PHYSICS (BS AND BA OPTIONS AVAILABLE)

This major is being discontinued and will not accept new students after September 30, 2020. Students who have declared this major prior to September 30, 2020 will use these standards to complete the program requirements.

Introduction

The Canisius University Physics major provides a strong background in the scientific skills of analysis and experimentation and gives students a broad choice of career opportunities. The Physics major is a preparation for further study in graduate physics and related areas such as oceanography, geophysics, patent law, medicine, engineering and astronomy and entry into research and development employment. The specific goal for majors is a thorough knowledge of basic physical science and the mathematical and experimental application of this basis to the study of natural phenomena. Other offerings are intended to give non-majors an appreciation of the relation between science and the world within which they live.

Our department offers a number of degree tracks to match with the students' interests and career goals.

- Bachelor's of Science (BS) in Physics (p. 2) - curriculum is designed to prepare the student for graduate school in physics, engineering, or a related scientific field.
- Bachelor's of Arts (BA) in Physics (p. 3) - curriculum is designed to cover the major topics in the Physics BS program with fewer requirements. This degree is optimal for students interested in a different career path such as teaching in secondary education, law, medicine, journalism, etc. The Physics BA is not meant as preparation for graduate school in physics or engineering. Curriculum easily allows for double majoring.
- Dual Degree Engineering Program (3+2 Physics/Engineering) (http://catalog.canisius.edu/undergraduate/college-arts-sciences/physics/pre-engineering-programs/3-2-program/) - the student spends 3 years studying Physics at Canisius University and the next 2 years in the Engineering Program at the University at Buffalo or Pennsylvania State University at Erie. At the end of the 5 years, the student will receive a Physics degree from Canisius University and a Engineering degree from the other school.
- Pre-engineering Program (2+2) (http://catalog.canisius.edu/undergraduate/college-arts-sciences/physics/pre-engineering-programs/2-2-program/) - the students spend their first 2 years at Canisius University taking the introductory physics, mathematics, and engineering courses. After transferring to the engineering school of their choice, they complete their engineering degree after the third and fourth years. This is a transfer program, and they are not awarded a degree from Canisius University.
- Dual Degree of Physics (Bachelor's) and Education (Master's) (p.) - Canisius University is now offering dual Bachelor of Arts degree in Physics and Master's Degree in Education who wish to add teacher certification. The Physics BA (p. 3) requirements are unchanged, but students are counseled to add certain education courses as electives during the undergraduate years so they are prepared to pursue both Adolescence Education 7-12 certification in their content area and Adolescence 7-12 Teaching Students with Disabilities Generalist.

Qualifications

Students must maintain a 2.0 GPA in their major and a 2.0 overall average to graduate with a degree in Physics. For admission to the advanced program (Junior/Senior level), a student must have completed, with a grade of at least C, General Physics (PHY 223, PHY 224,PHY 225) and Mathematics through Differential Equations (MAT 222). To qualify for graduation with a degree in Physics, a grade of C- or higher is required in PHY 225, PHY 226, and all 300- and 400-level Physics courses. Students are expected to be prepared to take Calculus 1 (MAT 111) their first semester at Canisius.

Advisement

All students should have an advisor in the major and should contact the department directly to have an advisor assigned if they do not already have one. Meetings with academic advisors are required prior to students receiving their PIN for course registration each semester. All majors should work closely with their advisor in discussing career expectations, choosing their major electives, developing their entire academic program and planning their co-curricular or supplemental academic experiences.

Advising is particularly important for Physics majors due to the highly structured curriculum and numerous course prerequisites.

Major Experiences

Physics majors use modern physics equipment like a 3D printer, lasers, X-ray florescence, a multi-channel nuclear spectrometer, various radiation detectors, and an X-ray spectrometer. They have access to departmental computers. In addition, a large supply of other equipment is available for students to use as early as their first semester. In addition to the standard physics major, students may also wish to consider the Dual Degree Engineering Program, which offers students the option of completing a Physics Degree at Canisius and an Engineering degree at University at Buffalo (UB) or Pennsylvania State University at Erie. For those interested in Physics teaching, a Physics Education program is offered in conjunction with the education department. The Physics Club offers opportunities for social activities, technical tours, lectures and other activities.

