PHYSICS (PHYS)

PHYS Class Schedule (https://courses.illinois.edu/schedule/DEFAULT/DEFAULT/PHYS)

Courses

**PHYS 100 Thinking About Physics** credit: 2 Hours.
Conceptual and problem solving skills in preparation for PHYS 211: --analysis and mathematical descriptions of physical situations -- understanding the meaning of the solutions Prerequisite: Credit or concurrent registration in MATH 220 or MATH 221.

**PHYS 101 College Physics: Mech & Heat** credit: 5 Hours.
Newton's Laws, work and energy, rotational motion, fluids, thermodynamics, and waves. A noncalculus-based approach for majors in the life sciences, preprofessional health programs, agriculture, and veterinary medicine. Credit is not given for both PHYS 101 and either PHYS 211 or PHYS 213. Prerequisite: Trigonometry. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

**PHYS 102 College Physics: E&M & Modern** credit: 5 Hours.
Electric forces and fields, electric potential, electric circuits, magnetic forces and fields, geometrical optics, relativity, and modern physics. A noncalculus-based approach for majors in the life sciences, preprofessional health programs, agriculture, and veterinary medicine. Credit is not given for both PHYS 102 and either PHYS 212 or PHYS 214. Prerequisite: PHYS 101. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

**PHYS 110 Physics Careers** credit: 0 Hours.
Exploration of careers founded on physics undergraduate training. Introduction to the Physics Department, faculty, research and curricula. Outside speaker presentations. Approved for S/U grading only.

**PHYS 123 Physics Made Easy** credit: 3 Hours.
Inquiry-based, nonmathematical, hands-on study of physics for elementary school teachers. Coverage of most of the National Science Education K-4 Content Standards. Additional fees may apply. See Class Schedule. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences

**PHYS 140 How Things Work** credit: 3 Hours.
Nonmathematical approach underscoring the generality and ubiquity of basic physical laws in understanding commonplace phenomena: musical instruments, photography, electric and electronic circuits, television, motors, engines, etc. Credit is not given to engineering majors. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

**PHYS 140** Physics of Societal Issues credit: 3 Hours.
Physics topics and applications relevant in the modern world: energy, quantum mechanics, electricity and magnetism, nuclear physics, waves, light, and outer space. Application to satellites, alternative energy, medical imaging, radiation, nuclear weapons, climate change, and electronics. Emphasis on analytical thinking and the applicability to modern societal issues. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

**PHYS 192 Science and Pseudoscience** credit: 1 Hour.
Extra-sensory perception, alien abduction, and psychic crime-solving from the standpoint of scientific inquiry and exploration; the scientific method, how science progresses, and the types of argumentative fallacies that pervade the pseudoscientific community; examples of good science and how the scientific method is self-correcting.

**PHYS 193 Physics of Music** credit: 2 Hours.
Physics of music and musical instruments; acoustical physics, propagation of sound waves, the biological physics of human hearing, and the acoustical physics associated with all types of musical instruments.

**PHYS 194 Behavior of Complex Systems** credit: 1 Hour.
Exploration of systems with simple rules that nevertheless exhibit complex behavior. Lecture demonstrations on fractal growth, chaos, catastrophes, self-assembly, lightning, turbulence, explosions, and human rhythms. Simple computer models which exhibit regular, irregular, symmetric, and self-similar patterns and dynamics. Dynamics of isolated and coupled complex systems and mathematical tools for quantifying complex behavior.

