

PHYSICS, B.S. (BEHREND)

Begin Campus: Any Penn State Campus

End Campus: Erie

Program Description

The major provides education in the fundamentals of physics and selected advanced topics to prepare graduates for graduate education or for careers in industry. Students have opportunities to participate in research with faculty. In addition to the traditional physics education offered in the General Physics option, the option in applied physics, Computational Physics, provides preparation for careers in technological fields.

What is Physics?

Physicists study natural phenomena in the universe, from the smallest length scales to the largest in the cosmos, to discover the basic principles or laws which govern the physical world. Knowledge of physics is crucial to truly understanding the world around us, the world inside us, and the world beyond us. This degree will provide students with the fundamental conceptual, mathematical, computational, and experimental tools that are needed to attack the scientific and technological problems of today and in the future.

You Might Like This Program If...

- You are interested in science, math, chemistry, astronomy, astrophysics, thermodynamics, optics, quantum mechanics, theoretical mechanics, electrodynamics, solid state physics, electricity, or magnetism.
- You enjoy both theoretical study and hands-on laboratory work.
- You can envision yourself studying the night sky in Penn State Behrend's Mehalso Observatory or Yahn Planetarium.
- You're looking for a foundational major that supports diverse career paths in the sciences, engineering, research, education, and health care.

Entrance to Major

To be eligible for entrance to the Physics major, a student must have:

1. attained at least a 2.00 cumulative grade-point average;
2. completed CHEM 110, MATH 140, MATH 141, PHYS 211, and PHYS 212, and earned a grade of C or better in each of these courses.

Degree Requirements

For the Bachelor of Science degree in Physics, a minimum of 122 credits is required:

Requirement	Credits
General Education	45
Electives	1
Requirements for the Major	94

18 of the 45 credits for General Education are included in the Requirements for the Major. This includes: 9 credits of GN courses; 6 credits of GQ courses; 3 credits of GWS courses.

Per Senate Policy 83.80.5, the college dean or campus chancellor and program faculty may require up to 24 credits of coursework in the major

to be taken at the location or in the college or program where the degree is earned.

Requirements for the Major

Each student must earn at least a grade of C in each 300- and 400-level course in the major field.

To graduate, a student enrolled in the major must earn a grade of C or better in each course designated by the major as a C-required course, as specified by Senate Policy 82-44 (<http://senate.psu.edu/policies-and-rules-for-undergraduate-students/82-00-and-83-00-degree-requirements/#82-44>).

Common Requirements for the Major (All Options)

Code	Title	Credits
Prescribed Courses		
CHEM 111	Experimental Chemistry I	1
CHEM 112	Chemical Principles II	3
CHEM 113	Experimental Chemistry II	1
CMPSC 121	Introduction to Programming Techniques	3
ENGL 202C	Effective Writing: Technical Writing	3
MATH 220	Matrices	2
MATH 230	Calculus and Vector Analysis	4
MATH 251	Ordinary and Partial Differential Equations	4
<i>Prescribed Courses: Require a grade of C or better</i>		
CHEM 110	Chemical Principles I	3
MATH 140	Calculus With Analytic Geometry I	4
MATH 141	Calculus with Analytic Geometry II	4
PHYS 211	General Physics: Mechanics	4
PHYS 212	General Physics: Electricity and Magnetism	4
PHYS 213	General Physics: Fluids and Thermal Physics	2
PHYS 214	General Physics: Wave Motion and Quantum Physics	2
PHYS 237	Introduction to Modern Physics	3
PHYS 400	Intermediate Electricity and Magnetism	3
PHYS 419	Theoretical Mechanics	3
PHYS 420	Thermal Physics	3
PHYS 421W	Research Methods in Physics	3
PHYS 458	Intermediate Optics	4
PHYS 494	Physics Research Project	3
Requirements for the Option		
Select an option		28

Requirements for the Option Computational Physics Option (28 credits)

Code	Title	Credits
Prescribed Courses		
CMPSC 122	Intermediate Programming	3
<i>Prescribed Courses: Require a grade of C or better</i>		
MATH 455	Introduction to Numerical Analysis I	3
PHYS 402	Electronics for Scientists	4
Additional Courses		
<i>Additional Courses: Require a grade of C or better</i>		
Select one of the following:		3
CMPSC 459	Scientific Visualization	
CMPSC 465	Data Structures and Algorithms	