The faculty in the department are active in research in the fields of experimental nuclear physics, robotics, physics education, and computational science. Students frequently join with a professor on his or her respective projects and perform a variety of research tasks. Students gain skills in large-scale computation, data analysis, electronics, and detector assembly and testing. In many cases, the research is interdisciplinary with the student working with a physics professor and a faculty member in the Mathematics (http://catalog.canisius.edu/undergraduate/college-arts-sciences/mathematics-statistics/), Computer Science (http://catalog.canisius.edu/undergraduate/college-arts-sciences/computer-science/), and Digital Media Arts (http://catalog.canisius.edu/undergraduate/college-arts-sciences/digital-media-arts/) Departments. Routinely, students present posters at local, statewide, and national conferences. Past students have conducting research through the National Science Foundation's Research Experience for Undergraduates at institutions such as University of Rochester, University of Notre Dame, and Baylor University.

Double Majors

Students who wish to expand their educational opportunities may decide to declare a double major. This decision may be based on career goals, planned graduate studies, and/or other student interests. Before a student declares a double major, it is important to meet with the appropriate academic departments for advisement. In order to declare a double major, the student must complete the Major/Minor Declaration form. This form will be

submitted electronically and reviewed and approved by each department chairperson as well as the appropriate associate dean.

Per university policy, each additional major requires a minimum of 15 credits that do not apply to the student's first or subsequent major. Some double major combinations can be completed within the minimum 120 credit hour degree requirement, but in other cases additional course work may be required. Please note that students will receive only one degree unless completing the dual degree (https://catalog.canisius.edu/undergraduate/academics/curricular-information/) requirement including at least 150 undergraduate credit hours, regardless of the number of majors they complete. Both (all) majors appear on a student's transcript.

Double majors in Physics BS (p. 2) and Computer Science (http://catalog.canisius.edu/undergraduate/college-arts-sciences/computer-science/), or Physics BS (p. 2) and Mathematics (http://catalog.canisius.edu/undergraduate/college-arts-sciences/mathematics-statistics/) are common and offer interesting career options. The Physics BA (p. 3) can be combined with almost any other program at the college.

Minors in Other Disciplines

Minors provide students the opportunity to pursue additional interests but generally do not require as many courses as a major. Minors generally range from five to eight required courses. To receive a minor, the student must complete at least 9 credit hours of coursework distinct from their other credentials (i.e., majors, other minors). The complete list of minors is available on the Canisius website (https://www.canisius.edu/academics/programs/undergraduate/?type%5B%5D=17) and in the catalog (https://catalog.canisius.edu/undergraduate/minors/) and provides links to each minor. Some majors and minors can be completed within the minimum 120 credit hour degree requirement, but in some cases additional coursework may be required. Students must complete the appropriate minor request form.

The Physics minor is particularly popular when combined with majors in Chemistry (http://catalog.canisius.edu/undergraduate/college-arts-sciences/chemistry/), Mathematics (http://catalog.canisius.edu/undergraduate/college-arts-sciences/mathematics-statistics/), or Computer Science (http://catalog.canisius.edu/undergraduate/college-arts-sciences/computer-science/).

Curriculum

Curriculum Requirements for a BS in Physics

An Ignatian Foundation

All undergraduate students must complete either the Canisius Core Curriculum (http://catalog.canisius.edu/undergraduate/academics/curricular-information/core-curriculum/) or the All-College Honors Curriculum (http://catalog.canisius.edu/undergraduate/academics/curricular-information/all-college-honors-program/). Many schools refer to their college-wide undergraduate requirements as "general education" requirements. We believe that the core curriculum and the honors curriculum are more than a series of required classes; they provide the basis for a Jesuit education both with content and with required knowledge and skills attributes that are central to our mission.

Free Electives

Students may graduate with a bachelor's degree with more but not less than 120 credit hours. Free electives are courses in addition to the Canisius Core Curriculum or All-College Honors Curriculum and major requirements sufficient to reach the minimum number of credits required for graduation.

The number of credits required to complete a bachelor's degree may vary depending on the student's major(s) and minor(s).

