

# PHYSICS

The Department of Physics and Engineering (<https://www.bethel.edu/undergrad/academics/physics>) seeks to prepare students in a liberal arts setting for careers in physics, engineering, and related fields. In addition to the B.S. in Electrical Engineering and the B.S. in Software Engineering, students oriented toward engineering careers are also 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 and Engineering 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.A. in Science Education 9-12: Physics Emphasis (<http://catalog.bethel.edu/arts-sciences/academic-programs-departments/physics/science-education-5-12-ba-physics-emphasis>)
- B.S. in Applied Physics (<http://catalog.bethel.edu/arts-sciences/academic-programs-departments/physics/applied-physics-bs>)
- B.S. in Physics (<http://catalog.bethel.edu/arts-sciences/academic-programs-departments/physics/physics-bs>)

## Minor in Physics

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

**PHY 102 • Physics of Everyday Life.** 3 Credits.  
Explores how physics concepts can be used to understand everyday phenomena in the world around us. Topics include mechanics, waves (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 PHY 102D is required. *Offered:* Interim.

**PHY 102D • Physics of Everyday Life-Lab.** 1 Credit.  
Laboratory experience accompanying PHY 102. *Corequisites:* Concurrent registration in PHY 102 is required. *Offered:* Interim.

**PHY 112 • 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 PHY 112D is required. *Offered:* Fall.

**PHY 112D • Introduction to Astronomy Lab.** 1 Credit.  
Laboratory experience accompanying PHY 112. Includes optics, atomic spectra, and observations with simple instruments and telescopes. *Corequisites:* Concurrent registration in PHY 112 is required. *Offered:* Fall.

**PHY 202 • Introductory Physics I.** 3 Credits.  
Mechanics, thermal properties of matter and mechanical waves. *Prerequisites:* MAT 123M, MAT 124M, 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 PHY 202D is required. *Offered:* Fall

**PHY 202D • Introductory Physics I Lab.** 1 Credit.  
Laboratory experience accompanying PHY 202. *Corequisites:* Concurrent registration in PHY 202 is required. *Offered:* Fall.

**PHY 206 • Introductory Physics II.** 3 Credits.  
Electricity and magnetism, sound waves, optical phenomena, and modern physics. *Prerequisites:* PHY 202/202D. *Corequisites:* Concurrent registration in PHY 207 is required. *Offered:* Spring

**PHY 207 • Introductory Physics II Lab.** 1 Credit.  
Laboratory experience accompanying PHY 206. *Corequisites:* Concurrent registration in PHY 206 is required. *Offered:* Spring.

**PHY 260 • 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:* PHY 296/297. *Offered:* Fall. *Special Notes:* Carries cross-credit in engineering.

## Physics 2

### **PHY 292 • General Physics I.** 3 Credits.

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

*Prerequisites:* MAT 124M (may be taken concurrently).

*Corequisites:* Concurrent registration in PHY 292D is required. Offered: Fall

### **PHY 292D • General Physics I Lab.** 1 Credit.

Laboratory experience accompanying PHY 292.

*Corequisites:* Concurrent registration in PHY 292 is required. Offered: Fall.

### **PHY 296 • General Physics II.** 3 Credits.

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

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

MAT 125 (may be taken concurrently). *Corequisites:*

Concurrent registration in PHY 297 is required. Offered:

Spring

### **PHY 297 • General Physics II Lab.** 1 Credit.

Laboratory experience accompanying PHY 296.

*Corequisites:* Concurrent registration in PHY 296 is required. Offered: Spring.

### **PHY 302 • Electronics.** 3 Credits.

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

*Prerequisites:* PHY 296/297 (grade of C or better); MAT

124M. *Corequisites:* Concurrent registration in PHY 303 is required. Offered: Fall

### **PHY 303 • Electronics Lab.** 1 Credit.

Laboratory experience accompanying PHY 302.

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 PHY 302 is required. Offered: Fall.

### **PHY 312 • Modern Physics.** 3 Credits.

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

*Prerequisites:* PHY 296/297 (grade of C or better); MAT

223. *Corequisites:* Concurrent registration in PHY 313 is required. Offered: Spring

### **PHY 313 • Modern Physics Lab.** 1 Credit.

Atomic and nuclear laboratory experiments accompanying PHY 312.