CMPSC 474	Operating System & Systems Programming	
Select 12 credits of the following:		12
EE 352	Signals and Systems: Continuous and Discrete-Time	
EE 453	Fundamentals of Digital Signal Processing	
MATH 456	Introduction to Numerical Analysis II	
ME 410	Heat Transfer	
ME 428	Applied Computational Fluid Dynamics	
PHYS 410	Introduction to Quantum Mechanics I	
PHYS 414	Solid State Physics	
PHYS 446	The Year in Physics: A Seminar on the Latest Research	
PHYS 494	Physics Research Project (1-3 credits)	
PHYS 495	Internship (1-3 credits)	

Supporting Courses and Related Areas

Select 3 credits from a school-approved list 3

General Physics Option (28 credits)

Code	Title	Credits
Prescribed Courses		
<i>Prescribed Courses: Require a grade of C or better</i>		
PHYS 410	Introduction to Quantum Mechanics I	3

Additional Courses

Additional Courses: Require a grade of C or better

Select 12 credits of the following:		12
MATH 421	Complex Analysis	
MATH 455	Introduction to Numerical Analysis I	
MATH 456	Introduction to Numerical Analysis II	
PHYS 402	Electronics for Scientists	
PHYS 414	Solid State Physics	
PHYS 446	The Year in Physics: A Seminar on the Latest Research	
PHYS 494	Physics Research Project (1-3 credits)	
PHYS 495	Internship (1-3 credits)	

Supporting Courses and Related Areas

Select one of the following two sequences: 13

Sequence A

Select 8 credits of a foreign language¹

Select 5 credits from a school-approved list

Sequence B

CMPSC 122 Intermediate Programming

Select one of the following:

CMPSC 459 Scientific Visualization²

CMPSC 465 Data Structures and Algorithms²

CMPSC 474 Operating System & Systems Programming²

Select 7 credits from a school-approved list

¹ Proficiency demo by examination or coursework to the level of the second semester in a foreign language is required. If fewer than 8 credits are needed to reach the required proficiency, students choose selections from a school-approved list to make a total of 8 credits.

² Course requires a grade of C or better.

General Education

Connecting career and curiosity, the General Education curriculum provides the opportunity for students to acquire transferable skills necessary to be successful in the future and to thrive while living in interconnected contexts. General Education aids students in developing intellectual curiosity, a strengthened ability to think, and a deeper sense of aesthetic appreciation. These are requirements for all baccalaureate students and are often partially incorporated into the requirements of a program. For additional information, see the General Education Requirements (<https://bulletins.psu.edu/undergraduate/general-education/baccalaureate-degree-general-education-program/>) section of the Bulletin and consult your academic adviser.

The keystone symbol appears next to the title of any course that is designated as a General Education course. Program requirements may also satisfy General Education requirements and vary for each program.

Foundations (grade of C or better is required.)

- **Quantification (GQ):** 6 credits
- **Writing and Speaking (GWS):** 9 credits

Knowledge Domains

- **Arts (GA):** 6 credits
- **Health and Wellness (GHW):** 3 credits
- **Humanities (GH):** 6 credits
- **Social and Behavioral Sciences (GS):** 6 credits
- **Natural Sciences (GN):** 9 credits

Integrative Studies (may also complete a Knowledge Domain requirement)

- **Inter-Domain or Approved Linked Courses:** 6 credits

University Degree Requirements**First Year Engagement**

All students enrolled in a college or the Division of Undergraduate Studies at University Park, and the World Campus are required to take 1 to 3 credits of the First-Year Seminar, as specified by their college First-Year Engagement Plan.

Other Penn State colleges and campuses may require the First-Year Seminar; colleges and campuses that do not require a First-Year Seminar provide students with a first-year engagement experience.

First-year baccalaureate students entering Penn State should consult their academic adviser for these requirements.

Cultures Requirement

6 credits are required and may satisfy other requirements

- **United States Cultures:** 3 credits
- **International Cultures:** 3 credits

Writing Across the Curriculum

3 credits required from the college of graduation and likely prescribed as part of major requirements.

Total Minimum Credits

A minimum of 120 degree credits must be earned for a baccalaureate degree. The requirements for some programs may exceed 120 credits. Students should consult with their college or department adviser for information on specific credit requirements.

Quality of Work

Candidates must complete the degree requirements for their major and earn at least a 2.00 grade-point average for all courses completed within their degree program.

Limitations on Source and Time for Credit Acquisition

The college dean or campus chancellor and program faculty may require up to 24 credits of course work in the major to be taken at the location or in the college or program where the degree is earned. Credit used toward degree programs may need to be earned from a particular source or within time constraints (see Senate Policy 83-80 (<http://senate.psu.edu/policies-and-rules-for-undergraduate-students/82-00-and-83-00-degree-requirements/#83-80>)). For more information, check the Suggested Academic Plan for your intended program.

