

# PHYSICS (PHY)

**NOTE: All prerequisites for Physics (PHY) courses must be completed with a grade of "C-" or better.**

## Physics (PHY) Courses

**PHY 1603. Algebra-based Physics I. (3-0) 3 Credit Hours. (TCCN = PHYS 1301)**

Prerequisite: MAT 1023 or MAT 1073 completed with a grade of "C-" or better; concurrent enrollment in PHY 1611 is recommended. The first of a two-part, algebra-based introduction to physics for biology and other majors that do not require calculus-based physics. Topics include mechanics, thermodynamics, vibrations and waves. Generally offered: Fall, Spring, Summer. Course Fees: LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 1611. Algebra-based Physics I Laboratory. (1-3) 1 Credit Hour. (TCCN = PHYS 1101)**

Prerequisite: Completion of or concurrent enrollment in PHY 1603. Laboratory accompanies PHY 1603; uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 1603. Generally offered: Fall, Spring, Summer. Course Fees: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 1623. Algebra-based Physics II. (3-0) 3 Credit Hours. (TCCN = PHYS 1302)**

Prerequisite: PHY 1603 completed with a grade of "C-" or better; concurrent enrollment in PHY 1631 is recommended. The second of a two-part, algebra-based introduction to physics for biology and other majors that do not require calculus-based physics. Topics include electricity, magnetism, optics, relativity, and quantum physics. Generally offered: Fall, Spring, Summer. Course Fees: LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 1631. Algebra-based Physics II Laboratory. (1-3) 1 Credit Hour. (TCCN = PHYS 1102)**

Prerequisites: PHY 1611 completed with a grade of "C-" or better and completion of or concurrent enrollment in PHY 1623. Laboratory accompanies PHY 1623; uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 1623. Generally offered: Fall, Spring, Summer. Course Fees: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 1943. Physics for Scientists and Engineers I. (3-1) 3 Credit Hours. (TCCN = PHYS 2325)**

Prerequisite: MAT 1193 or MAT 1213 (or MAT 1214 in previous catalogs) with a grade of "C-" or better; completion of or concurrent enrollment in MAT 1223 (or MAT 1224 in previous catalogs) (if student took MAT 1213 or MAT 1214), or STA 1403 (if student took MAT 1193) is required; concurrent enrollment in PHY 1951 is recommended. The first of a two-part, calculus-based introduction to classical physics, designed for physical sciences, mathematics, and engineering majors. Topics include mechanics and Newton's laws, conservation laws, gravitation, rotational motion and rigid bodies, oscillations and waves. Classes meet weekly for three hours of lecture and one hour of recitation. May apply toward the Core Curriculum requirement in Life and Physical Sciences. (Formerly PHY 1903 and PHY 1904. Credit cannot be earned for more than one of the following: PHY 1903, PHY 1904, or PHY 1943.) Generally offered: Fall, Spring, Summer. Course Fee: LRC1 \$12; LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 1951. Physics for Scientists and Engineers I Laboratory. (1-3) 1 Credit Hour.**

Prerequisite: Completion of, with a grade of "C-" or better, or concurrent enrollment in PHY 1943. Laboratory to accompany PHY 1943; uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 1943. (Formerly PHY 1911. Credit cannot be earned for both PHY 1951 and PHY 1911.) Generally offered: Fall, Spring, Summer. Course Fee: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 1963. Physics for Scientists and Engineers II. (3-1) 3 Credit Hours. (TCCN = PHYS 2326)**

Prerequisite: PHY 1943, and MAT 1223 (or MAT 1224 in previous catalogs) or (MAT 1193 and STA 1403) completed with grades of "C-" or better; concurrent enrollment in PHY 1971 is recommended. The second of a two-part, calculus-based introduction to classical physics, designed for physical sciences, mathematics, and engineering majors. Topics include an introduction to thermal physics, electricity and magnetism, fundamentals of circuits, electromagnetic induction, AC circuits, electromagnetic waves, and Maxwell's equations. Classes meet weekly for three hours of lecture and one hour of recitation. May apply toward the Core Curriculum requirement in Life and Physical Sciences. (Formerly PHY 1923 and PHY 1924. Credit cannot be earned for more than one of the following: PHY 1923, PHY 1924, or PHY 1963.) Generally offered: Fall, Spring, Summer. Course Fee: LRC1 \$12; LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 1971. Physics for Scientists and Engineers II Laboratory. (1-3) 1 Credit Hour.**

