Physics and Astronomy

Professors: Stephen G. Naculich†, Dale A. Syphers
Associate Professors: Mark Battle, Thomas Baumgarte, Madeleine Msall, *Chair*
Visiting Instructor: Yoshihiro Sato
Lecturer: Karen Topp
Laboratory Instructors: Kenneth Dennison, Gary L. Miers
Department Coordinator: Dominica Lord-Wood

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. For those considering a program in engineering, consult pages 45–46. A major with an interest in an interdisciplinary area such as geophysics, biophysics, or oceanography will 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. For a career in industrial management, some courses in economics and government should be included.

Requirements for the Major in Physics

A student majoring in physics is expected to complete **Mathematics 161**, **171**, **Physics 103**, **104**, **223**, **229**, one 300-level methods course (**Physics 300**, **301**, or **302**), and three additional approved courses above **104** (one of which may be **Mathematics 181** or above). At least five physics courses must be taken at Bowdoin.

For honors work, a student is expected to complete **Mathematics 181**, and **Physics 103**, **104**, **223**, **229**, **300**, **310**, **451**, and four additional courses, two of which must be at the 300 level, and one of which may be in mathematics above **Mathematics 181**.

Requirements for the Minor in Physics

The minor consists of at least four Bowdoin physics courses numbered **103** or higher, at least one of which is **Physics 104**.

Interdisciplinary Majors

The department participates in interdisciplinary programs in chemical physics, and geology and physics. See pages 204 and 207.

Prerequisites

Students must earn a grade of C- or above in any prerequisite physics course.

Introductory, Intermediate, and Advanced Courses

[**50a - MCSR. Physics of Musical Sound.**]

62a - MCSR, INS. Contemporary Astronomy. Fall 2008. YOSHIHIRO SATO.

A mix of qualitative and quantitative discussion of topics including the night sky, the solar system and its origin, the nature of stars and galaxies, stellar evolution, and the formation and evolution of the universe. Several nighttime observing sessions are required. Students who have credit for or are concurrently taking any physics course numbered **100** or above do not receive credit for this course.

[**80a** - **INS**. **Light and Color**.]

81a - **INS**. **Physics of the Environment**. Spring 2009. MARK BATTLE.

An introduction to the physics of environmental issues, including past climates, anthropogenic climate change, ozone destruction, and energy production and efficiency. (Same as **Environmental Studies 81**.)

93a. **Introduction to Physical Reasoning**. Fall 2008. MADELEINE MSALL.

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 course 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. *To ensure proper placement, students are expected to have taken the physics placement examination prior to registering for* ***Physics 93***.

103a - **MCSR**, **INS**. **Introductory Physics I**. Every semester. Fall 2008. THOMAS BAUMGARTE AND DALE SYPHERS. Spring 2009. KAREN TOPP.

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 103***.

Prerequisite: Previous credit or concurrent registration in **Mathematics 161** or **171** or higher, or permission of the instructor.

104a - **MCSR**, **INS**. **Introductory Physics II**. Every semester. Fall 2008. MARK BATTLE. Spring 2009. DALE SYPHERS.

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. Three hours of laboratory work per week will include an introduction to the use of electronic instrumentation.

Prerequisite: **Physics 103** and previous credit or concurrent registration in **Mathematics 171** or **181**, or permission of the instructor.

162a - **INS**. **Stars and Galaxies**. Spring 2009. THE DEPARTMENT.

A quantitative introduction to astronomy, with emphasis on stars, stellar dynamics, and the structures they form, from binary stars to galaxies. Topics include the night sky, stellar structure and evolution, white dwarfs, neutron stars, black holes, quasars, and the expansion of the universe. Several nighttime observing sessions are required. Intended for both science majors and non-majors who are secure in their mathematical skills. A working familiarity with algebra, trigonometry, geometry, and calculus is expected. Does not satisfy pre-med or other science departments' requirements for a second course in physics.

Prerequisite: **Mathematics 161** or higher, or permission of the instructor.

223a - **INS**. **Electric Fields and Circuits**. Every fall. Fall 2008. KAREN TOPP.

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.

Prerequisite: **Physics 104** or permission of the instructor.

224a. **Quantum Physics and Relativity**. Every spring. Spring 2009. THOMAS BAUMGARTE.

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. Students who have credit for or are concurrently taking **Physics 275**, **310**, or **375** do not receive credit for this course.

Prerequisite: **Physics 104** or permission of the instructor.

229a. **Statistical Physics**. Every spring. Spring 2009. MADELEINE MSALL.

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.

Prerequisite: **Physics 104** or permission of the instructor.