**PHYS 199 Undergraduate Open Seminar** credit: 0 to 5 Hours.
Approved for letter and S/U grading. May be repeated.

**PHYS 211 University Physics: Mechanics** credit: 4 Hours.
Newton's Laws, work and energy, static properties and fluids, oscillations, transverse waves, systems of particles, and rotations. A calculus-based approach for majors in engineering, mathematics, physics and chemistry. Credit is not given for both PHYS 211 and PHYS 101. Prerequisite: Credit or concurrent registration in MATH 231. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

**PHYS 212 University Physics: Elec & Mag** credit: 4 Hours.
Coulomb's Law, electric fields, Gauss' Law, electric potential, capacitance, circuits, magnetic forces and fields, Ampere's law, induction, electromagnetic waves, polarization, and geometrical optics. A calculus-based approach for majors in engineering, mathematics, physics, and chemistry. Credit is not given for both PHYS 212 and PHYS 102. Prerequisite: PHYS 211; credit or concurrent registration in MATH 241. This course satisfies the General Education Criteria for: Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

Information listed in this catalog is current as of 04/2018
PHYS 213  Univ Physics: Thermal Physics  credit: 2 Hours.
First and second laws of thermodynamics including kinetic theory of gases, heat capacity, heat engines, introduction to entropy and statistical mechanics, and introduction to application of free energy and Boltzmann factor. A calculus-based approach for majors in engineering, mathematics, physics and chemistry. Credit is not given for both PHYS 213 and PHYS 101. Prerequisite: PHYS 211; credit or concurrent registration in MATH 241.
This course satisfies the General Education Criteria for:
Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

PHYS 214  Univ Physics: Quantum Physics  credit: 2 Hours.
Interference and diffraction, photons and matter waves, the Bohr atom, uncertainty principle, and wave mechanics. A calculus-based course for majors in engineering, mathematics, physics, and chemistry. Credit is not given for both PHYS 214 and PHYS 102. Prerequisite: PHYS 212.
This course satisfies the General Education Criteria for:
Nat Sci Tech - Phys Sciences
Quantitative Reasoning II

PHYS 221  Enrichment Mechanics  credit: 1 Hour.
Supplement to PHYS 211 with a collaborative group learning approach to improving conceptual understanding and problem solving in introductory calculus-based mechanics. Prerequisite: PHYS 100; concurrent registration in PHYS 211.

PHYS 222  Enrichment E & M  credit: 1 Hour.
Supplement to PHYS 212 with a collaborative group learning approach to improving conceptual understanding and problem solving in introductory calculus-based electricity & magnetism. Prerequisite: PHYS 100; concurrent registration in PHYS 212.

PHYS 225  Relativity & Math Applications  credit: 2 Hours.
Theory of Special Relativity, with applications to kinematics and dynamics. Key mathematical methods as they apply to aspects of electromagnetic theory and classical mechanics, including vector analysis, series expansions, matrices, Fourier analysis, partial differentiation, three-dimensional calculus, and simple differential equations. Prerequisite: Credit or concurrent registration in PHYS 212.

PHYS 280  Nuclear Weapons & Arms Control  credit: 3 Hours.
Nontechnical analysis of the physics of nuclear weapons, nuclear weapon effects, delivery systems, and defenses against nuclear attack; presentation of current issues; basis for making informed judgments about nuclear armaments and arms control. Same as GLBL 280.
This course satisfies the General Education Criteria for:
Advanced Composition

PHYS 298  Freshmen/Sophomore Special Topics in Physics  credit: 0 to 4 Hours.
Topical offerings of technical interest, skills, and knowledge in physics, and its practice, intended to augment the existing curriculum at the introductory level. Approved for Letter and S/U grading. May be repeated in separate terms up to 12 credit hours if topics vary. Prerequisite: See Class Schedule or departmental course information for topics and prerequisites. For students with freshman or sophomore standing.

PHYS 325  Classical Mechanics I  credit: 3 Hours.
Kinematics and dynamics of classical systems, including a review of Newtonian kinematics and dynamics. Three dimensional motion, variable mass, and conservation laws; damped and periodically driven oscillations; gravitational potential of extended objects and motion in rotating frames of reference; Lagrangian and Hamiltonian mechanics. Prerequisite: PHYS 225; credit or concurrent registration in MATH 285.