*Corequisites:* Concurrent registration in PHY 312 is required. Offered: Spring.

### **PHY 320 • 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:* MAT 222; MAT 223. Offered: Fall. *Special Notes:* Carries cross-credit in engineering.

### **PHY 332 • Optics.** 3 Credits.

Principles of geometrical and physical optics.

*Prerequisites:* PHY 312/313; MAT 223. *Corequisites:*

Concurrent registration in PHY 333 is required. Offered: Spring, even # years

### **PHY 333 • Optics Lab.** 1 Credit.

Laboratory experience accompanying PHY 332 emphasizing physical optics measurements, laser technology, and holography.

*Corequisites:* Concurrent registration in PHY 332 is required. Offered: Spring, even # years.

### **PHY 340 • Mechanics.** 4 Credits.

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

*Prerequisites:* PHY 296/297 (grade of C or better); MAT 222; MAT 223. Offered: Fall.

### **PHY 352 • 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:* MAT 223; PHY 296/297, and PHY 302/303 (grade of C or better) or consent of instructor.

*Corequisites:* Concurrent registration in PHY 353 is required. Offered: Spring. *Special Notes:* Carries cross-credit in engineering.

### **PHY 353 • Computer Methods in Physics and Engineering Lab.** 1 Credit.

Laboratory experience accompanying PHY 352.

*Corequisites:* Concurrent registration in PHY 352 is required. Offered: Spring. *Special Notes:* Carries cross-credit in engineering.

### **PHY 365 • 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 PHY 490 and external research experiences such as those found in industry, summer fellowship programs, and graduate schools.

*Prerequisites:* PHY 260; PHY 312/313; junior standing; a major in the physics department. Offered: Spring

### **PHY 400 • Electricity and Magnetism.** 4 Credits.

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

*Prerequisites:* PHY 296/297 (grade of C or better); MAT 222; MAT 223. Offered: Fall, odd # years

### **PHY 410 • Thermodynamics.** 4 Credits.

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

*Prerequisites:* PHY 296/297 (grade of C or better); MAT 223. PHY 312/313 is strongly recommended. Offered:

Spring, odd # years

**PHY 422 • 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:* PHY 296/297 (grade of C or better); MAT 223. *Corequisites:* Concurrent registration in PHY 423 is required. *Offered:* Fall, odd # years. *Special Notes:* Carries cross-credit in engineering.

**PHY 423 • Fluid Mechanics Lab.** 1 Credit.

Laboratory experience accompanying PHY 422.

*Corequisites:* Concurrent registration in PHY 422 required. *Offered:* Fall, odd # years. *Special Notes:* Carries cross-credit in engineering.

**PHY 424 • 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:* PHY 302/303 or PHY 312/313. *Corequisites:* Concurrent registration in PHY 425 is required. *Offered:* Fall, even # years. *Special Notes:* Carries cross-credit in engineering.

**PHY 425 • Materials and Devices Lab.** 1 Credit.

Laboratory component of PHY 424.

*Corequisites:* Concurrent registration in PHY 424 required. *Offered:* Fall, even # years. *Special Notes:* Carries cross-credit in engineering.

**PHY 432 • Topics in Contemporary Optics.** 3 Credits.

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

*Prerequisites:* PHY 312/313; MAT 222; MAT 223. *Concurrent registration in PHY 433 is required. Offered:* Spring, odd # years

**PHY 433 • Topics in Contemporary Optics Lab.** 1 Credit.

Laboratory experience accompanying PHY 432.

*Corequisites:* Concurrent registration in PHY 432 is required. *Offered:* Spring, odd # years.

**PHY 440 • Quantum Mechanics.** 4 Credits.

Concepts and techniques of quantum mechanics.

*Prerequisites:* PHY 312/313; MAT 222; MAT 223. *Offered:* Fall, even # years

**PHY 450 • 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:* PHY 302 and PHY 352 (may be taken concurrently); MAT 222. *Repeatable course:* Course may be repeated when a different topic is emphasized. *Special Notes:* Carries cross-credit in Engineering. *Offered:* Occasionally.

**PHY 481 • 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

**PHY 490 • Research.** 3 Credits.

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

*Prerequisites:* Senior standing; PHY 365; major in physics department. *Offered:* Fall, spring