

# PHYSICS

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The Department of Physics seeks to prepare students in a liberal arts setting for careers in physics, engineering, and related fields. Students oriented toward engineering careers are encouraged to consider the dual-degree program in engineering and liberal arts (listed in the Engineering section of this catalog), the applied physics major, and the major in physics followed by a graduate program in engineering. The department is also committed to making physics a significant component of the liberal arts experience for other Bethel students.

**Advanced Placement:** The physics department requires a score of 4 or better on the AP exam in order for the exam to be used to fulfill course requirements in the majors it offers. Students with a score of 3 will receive elective credit or receive credit toward General Education requirements. Students should consult the department chair with questions on AP exams and requirements for majors.

## Majors in Physics

- B.A. in Physics (<http://catalog.bethel.edu/arts-sciences/academic-programs-departments/physics/physics-ba>)
- B.S. in Physics (<http://catalog.bethel.edu/arts-sciences/academic-programs-departments/physics/physics-bs>)
- B.S. in Applied Physics (<http://catalog.bethel.edu/arts-sciences/academic-programs-departments/physics/applied-physics-bs>)
- B.A. in Science Education 5-12: Physics Emphasis (<http://catalog.bethel.edu/arts-sciences/academic-programs-departments/physics/science-education-5-12-ba-physics-emphasis>)
- B.A. in Engineering (<http://catalog.bethel.edu/arts-sciences/academic-programs-departments/engineering/engineering-ba>) (See Engineering section)

## Minor in Physics

- Physics (<http://catalog.bethel.edu/arts-sciences/academic-programs-departments/physics/physics-minor>)

### PHY102 • Concepts in Physics. 3 Credits.

Physical perspective of the universe designed for liberal arts students. Topics from mechanics, wave motion (including sound and light), thermodynamics, and atomic and nuclear physics. Lecture demonstrations and laboratories stress a clear understanding of observed phenomena.

*Corequisites:* Concurrent registration in PHY102D is required. Offered: Spring.

### PHY102D • Concepts in Physics Lab. 1 Credit.

Laboratory experience accompanying PHY102. *Corequisites:* Concurrent registration in PHY102 is required. Offered: Spring.

### PHY112 • Introduction to Astronomy. 3 Credits.

The concepts, techniques, and tools of astronomy and astrophysics for nonscience students. Includes historical overview; identification of constellations; telescopes; the nature of light, atomic spectra, and structure; the nuclear physics of stars; the life cycle of stars; and current theories of the fate of the universe.

*Corequisites:* Concurrent registration in PHY112D is required. Offered: Fall.

### PHY112D • Introduction to Astronomy Lab. 1 Credit.

Laboratory experience accompanying PHY112. Includes optics, atomic spectra, and observations with simple instruments and telescopes.

*Corequisites:* Concurrent registration in PHY112 is required. Offered: Fall.

### PHY202 • Introductory Physics I. 3 Credits.

Mechanics, thermal properties of matter and mechanical waves.

*Prerequisites:* MAT123M, MAT124M, or solid understanding and competency in high school mathematics as demonstrated by at least one of the following: a Math ACT score of at least 23, 519 on the Math portion of the SAT, a Math Placement Test score of at least 3. *Corequisites:* Concurrent registration in PHY202D is required. Offered: Fall

### PHY202D • Introductory Physics I Lab. 1 Credit.

Laboratory experience accompanying PHY202. *Corequisites:* Concurrent registration in PHY202 is required. Offered: Fall.

### PHY206 • Introductory Physics II. 3 Credits.

Electricity and magnetism, sound waves, optical phenomena, and modern physics.

*Prerequisites:* PHY202/202D. *Corequisites:* Concurrent registration in PHY207 is required. Offered: Spring

### PHY207 • Introductory Physics II Lab. 1 Credit.

Laboratory experience accompanying PHY206. *Corequisites:* Concurrent registration in PHY206 is required. Offered: Spring.

### PHY260 • Careers in Engineering and Physics Seminar.

1 Credit.

Focus on developing careers in high-technology fields such as engineering and physics. Emphasis on exploring some of the wide variety of specific careers possible through methods such as video, lecture, tours, and guest speakers. Development of practical professional skills such as writing resumes and cover letters, accumulating connections and experience, and developing techniques for interviewing.