235a. **Engineering Physics**. Every other spring. Spring 2010. DALE SYPHERS.

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.

Prerequisite: **Physics 104** or permission of the instructor.

240a. **Modern Electronics**. Every other spring. Spring 2009. THE DEPARTMENT.

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.

Prerequisite: **Physics 103** or **104**, or permission of the instructor.

250a. **Acoustics**. Every other fall. Fall 2009. THE DEPARTMENT.

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.

Prerequisite: **Physics 104** or permission of the instructor.

251a. **Physics of Solids**. Every other spring. Spring 2010. THE DEPARTMENT.

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, geology, or chemistry majors with an interest in materials physics or electrical engineering.

Prerequisite: **Physics 104** or permission of the instructor.

257a. **Atmosphere and Ocean Dynamics**. Fall 2008. MARK BATTLE.

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 **Environmental Studies 253** and **Geology 257**.)

Prerequisite: **Physics 104** or permission of the instructor.

262a. **Astrophysics**. Every other fall. Fall 2008. DALE SYPHERS.

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

Prerequisite: **Physics 104** or permission of the instructor.

280a. **Nuclear and Particle Physics**. Every other spring. Spring 2009. MARK BATTLE.

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.

Prerequisite: **Physics 104** or permission of the instructor.

291a–294a. **Intermediate Independent Study in Physics**. THE DEPARTMENT.

Topics to be arranged by the student and the faculty. If the investigations concern the teaching of physics, this course may satisfy certain of the requirements for the Maine State Teacher's Certificate. Students doing independent study normally have completed a 200-level physics course.

300a. **Methods of Theoretical Physics**. Every fall. Fall 2008. THOMAS BAUMGARTE.

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.

Prerequisite: **Physics 104** and **Mathematics 181**, or permission of the instructor.

301a. **Methods of Experimental Physics**. Every spring. Spring 2009. MADELEINE MSALL.

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.

Prerequisite: **Physics 223** or permission of the instructor.

302a. **Methods of Computational Physics**. Every other fall. Fall 2009. THOMAS BAUMGARTE.

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.

Prerequisite: **Physics 104** or permission of the instructor.

310a. **Introductory Quantum Mechanics**. Every fall. Fall 2008. YOSHIHIRO SATO.

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

Prerequisite: **Physics 300** or permission of the instructor.

Note: Beginning in Fall 2009, the title of this course will be *Quantum Mechanics*, and its prerequisite will be **Physics 224** and **300**.

320a. **Electromagnetic Theory**. Every other spring. Spring 2010. THE DEPARTMENT.

First the Maxwell relations are presented as a natural extension of basic experimental laws; then emphasis is given to the radiation and transmission of electromagnetic waves.

Prerequisite: **Physics 223** and **300**, or permission of the instructor.

357a. **The Physics of Climate**. Every other spring. Spring 2009. MARK BATTLE.

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 will also be studied. (Same as **Environmental Studies 357** and **Geology 357**.)

Prerequisite: **Physics 229**, **255**, **256**, or **300**, or permission of the instructor.

370a. **Advanced Mechanics**. Every other spring. Spring 2009. THE DEPARTMENT.

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.

Prerequisite: **Physics 300** or permission of the instructor.

401a–404a. **Advanced Independent Study in Physics**. THE DEPARTMENT.

Topics to be arranged by the student and the faculty. Students doing advanced independent study normally have completed a 300-level physics course.

451a–452a. **Honors in Physics**. THE DEPARTMENT.

Programs of study are available in semiconductor physics, microfabrication, superconductivity and superfluidity, astrophysics, relativity, ultrasound, and atmospheric physics. Work done in these topics normally serves as the basis for an honors paper.

Prerequisite: Permission of the instructor.

Psychology

Professors: Barbara S. Held†, Louisa M. Slowiaczek
Associate Professors: Suzanne Lovett†, Samuel P. Putnam, *Chair;* Paul Schaffner
Joint Appointments with Neuroscience: Associate Professor Richmond R. Thompson, Assistant Professor Seth J. Ramus
Visiting Assistant Professors: Rachel W. Kallen, Julie Quimby
Senior Department Coordinator: Donna M. Trout

Students in the Department of Psychology may elect a major within the psychology program, or they may elect an interdisciplinary major in neuroscience, sponsored jointly by the Departments of Psychology and Biology (see Neuroscience, pages 228–29). The program in psychology examines contemporary perspectives on principles of human behavior, in areas ranging from cognition, language, development, and behavioral neuroscience to interpersonal relations and psychopathology. Its approach emphasizes scientific methods of inquiry and analysis.