PHYSICS AND ASTRONOMY

Overview & Learning Goals
Learning Goals

1. Demonstrate the ability to use basic mathematical tools (algebra, basic differential and/or integral calculus, trigonometry, geometry) to describe physical situations, whether experimental or theoretical (all sub-1100 courses focus on this).
2. Explore the relationship between physical theory and experiment through mathematical descriptions and instrument-based verification.
3. Improve understanding of physical law through the ability to solve increasingly complex problems in physics with more complex mathematical tools (multivariate calculus, differential equations, linear algebra, and more complex math tools).
4. Use sophisticated instrumentation and computation to explore physical phenomena.
5. Improve understanding of uncertainty and its key role in defining how we know what we know.
6. Expand theoretical, computational, and experimental toolkit through 3000-level methods curriculum.

Options for Majoring and Minoring in the Department

Students may elect to major in physics and astronomy, the chemical physics interdisciplinary major, the physics and education interdisciplinary major, or to coordinate a major in physics and astronomy with digital and computational studies, education, or environmental studies. Students pursuing interdisciplinary or coordinate majors may not normally elect a second major. Non-majors may elect to minor in physics and astronomy.

Department Website (https://www.bowdoin.edu/physics/)

Faculty

Stephen G. Naculich, *Department Chair*
Emily C. Green, *Department Coordinator*

Professors: Mark O. Battle, Thomas Baumgarte‡, Elizabeth F. McCormack, Madeleine E. Msall‡, Stephen G. Naculich, Dale A. Syphers
Assistant Professor: Felicia McBride
Senior Lecturer: Karen Topp**
Laboratory Instructors: Kenneth Dennison, Dana Peirce, Mileidy Varela-Madera

Faculty Website (https://www.bowdoin.edu/physics/faculty-and-staff/)

Requirements
Physics Major

The major requires nine courses.

Code	Title	Credits
Required Courses		
Mathematics through 1700, or placement above 1700		1
PHYS 1130	Introductory Physics I (or placement above 1130)	1
PHYS 1140	Introductory Physics II	1
PHYS 2130	Electric Fields and Circuits	1
PHYS 2140	Quantum Physics and Relativity	1
PHYS 2150	Statistical Physics	1
Select one of the following advanced methods courses:		1
PHYS 3000	Methods of Theoretical Physics	
PHYS 3010	Methods of Experimental Physics	
PHYS 3020	Methods of Computational Physics	
Select two additional approved courses higher than 1140. [a]		2

Students pursuing honors are expected to take MATH 1800 Multivariate Calculus (or have a placement above MATH 1800 Multivariate Calculus), PHYS 1130 Introductory Physics I (or placement above PHYS 1130 Introductory Physics I), PHYS 1140 (https://bowdoin-curr.courseleaf.com/search/?P=PHYS%201140) Introductory Physics II, PHYS 2130 (https://bowdoin-curr.courseleaf.com/search/?P=PHYS%202130) Electric Fields and Circuits, PHYS 2140 (https://bowdoin-curr.courseleaf.com/search/?P=PHYS%202140) Quantum Physics and Relativity, PHYS 2150 (https://bowdoin-curr.courseleaf.com/search/?P=PHYS%202150) Statistical Physics, PHYS 3000 (https://bowdoin-curr.courseleaf.com/search/?P=PHYS%203000) Methods of Theoretical Physics, PHYS 4050, and four additional courses above PHYS 1140 Introductory Physics II, three of which must be above PHYS 3000 Methods of Theoretical Physics and one of which can be the second semester of honors, PHYS 4051.

[a] One may be a physics course numbered below PHYS 1110, or MATH 1800 Multivariate Calculus or higher; or CSCI 1101 Introduction to Computer Science.

Physics Minor

The minor consists of at least four physics courses (completed at Bowdoin) numbered 1130 or higher, one of which must be PHYS 1140 Introductory Physics II.

Interdisciplinary Major

The department participates in the interdisciplinary major programs of chemical physics and physics and education. See the Interdisciplinary Majors (https://bowdoin-public.courseleaf.com/departments-programs/interdisciplinary-majors/).

