

Physics (PHYS)

Courses

PHYS 100. Preparatory Physics. 3 hours.

Introduction to basic physics concepts, problem-solving skills, and quantitative reasoning. Course Information: No credit toward the Major in Physics, BS in Physics, or Minor in Physics. Prerequisite(s): Grade of C or better or concurrent registration in MATH 121; and appropriate score on the department placement test.

PHYS 101. Active Learning of the Physical World. 4 hours.

A continuation of the first 7 weeks of PHYS 141, focusing on the exploration of the physical world through active learning. Student-centered learning through team activities in small group settings, working on problem-solving activities. Course Information: Credit is not given for PHYS 101 if student has credit in PHYS 141. Enrollment available only after week 7 and only to students currently enrolled in PHYS 141. Prerequisite(s): Physics 141; and registration and approval of the department. Restricted to students currently enrolled in PHYS 141.

PHYS 112. Astronomy and the Universe. 4 hours.

Astronomy in the context of the scientific process, history and current events. Covers the Solar System, stars and galaxies and the origin and fate of the universe. Class Schedule Information: To be properly registered, students must enroll in one Laboratory and one Lecture. *Natural World - With Lab course.*

PHYS 116. Energy for Future Decision-Makers. 3 hours.

Survey of energy sustainability and environmental issues. All energy forms of production, sources, storage, and uses; their environmental implications on a global scale within the scientific, technological, political, economic, and social context. Course Information: Same as EAES 116. Recommended background: High school algebra. *Natural World - No Lab course.*

PHYS 118. Physics in Modern Medicine. 3 hours.

Survey course of physical technologies used in modern medicine and the underlying physics, including applications of optics, imaging, and nuclear medicine to diagnosis, surgery, therapy and treatment. Course Information: Prerequisite(s): High school algebra, trigonometry, and biology. *Natural World - No Lab course.*

PHYS 131. Introductory Physics for Life Sciences I. 4 hours.

Algebra-based physics and its relationship to the life sciences, including mechanics, waves, diffusion and fluids with applications to molecular, cell and human biology. Course Information: Prerequisite(s): High school algebra and trigonometry. Credit for PHYS 131 is not given if the student has credit for PHYS 105 or PHYS 141. To be properly registered, students must enroll in one Laboratory, one Lecture and one Discussion/Recitation. *Natural World - With Lab course.*

PHYS 132. Introductory Physics for Life Sciences II. 4 hours.

Algebra-based physics and its relationship to the life sciences, including electromagnetism, optical, quantum, and thermal physics, with applications to molecular, cell and human biology. Course Information: Prerequisite(s): Grade of C or better in PHYS 105 and Grade of C or better in PHYS 106; or Grade of C or better in PHYS 131. Credit for PHYS 132 is not given if the student has credit for PHYS 107 or PHYS 142. To be properly registered, student must enroll in one Laboratory, one Discussion/Recitation and one Lecture. *Natural World - With Lab course.*

PHYS 141. General Physics I (Mechanics). 4 hours.

Kinematics, vectors, Newton's laws of motion; linear momentum, collisions; work and kinetic energy; potential energy, conservation of energy; rotational kinematics and energy; rotational dynamics, static equilibrium; simple harmonic motion. Course Information: Students may obtain one additional hour of credit by concurrently registering in PHYS 144. Prerequisite(s): Grade of C or better or concurrent registration in MATH 180; or approval of the department; and Grade of C or better in PHYS 100 or adequate performance on the departmental placement test. Class Schedule Information: During the fall and spring terms, combined-section final exam will be held on Wednesday of finals week from 6 to 8 p.m. To be properly registered, students must enroll in one Laboratory and one Lecture-Discussion. *Natural World - With Lab course.*

PHYS 142. General Physics II (Electricity and Magnetism). 4 hours.