Program Learning Objectives

- **Core Knowledge:** Learn, integrate, and apply knowledge and methodological approaches from the basic core areas of electricity and magnetism, thermodynamics, optics, and quantum mechanics.
- **Mathematical Models:** Build a conceptual understanding of the connections between our mathematical models and the nature of the universe.
- **Critical Thinking:** Use critical thinking to formulate and solve quantitative physical problems by applying theory, mathematical, and computational methods.
- **Scientific Inquiry:** Apply the methods of scientific inquiry in designing and performing experiments and using data analysis for laboratory and research projects.
- **Communication:** Effectively communicate their course work and research through organized, logical, and scientifically sound oral and written reports.

Academic Advising

The objectives of the university's academic advising program are to help advisees identify and achieve their academic goals, to promote their intellectual discovery, and to encourage students to take advantage of both in-and-out-of class educational opportunities in order that they become self-directed learners and decision makers.

Both advisers and advisees share responsibility for making the advising relationship succeed. By encouraging their advisees to become engaged in their education, to meet their educational goals, and to develop the habit of learning, advisers assume a significant educational role. The advisee's unit of enrollment will provide each advisee with a primary academic adviser, the information needed to plan the chosen program of study, and referrals to other specialized resources.

READ SENATE POLICY 32-00: ADVISING POLICY (<https://senate.psu.edu/policies-and-rules-for-undergraduate-students/32-00-advising-policy/>)

Erie

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Suggested Academic Plan

The suggested academic plan(s) listed on this page are the plan(s) that are in effect during the 2022-23 academic year. To access previous years' suggested academic plans, please visit the archive (<https://bulletins.psu.edu/undergraduate/archive/>) to view the appropriate Undergraduate Bulletin edition (*Note: the archive only contains suggested academic plans beginning with the 2018-19 edition of the Undergraduate Bulletin*).

General Physics Option: Physics, B.S. at Erie Campus

The course series listed below provides **only one** of the many possible ways to move through this curriculum. The University may make changes in policies, procedures, educational offerings, and requirements at any time. This plan should be used in conjunction with your degree audit (accessible in LionPATH as either an **Academic Requirements** or **What If** report). Please consult with a Penn State academic adviser on a regular basis to develop and refine an academic plan that is appropriate for you.

First Year

Fall	Credits Spring	Credits
CHEM 110 ^{*#†}	3 CHEM 112 [†]	3
CHEM 111 [†]	1 CHEM 113 [†]	1
MATH 140 ^{*†##}	4 MATH 141 ^{*†##}	4
ENGL 15 or 30H ^{††}	3 PHYS 211 ^{*#}	4
General Education Course	3 General Education Course	3
General Education Course (GHW)	1.5 General Education Course (GWH)	1.5
PSU 7	1	
	16.5	16.5

Second Year

Fall	Credits Spring	Credits
PHYS 212 ^{*#}	4 CMPSC 121	3
PHYS 213 [*]	2 PHYS 237 [*]	3
PHYS 214 [*]	2 MATH 251	4
MATH 220	2 CAS 100 ^{††}	3
MATH 230	4 General Education Course	3
General Education Course	3	
	17	16

Third Year

Fall	Credits Spring	Credits
PHYS 421W [*]	3 PHYS 419 [*]	3
PHYS 420 [*]	3 PHYS 414 (Supports Additional Course Selection) [*]	3
CMPSC 122 (or World Language - 4 credits)	3 CMPSC 465 or 474 (or World Language - 4 credits) [*]	3
ENGL 202C [†]	3 PHYS 494 or 495 [*]	3
PHYS 494 or 495 (PHYS 494 Supports Additional Course Selection) [*]	1 Additional Course Selection [*]	3
General Education Course (GN)	3	
	16	15

Fourth Year

Fall	Credits Spring	Credits
PHYS 400*	3 PHYS 410*	3
PHYS 402*	4 PHYS 458*	4
Supporting Courses and Related Areas	3-4 Supporting Courses and Related Areas	3-4
General Education Course	3 General Education Course	3
	13-14	13-14

Total Credits 123-125

- * Course requires a grade of C or better for the major
 ‡ Course requires a grade of C or better for General Education
 # Course is an Entrance to Major requirement
 † Course satisfies General Education and degree requirement

University Requirements and General Education Notes:

US and IL are abbreviations used to designate courses that satisfy University Requirements (United States and International Cultures).

W, M, X, and Y are the suffixes at the end of a course number used to designate courses that satisfy University Writing Across the Curriculum requirement.