Additional Information
Additional Information and Department Policies

- Students must earn a grade of C- or above in any prerequisite physics course. Up to two courses with a grade of D are allowed to be counted toward the major.
- Courses that count toward the major or minor must be taken for regular letter grades (not Credit/D/Fail).
- Majors must complete at least five physics courses at Bowdoin.
- Students interested in applying coursework taken at another college or university to the major or minor should consult the department.
- Up to two independent studies, including honors projects, may count towards the elective requirements of the major and one independent study may count toward the minor.
- Students pursuing honors should consult with faculty about available projects and plan for two semesters of honors research (PHYS 4050 and PHYS 4051).

- Majors and minors may double-count an unlimited number of courses with another department or program.
- The major program depends to some extent on the student's goals, which should be discussed with the department. Those who intend to do graduate work in physics or an allied field should plan to do an honors project.
- Students considering a program in engineering should consult the Special Areas of Study (https://bowdoin-public.courseleaf.com/departments-programs/interdisciplinary-majors/#specialareasofstudytext).
- A major with an interest in an interdisciplinary area—such as geophysics, biophysics, or oceanography—should choose appropriate courses in related departments.
- Secondary school teaching requires a broad base in science courses, as well as the necessary courses for teacher certification. Students who know they want to do this should consider the physics and education interdisciplinary major.
- For a career in industrial management, some courses in economics and government should be included.

Advanced Placement/International Baccalaureate (AP/IB):

- Students who receive a minimum score of four on the Physics 1 AP exam are exempt from taking PHYS 1130 Introductory Physics I, and do not need to take an additional course to replace it. No AP credit is awarded for the Physics 2 AP exam.
- Students who receive a minimum score of four on the Physics C: Mechanics AP exam, or a minimum score of six on the Physics without Optics IB exam, are eligible to receive one credit toward the major, are exempt from taking PHYS 1130 Introductory Physics I, and are placed in PHYS 1140 Introductory Physics II. To earn the credit, a minimum grade of C- (not taken Credit/D/Fail) must be received in PHYS 1140 Introductory Physics II by the end of their junior year or no credit is awarded. Students who receive a minimum score of six on the Physics with Optics IB exam are eligible to receive one credit toward the major and have the option of being placed in either PHYS 1140 Introductory Physics II or PHYS 2130 Electric Fields and Circuits. To receive the credit, the student must earn a minimum grade of C- (not taken Credit/D/Fail) in the course in which they choose to be placed, and are strongly encouraged to complete the required course by the end of their junior year or prior.
  - Minors meeting either of the criteria above are exempt from taking PHYS 1130 Introductory Physics I, but must take at least four Bowdoin physics courses.
- No credit is awarded for the Physics 2 or Physics C: Electricity and Magnetism AP exams.
- In order to receive credit for AP/IB work, students must have their scores officially reported to the Office of the Registrar by the end of their sophomore year at Bowdoin.

Interdisciplinary Majors

The department of physics and astronomy participates in an interdisciplinary major, chemical physics, with the department of chemistry as well as an interdisciplinary major, physics and education, with the department of education. See the Interdisciplinary Majors (https://catalogue.bowdoin.edu/departments-programs/interdisciplinary-majors/) section for more information. In addition, students are able to declare a coordinate major between physics and digital and computational studies, education, or environmental studies as well.

The departments of physics and earth and oceanographic science have identified major/minor pathways for students interested in majoring in physics with an earth and oceanographic science application (physics major/earth and oceanographic science minor) and for students interested in majoring in earth and oceanographic science with a physics application (earth and oceanographic science major/physics minor).