Electrostatics; electric currents; d-c circuits; magnetic fields; magnetic media; electromagnetic induction; a-c circuits; Maxwell's equations; electromagnetic waves; reflection and refraction; interference; geometrical optics. Course Information: Prerequisite(s): Grade of C or better in PHYS 141; and Grade of C or better or concurrent registration in MATH 181. *Natural World - With Lab course.*

PHYS 144. Problem-Solving Workshop for General Physics I (Mechanics). 1 hour.

A workshop where smaller groups of students work together with the instructor to enhance their problem solving skills by solving additional problems both similar to, as well as more challenging than, the ones given in Physics 141. Course Information: Satisfactory/Unsatisfactory grading only. Must enroll concurrently in PHYS 141.

PHYS 145. Problem-Solving Workshop for General Physics II (Electricity and Magnetism). 1 hour.

A workshop where smaller groups of students work together with the instructor to enhance their problem-solving skills by solving additional problems both similar to, as well as more challenging than, problems given in Physics 142. Course Information: Satisfactory/Unsatisfactory grading only. Requires concurrent registration in PHYS 142.

PHYS 215. Computational and Mathematical Methods for the Physical Sciences. 4 hours.

Computational and mathematical methods applied to basic problems in physics. Course Information: Extensive computer use required. Prerequisite(s): Grade of C or better in PHYS 142; or Grade of B or better in PHYS 107 or Grade of B or better in PHYS 132; and Grade of C or better in MATH 181 and Grade of C or better or concurrent registration in MATH 210. Class Schedule Information: To be properly registered, students must enroll in one Lecture and one Laboratory.

PHYS 230. Fundamentals of Relativity. 3 hours.

Introduction to the theory of relativity, including special relativity (Lorentz contraction, time dilation, energy-mass equivalence, kinematics and electrodynamics) and general relativity (gravity, black holes). Course Information: Prerequisite(s): Grade of C or better in MATH 181; and Grade of C or better in PHYS 142; or Grade of B or better in PHYS 107 or Grade of B or better in PHYS 132.

PHYS 240. Fundamentals of Modern Quantum Theory. 3 hours.

Modern introduction to the quantum theory including discrete systems (qubits, etc.), quantum measurement theory, entanglement, Bell's Theorem, the Uncertainty Principle, one-dimensional potential models, and the Schrodinger-von Neumann equation. Course Information: Prerequisite(s): Grade of C or better in MATH 181; and Grade of C or better in PHYS 142; or Grade of B or better in PHYS 107 or Grade of B or better in PHYS 132. Physics majors (BA and BS) are required to register concurrently for PHYS 241.

PHYS 241. Experiments in Modern Physics. 1 hour.

Companion course to PHYS 240 that includes laboratory experiments on introductory quantum theory and modern physics. Course Information: Prerequisite(s): Grade of C or better in MATH 181; and Grade of C or better in PHYS 142; or Grade of B or better in PHYS 107 or Grade of B or better in PHYS 132. Requires concurrent registration in PHYS 240 or approval of the department.

PHYS 245. Introduction to Vibrations, Waves, and Thermal Physics. 4 hours.

Free, forced, damped, and coupled oscillations; normal modes; Fourier analysis; resonance; waves; interference; diffraction; heat energy; entropy; introduction to thermodynamics, kinetic theory of gases, and basic statistical physics. Course Information: Prerequisite(s): Grade of C or better in MATH 181; and Grade of C or better in PHYS 142; or Grade of B or better in PHYS 107 or Grade of B or better in PHYS 132. Recommended background: Credit or concurrent registration in MATH 220. Class Schedule Information: To be properly registered, students must enroll in one Laboratory and one Lecture.

PHYS 260. Introduction to Thermal Physics. 2 hours.

Calculus-based introduction to thermal physics. The first and second laws of thermodynamics, entropy, free energy, statistical physics, and their applications. Course Information: Extensive computer use required. Computer and internet access are required. This course does not satisfy the requirements for BA and BS degrees in physics. Prerequisite(s): Grade of C or better in PHYS 141 and Grade of C or better in MATH 181. Class Schedule Information: To be properly registered, students must enroll in one Lecture and one Discussion.

PHYS 391. Physics Seminar. 1 hour.