GWS, GQ, GHW, GN, GA, GH, and GS are abbreviations used to identify General Education program courses. General Education includes Foundations (GWS and GQ) and Knowledge Domains (GHW, GN, GA, GH, GS, and Integrative Studies). Foundations courses (GWS and GQ) require a grade of 'C' or better.

Integrative Studies courses are required for the General Education program. N is the suffix at the end of a course number used to designate an Inter-Domain course and Z is the suffix at the end of a course number used to designate a Linked course.

Program NotesScheduling patterns for courses not taught each semester

Some major requirements will be offered only once a year or every other year depending on demand. 400 level physics courses are taught on a rotating basis; courses are taught only once every other year.

-Fall only courses include: CMPSC 474, MATH 455, PHYS 400, PHYS 402, PHYS 420, PHYS 421W

-Spring only courses include: CMPSC 455, MATH 421, ME 428, MATH 456, PHYS 410, PHYS 414, PHYS 419, PHYS 458

- 1.) All first year baccalaureate degree candidates are required to complete, during the first academic year, a seminar course.
- 2.) Any 300 or 400 level science or mathematics course requires a C or better.
- 3.) Students with a prior introduction to calculus may take MATH 140 and PHYS 211 concurrently in their first semester.
4. A course noting "Supports Additional Course Selection" counts as an "Additional Course Selection." A total of 23 credits must be taken in this area. Possible course substitutions are listed below in the Additional Course Selection List. Please note that three credits of PHYS 494 and/or PHYS 495 are prescribed. Any additional credits in PHYS 494 or PHYS 495 (up to a maximum of 3 credits) may be applied to the additional course requirement.
- 5.) Supporting Courses - students must select (3) credits from the following: CMPSC 459 Scientific Visualization, CMPSC 456 Introduction

to Numerical Analysis II, CMPSC 474 Operating System & Systems Programming. CMPSC 456 is recommended.
 6.) Students must select (3) credits from the Supporting Course List below. MATH 456 or CMPSC 456 is recommended.

Advising NotesAdditional Course Selection List*

EE 352 Signals and Systems: Continuous and Discrete-Time
 PHYS 414 Solid State Physics
 MATH 421 Complex Analysis
 MATH 455 Introduction to Numerical Analysis I
 MATH 456 Introduction to Numerical Analysis II
 PHYS 402 Electronics for Scientists
 PHYS 446 The Year in Physics: A Seminar on the Latest Research
 PHYS 494 Physics Research Project
 PHYS 495 Internship

Supporting Course List

ASTRO 291 or higher
 BIOL 110 or higher
 CHEM 210 or higher
 CMPSC 200 or higher
 MATH 300 or 400 level*
 STAT 300 or 400 level*

Unacceptable Courses for the Physics Major or Minor

Math courses below MATH 140
 Physics courses below PHYS 211
 PHYS 250
 PHYS 251

Computational Physics Option: Physics, B.S. at Erie Campus

The course series listed below provides **only one** of the many possible ways to move through this curriculum. The University may make changes in policies, procedures, educational offerings, and requirements at any time. This plan should be used in conjunction with your degree audit (accessible in LionPATH as either an **Academic Requirements** or **What If** report). Please consult with a Penn State academic adviser on a regular basis to develop and refine an academic plan that is appropriate for you.

First Year

Fall	Credits	Spring	Credits
CHEM 110 ^{*#†}	3	CHEM 112 [†]	3
CHEM 111 ^{††}	1	CHEM 113 [†]	1
MATH 140 ^{*#†}	4	MATH 141 ^{*†#†}	4
ENGL 15 or 30H ^{††}	3	PHYS 211 ^{*#}	4
General Education Course	3	General Education Course	3
General Education Course (GHW)	1.5	General Education Course (GHW)	1.5
PSU 7	1		
	16.5		16.5

Second Year

Fall	Credits	Spring	Credits
PHYS 212 ^{*#}	4	PHYS 237 [*]	3
PHYS 213 [*]	2	MATH 251	4
PHYS 214 [*]	2	CAS 100 ^{††}	3
MATH 220	2	CMPSC 122	3
MATH 230	4	General Education Course	3
CMPSC 121	3		
	17		16

Third Year

Fall	Credits	Spring	Credits
PHYS 420 [*]	3	PHYS 419 [*]	3
PHYS 421W [*]	3	PHYS 414 (Supports Additional Course Selection) [*]	3
General Education Course (GN) [†]	3	CMPSC 465 [*]	3
PHYS 494 (Supports Additional Course Selection) [*]	1	PHYS 494 or 495 [*]	3
CMPSC 474 [*]	3	General Education Course	3
ENGL 202C ^{††}	3		
	16		15

Fourth Year

Fall	Credits	Spring	Credits
PHYS 400 [*]	3	EE 352 (Supports Additional Course Selection) [*]	4
PHYS 402 [*]	4	PHYS 458 [*]	4
MATH 455 or CMPSC 455 [*]	3	MATH 456 or CMPSC 456 (MATH 456 Supports Additional Course Selection) [*]	3

General Education Course	3 General Education Course	3
	13	14

Total Credits 124

- * Course requires a grade of C or better for the major
- ‡ Course requires a grade of C or better for General Education
- # Course is an Entrance to Major requirement
- † Course satisfies General Education and degree requirement

University Requirements and General Education Notes:

US and IL are abbreviations used to designate courses that satisfy University Requirements (United States and International Cultures).