Prerequisite: PHY 1951 completed with a grade of "C-" or better and completion of or concurrent enrollment in PHY 1963. Laboratory to accompany PHY 1963; uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 1963. (Formerly PHY 1931. Credit cannot be earned for both PHY 1971 and PHY 1931.) Generally offered: Fall, Spring, Summer. Course Fee: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 2103. Modern Physics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 or MAT 2213 (or MAT 2214 in previous catalogs) completed with a grade of "C-" or better, and completion of or concurrent enrollment in PHY 3203, or consent of instructor. Topics include special relativity, Planck's Radiation Law, elements of quantum mechanics, atomic and molecular structures, spectra, the atomic nucleus, nuclear reactions, and an introduction to elementary particles. (Formerly PHY 3103. Credit cannot be earned for both PHY 2103 and PHY 3103.) Generally offered: Fall, Spring. Course Fee: LRS1 \$46.20; STSI \$21.60; DL01 \$75.

**PHY 2111. Modern Physics Laboratory. (1-3) 1 Credit Hour.**

Prerequisites: PHY 1963, PHY 1971, and completion of, with a grade of "C-" or better, or concurrent enrollment in PHY 2103. Laboratory to accompany PHY 2103; Uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 2103. Generally offered: Fall, Spring. Course Fees: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 2823. Mathematical Physics I. (3-0) 3 Credit Hours.**

Prerequisite: MAT 2213 (or MAT 2214 in previous catalogs), and PHY 1963, or consent of instructor. Topics may include vector analysis, introduction to complex variables, Fourier series, ordinary differential equations, linear algebra, and selected applications to problems in mechanics and electromagnetic theory. All sections of this course have a Mathematica software component to illustrate and reinforce concepts. (Formerly PHY 3823. Credit cannot be earned for both PHY 2823 and PHY 3823.) Generally offered: Fall, Spring. Course Fee: LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 3203. Classical Mechanics I. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 and completion of, with a grade of "C-" or better, or concurrent enrollment in PHY 2823, or consent of instructor. Topics include Newtonian mechanics, oscillations, central-force motion, gravitation, Hamiltonian, and Lagrangian dynamics. Some sections of this course include the use of Mathematica software package as a key component to illustrate and reinforce concepts used in Classical Mechanics. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3293. Thermal Physics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 and PHY 2823, or consent of instructor. Topics include fundamentals of thermodynamics: entropy, free energy, phase transitions, and thermodynamic potentials; equilibrium, Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac distribution functions; derivation of macroscopic equilibrium thermodynamics from statistical mechanics. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3313. Materials Physics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2103 or consent of instructor. Topics covered include crystal structure and band theory, density functional theory, a survey of properties of metals and semiconductors, phonons, electron-phonon interaction and superconductivity. (Formerly titled "Solid State Physics.") Generally offered: Fall, Spring. This course has Differential Tuition.

**PHY 3343. Physics Research Laboratory. (0-9) 3 Credit Hours.**

Prerequisite: PHY 1971, PHY 2103, and PHY 2111. This course provides students majoring in physics the opportunity to acquire knowledge in advanced experimental techniques gained through actual participation in real-world physics research labs. (Formerly titled "Advanced Physics Laboratory.") Generally offered: Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3423. Electricity and Magnetism. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963, PHY 2823, and completion of (with a grade of "C-" or better) or concurrent enrollment in MAT 3613, or consent of instructor. Topics include vector calculus, electrostatics, magnetostatics, Faraday's Law, and solutions to Laplace's equation. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3443. Modern Optics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 3423 or consent of instructor. Topics include reflection, refraction, absorption, polarization, and diffraction of light, filters, lasers, nonlinear properties, and Fourier optics. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3453. Lasers: Theory and Applications. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2103 or consent of instructor. Topics include basic principles and designs of lasers: Einstein A and B coefficients; semiclassical laser theory; the phase-coherent nature of the stimulated emission process; and laser efficiency. Various applications of lasers, such as laser-induced fluorescence, light wave communications, holography, surgery, and laser fusion. This course has Differential Tuition.

**PHY 3513. Electrodynamics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2823 and PHY 3423, or consent of instructor. Continuation of the material started in PHY 3423. Topics include Maxwell's equations, electromagnetic waves, wave guides, and radiation from accelerated charges. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3583. Mathematical Physics II. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2823 or consent of instructor. Topics may include series solutions of differential equations, partial differential equations of physics, special functions, integral transforms and introduction to tensor calculus. Applications may include topics in classical and quantum mechanics, electrostatics and electrodynamics. (Formerly PHY 4823. Credit cannot be earned for both PHY 3583 and PHY 4823.) Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: MEPA \$18; DL01 \$75.

