PHYSICS (PHYS)

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.