Preparation and presentation by students of talks on topics of current interest in physics. Course Information: Satisfactory/Unsatisfactory grading only. May be repeated to a maximum of 4 hours. Prerequisite(s): Senior standing.

PHYS 392. Physics Research. 2-4 hours.

Research under the close supervision of a faculty member. Course Information: Prerequisite(s): Approval of the department. Class Schedule Information: This course counts toward the limited number of independent study hours accepted toward the degree and the major.

PHYS 393. Special Problems. 2-4 hours.

Special problems or reading in modern physics under individual arrangement with a faculty member. Course Information: Prerequisite(s): Approval of the department. Class Schedule Information: This course counts toward the limited number of independent study hours accepted toward the degree and the major.

PHYS 401. Electromagnetism I. 4 hours.

Vector calculus; electrostatic and magnetostatic fields in vacuum; electrostatic boundary-value problems; electrodynamics; Maxwell's equations; electromagnetic waves in vacuum; reflection and transmission phenomena in linear media. Prerequisite(s): PHYS 215 and MATH 220; or approval of the department.

PHYS 402. Electromagnetism II. 4 hours.

Electrostatics, magnetostatics, and electromagnetic waves in matter; radiation; relativistic electrodynamics; special topics chosen by the instructor. Course Information: Prerequisite(s): PHYS 230 and PHYS 401; or approval of the department.

PHYS 411. Quantum Mechanics I. 4 hours.

Wave particle duality; wave functions; matrix representation; operators and observables; 1-D potentials; harmonic oscillator; eigenvalues and eigenfunctions; time-independent perturbation theory; approximation methods; 3-D Schroedinger's equation. Course Information: Prerequisite(s): PHYS 215 and PHYS 240 and PHYS 245; or approval of the department. Recommended background: MATH 220.

PHYS 412. Quantum Mechanics II. 4 hours.

This is the second semester of a two-semester undergraduate level sequence on the concepts and methods of Quantum Mechanics and their applications. Course Information: Prerequisite(s): PHYS 411; or approval of the department.

PHYS 421. Modern Physics: Atoms and Molecules. 4 hours.

Hydrogenic atoms, electron spin, external fields, multi-electron atoms, diatomic molecules, line widths, photons, radiation from atoms and other electromagnetic processes, positrons, positronium, elastic electron scattering. Course Information: Prerequisite(s): Credit or concurrent registration in PHYS 411.

PHYS 425. Modern Optics. 4 hours.

Review of electromagnetic wave theory and introductory optics; advanced geometrical optics; Fourier transforms and optics; interference and diffraction; solar cells and LEDs; laser cavities and gain media; introduction to nonlinear and fiber optics. Course Information: Prerequisite(s): PHYS 240; or approval of the department. Class Schedule Information: To be properly registered, students must enroll in one Discussion, one Laboratory and one Lecture.

PHYS 431. Modern Physics: Condensed Matter. 4 hours.

Crystal structures; interatomic binding; lattice vibrations; thermal and magnetic properties; quantum statistical mechanics; free electron theory of metals; electronic band theory; semiconductors and insulators; superconductivity. Course Information: Prerequisite(s): PHYS 411 and PHYS 461; or consent of the instructor.

PHYS 441. Theoretical Mechanics. 4 hours.

Review of Newtonian mechanics, variational calculus, Lagrangian mechanics, central force problems, non-inertial frames, rigid body motion, coupled oscillators, non-linear mechanics, Hamiltonian mechanics, and numerical examples. Course Information: Prerequisite(s): PHYS 215 and Credit or concurrent registration in PHYS 245; or approval of the department.

PHYS 450. Molecular Biophysics of the Cell. 4 hours.

Introduction to force, time energies at nanometer scales; Boltzmann distribution; hydrodynamic drag; Brownian motions; DNA, RNA protein structure and function; sedimentation; chemical kinetics; general aspects of flexible polymers. Course Information: Same as BME 450. Prerequisite(s): PHYS 245 or the equivalent; or approval of the department.