PHYS 326  Classical Mechanics II  credit: 3 Hours.
Continuation of PHYS 325. Central force motion, collisions and scattering, rotational motion, coupled oscillations, continuous media, and fluid dynamics. Prerequisite: PHYS 325.

PHYS 329  Atmospheric Dynamics I  credit: 3 Hours.
Same as ATMS 302. See ATMS 302.

PHYS 330  Atmospheric Dynamics II  credit: 3 Hours.
Same as ATMS 312. See ATMS 312.

PHYS 398  Sophomore/Junior Special Topics in Physics  credit: 1 to 4 Hours.
Topical offerings of technical interest, skills, and knowledge in physics, and its practice, intended to augment the existing curriculum at the intermediate level. Approved for Letter and S/U grading. May be repeated in separate terms up to 12 hours if topics vary. Prerequisite: See Class Schedule or departmental course information for topics and prerequisites. For students with sophomore or junior standing.

PHYS 401  Classical Physics Lab  credit: 3 Hours.
Experiments and techniques in classical mechanics and electromagnetism. Dynamics of electrical and mechanical oscillators in the linear domain. Fourier analysis of system response. Measurements of electrostatic fields, transmission lines, waves, and radiation. Electromagnetic phenomena in dielectrics, conductors, and magnetic materials. Instruction in data analysis and report writing. 3 undergraduate hours. 3 graduate hours. Prerequisite: Credit or concurrent enrollment in PHYS 325.

PHYS 402  Light  credit: 3 or 4 Hours.
Wave kinematics; geometrical optics: basic concepts, ray-tracing and matrix formalism, Gaussian imaging by thick lenses, stops, apertures, and intensity relations; interference; interference spectroscopy and coherence; diffraction: Fresnel-Kirchhoff formulation, Fraunhofer case, Fresnel case, and holography; polarized light. 4 undergraduate hours. 3 or 4 graduate hours. (3 hours without lab). Prerequisite: MATH 285; PHYS 102 or PHYS 214.

PHYS 403  Modern Experimental Physics  credit: 4 or 5 Hours.
Techniques and experiments in the physics of atoms, atomic nuclei, molecules, the solid state, and other areas of modern physical research. 5 undergraduate hours. 4 graduate hours. Prerequisite: Credit or concurrent registration in PHYS 486.

PHYS 404  Electronic Circuits  credit: 4 or 5 Hours.
Physics of semiconductor devices; theory and application of discrete and integrated devices in linear circuits; use of operational amplifiers and feedback; regulation, oscillators, and modulation; emphasizes practical experience. 5 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 213 and PHYS 214.

PHYS 406  Acoustical Physics of Music  credit: 4 Hours.
Acoustical physics associated with music and musical instruments, propagation of sound waves in and from musical instruments, and the biological physics of human hearing. Investigation of topics via advanced laboratory and data acquisition techniques. 4 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 213 and PHYS 214.

PHYS 419  Space, Time, and Matter-ACP  credit: 3 or 4 Hours.
Identical to PHYS 420 except for the additional writing component including a final term paper. Same as PHIL 419. 3 undergraduate hours. 4 graduate hours. Credit is not given for both PHYS 419 and PHYS 420. Prerequisite: PHIL 101; PHYS 101 or PHYS 211.
This course satisfies the General Education Criteria for:
Advanced Composition
PHYS 420  Space, Time, and Matter  credit: 2 Hours.
Philosophical examination of some fundamental concepts and theories of the physical world, such as time, matter, space, and geometry; interpretation of quantum theory. Same as PHIL 420. 2 undergraduate hours. 2 graduate hours. Credit is not given for both PHYS 420 and PHYS 419. Prerequisite: PHIL 101; PHYS 101 or PHYS 211.

PHYS 427  Thermal & Statistical Physics  credit: 4 Hours.
Equilibrium thermodynamics, statistical mechanics, and kinetic theory of gases. A unified treatment is used in that the principles of heat and thermodynamics are discussed along with statistical postulates and the microscopic approach of introductory quantum mechanics. 4 undergraduate hours. 4 graduate hours. Credit is not given for both PHYS 427 and any of ME 404, CHEM 444, MSE 500. Prerequisite: PHYS 213, PHYS 214, and PHYS 325.