Major Requirements

Code	Title	Credits
PHY 104	Seminar for Physics and Pre-engineering Majors	0
CSC 111 & 111L	Introduction to Programming and Introduction to Programming Laboratory	4
PHY 223 & 223L	General Physics for Physical Science Majors I and General Physics for Physical Science Majors I Laboratory	4
PHY 224 & 224L	General Physics for Physical Science Majors II and General Physics for Physical Science Majors I Laboratory	4
PHY 225 & 225L	General Physics for Physical Science Majors III and General Physics for Physical Science Majors III Laboratory	4
PHY 226 & 226L	Basic Electronics and Basic Electronics Laboratory	4
PHY 330	Electrodynamics I	3
PHY 331	Electrodynamics II	3
PHY 332	Statistical and Thermal Physics	3
PHY 335	Mathematical Analysis for Physicists	4
PHY 350 & PHY 351	Modern Physics Laboratory and Advanced Laboratory	2
PHY 443	Classical Mechanics	3
PHY 445	Special Topics in Physics	1
PHY 446	Quantum Mechanics I	4
PHY 447	Quantum Mechanics II	3
PHY 498	Senior Project	1-3
CHM 111 & 111L	General Chemistry I and General Chemistry I Laboratory	4
MAT 111 & MAT 112	Calculus I and Calculus II	8
MAT 211	Calculus III	4
MAT 222	Differential Equations	3
Science elective (Science Elective to be chosen from BIO 111, CHM 112, CSC 112, MAT 219 or MAT 351)		3-4
Total Credits		**69-72**

Major Electives

Computer Science (http://catalog.canisius.edu/undergraduate/college-arts-sciences/computer-science/) and Mathematics (http://catalog.canisius.edu/undergraduate/college-arts-sciences/mathematics-statistics/) courses are highly recommended, particularly linear algebra.

Difference with the Physics BA Degree

The Physics BS degree program is designed to prepare the students for graduate school in Physics, Engineering, or a related scientific field. Therefore, it has more major course requirements than the Physics BA degree. The first 2 years of both programs are identical. The Physics BS degree requires more major courses in the third and fourth years in order to provide more depth or knowledge and experience. The student is advised to consult the BS and BA Roadmaps for the specific differences.

Additional Course Considerations

Courses in the Junior and Senior years rotate on a two year basis. Please consult your advisor about which set of courses is available in any given year.

Note: Course availability may be a factor in determining time to degree completion for transfer students. Discussion with department faculty is highly recommended for transfer students.

Roadmap

Recommended Semester Schedule for Major Course Requirements for a BS in Physics

Freshman	
Fall	**Spring**
MAT 111	MAT 112
PHY 104	PHY 104
PHY 223 & 223L	PHY 224 & 224L
CSC 111 & 111L	
Sophomore	
Fall	**Spring**
MAT 211	MAT 222
PHY 104	PHY 104
PHY 225 & 225L	PHY 226 & 226L
CHM 111 & 111L	Science Elective[1]
Junior	
Fall	**Spring**
PHY 104	PHY 104
PHY 330	PHY 331
PHY 335	PHY 351
PHY 350	
Senior	
Fall	**Spring**
PHY 104	PHY 104
PHY 446	PHY 332
PHY 443	PHY 445
	PHY 447
	PHY 498

[1] Science Elective to be chosen from BIO 111, CHM 112, CSC 112, MAT 219 or MAT 351. The science elective may be taken in a subsequent semester if it requires a prerequisite. In this case, take a course in the Core Curriculum in the spring semester of the freshman year.

Curriculum

Curriculum Requirements for a BA in Physics

An Ignatian Foundation

All undergraduate students must complete either the Canisius Core Curriculum (http://catalog.canisius.edu/undergraduate/academics/curricular-information/core-curriculum/) or the All-College Honors Curriculum (http://catalog.canisius.edu/undergraduate/academics/curricular-information/all-college-honors-program/). Many schools refer to their college-wide undergraduate requirements as "general education" requirements. We believe that the core curriculum and the honors curriculum are more than a series of required classes; they provide the basis for a Jesuit education both with content and with required knowledge and skills attributes that are central to our mission.