Students pursuing the physics major/earth and oceanographic science minor with interests in the **solid earth** discipline would be best served by selecting:

Code	Title	Credits
EOS 1105	Introducing Earth	
EOS 2005/ ENVS 2221	Biogeochemistry: An Analysis of Global Change	
Select two of the following:		
EOS 2125	Field Studies in Structural Geology	
EOS 2145	The Plate Tectonics Revolution	
EOS 2155	Geomechanics and Numerical Modeling	
EOS 2165	Mountains to Trenches: Petrology and Process	
EOS 3115	Research in Mineral Science	

Those with interests in the **surface earth** discipline should select:

Code	Title	Credits
EOS 1305	Environmental Geology and Hydrology	
EOS 2005/ ENVS 2221	Biogeochemistry: An Analysis of Global Change	
EOS 2325	Environmental Chemistry	
EOS 2345/ ENVS 2270	Geomorphology: Form and Process at the Earth's Surface	

Those with interests in the **oceanography** discipline should choose:

Code	Title	Credits
EOS 1505	Oceanography	
EOS 2005/ ENVS 2221	Biogeochemistry: An Analysis of Global Change	
Select two of the following:		
EOS 2525	Marine Biogeochemistry	
EOS 2530	Poles Apart: Exploration of Earth's High Latitudes	
EOS 2540	Equatorial Oceanography	
EOS 2550	Satellite Remote Sensing of the Ocean	
EOS 2585/ ENVS 2282	Ocean and Climate	
EOS 3515	Research in Oceanography: Topics in Paleoceanography	

Physics and 3-2 Engineering

Please consult the Special Areas of Study section (https://bowdoin-public.courseleaf.com/departments-programs/interdisciplinary-majors/#specialareasofstudytext) for additional information. Students planning to pursue one of the 3-2 engineering options and graduating with a physics degree must take:

Code	Title	Credits
PHYS 1140	Introductory Physics II	1
PHYS 2130	Electric Fields and Circuits	1

PHYS 2150	Statistical Physics	1
PHYS 3000	Methods of Theoretical Physics	1
or MATH 2208	Ordinary Differential Equations	
CHEM 1102	Introductory Chemistry II	1
or CHEM 1109	General Chemistry	
MATH 1800 or higher		
CSCI 1101	Introduction to Computer Science	1

Other courses are expected by the partnering engineering institution and students should contact the advisor in Bowdoin's Department of Physics and Astronomy for more information.

Information for Incoming Students (p. 3)

Physics has a placement test to help determine which entry-level course in the physics sequence is the appropriate starting point for each student.

Topical physics courses, which many students choose out of general interest in physics or to satisfy college distribution requirements, do not require a placement exam. PHYS 1510 Introductory Astronomy is open to all students interested in the ideas of physics and their impact on our built and natural world.

PHYS 1130 Introductory Physics I and PHYS 1140 Introductory Physics II, both offered every semester, provide students with physics tools that support their future work in STEM majors and career fields. PHYS 1093 Introduction to Quantitative Reasoning in the Physical Sciences can help prepare students for the pace and intensity of these introductory courses.

Students cannot enroll in PHYS 1093 Introduction to Quantitative Reasoning in the Physical Sciences or PHYS 1130 Introductory Physics I without taking the placement test. If a student has not completed the on-line physics placement test prior to arriving on campus, they should contact the department to complete the placement exam as soon as possible to be able to register for introductory physics at Bowdoin. The only introductory students who are exempt from the placement exam are students who submit qualifying official scores on AP (4 or 5) or IB (6 or 7) exams to the Bowdoin Registrar and those who transfer college credits in physics to Bowdoin. Please e-mail Emily Green (https://www.bowdoin.edu/profiles/staff/egreen/) if you have questions about placement or testing.

The three entry point options to the introductory physics sequence are:

PHYS 1093 Introduction to Quantitative Reasoning in the Physical Sciences develops applied mathematical and physical reasoning skills. This course focuses on improving independent problem-solving skills and STEM literacy with individualized support. Students learn how to build upon and apply quantitative skills that they already have to problem solving for the physical sciences. This course works very well in conjunction with another introductory STEM course in the first college semester, including CHEM 1091 Introductory Chemistry and Quantitative Reasoning I or CHEM 1101 Introductory Chemistry I. It satisfies the Mathematical, Computational and Statistical Reasoning (MCSR) distribution requirement. There is no math prerequisite for enrollment in this class.

PHYS 1130 Introductory Physics I is the first semester of a two-part, calculus-based physics sequence. This course in Newtonian Mechanics with laboratory. It is required for all physics, biochemistry, chemistry, and chemical physics majors, and for pre-medical, pre-health, and pre-dental students. This course can satisfy
either the Mathematical, Computational and Statistical Reasoning (MCSR) distribution requirement or the Inquiry in the Natural Sciences (INS) distribution requirement. Mathematics prerequisite: concurrent enrollment in or previous credit for MATH 1600 Differential Calculus, or placement in MATH 1700 Integral Calculus or above.