PHYS 435  Electromagnetic Fields I  credit: 3 Hours.
Static electric and magnetic fields, their interactions with electric charge and current, and their transformation properties; the effect of special relativity is incorporated. Macroscopic fields in material media are described. 3 undergraduate hours. 3 graduate hours. Prerequisite: MATH 285; credit or concurrent enrollment in PHYS 325.

PHYS 436  Electromagnetic Fields II  credit: 3 Hours.
Time-dependent fields. Electromagnetic induction, Maxwell's equations, electromagnetic wave propagation in various media and structures, and electromagnetic radiation from charge and current distributions. Relativistic covariance of Maxwell's equations. Course Information:3 undergraduate hours. 3 graduate hours. Prerequisite: PHYS 435.

PHYS 460  Condensed Matter Physics  credit: 4 Hours.
Bonding and structure of crystals; energy bands in insulators, semiconductors, and metals; electrical conductivity; optical properties; lattice vibrations; elasticity; point defects; dislocations. 4 undergraduate hours. 4 graduate hours. Credit is not given for both PHYS 460 and MSE 304. Prerequisite: PHYS 435; PHYS 485 or PHYS 486.

PHYS 466  Atomic Scale Simulations  credit: 3 or 4 Hours.
The nature and properties of nuclei and elementary particles, symmetries, interactions, nuclear models, tools and techniques of experimental subatomic physics, and applications to power generation, astrophysics, chemistry, medicine, and biology. 4 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 485 or PHYS 486.

PHYS 475  Introduction to Biophysics  credit: 3 or 4 Hours.
Major concepts of physics inherent to biological systems. Basics of biology, including protein and DNA structure and their organization into cells with a focus on single molecule biophysics. Major experimental techniques including x-ray diffraction, optical and magnetic traps, and fluorescence microscopy, including new super-resolution techniques. Applications to cytoplasmic and nuclear molecular motors, bacterial motion, nerves, and vision. Same as BIOP 401. 3 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 213 and PHYS 214.

PHYS 485  Atomic Phys & Quantum Theory  credit: 3 Hours.
Basic concepts of quantum theory which underlie modern theories of the properties of materials; elements of atomic and nuclear theory; kinetic theory and statistical mechanics; quantum theory and simple applications; atomic spectra and atomic structure; molecular structure and chemical binding. 3 undergraduate hours. 3 graduate hours. Credit is not given for both PHYS 485 and CHEM 442. Prerequisite: MATH 285 and PHYS 214.

PHYS 486  Quantum Physics I  credit: 4 Hours.
Atomic phenomena integrated with an introduction to quantum theory; evidence for the atomic nature of matter and the properties of the Schrodinger equation, single particle solutions in one dimension, the hydrogen atom, perturbation theory, external fields, and atomic spectroscopy of outer electrons. 4 undergraduate hours. 4 graduate hours. Prerequisite: MATH 285; PHYS 214; credit or concurrent registration in MATH 415.

PHYS 487  Quantum Physics II  credit: 4 Hours.
Continuation of PHYS 486. Identical particles, spectral hyperfine structure, magnetic properties of matter, atomic spectroscopy of inner electrons, high-energy photon effects, molecular binding and spectra, emission and absorption of light, and symmetry principles. 4 undergraduate hours. 4 graduate hours. Prerequisite: PHYS 486.

PHYS 496  Intro to Physics Research  credit: 3 Hours.
Examination of current research topics through extensive reading, writing, and oral-presentation activities. 3 undergraduate hours. No graduate credit. This course satisfies the General Education Criteria for: Advanced Composition

PHYS 497  Individual Study  credit: 1 to 4 Hours.
Individual study at an advanced level in a subject not covered by course offerings. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated. Prerequisite: Consent of instructor.