Free Electives

Students may graduate with a bachelor's degree with more but not less than 120 credit hours. Free electives are courses in addition to the Canisius Core Curriculum or All-College Honors Curriculum and major requirements sufficient to reach the minimum number of credits required for graduation. The number of credits required to complete a bachelor's degree may vary depending on the student's major(s) and minor(s).

Major Requirements

Code	Title	Credits
PHY 104	Seminar for Physics and Pre-engineering Majors	0
CSC 111 & 111L	Introduction to Programming and Introduction to Programming Laboratory	4
PHY 223 & 223L	General Physics for Physical Science Majors I and General Physics for Physical Science Majors I Laboratory	4
PHY 224 & 224L	General Physics for Physical Science Majors II and General Physics for Physical Science Majors I Laboratory	4
PHY 225 & 225L	General Physics for Physical Science Majors III and General Physics for Physical Science Majors III Laboratory	4
PHY 226 & 226L	Basic Electronics and Basic Electronics Laboratory	4
PHY 350	Modern Physics Laboratory	1
or PHY 351	Advanced Laboratory	
PHY 445	Special Topics in Physics	1
PHY 498	Senior Project	1-3
Choose 4 of the following upper division courses		12-14
PHY 330	Electrodynamics I	
PHY 331	Electrodynamics II	
PHY 332	Statistical and Thermal Physics	
PHY 335	Mathematical Analysis for Physicists	
PHY 443	Classical Mechanics	
PHY 446	Quantum Mechanics I	
PHY 447	Quantum Mechanics II	
CHM 111 & 111L	General Chemistry I and General Chemistry I Laboratory	4
MAT 111	Calculus I	4
MAT 112	Calculus II	4
MAT 211	Calculus III	4
MAT 222	Differential Equations	3
Science Elective (choose one of the following):		4
BIO 111 & 111L	Introductory Biology I and Introductory Biology Laboratory I	
CHM 112 & 112L	General Chemistry II and General Chemistry II Laboratory	
CSC 112 & 112L	Data Structures and Data Structures Laboratory	
MAT 219	Linear Algebra	

MAT 351	Probability & Statistics I	
Total Credits		**58-62**

Major Electives

Computer Science (http://catalog.canisius.edu/undergraduate/college-arts-sciences/computer-science/) and Mathematics (http://catalog.canisius.edu/undergraduate/college-arts-sciences/mathematics-statistics/) courses are highly recommended, particularly linear algebra.

Difference with the Physics BS Degree

The Physics BA degree program is designed to provide the basic topics in the field of physics and the tools to apply mathematical and scientific skills to different disciplines. **This program is not a preparation for graduate school in physics or engineering.** The program does provide the students with the freedom to explore other programs like education, journalism, pre-law, pre-medicine, and finance, to name a few. **The Physics BA is easier to double major than the Physics BS.** Therefore, it has fewer major course requirements than the Physics BS degree. The first 2 years of both programs are identical. The Physics BA degree requires fewer major courses in the third and fourth years to allow the students to take a variety of electives and try different fields. The student is advised to consult the BS and BA Roadmaps for the specific differences.

Additional Course Considerations

Courses in the Junior and Senior years rotate on a two year basis. Please consult your advisor about which set of courses is available in any given year.

Note: Course availability may be a factor in determining time to degree completion for transfer students. Discussion with department faculty is highly recommended for transfer students.

Roadmap

Recommended Semester Schedule for Major Course Requirements for a BA in Physics

Freshman	
Fall	**Spring**
MAT 111	MAT 112
PHY 104	PHY 104
PHY 223 & 223L	PHY 224 & 224L
CSC 111 & 111L	
Sophomore	
Fall	**Spring**
MAT 211	MAT 222
PHY 104	PHY 104
PHY 225 & 225L	PHY 226 & 226L
CHM 111 & 111L	Science Electvie[1]
Junior	
Fall	**Spring**
PHY 104	PHY 104
PHY 350	PHY 351 (if did not take PHY 350)
PHY elective[2]	PHY elective[2]
Senior	
Fall	**Spring**
PHY 104	PHY 104
PHY elective[2]	PHY 445
	PHY 498
	PHY elective[2]

1. Science Elective to be chosen from BIO 111, CHM 112, CSC 112, MAT 219 or MAT 351. The science elective may be taken in a subsequent semester if it requires a prerequisite. In this case, take a course in the Core Curriculum in the spring semester of the freshman year.
2. Choice of upper division courses: PHY 330, PHY 331, PHY 332, PHY 335, PHY 443, PHY 446, and PHY 447

Minor

The physics minor requires seven courses, which are to be distributed as follows.