PHYS 1140 Introductory Physics II is the second semester of calculus-based physics with laboratory that covers many applications of modern physics. It is required for all physics, chemistry, and chemical physics majors, and for pre-medical, pre-health, and pre-dental students. This course can satisfy either the Mathematical, Computational and Statistical Reasoning (MCSR) distribution requirement or the Inquiry in the Natural Sciences (INS) distribution requirement. Students with qualifying scores on advanced placement exams can be placed in PHYS 1140 Introductory Physics II without taking the departmental placement exams. All others must take the placement exam. Mathematics prerequisite: concurrent enrollment in or previous credit for MATH 1700 Integral Calculus or MATH 1750 Intermediate Integral Calculus, or placement in MATH 1800 Multivariate Calculus or above.

Courses

PHYS 1033 (a) The Nature of Time
Every Fall. Enrollment limit: 16.

What is time, anyway? What do we know about it? How do we understand it? How do we track it? What are the scales and paces of time that apply across different fields of inquiry? In this course students will explore various perspectives on time, aspects of historical and modern time-keeping devices, and applications of time in modern life. Students will develop their writing and research skills through drafts and revisions of various written assignments and receive individualized feedback on their work. The writing assignments will be useful for all subsequent areas of study as they will focus on writing as an opportunity to engage, explore, synthesize, and express information and ideas.

Previous terms offered: Fall 2021.

PHYS 1082 (a, INS, MCSR) Physics of Musical Sound
Every Other Fall. Enrollment limit: 30.

An introduction to the physics of sound, specifically relating to the production and perception of music. Topics include simple vibrating systems; waves and wave propagation; resonance; understanding intervals, scales, and tuning; sound intensity and measurement; sound spectra; how various musical instruments and the human voice work. Students expected to have some familiarity with basic musical concepts such as scales and intervals. Students with musical experience who have not taken the music placement test, nor registered for any music ensemble or lesson as listed in the prerequisites, may e-mail ktopp@bowdoin.edu with a quick description of their musical background. Not open to students who have credit for or are concurrently taking any physics course numbered 1100 or higher.

Prerequisites: MUS 1051 or Placement in MUS 1401 or Placement in MUS 2403 or MUS 1801 - 1878 or MUS 2701 - 2752 or MUS 2769 - 2779 or MUS 2783 or MUS 2801 - 2878.

Previous terms offered: Spring 2023, Fall 2021, Fall 2019.

PHYS 1083 (a, INS, MCSR) Energy, Physics, and Technology
Every Other Spring. Enrollment limit: 50.

How much can we do to reduce the disruptions of the Earth's physical, ecological, and social systems caused by global climate change? How much climate change itself can we avoid? A lot depends on the physical processes that govern the extraction, transmission, storage, and use of available energy. Introduces the physics of solar, wind, nuclear, and hydroelectric power and discusses the physical constraints on their efficiency, productivity, and safety. Reviews current technology and quantitatively analyzes the effectiveness of different strategies to reduce greenhouse gas emissions. Not open to students with credit for Physics 1140. (Same as: ENVS 1083)

Previous terms offered: Spring 2022, Spring 2020.

PHYS 1093 (a, MCSR) Introduction to Quantitative Reasoning in the Physical Sciences
Liz McCormack.
Every Fall. Fall 2023. Enrollment limit: 20.

Climate science. Quantum Physics. Bioengineering. Rocket science. Who can understand it? Anyone with high school mathematics (geometry and algebra) can start. Getting started in physics requires an ability to mathematically describe real world objects and experiences. Prepares students for additional work in physical science and engineering by focused practice in quantitative description, interpretation, and calculation. Includes hands-on measurements, some introductory computer programming, and many questions about the physics all around us. Registration for this course is by placement only. To ensure proper placement, students must have taken the physics placement examination prior to registering for Physics 1093. (Same as: CHEM 1093)

Prerequisites: Placement in PHYS 1093.