PHYS 498  Special Topics in Physics  credit: 1 to 4 Hours.
Subject offerings of new and developing areas of knowledge in physics intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the same or separate terms if topics vary.

PHYS 499  Senior Thesis  credit: 3 Hours.
Faculty-guided writing of a senior thesis involving independent research Oral presentations of research and outside journal articles, proposal writing and reviewing, poster presentation, preparation of graduate school applications, and discussion of physics frontiers with outside experts. 3 undergraduate hours. No graduate credit. Prerequisite: PHYS 496.

PHYS 504  Statistical Physics  credit: 4 Hours.
Single-particle distribution functions; classical and quantum mechanical systems, Boltzmann equation, virial theorem, and equations of state for gases; formal theory: ensembles, identical particles, thermodynamics of simple systems, and distribution functions; nonequilibrium problems; conservation laws and hydrodynamic equations, sound waves, and transport coefficients; plasmas, normal Fermi fluid, superfluids, and systems with internal degrees of freedom. Prerequisite: PHYS 427 and PHYS 486.

PHYS 505  Classical Electromagnetism  credit: 4 Hours.
Review of Maxwell's equations; relativistic formulation of the electromagnetic field and the motion of charged particles; plane and guided waves; retarded potentials; radiation from simple antennas; radiation from accelerated charged particles; scattering and further topics. Prerequisite: PHYS 436.
PHYS 508 Mathematical Physics I credit: 4 Hours.
Core techniques of mathematical physics widely used in the physical sciences. Calculus of variations and its applications; partial differential equations of mathematical physics (including classification and boundary conditions); separation of variables, series solutions of ordinary differential equations and Sturm-Liouville eigenproblems; Legendre polynomials, spherical harmonics, Bessel functions and their applications; normal mode eigenproblems (including the wave and diffusion equations); inhomogeneous ordinary differential equations (including variation of parameters); inhomogeneous partial differential equations and Green functions; potential theory; integral equations (including Fredholm theory). Prerequisite: MATH 285.

PHYS 509 Mathematical Physics II credit: 4 Hours.
Continuation of PHYS 508. Further core techniques of mathematical physics widely used in the physical sciences. Complex variables; group theory in classical and quantum systems; tensors in physics; differential forms and their applications in mechanics; electromagnetism. Prerequisite: PHYS 508.

PHYS 510 Nonlinear Dynamics credit: 4 Hours.
Broad introduction to nonlinear dynamics of physical systems with varying degrees of complexity; survey of a variety of concepts associated with bifurcation phenomena, mappings, nonlinear oscillations, chaotic behavior, strange attractors, and solitons. Topics of current interest. Prerequisite: PHYS 326.

PHYS 513 Quantum Optics & Information credit: 4 Hours.
Experimental and theoretical fundamentals of quantum information, using nonclassical features of quantum physics (wave-particle duality, superposition, and entanglement) to surpass the information-processing capabilities of classical systems. Underlying fundamental quantum phenomena, including tests of nonlocality, quantum erasers, the quantum Zeno effect, squeezed light, multi-particle interference, state transformations of the Bloch sphere, and decoherence; quantum cryptography and teleportation; quantum information theory; quantum computation algorithms and techniques for error correction; experimental "qubit" systems. Prerequisite: Recommended: PHYS 580.

PHYS 514 Modern Atomic Physics credit: 4 Hours.
Rigorous survey of modern atomic, molecular, and optical physics, including a functional approach to theory and an overview of experimental techniques. Atomic structure, including fine and hyperfine structure, multi-electron atoms, and relativistic effects; interaction of single atoms with dynamic and static electromagnetic fields, ultracold collisions between atoms; laser cooling, evaporative cooling, and magnetic trapping; Paul and Penning traps; quantum degenerate gases; atom interferometry. Prerequisite: PHYS 427, PHYS 436, and PHYS 487.