Code	Title	Credits
Four Required Courses:		
PHY 223 & 223L	General Physics for Physical Science Majors I and General Physics for Physical Science Majors I Laboratory	4
PHY 224 & 224L	General Physics for Physical Science Majors II and General Physics for Physical Science Majors I Laboratory	4
PHY 225 & 225L	General Physics for Physical Science Majors III and General Physics for Physical Science Majors III Laboratory	4
MAT 211	Calculus III	4
Select three courses from the following two groups. At least one of these three must be selected from Group I:		8-12
Group I:		
PHY 330	Electrodynamics I [1,3]	
PHY 331	Electrodynamics II [1]	
PHY 332	Statistical and Thermal Physics [5]	
PHY 443	Classical Mechanics [4]	
PHY 446	Quantum Mechanics I [2]	
Group II:		
PHY 226	Basic Electronics	
Two lab credits from the following: PHY 350, PHY 351, PHY 445		
MAT 222	Differential Equations	
PHY 335	Mathematical Analysis for Physicists	
PHY 447	Quantum Mechanics II	
CHM 301 & 301L	Fundamental Physical Chemistry and Fundamental Physical Chemistry Laboratory	
Total Credits		**24-28**

1. PHY 331 requires PHY 330 as a prerequisite.
2. PHY 446 is required for PHY 447.
3. PHY 335 is highly recommended as a co-requisite for PHY 330.
4. PHY 443 requires MAT 222 as a prerequisite.
5. If CHM 301 is used for Group II, PHY 332 cannot be used for Group I.

Note: MAT 111 and MAT 112 are prerequisites for one or more of the courses listed above. The Physics minor is particularly popular when combined with majors in Chemistry, Mathematics, or Computer Science.

Minors are an important part of the undergraduate curriculum. If students declare a minor by sophomore year, they can usually complete it in a timely manner. Students should work with their advisor to determine if it is possible that the minor can be completed by graduation.

To receive a minor, a student must complete at least 9 credit hours of coursework distinct from their major(s) and from other minors, and students must complete more than 50% of the coursework required for the minor at Canisius. Please note that "ancillary/supporting" courses required for a major may still count as distinct courses as long as the remaining coursework still meets the 30 credit-hours required for a major. For more information about minor policies, please see the Declaring Majors and Minors (http://catalog.canisius.edu/undergraduate/academics/student-records/declaring-majors-minors/) page in the catalog.

Courses

PHY 104 Seminar for Physics and Pre-engineering Majors **0 Credits**
A key aspect of science is the communication of ideas. The seminar is one method of sharing scientific ideas and results. This course gathers Physics and Pre-engineering majors to learn about advances in their respective fields, about related careers, and about the research performed by the department faculty.
Prerequisite: None. **Corequisite:** None.
Offered: every fall & spring.

PHY 131 Earthquakes: Seismology and Society **3 Credits**
The science behind earthquakes: causes, locations, frequency and measurement; affects on geography, human structures and society.
Fulfills College Core: Field 6 (Natural Sciences), Global Awareness
Offered: once a year.

PHY 201 College Physics I **3 Credits**
This algebra-based, introductory course for health science majors covers mechanics, heat, and fluid dynamics. Topics include velocity and acceleration, Newton's laws of motion, work, energy, power momentum, torque, vibratory motion, elastic properties of solids, fluids at rest and in motion, properties of gases, and the transfer of heat.
Prerequisites: MAT 110 or MAT 111. **Corequisite:** PHY 201L.
Offered: every fall.

PHY 201L College Physics I Laboratory **1 Credit**
Laboratory for College Physics I. This lab course engages students in experimental measurements spanning the areas of mechanics, with the objective of training students in experimental measurements, data manipulation and analysis, error analysis, deductive thinking, and instrumentation, providing depth to students' understanding of the phenomena taught in PHY201.
Prerequisite: MAT 110 or MAT 111. **Corequisite:** PHY 201.
Offered: every fall.