*Prerequisites:* PHY296/297. Offered: Fall. *Special Notes:*

Carries cross-credit in engineering.

## Physics 2

### **PHY292 • General Physics I.** 3 Credits.

Kinematics, mechanics, oscillations, fluids, and conservation principles.

*Prerequisites:* MAT124M (may be taken concurrently).

*Corequisites:* Concurrent registration in PHY292D is required. Offered: Fall

### **PHY292D • General Physics I Lab.** 1 Credit.

Laboratory experience accompanying PHY292.

*Corequisites:* Concurrent registration in PHY292 is required. Offered: Fall.

### **PHY296 • General Physics II.** 3 Credits.

Electricity, magnetism, thermodynamics, sound waves, and optics.

*Prerequisites:* PHY292/292D (with a grade of C or better);

MAT125 (may be taken concurrently). *Corequisites:*

Concurrent registration in PHY297 is required. Offered: Spring

### **PHY297 • General Physics II Lab.** 1 Credit.

Laboratory experience accompanying PHY296.

*Corequisites:* Concurrent registration in PHY296 is required. Offered: Spring.

### **PHY302 • Electronics.** 3 Credits.

Fundamentals of digital and analog electronics intended for scientists and engineers.

*Prerequisites:* PHY296/297 (grade of C or better);

MAT124M. *Corequisites:* Concurrent registration in PHY303 is required. Offered: Fall

### **PHY303 • Electronics Lab.** 1 Credit.

Laboratory experience accompanying PHY302.

Extensive laboratory exercises and a choice of projects provide hands-on experience with circuits using transistors, operational amplifiers, logic gates, flip-flops, and other devices.

*Corequisites:* Concurrent registration in PHY302 is required. Offered: Fall.

### **PHY312 • Modern Physics.** 3 Credits.

Relativity, quantum theory, atomic structure, nuclear structure, and elementary particles.

*Prerequisites:* PHY296/297 (grade of C or better); MAT223.

*Corequisites:* Concurrent registration in PHY313 is required. Offered: Spring

### **PHY313 • Modern Physics Lab.** 1 Credit.

Atomic and nuclear laboratory experiments accompanying PHY312.

*Corequisites:* Concurrent registration in PHY312 is required. Offered: Spring.

### **PHY320 • Mathematical Methods in Physics and Engineering.** 4 Credits.

Development of skill in mathematical techniques useful in the solution of physics and engineering problems. Included are vector analysis; line and surface integrals; Fourier analysis; partial differential equations; and linear algebra topics such as basis, dimension, matrices, eigenvalues/eigenvectors.

*Prerequisites:* MAT222; MAT223. Offered: Fall. *Special Notes:* Carries cross-credit in engineering.

### **PHY332 • Optics.** 3 Credits.

Principles of geometrical and physical optics.

*Prerequisites:* PHY312/313; MAT223. *Corequisites:*

Concurrent registration in PHY333 is required. Offered: Spring, even # years

### **PHY333 • Optics Lab.** 1 Credit.

Laboratory experience accompanying PHY332 emphasizing physical optics measurements, laser technology, and holography.

*Corequisites:* Concurrent registration in PHY332 is required. Offered: Spring, even # years.

### **PHY340 • Mechanics.** 4 Credits.

Particle dynamics, conservative motion, central forces, accelerated coordinate systems, and Lagrange's equations of motion.

*Prerequisites:* PHY296/297 (grade of C or better); MAT222; MAT223. Offered: Spring

### **PHY352 • Computer Methods in Physics and Engineering.** 3 Credits.

Application of the computer to solving applied problems of interest to physicists and engineers. Computer techniques are developed for numerical methods, simulation models, and data acquisition and control in the laboratory.

*Prerequisites:* MAT223; PHY296/297, and PHY302/303 (grade of C or better) or consent of instructor.

*Corequisites:* Concurrent registration in PHY353 is required. Offered: Spring. *Special Notes:* Carries cross-credit in engineering.

### **PHY353 • Computer Methods in Physics and Engineering Lab.** 1 Credit.

Laboratory experience accompanying PHY352.

*Corequisites:* Concurrent registration in PHY352 is required. Offered: Spring. *Special Notes:* Carries cross-credit in engineering.