PHYS 451. Modern Physics: Nuclei and Elementary Particles. 4 hours.

Accelerators, detectors, symmetries, conservation laws, leptons, weak interactions, electroweak theory, strong interactions, hadrons, nuclear forces, systematics and reactions, nuclear models, nuclear astrophysics, quarks, quantum chromodynamics. Course Information: Prerequisite(s): PHYS 411.

PHYS 461. Thermal and Statistical Physics. 4 hours.

Thermal equilibrium (Zeroth Law); thermodynamic states (First Law); irreversibility; entropy (Second Law); thermodynamic potentials and properties; phase transitions; kinetic theory of gases; classical statistical mechanics. Course Information: Prerequisite(s): PHYS 245; or approval of the department.

PHYS 469. The Learning and Teaching of Physics. 4 hours.

Provides teacher candidates with the foundations and experiences necessary for teaching physics in secondary schools. For those currently teaching, it will also provide tools and background to improve their physics instruction. Course Information: 4 hours. Extensive computer use required. Prerequisite(s): PHYS 142; or PHYS 107 and PHYS 108; or approval of the department. Class Schedule Information: To be properly registered, students must enroll in one Lecture-Discussion and one Laboratory.

PHYS 470. Educational Practice with Seminar I. 6 hours.

The first half of a two-segment sequence of practice teaching, including seminar, to meet certification requirements for teaching in grades six through twelve. Course Information: Graduate credit only with approval of the department. Prerequisite(s): Good academic standing in a teacher education program, completion of 100 clock hours of pre-student-teaching field experiences, and approval of the department. Class Schedule Information: To be properly registered, students must enroll in one Lecture-Discussion and one Practice.

PHYS 471. Educational Practice with Seminar II. 6 hours.

The second half of a two-segment sequence of practice teaching, including seminar, to meet certification requirements for teaching in grades six through twelve. Course Information: Graduate credit only with approval of the department. Prerequisite(s): Good academic standing in a teacher education program, completion of 100 clock hours of pre-student-teaching field experiences, credit or concurrent registration in PHYS 470, and approval of the department. Class Schedule Information: To be properly registered, students must enroll in one Conference and one Practice.

PHYS 475. Learning and Teaching of Physical Sciences. 3 hours.

Provides teacher candidates with the foundation and experience necessary to teach physical sciences in secondary schools. Course Information: Same as CHEM 475. Prerequisite(s): Senior standing or above; or approval of the department. Recommended background: Knowledge of first-year college physics and chemistry. Class Schedule: To be properly registered students must enroll in one Lecture-Discussion and one Laboratory.

PHYS 480. Elements of Machining Scientific Equipment. 1 hour.

Elements of machining scientific equipment, including the use of machine shop tools and technical drawing of scientific apparatus. Course Information: Same as CHEM 480 and EAES 478. Satisfactory/Unsatisfactory grading only. Prerequisite(s): Graduate standing; and approval of the department.

PHYS 481. Modern Experimental Physics I. 4 hours.

Theory and experimental use of linear circuits, semiconductor devices, amplifiers, oscillators. Techniques and experiments in atomic, molecular and solid-state physics. Course Information: Prerequisite(s): PHYS 240; or approval of the department. Requires concurrent registration in PHYS 499 for students enrolled in the BA or BS in Physics programs. Class Schedule Information: To be properly registered, students must enroll in one Laboratory and one Lecture-Discussion.

PHYS 482. Modern Experimental Physics II. 4 hours.

Techniques and experiments in nuclear and particle physics. Gamma-gamma correlations, muon lifetime, Compton scattering, alpha particle scattering. Computer-based experimentation. Course Information: Prerequisite(s): PHYS 481; or approval of the department. Class Schedule Information: To be properly registered, students must enroll in one Laboratory and one Lecture-Discussion.

PHYS 491. Special Topics in Physics. 1-4 hours.

Selected topics of current interest in Physics. Course Information: May be repeated. Prerequisite(s): PHYS 215 and sophomore standing or above; or approval of the department.