PHY 202 College Physics II **3 Credits**
This continuation of PHY201 covers electricity and magnetism, light and optics. Topics include magnetism and electricity; simple electric circuits; electrical instruments; generators and motors; characteristics of wave motion; light and illumination; reflection; refraction, interference; polarization of light, color, and the spectrum.
Prerequisite: Minimum grade of C- in PHY 201 and PHY 201L. **Corequisite:** PHY 202L.
Offered: every spring.

PHY 202L College Physics II Laboratory **1 Credit**
This laboratory provides students with a greater understanding of electromagnetic phenomena, wave phenomena, and optics, and supports PHY202. Measurements of microscopic quantities, like the charge and mass of the electron, give students an opportunity to explore the structure of matter. Other experiments involve the physics of electrical currents, electric properties of bulk matter, magnetic fields and their effect on beams, wave phenomena, and the nature of light and its interaction with optical materials. This course trains students in experimental measurements, data manipulation and analysis, error analysis, deductive thinking, and instrumentation.
Prerequisite: min grade of C- in PHY 201 and 201L. **Corequisite:** PHY 202.
Offered: every spring.

PHY 223 General Physics for Physical Science Majors I **3 Credits**
Calculus-based general physics. Mechanics of rigid bodies.
Prerequisite: MAT 110 or MAT 111. **Corequisite:** PHY 223L.
Fulfills College Core: Field 6 (Natural Sciences)
Offered: every fall.

PHY 223L General Physics for Physical Science Majors I Laboratory **1 Credit**
Laboratory for calculus-based general physics I.
Prerequisite: MAT 110 or MAT 111 **Corequisite:** PHY 223.
Offered: every fall.

PHY 224 General Physics for Physical Science Majors II **3 Credits**
Calculus-based general physics. Electricity and magnetism,geometrical and physical optics.
Prerequisite: minimum grade of C- in PHY 223 and PHY 223L. **Corequisite:** PHY 224L.
Offered: every spring.

PHY 224L General Physics for Physical Science Majors I Laboratory **1 Credit**
Laboratory for calculus-based general physics II.
Prerequisites: min grade of C- in PHY 223 and PHY 223L **Corequisite:** PHY 224.
Offered: every spring.

PHY 225 General Physics for Physical Science Majors III **3 Credits**
Calculus-based general physics. Mechanics of fluids, mechanical waves, thermodynamics and kinetic theory, geometrical and physical optics, special theory of relativity.
Prerequisite: PHY 224 with a minimum grade of C-, and MAT 211 which may be taken concurrently. **Corequisite:** PHY 225L.
Offered: every fall.

PHY 225L General Physics for Physical Science Majors III Laboratory **1 Credit**
Laboratory for calculus-based general physics III.
Corequisite: PHY 225.
Offered: every fall.

PHY 226 Basic Electronics **3 Credits**
Circuit analysis, power supplies, semiconductor physics, operational amplifiers, digital electronics. Integrated circuit techniques. Includes laboratory work each week.
Prerequisite: minimum grade of C- in PHY 224. **Corequisite:** PHY 226L.
Offered: spring.

PHY 226L Basic Electronics Laboratory **1 Credit**
Laboratory for basic electronics course.
Corequisite: PHY 226.
Offered: every spring.

PHY 330 Electrodynamics I 3 Credits
Static and time-varying classical electric and magnetic fields in free-space and matter. Prior completion of or concurrent registration for PHY 335 is strongly encouraged.
Prerequisite: Minimum of C- in PHY 224.
Offered: fall of odd-numbered years.

PHY 331 Electrodynamics II 3 Credits
Primary topic: electromagnetic waves in free-space and matter, beginning with the Maxwell equations. Additional topics: radiation and special relativity.
Prerequisite: PHY 330.
Offered: spring of even-numbered years.

PHY 332 Statistical and Thermal Physics 3 Credits
Develops statistical concepts and methods used to relate macroscopic to microscopic descriptions of many particle systems.
Prerequisite: PHY 225.
Offered: spring of odd-numbered years.