Previous terms offered: Fall 2022, Fall 2021, Fall 2020.

PHYS 1130 (a, INS, MCSR) Introductory Physics I
Mark Battle; Dana Peirce; Karen Topp.
Every Semester. Fall 2023; Spring 2024. Enrollment limit: 50.

An introduction to the conservation laws, forces, and interactions that govern the dynamics of particles and systems. Shows how a small set of fundamental principles and interactions allow us to model a wide variety of physical situations, using both classical and modern concepts. A prime goal of the course is to have the participants learn to actively connect the concepts with the modeling process. Three hours of laboratory work per week. To ensure proper placement, students are expected to have taken the physics placement examination prior to registering for Physics 1130.

Prerequisites: Two of: PHYS 1093 (same as CHEM 1093) or Placement in PHYS 1130 and MATH 1600 or higher or Placement in MATH 1700 (M) or Placement in MATH 1750 (M) or Placement in MATH 1800 (M) or Placement in MATH 2020 or 2206 (M) or Placement in 2000, 2020, 2206 (M).

Previous terms offered: Spring 2023, Fall 2022, Spring 2022, Fall 2021, Spring 2021, Fall 2020, Spring 2020, Fall 2019.

PHYS 1140 (a, INS, MCSR) Introductory Physics II
Liz McCormack; Felicia McBride; Mileidy Varela-Madera.
Every Semester. Fall 2023; Spring 2024. Enrollment limit: 48.

An introduction to the interactions of matter and radiation. Topics include the classical and quantum physics of electromagnetic radiation and its interaction with matter, quantum properties of atoms, and atomic and nuclear spectra. Laboratory work (three hours per week) includes an introduction to the use of electronic instrumentation.

Prerequisites: Two of: PHYS 1130 or Placement in PHYS 1140 and MATH 1700 - 1800 or Placement in MATH 1800 (M) or Placement in MATH 2020 or 2206 (M) or Placement in 2000, 2020, 2206 (M).

Previous terms offered: Spring 2023, Fall 2022, Spring 2022, Fall 2021, Spring 2021, Fall 2020, Spring 2020, Fall 2019.

PHYS 1510 (a, INS, MCSR) Introductory Astronomy
Felicia McBride.
Every Spring. Fall 2023. Enrollment limit: 50.

A quantitative introduction to astronomy with emphasis on stars and the structures they form, from binaries to galaxies. Topics include the night sky, the solar system, stellar structure and evolution, white dwarfs, neutron stars, black holes, and the expansion of the universe. Several nighttime observing sessions required. Does not satisfy pre-med or other science departments' requirements for a second course in physics.

Prerequisites: MATH 1600 or higher or Placement in MATH 1700 (M) or Placement in MATH 1750 (M) or Placement in MATH 1800 (M) or Placement in MATH 2020 or 2206 (M) or Placement in 2000, 2020, 2206 (M).

Previous terms offered: Spring 2023, Fall 2022, Spring 2022, Fall 2021, Fall 2020, Spring 2020, Fall 2019.

PHYS 2130 (a, INS, MCSR) Electric Fields and Circuits
Dale Syphers; Kenneth Dennison.
Every Fall. Fall 2023. Enrollment limit: 30.

The basic phenomena of the electromagnetic interaction are introduced. The basic relations are then specialized for a more detailed study of linear circuit theory. Laboratory work stresses the fundamentals of electronic instrumentation and measurement with basic circuit components such as resistors, capacitors, inductors, diodes, and transistors. Three hours of laboratory work per week.

Prerequisites: PHYS 1140.

Previous terms offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019.

PHYS 2140 (a, INS, MCSR) Quantum Physics and Relativity
Stephen Naculich.
Every Spring. Spring 2024. Enrollment limit: 35.

An introduction to two cornerstones of twentieth-century physics, quantum mechanics, and special relativity. The introduction to wave mechanics includes solutions to the time-independent Schrödinger equation in one and three dimensions with applications. Topics in relativity include the Galilean and Einsteinian principles of relativity, the "paradoxes" of special relativity, Lorentz transformations, space-time invariants, and the relativistic dynamics of particles. Not open to students who have credit for or are concurrently taking Physics 3140 or 3500.