W, M, X, and Y are the suffixes at the end of a course number used to designate courses that satisfy University Writing Across the Curriculum requirement.

GWS, GQ, GHW, GN, GA, GH, and GS are abbreviations used to identify General Education program courses. General Education includes Foundations (GWS and GQ) and Knowledge Domains (GHW, GN, GA, GH, GS, and Integrative Studies). Foundations courses (GWS and GQ) require a grade of 'C' or better.

Integrative Studies courses are required for the General Education program. N is the suffix at the end of a course number used to designate an Inter-Domain course and Z is the suffix at the end of a course number used to designate a Linked course.

Program Note

- 1.) All first-year baccalaureate candidates are required to complete, during the first academic year, a seminar course.
- 2.) Any 300 or 400 level Science or Math course requires a C or better.
- 3.) Students with a prior introduction to calculus may take MATH 140 and PHYS 211 concurrently in their first semester.
- 4.) A course noting "Supports Additional Course Selection" counts as an "Additional Course Selection." A total of 23 credits must be taken in this area. Possible course substitutions are listed below in the Additional Course Selection List. Please note that three credits of PHYS 494 and/or PHYS 495 are prescribed. Any additional credits in PHYS 494 or PHYS 495 (up to a maximum of 3 credits) may be applied to the additional course requirement.
- 5.) Supporting Courses - students must select (3) credits from the following: CMPSC 459 Scientific Visualization, CMPSC 456 Introduction to Numerical Analysis II, CMPSC 474 Operating System & Systems Programming. CMPSC 456 is recommended.
- 6.) Students must select (3) credits from the Supporting Course List below. MATH 456 or CMPSC 456 is recommended.

Advising Notes

Additional Course Selection List*

- EE 352 Signals and Systems: Continuous and Discrete-Time
- EE 453 Fundamentals of Digital Signal Processing
- ME 410 Heat Transfer
- ME 428 Applied Computational Fluid Dynamics
- PHYS 410 Introduction to Quantum Mechanics I
- PHYS 414 Solid State Physics

Supporting Course List

- ASTRO 291 or higher
- BIOL 110 or higher
- CHEM 210 or higher
- CMPSC 200 or higher

MATH 300 or 400 level*

STAT 300 or 400 level*

Unacceptable Courses for the Physics Major or Minor

Math courses below MATH 140

Physics courses below PHYS 211

PHYS 250

PHYS 251

Career Paths

The U.S. Bureau of Labor Statistics predicts physics careers will have higher than average job growth in the next decade. Undergraduate research and internships offer Behrend physics students opportunities to integrate academic study with professional experience. To tailor your degree to your career interests, you'll study one of two options, General Physics and Computational Physics. Penn State Behrend has a comprehensive support system to help you identify and achieve your goals for college and beyond. Meet with your academic adviser often and take advantage of the services offered by the Academic and Career Planning Center beginning in your first semester.

Careers

Physics is a discipline without limits. Penn State Behrend B.S. in Physics graduates are working in careers as diverse as laser-light design for major concert and theatre productions to radiation damage research at Los Alamos National Laboratories to component design engineering at Rolls-Royce.

MORE INFORMATION ABOUT POTENTIAL CAREER OPTIONS FOR GRADUATES OF THE PHYSICS PROGRAM (<http://behrend.psu.edu/school-of-science/academic-programs/physics/>)

Opportunities for Graduate Studies

Physics is a common foundational major for graduate study. Penn State Behrend Physics graduates have pursued advanced degrees in physics, astronomy, materials science, materials engineering, bioengineering, electrical engineering, and secondary education.

MORE INFORMATION ABOUT OPPORTUNITIES FOR GRADUATE STUDIES (<http://behrend.psu.edu/school-of-science/academic-programs/physics/>)

Professional Resources

- Institute of Physics (<http://www.physics.org/>)
- American Institute of Physics (<https://www.aip.org/>)
- American Physical Society (<https://www.aps.org/>)

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