PHY 335 Mathematical Analysis for Physicists 4 Credits
Theory and applications of infinite series, Fourier series, Green's functions, Fourier integrals, vector calculus, linear algebra, partial differential equations, and complex variable.
Prerequisite: MAT 222 or permission of instructor.
Offered: fall of odd-numbered years.

PHY 350 Modern Physics Laboratory 1 Credit
This course covers the basic principles of 20th century modern physics. The topics include blackbody radiation, particle/wave duality, x-ray diffraction, Bohr's model of the atom, quantum tunneling, and the Schrodinger equation.
Prerequisite: PHY 225.
Fulfills College Core: Advanced Writing-Intensive
Offered: every fall.

PHY 351 Advanced Laboratory 1 Credit
This course emphasizes advanced experiments and experimental technique. Topics include, but are not restricted to, dosimetry, radiation detection, gamma-ray spectroscopy, Rutherford scattering, atomic spectroscopy, thin-film deposition, and magnetic resonance.
Prerequisite: PHY 225.
Fulfills College Core: Oral Communication
Offered: every spring.

PHY 443 Classical Mechanics 3 Credits
One, two, and three dimensional motion of a particle, non- inertial systems, classical scattering, rigid-body motion. Lagrange and Hamilton equations, calculus of variations, oscillations.
Prerequisite: PHY 225 & MAT 222.
Offered: fall of even-numbered years.

PHY 445 Special Topics in Physics 1 Credit
This course will cover model formation and development using archival journal articles in physics. The subject material will rotate by semester among topics such as astrophysics, quantum theory, and thermodynamics. Students will be expected to read and critique journal articles, lead discussions on journal articles, and trace the development of an area of physics through assigned readings.
Prerequisite: permission of instructor. **Restriction:** must be physics major or minor with senior standing.
Offered: spring of odd-numbered years.

PHY 446 Quantum Mechanics I 4 Credits
Experimental basis of quantum mechanics, state functions, operators. Review of linear algebra techniques and introduction of the Dirac notation.
Corequisite: PHY 225 & MAT 222.
Offered: fall of even-numbered years.

PHY 447 Quantum Mechanics II 3 Credits
Application of Schrodinger's equation, Hamiltonian mechanics, angular momentum, intrinsic spin, parity, and time-dependent quantum mechanics. PHY 446 is highly recommended.
Prerequisite: PHY446.
Offered: spring of odd-numbered years.

PHY 498 Senior Project 1-3 Credits
A one-semester research project done under the supervision of a faculty member.
Prerequisite: permission of department chair. **Restriction:** senior standing in physics.
Offered: spring.

PHY 499 Independent Study 1-3 Credits
An independent study with a faculty member of the Physics Department. Independent studies require an application and approval by the associate dean.
Prerequisite: permission of the instructor, department chair, & associate dean. **Restriction:** permission of the chair.
Offered: fall & spring.

Learning Goals & Objectives

Student Learning Goal 1

Physics majors will know how to learn physics.

Students will:

- **Objective A**: Critically assess written expositions of physics, contrasting those ideas which are fundamental from those which are consequential;
- **Objective B:** Identify the circumstances under which a principle applies.

Student Learning Goal 2

Physics majors are critical thinkers that can produce analytical solutions to physical problems.

Students will:

- **Objective A**: Identify a problem and generate equivalent statements of a problem;
- **Objective B:** Delineate the principles of physics and analytical techniques used to obtain a solution to a problem;
- **Objective C**: Apply the principles and techniques of physics to obtain a solution to a problem.

Student Learning Goal 3

Physics majors possess the technical skills needed to function effectively in a physics laboratory.

Students will:

- **Objective A**: Collect a broad range of data with an ability to adapt to new experimental methods, apparatus and tools;
- **Objective B**: Apply fundamental statistical methods to analyze data;
- **Objective C**: Display data with clarity.

Student Learning Goal 4

Physics majors communicate ideas in physics with precision and clarity.

Students will:

- **Objective A:** Produce precise and clear expository written material about physics;
- **Objective B**: Produce well-organized and clear oral presentations of physics material.