Prerequisites: PHYS 1140.

Previous terms offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020.

PHYS 2150 (a, INS, MCSR) Statistical Physics
Mark Battle.
Every Spring. Spring 2024. Enrollment limit: 35.

Develops a framework capable of predicting the properties of systems with many particles. This framework, combined with simple atomic and molecular models, leads to an understanding of such concepts as entropy, temperature, and chemical potential. Some probability theory is developed as a mathematical tool.

Prerequisites: PHYS 1140.

Previous terms offered: Spring 2023, Spring 2022, Spring 2021, Spring 2020.

PHYS 2220 (a, INS, MCSR) Engineering Physics
Dale Syphers.
Every Other Spring. Fall 2023. Enrollment limit: 35.

Examines the physics of materials from an engineering viewpoint, with attention to the concepts of stress, strain, shear, torsion, bending moments, deformation of materials, and other applications of physics to real materials, with an emphasis on their structural properties. Also covers recent advances, such as applying these physics concepts to ultra-small materials in nano-machines. Intended for physics majors and architecture students with an interest in civil or mechanical engineering or applied materials science.

Prerequisites: PHYS 1140.

Previous terms offered: Fall 2021.

PHYS 2230 (a, INS, MCSR) Modern Electronics
Every Other Spring. Enrollment limit: 35.

A brief introduction to the physics of semiconductors and semiconductor devices, culminating in an understanding of the structure of integrated circuits. Topics include a description of currently available integrated circuits for analog and digital applications and their use in modern electronic instrumentation. Weekly laboratory exercises with integrated circuits.

Prerequisites: PHYS 1130 or PHYS 1140.

Previous terms offered: Spring 2022.

PHYS 2240 (a, INS, MCSR) Acoustics
Every Other Fall. Enrollment limit: 35.

An introduction to the motion and propagation of sound waves. Covers selected topics related to normal modes of sound waves in enclosed spaces, noise, acoustical measurements, the ear and hearing, phase relationships between sound waves, and many others, providing a technical understanding of our aural experiences.

Prerequisites: PHYS 1140.

Previous terms offered: Fall 2022, Fall 2020.

PHYS 2250 (a, INS, MCSR) Physics of Solids
Every Other Spring. Enrollment limit: 35.

Solid state physics describes the microscopic origin of the thermal, mechanical, electrical and magnetic properties of solids. Examines trends in the behavior of materials and evaluates the success of classical and semi-classical solid state models in explaining these trends and in predicting material properties. Applications include solid state lasers, semiconductor devices, and superconductivity. Intended for physics, chemistry, or earth and oceanographic science majors with an interest in materials physics or electrical engineering.

Prerequisites: PHYS 2140 or CHEM 2520.

Previous terms offered: Fall 2021, Spring 2020.

PHYS 2260 (a, INS, MCSR) Nuclear and Particle Physics
Every Other Spring. Enrollment limit: 35.

An introduction to the physics of subatomic systems, with a particular emphasis on the standard model of elementary particles and their interactions. Basic concepts in quantum mechanics and special relativity are introduced as needed.

Prerequisites: PHYS 2140.

Previous terms offered: Spring 2023, Spring 2021.

PHYS 2310 (a) Big Data in Astrophysics and Cosmology
Non-Standard Rotation. Enrollment limit: 18.

Astronomy has been transformed in recent years by the open availability of large data sets. This course uses several astronomical "case studies" to introduce methods and computational tools for analysis of data, after which students will design, complete, and present an astronomical data analysis project of their own. Students will examine the abilities and limitations of these methods, and their impact on the types of questions we can answer and who has access to research. Possible topics include but are not limited to: using galaxy surveys to find large-scale structure in the universe, finding and characterizing exoplanets or binary star systems from light curves, or using supernova data to estimate cosmological parameters. Computation is an important part of the course, but programming experience is not required. (Same as: DCS 2310)

Prerequisites: PHYS 1130 or PHYS 1510.

Previous terms offered: Spring 2021.