**PHY 3603. Cosmology. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 and PHY 2103, or consent of instructor. This course is an introduction to physical cosmology. Topics include large-scale structure, expansion and age of the universe; non-Euclidean spaces, big bang cosmology, baryogenesis, nucleosynthesis, and cosmic microwave background radiation; particle physics and inflationary cosmology. (Formerly PHY 4033. Credit cannot be earned for both PHY 3603 and PHY 4033.) This course has Differential Tuition. Course Fee: MEPA \$18.

**PHY 4013. Relativity: Special and General. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2823 and PHY 3203, or consent of instructor. Topics include special relativity: Lorentz transformations, four-vectors, geometry of flat space-time, relativistic dynamics. General relativity: Principle of equivalence, introduction to tensor calculus, Einstein's field equations, Schwarzschild's solution, black holes. Introduction to cosmology. This course has Differential Tuition.

**PHY 4263. Quantum Mechanics I. (3-0) 3 Credit Hours.**

Prerequisites: PHY 2103, PHY 3203, MAT 2233, and completion of or concurrent enrollment in PHY 3583, or consent of instructor. Topics include the time-independent Schrodinger equation; operator methods, and the postulates of quantum mechanics; one-dimensional potentials; quantum harmonic oscillator; angular momentum and spin; entanglement and its applications; quantum mechanics in three dimensions and the hydrogen atom. Generally offered: Fall, Spring. This course has Differential Tuition. Course fee: DL01 \$75.

**PHY 4423. Quantum Mechanics II. (3-0) 3 Credit Hours.**

Prerequisite: PHY 3583 and PHY 4263, or consent of instructor. Topics include identical particles; time-independent perturbation theory; WKB approximation, time-dependent perturbation theory, the variational principle; the adiabatic approximation and Berry's phase; scattering. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 4623. Nanotechnology. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2103 or consent of instructor. This course will describe the fundamentals of nanotechnology, including properties of matter at the nanometric size. This course has Differential Tuition.

**PHY 4833. Molecular Biophysics. (3-0) 3 Credit Hours.**

Prerequisites: CHE 1113 and one of the following: PHY 2103, CHE 3804, or CHE 4354 (formerly CHE 3854). Topics include interaction between molecules, principles of thermodynamics (enthalpy, entropy, free energy) applied to biomolecules, Brownian motion and diffusion of molecules, structure of proteins, and principles of quantum mechanics. Biophysical techniques: absorption spectroscopy, transient absorption, fluorescence spectroscopy, fluorescence lifetime, FTIR spectroscopy, linear and circular dichroism, x-ray crystallography, and atomic force microscopy. Generally offered: Spring. This course has Differential Tuition. Course fee: DL01 \$75.

**PHY 4911. Independent Study. (0-0) 1 Credit Hour.**

Prerequisite: Permission in writing (form available) from the instructor, the student's advisor, the Department Chair, and Dean of the College in which the course is offered. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 6 semester credit hours, regardless of discipline, will apply to a bachelor's degree in physics. This course has Differential Tuition.

**PHY 4913. Independent Study. (0-0) 3 Credit Hours.**

Prerequisite: Permission in writing (form available) from the instructor, the student's advisor, the Department Chair, and Dean of the College in which the course is offered. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 6 semester credit hours, regardless of discipline, will apply to a bachelor's degree in physics. Generally offered: Spring. This course has Differential Tuition.

**PHY 4953. Special Studies in Physics. (3-0) 3 Credit Hours.**

Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Studies may be repeated for credit when the topics vary, but not more than 6 semester credit hours, regardless of discipline, will apply to a bachelor's degree. Generally offered: Spring. This course has Differential Tuition. Course fee: DL01 \$75.

**PHY 4983. Unifying Concepts in Physics. (3-0) 3 Credit Hours.**

Prerequisites: PHY 3293, PHY 3513, PHY 4263, and completion with a grade of "C-" or better or concurrent enrollment in PHY 3583, or consent of instructor. This advanced course is designed to help the students develop a more mature and coherent understanding of the whole discipline through an in-depth exploration of the major branches of physics and their theoretical interconnections. Generally offered: Fall. This course has Differential Tuition. Course Fee: MEPA \$18; DL01 \$75.

**PHY 4993. Directed Research. (0-0) 3 Credit Hours.**

Prerequisite: Approval from the instructor, the Department Chair, and the Associate Dean of Undergraduate Studies in the College for which this course is offered; form available on the College of Sciences website. Supervised research mentored by a faculty member engaged in active research within the student's designated area of concentration. Students may produce a thesis in addition to active research. May be repeated. This course can also be used for students pursuing the COS Undergraduate Thesis Option. This course has Differential Tuition.