Ed. Distribution/Diversity course (example: Arts & Humanities/Global Perspective)		3
Gen. Ed. Skills course (example: Lower-division Written Communication)		3
	Credit Hours	**15**
Spring Semester		
PHYS 1125 or PHYS 1120	General Physics 2 for Majors or General Physics 2	4
PHYS 1140	Experimental Physics 1	1
MATH 2300 or APPM 1360	Calculus 2 or Calculus 2 for Engineers	4-5
CHEM 1113	General Chemistry 1	4
CHEM 1114	Laboratory in General Chemistry 1	1
	Credit Hours	**14-15**
Year Two		
Fall Semester		
PHYS 2170	Foundations of Modern Physics	3
PHYS 2150	Experimental Physics 2	1
MATH 2400 or APPM 2350	Calculus 3 or Calculus 3 for Engineers	4-5
MATH 2130	Introduction to Linear Algebra for Non-Mathematics Majors (or elective if completing APPM track)	3
Gen. Ed. Distribution course (example: Arts & Humanities)		3
	Credit Hours	**14-15**
Spring Semester		
PHYS 2210	Classical Mechanics and Mathematical Methods 1	3

MATH 3430 or APPM 2360	Ordinary Differential Equations or Introduction to Differential Equations with Linear Algebra	3
	Credit Hours	**6**
Year Three		
Fall Semester		
PHYS 3210	Classical Mechanics and Mathematical Methods 2	3
PHYS 3310	Principles of Electricity and Magnetism 1	3
PHYS 3330	Electronics for the Physical Sciences	2
Gen. Ed. Distribution course (example: Social Sciences)		3
Gen. Ed. Distribution course (example: Arts & Humanities)		3
Elective		3
	Credit Hours	**17**
Spring Semester		
PHYS 3220	Quantum Mechanics 1	3
PHYS 3320	Principles of Electricity and Magnetism 2	3
PHYS Upper-division elective		3
Gen. Ed. Distribution course (example: Social Sciences)		3
Elective		3
	Credit Hours	**15**
Year Four		
Fall Semester		
PHYS 4230	Thermodynamics and Statistical Mechanics	3
PHYS 4410	Quantum Mechanics 2	3
PHYS: Elective from approved list (or general elective if Programming course was PHYS 2600)		3
Gen. Ed. Skills course (example: Upper-division Written Communication)		3
Upper-division elective		3
	Credit Hours	**15**
Spring Semester		
PHYS: Upper Division Elective from approved list		3
Gen. Ed. Distribution/Diversity course (example: Social Science/US Perspective)		3
PHYS Reserach/Lab Elective		3
Upper-division elective		3
Lower or Upper-division elective		3
	Credit Hours	**15**
	Total Credit Hours	**111-113**

Learning Outcomes

By the completion of the program, students will be able to:

- Have the knowledge of the basic subfields of physics (classical mechanics, electricity and magnetism, quantum mechanics, statistical mechanics and thermodynamics), as well as at least one specialty area of application (e.g., condensed matter physics or optics).
- Apply major principles of physics towards solving problems in various subfields of physics, including the use of mathematical and computational tools as appropriate.
- Assemble and use experimental apparatus to conduct and analyze measurements of physical phenomena.
- Have the knowledge of the role of systematic and random experimental errors, along with methods used to analyze experimental uncertainty and compare experiment with theory.
- Collaborate effectively and communicate results of scientific inquiries verbally and in writing.