PHYS 2340 (a, INS, MCSR) Optical Physics
Liz McCormack; Kenneth Dennison.
Every Other Spring. Spring 2024. Enrollment limit: 24.

A laboratory-based introduction to the principles of physical optics and their application to imaging in the life and physical sciences. Students will learn methods of analysis to understand wave propagation, interference, diffraction, and polarization. Topics include the physics of lasers, microscopes, telescopes, spectroscopy, and other examples derived from student interest. Weekly laboratory exercises culminate in final projects.

Prerequisites: PHYS 1140.

Previous terms offered: Spring 2023.

PHYS 2410 (a, INS, MCSR) Accident Reconstruction: Physics, The Common Good, and Justice
Non-Standard Rotation. Enrollment limit: 35.

Introduces the applications of physics pertinent to accident reconstruction and analyzes three complex cases that were criminal prosecutions. Instructor analyzes the first case to show how the physics is applied, the second is done in tandem with students, and the third is mostly analyzed by the students,using what they have learned. The report on this third case serves as the final project for the course. While Physics 1130 is the only prerequisite for the course, familiarity with vectors and matrices, or a desire to learn how to use them, is necessary.

Prerequisites: PHYS 1130.

Previous terms offered: Fall 2022.

PHYS 2510 (a) Astrophysics
Felicia McBride.
Every Other Fall. Spring 2024. Enrollment limit: 35.

A quantitative discussion that introduces the principal topics of astrophysics, including stellar structure and evolution, planetary physics, and cosmology.

Prerequisites: Two of: PHYS 1140 and PHYS 1510.

Previous terms offered: Fall 2022, Fall 2020.

PHYS 2730 (a, INS, MCSR) Laboratory in Modern Solid State Electronics
Non-Standard Rotation. Enrollment limit: 20.

Integrated circuits and solid state devices are the building blocks for all computer and robotic applications. This hands-on course builds understanding of the physics of semiconductors and semiconductor devices, along with skills for building and trouble-shooting integrated circuits. Lecture discussions of analog and digital integrated circuits support project-based explorations of their use in modern electronic instrumentation. Students will receive an ADALM2000 electronics test module for home use to enable measurement and testing of circuit design and robotics projects.

Prerequisites: PHYS 2130.

Previous terms offered: Spring 2021.

PHYS 2810 (a, INS, MCSR) Atmospheric and Ocean Dynamics
Mark Battle.
Every Other Fall. Fall 2023. Enrollment limit: 35.

A mathematically rigorous analysis of the motions of the atmosphere and oceans on a variety of spatial and temporal scales. Covers fluid dynamics in inertial and rotating reference frames, as well as global and local energy balance, applied to the coupled ocean-atmosphere system. (Same as: ENVS 2253, EOS 2810)

Prerequisites: PHYS 1140.

Previous terms offered: Fall 2020.

PHYS 2900 (a, INS, MCSR) Topics in Contemporary Physics
Non-Standard Rotation. Enrollment limit: 35. .5 Credit Credit/D/F Only.

Seminar exploring recent results from research in all fields of physics. Focuses on discussion of papers in the scientific literature. Grading is Credit/D/Fail. One-half credit.

Prerequisites: PHYS 2130 or PHYS 2140 or PHYS 2150.

Previous terms offered: Fall 2020, Fall 2019.

PHYS 3000 (a, INS, MCSR) Methods of Theoretical Physics
Stephen Naculich.
Every Fall. Fall 2023. Enrollment limit: 20.

Mathematics is the language of physics. Similar mathematical techniques occur in different areas of physics. A physical situation may first be expressed in mathematical terms, usually in the form of a differential or integral equation. After the formal mathematical solution is obtained, the physical conditions determine the physically viable result. Examples are drawn from heat flow, gravitational fields, and electrostatic fields.

Prerequisites: Two of: either PHYS 2130 or PHYS 2140 or PHYS 2150 and MATH 1800 or Placement in MATH 2020 or 2206 (M) or Placement in 2000, 2020, 2206 (M).

Previous terms offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019.

PHYS 3010 (a, INS, MCSR) Methods of Experimental Physics
Dale Syphers.
Every Spring. Spring 2024. Enrollment limit: 14.