### **PHY365 • Physics Research Seminar.** 1 Credit.

An introduction to research in physics and the development of scientific writing skills. Emphasis placed on preparing for departmental research experiences such as PHY490 and external research experiences such as those found in industry, summer fellowship programs, and graduate schools.

*Prerequisites:* PHY260; PHY312/313; junior standing; a major in the physics department. Offered: Spring

### **PHY400 • Electricity and Magnetism.** 4 Credits.

Electro- and magnetostatics, electric and magnetic fields, and electromagnetic waves.

*Prerequisites:* PHY296/297 (grade of C or better); MAT222; MAT223. Offered: Fall, odd # years

### **PHY410 • Thermodynamics.** 4 Credits.

Laws of thermodynamics, conditions for thermodynamic equilibrium, and fundamentals of statistical mechanics.

*Prerequisites:* PHY296/297 (grade of C or better); MAT223. PHY312/313 is strongly recommended. Offered: Spring, odd # years

**PHY422 • Fluid Mechanics.** 3 Credits.

Laws of statics, kinematics, and dynamics applied to fluid mechanics. Integral and differential conservation laws for mass, momentum, and energy. Dimensional analysis, viscous pipe flow, boundary layers, separated flows, and potential flow.

*Prerequisites:* PHY296/297 (grade of C or better); MAT223. *Corequisites:* Concurrent registration in PHY423 is required. *Offered:* Fall, odd # years. *Special Notes:* Carries cross-credit in engineering.

**PHY423 • Fluid Mechanics Lab.** 1 Credit.

Laboratory experience accompanying PHY422.

*Corequisites:* Concurrent registration in PHY422 required. *Offered:* Fall, odd # years. *Special Notes:* Carries cross-credit in engineering.

**PHY424 • Materials and Devices.** 3 Credits.

Theory and application of condensed matter and materials. Physical origin of electrical, optical, mechanical, thermal, and magnetic properties.

Particular emphasis on devices such as pn junction diodes, LEDs, solar cells, piezoelectrics, liquid crystals, nanostructures, and sensors. An accompanying lab explores characterization of materials and design, fabrication, and testing of devices.

*Prerequisites:* PHY302/303 or PHY312/313. *Corequisites:* Concurrent registration in PHY425 is required. *Offered:* Fall, even # years. *Special Notes:* Carries cross-credit in engineering.

**PHY425 • Materials and Devices Lab.** 1 Credit.

Laboratory component of PHY424.

*Corequisites:* Concurrent registration in PHY424 required. *Offered:* Fall, even # years. *Special Notes:* Carries cross-credit in engineering.

**PHY432 • Topics in Contemporary Optics.** 3 Credits.

Fourier optics, theory of coherence, quantum optics, nonlinear optics, and the physics of lasers.

*Prerequisites:* PHY312/313; MAT222; MAT223. *Concurrent registration in PHY433 is required.* *Offered:* Spring, odd # years

**PHY433 • Topics in Contemporary Optics Lab.** 1 Credit.

Laboratory experience accompanying PHY432.

*Corequisites:* Concurrent registration in PHY432 is required. *Offered:* Spring, odd # years.

**PHY440 • Quantum Mechanics.** 4 Credits.

Concepts and techniques of quantum mechanics.

*Prerequisites:* PHY312/313; MAT222; MAT223. *Offered:* Fall, even # years

**PHY450 • Topics in Applied Physics and Engineering.** 3-4 Credits.

Topics selected from various fields of engineering and applied physics for the purpose of illustrating the practical application of physical principles. Emphasis on developing the skills and viewpoints commonly used by engineers and industrial physicists. The field of engineering or applied physics is announced prior to registration.

*Prerequisites:* PHY302 and PHY352 (may be taken concurrently); MAT222. *Repeatable course:* Course may be repeated when a different topic is emphasized. *Offered:* Occasionally. *Special Notes:* Carries cross-credit in engineering.

**PHY481 • Internship in Physics.** 1-4 Credits.

A practical experience in an off-campus professional setting in which the student applies the skills and perspectives of a physicist. Designed by student in consultation with a faculty member.

*Prerequisites:* Major in applied physics or physics; junior or senior standing. *Offered:* Fall, spring

**PHY490 • Research.** 3 Credits.

An opportunity for individual student projects under the supervision of the faculty.

*Prerequisites:* Senior standing; PHY365; major in physics department. *Offered:* Fall, spring