PHYS 494. Special Topics in Physics Teaching. 2-4 hours.

Seminar on various topics related to the teaching of physics. Subjects are announced. Course Information: May be repeated. Students may register in more than one section per term. Supervised teaching practice included. Prerequisite(s): Graduate standing or approval of the department.

PHYS 499. Survey of Physics Problems. 1 hour.

Problem-solving techniques applied to the variety of undergraduate physics topics. Course Information: No graduation credit for graduate students. Grade of C or better required to graduate with an undergraduate degree in physics. Co-requisite(s): Concurrent registration in PHYS 481.

PHYS 501. Electrodynamics. 4 hours.

Maxwell's equations, special relativity, relativistic electrodynamics, non-relativistic and relativistic radiation, Lienard-Wiechert potentials, Lagrangians in electrodynamics. Course Information: Prerequisite(s): Upper-level undergraduate electrodynamics or approval of the department.

PHYS 511. Quantum Mechanics I. 4 hours.

Linear operators, vector spaces. Schroedinger equation. Heisenberg formalism. Multi/identical particle systems, approximation methods, perturbation theory, symmetries and groups, conservation laws, angular momentum, spin. Wigner-Eckart theorem. Course Information: Prerequisite(s): PHYS 412 or approval of the department.

PHYS 512. Quantum Mechanics II. 4 hours.

Scattering theory; partial waves; born approximation; density matrix; interaction of radiation with matter; Klein-Gordon and Dirac equations; free-particle solutions; antiparticles; relativistic hydrogen atom; second quantization. Course Information: Prerequisite(s): PHYS 511 or approval of the department.

PHYS 513. Quantum Field Theory I. 4 hours.

Classical field theory, Hamiltonian and Lagrangian techniques, second quantization, bosons and fermions, quantum fields, path integrals, perturbation theory, Feynman diagrams, renormalization, global and local symmetries, quantum electrodynamics. Course Information: PHYS 501 and Credit or concurrent registration in PHYS 512 or approval of the department.

PHYS 515. Methods in Mathematical Physics. 3 hours.

Applications of mathematical methods to physics problems, linear operators, orthogonal functions, Green's functions, ordinary and partial differential equations, Sturm-Liouville problem, Hilbert space, group theory. Course Information: Prerequisite(s): PHYS 215.

PHYS 524. Group Theory in Physics. 3 hours.

Applications of group theory and symmetry principles to problems in elementary particle, solid state, atomic and molecular physics. Course Information: Prerequisite(s): PHYS 512 or approval of the department.

PHYS 525. Optics and Photonics. 2 hours.

Electromagnetic wave theory; advanced geometrical, nonlinear, fiber, and Fourier optics; Fourier transforms; interference; diffraction; solar cells; LEDs; laser cavities; gain media. More challenging problem sets, exams, labs than in Phys 425. Course Information: Corequisites: Requires concurrent registration in PHYS 425. To be properly registered, students must enroll in one Lecture, one Laboratory, and one Discussion.

PHYS 531. Solid State Physics I. 4 hours.

Physics of solid state materials: single particle approximation, crystal lattices, electrons in a crystal potential, lattice vibrations, transport properties, optical properties, semiconductors. Course Information: Prerequisite(s): PHYS 511 and upper-level undergraduate course in thermal and statistical physics or approval of the department.

PHYS 532. Solid State Physics II. 4 hours.

Second quantization; Green's functions; perturbation expansions; fluctuation-dissipation; spectroscopy; linear response; Fermi liquids; superconductivity; ferromagnetism and anti-ferromagnetism. Course Information: Prerequisite(s): PHYS 512 and PHYS 531 or approval of department.

PHYS 533. Solid State Physics III. 4 hours.

Advanced theory, including magnetism; Kondo effect; electronic transport in disordered systems; non-equilibrium phenomena: Keldysh formalism, charge and energy transport; quantum field theory of superconductivity, topological materials. Course Information: Prerequisite(s): PHYS 532 or approval of the department.