Intended to provide advanced students with experience in the design, execution, and analysis of laboratory experiments. Projects in optical holography, nuclear physics, cryogenics, and materials physics are developed by the students.

Prerequisites: PHYS 2130.

Previous terms offered: Spring 2023, Spring 2022, Spring 2020.

PHYS 3020 (a, INS, MCSR) Methods of Computational Physics
Every Other Fall. Enrollment limit: 20.

An introduction to the use of computers to solve problems in physics. Problems are drawn from several different branches of physics, including mechanics, hydrodynamics, electromagnetism, and astrophysics. Numerical methods discussed include the solving of linear algebra and eigenvalue problems, ordinary and partial differential equations, and Monte Carlo techniques. Basic knowledge of a programming language is expected.

Prerequisites: Two of: PHYS 1140 and either CSCI 1101 or Placement in above CSCI 1101 or CSCI 1103.

Previous terms offered: Fall 2022, Fall 2021, Fall 2019.

PHYS 3120 (a, INS, MCSR) Advanced Mechanics
Stephen Naculich.
Every Other Spring. Spring 2024. Enrollment limit: 20.

A thorough review of particle dynamics, followed by the development of Lagrange's and Hamilton's equations and their applications to rigid body motion and the oscillations of coupled systems.

Prerequisites: PHYS 3000.

Previous terms offered: Spring 2022, Spring 2020.

PHYS 3130 (a) Electromagnetism
Every Other Spring. Enrollment limit: 20.

A mathematically rigorous treatment of Maxwell's equations and techniques for their solution. Develops and employs mathematical tools such as scalar and vector potentials, Green functions, and multipole expansions to explore the properties of electric and magnetic fields, including electromagnetic waves and radiation.

Prerequisites: Two of: PHYS 2130 and PHYS 3000.

Previous terms offered: Spring 2023, Spring 2021.

PHYS 3140 (a, INS, MCSR) Quantum Mechanics
Stephen Naculich.
Every Fall. Fall 2023. Enrollment limit: 20.

A mathematically rigorous development of quantum mechanics, emphasizing the vector space structure of the theory through the use of Dirac bracket notation. Linear algebra developed as needed.

Prerequisites: Two of: PHYS 2140 and PHYS 3000.

Previous terms offered: Fall 2022, Fall 2021, Fall 2020, Fall 2019.

PHYS 3200 (a, MCSR) Fields, Particles, and Symmetries
Non-Standard Rotation. Enrollment limit: 16.

An introduction to the theory of relativistic quantum fields, which are the foundational entities of the standard model of elementary particle physics. Topics will include: Lagrangian formulation of the classical mechanics of particles and fields, Noether's theorem relating symmetries to conservation laws, the quantization of bosonic and fermionic fields, the role of abelian and nonabelian gauge symmetries in determining the form of interactions among elementary particles, the use of Feynman diagrams to compute elementary processes, the spontaneous breaking of symmetry, and the Higgs mechanism.

Prerequisites: Two of: PHYS 2140 and PHYS 3000.

Previous terms offered: Fall 2022.

PHYS 3500 (a, INS, MCSR) General Relativity
Every Other Spring. Enrollment limit: 35.

First discusses special relativity, introducing the concept of four-dimensional space-time. Then develops the mathematical tools to describe space-time curvature, leading to the formulation of Einstein's equations of general relativity. Finishes by studying some of the most important astrophysical consequences of general relativity, including black holes, neutron stars, and gravitational radiation.

Prerequisites: Two of: PHYS 2140 and PHYS 3000.

Previous terms offered: Spring 2022, Spring 2020.

PHYS 3810 (a) The Physics of Climate
Non-Standard Rotation. Enrollment limit: 35.

A rigorous treatment of the earth's climate, based on physical principles. Topics include climate feedbacks, sensitivity to perturbations, and the connections between climate and radiative transfer, atmospheric composition, and large-scale circulation of the oceans and atmospheres. Anthropogenic climate change also studied. (Same as: ENVS 3957, EOS 3050)

Prerequisites: PHYS 2150 or PHYS 2810 (same as ENVS 2253 and EOS 2810) or PHYS 3000.

Previous terms offered: Spring 2021.