PHYS 515 General Relativity I credit: 4 Hours.
Systematic introduction to Einstein’s theory, with emphasis on modern coordinate-free methods of computation. Review of special relativity, modern differential geometry, foundations of general relativity, laws of physics in the presence of a gravitational field, linearized theory, and experimental tests of gravitation theories. Same as ASTR 515. Prerequisite: PHYS 436.

PHYS 516 General Relativity II credit: 4 Hours.
Continuation of PHYS 515 with emphasis on applications to astrophysics and cosmology. Relativistic stars, gravitational collapse, black holes, gravitational waves, numerical relativity, and cosmology. Same as ASTR 516. Prerequisite: PHYS 515.

PHYS 540 Astrophysics credit: 4 Hours.
Fundamental aspect of astrophysics and cosmology and new developments in these fields. Basic physical concepts and principles, the key observational evidence, and illustrative calculations. Relativistic cosmological models, inflation, Big-Bang nucleosynthesis, and the cosmic microwave background; formation and evolution of galaxy clusters, galaxies, and stars; formation, structure, and evolution of white dwarfs, neutron stars, and black holes; rotation- and accretion-powered pulsars, X-ray and y-ray stars, and gravitational radiation. Same as ASTR 540. Prerequisite: PHYS 435; PHYS 485 or PHYS 486.

PHYS 541 Physics of Compact Objects credit: 4 Hours.

PHYS 542 Theoretical Stellar Physics credit: 4 Hours.
Same as ASTR 504. See ASTR 504.

PHYS 550 Biomolecular Physics credit: 4 Hours.
Physical concepts governing the structure and function of biological macromolecules; general properties, spatial structure, energy levels, dynamics and functions, and relation to other complex physical systems such as glasses; recent research in biomolecular physics; physical techniques and concepts from theoretical physics emphasized. Same as BIOP 550 and MCB 550. Prerequisite: CHEM 104; PHYS 485 or PHYS 487.

PHYS 552 Optical Spectroscopy credit: 4 Hours.
Theoretical and experimental fundamentals of optical spectroscopy. Light-matter interaction (absorption of UV, visible, IR), emission spectroscopy (fluorescence, Raman and light scattering), theoretical backgrounds of molecular electronic and vibrational transitions, modern experimental techniques, and data analysis of the optical spectroscopy experiments. Laboratory exercises applying spectroscopy to a broad spectrum of disciplines, including biophysical examples. Prerequisite: PHYS 427 and PHYS 487.

PHYS 554 Nonequilibrium Stat Mechanics credit: 4 Hours.
Mathematical description of classical and quantum stochastic systems, thoroughly addressing the tools and the mode of thinking of nonequilibrium statistical mechanics. Equilibrium statistical mechanics (review); Einstein and Smoluchowski diffusion equation; generalized moment expansion of correlation functions; noise-induced limit cycles; time series analysis; diffusion-controlled reactions; classical dynamics under the influence of stochastic forces; observables connected with Brownian transport, echoes, and hysteresis; spin-boson model. Examples from biological physics and theoretical condensed matter physics. Prerequisite: PHYS 504.

PHYS 560 Condensed Matter Physics I credit: 4 Hours.
Crystalline perfection, free-electron gas, screening, plasma oscillations, and dielectric response; Bloch electrons, Brillouin zones, and band structure; semiconductors, intrinsic and extrinsic, with applications; phonons, elasticity, and anharmonicity; ferromagnetism and second-order phase transitions; superconductivity. Prerequisite: PHYS 427 and PHYS 580.
PHYS 561 Condensed Matter Physics II credit: 4 Hours.
Hartree-Fock theory and electron-electron interactions; electron-phonon interactions; electron dynamics and transport; BCS theory of superconductivity; elastic properties; thermal properties due to anharmonicity; defects in solids. Prerequisite: PHYS 560 and PHYS 581.