PHYS 540. Physics of Semiconductor Devices. 4 hours.

Electrons in periodic lattice; equilibrium carrier distribution; energy band diagrams in junctions, in homogeneous semiconductors; recombination and generation; non-equilibrium processes, radiation and electric fields; diodes. Course Information: Same as ECE 540. Prerequisite(s): ECE 346 or the equivalent.

PHYS 545. Introduction to General Relativity. 3 hours.

Principle of equivalence, the metric field and geodesics, tensor analysis and differential geometry, Einstein's equations and the action principle, gravitational fields and waves, black holes. Course Information: Prerequisite(s): PHYS 502 and PHYS 541 or approval of the department.

PHYS 551. Nuclear and Particle Physics I. 4 hours.

Relativistic quantum field theory and Abelian gauge theory in the context of high energy nuclear and particle physics. Course Information: Prerequisite(s): PHYS 513 or consent of the department.

PHYS 552. Nuclear and Particle Physics II. 4 hours.

Non-abelian gauge theories and thermal quantum field theory and their applications to high energy nuclear and particle physics, including the Standard Model, phase transitions in strong interactions, quark-gluon plasma. Course Information: Prerequisite(s): PHYS 551 or consent of the department.

PHYS 561. Statistical Mechanics I. 3 hours.

Statistical mechanics and applications: phase space, ensemble theory, partition functions, Boltzmann and quantum statistics. Course Information: Prerequisite(s): Upper-level undergraduate course in thermal and statistical physics or consent of the department.

PHYS 562. Statistical Mechanics II. 3 hours.

Advanced exploration of topics in equilibrium and non-equilibrium statistical mechanics – topics such as phase transitions, renormalization group methods, criticality, fluctuations, correlation functions, dynamics, transport, active matter, liquids. Course Information: Prerequisite(s): PHYS 561 or consent of the department.

PHYS 571. Biological Physics I. 4 hours.

Soft matter concepts applied to molecular and cellular biophysics: self-assembly, electrostatics, mechanics of biopolymers, properties of membranes, correlation functions, experimental and computational methods. Course Information: Prerequisite(s): PHYS 450 and upper-level undergraduate course in thermal and statistical physics or approval of the department.

PHYS 572. Biological Physics II. 4 hours.

Soft matter concepts applied to molecular and cellular biophysics: chemical kinetics, diffusive processes, transport in the cell, dynamic filaments, mechanics of the cytoskeleton, biomolecular condensates, experimental and computational methods. Course Information: Prerequisite(s): PHYS 571; or approval of the department.

PHYS 581. Advanced Experimental Physics. 2 hours.

Experimental techniques in atomic, molecular and solid-cular and solid-state physics. Course Information: Prerequisite(s): PHYS 431 or consent of the instructor.

PHYS 594. Special Topics in Modern Physics. 1-4 hours.

Lectures on topics of current interest. Subjects are announced in the previous semester. Course Information: May be repeated. Students may register in more than one section per term. Prerequisite(s): PHYS 512.

PHYS 595. Graduate Seminar. 1 hour.

Seminars in areas of research activity within the department covering recent contributions to the literature and research in progress. Presentations by students, faculty and scientists from other institutions. Course Information: Satisfactory/Unsatisfactory grading only. May be repeated to a maximum of 6 hours. Students may register in more than one section per term.

PHYS 596. Individual Study. 2-4 hours.

Special topics. Outside reading and a term paper are assigned by a special arrangement with the department and faculty. Course Information: Satisfactory/Unsatisfactory grading only. May be repeated. Students may register in more than one section per term. Prerequisite(s): Approval of the department.

PHYS 598. Master's Thesis Research. 0-16 hours.

Student may elect to do thesis research to fulfill partial requirement for master's degree. Course Information: Satisfactory/Unsatisfactory grading only. Prerequisite(s): Approval of the department.

PHYS 599. Thesis Research. 0-16 hours.

Ph.D. thesis research. Course Information: Satisfactory/Unsatisfactory grading only. May be repeated. Prerequisite(s): Approval of the department.