PHYS 563 Phase Transitions credit: 4 Hours.
Phenomenology of phase transitions, scaling, critical behavior, and multi-criticality; Landau theory of phase transitions; renormalization group methods, including lattice models and epsilon-expansion; numerical methods; critical dynamics; selected additional topics. Prerequisite: PHYS 504.

PHYS 565 Theory of Semicond & Devices credit: 4 Hours.
Same as ECE 535. See ECE 535.

PHYS 569 Emergent States of Matter credit: 4 Hours.
Consequences of broken symmetry in condensed matter, the emergence of novel ground states, and the nature of the excitations that arise. Examination of specific systems such as superconductivity, superfluidity, Bose-Einstein condensates, the quantum Hall states, liquid crystals, biological systems and patterns in Rayleigh-Benard convection. Prerequisite: PHYS 504 and PHYS 580.

PHYS 570 Subatomic Physics credit: 4 Hours.
Nuclear systematics, nucleon-nucleon interaction, shell model, and single-particle and collective excitations; hadron spectroscopy, hadronic quantum numbers, quark-parton model, and hadron dynamics; weak interactions. Prerequisite: PHYS 580; concurrent registration in PHYS 581.

PHYS 575 Particle Physics I credit: 4 Hours.
Basic calculations in elementary particle theory. Quantum electrodynamics, quantum chromodynamics, and the Glashow-Weinberg-Salam theory of weak and electromagnetic interactions as applied to the phenomenology of particle decays and high energy reactions. Prerequisite: PHYS 570. Recommended: credit or concurrent registration in PHYS 582.

PHYS 576 Particle Physics II credit: 4 Hours.
Continuation of PHYS 575. Current topics in particle theory. Typically three or four different subjects in depth which may change with each offering. Prerequisite: PHYS 575.

PHYS 580 Quantum Mechanics I credit: 4 Hours.
Second course in quantum mechanics. Operators, state vectors, and the formal structure of quantum theory; operator treatments of simple systems; angular momentum and vector addition coefficients; stationary state perturbation theory; introduction to scattering theory for particles without spin, partial wave analysis, and Born approximation; examples taken from atomic, nuclear, and elementary particle physics. Prerequisite: PHYS 485 or PHYS 487.

PHYS 581 Quantum Mechanics II credit: 4 Hours.
Spin and identical particles, simple many-particle systems and elements of second-quantization theory; time-dependent processes, radiative transitions, and quantization of the electromagnetic field; scattering of particles with spin; polarization; introduction to the Klein-Gordon and Dirac equations and properties of simple relativistic systems. Prerequisite: PHYS 580.

PHYS 582 General Field Theory credit: 4 Hours.
Standard techniques of field theory as used by experimenters and theorists; relativistic quantum mechanics of a single particle; Lagrangian field theories, perturbation theory, and calculation of lowest-order processes; introduction to Feynman diagrams and higher order processes; examples taken from quantum electrodynamics, solid-state and elementary particle physics, and many-body theory. Prerequisite: PHYS 581.

PHYS 583 Advanced Field Theory credit: 4 Hours.
Quantization and Feynman path integral; gauge theories and renormalization; renormalization group with applications to particle physics and critical phenomena; approximation methods and recent developments. Prerequisite: PHYS 582.

PHYS 596 Graduate Physics Orientation credit: 1 Hour.
Introduction to research in the Department of Physics. Advice on choosing a field of research and finding a research advisor. Faculty-presented overviews of the major areas of research available in the Physics Department. General discussions on instructional topics as well as ethics in teaching and sciences.

PHYS 597 Individual Study credit: 1 to 16 Hours.
Individual study in a subject not covered in course offerings may be arranged for credit by registration under this number. May be repeated. 2 to 16 hours for full term; 1 to 8 hours for half-term. Prerequisite: Consent of instructor.

PHYS 598 Special Topics in Physics credit: 1 to 4 Hours.
Subject offerings of new and developing areas of knowledge in physics intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary.

PHYS 599 Thesis Research credit: 0 to 16 Hours.
Approved for S/U grading only. May be repeated.