PHY

Physics

PHY 501: Classical Mechanics

Analytical classical mechanics including Lagrangian and Hamiltonian formulations and the Hamilton-Jacoby theory. Variational principles, symmetries and conservative laws. Selected advanced problems such as parametric and nonlinear oscillations, planetary motion, classical theory of scattering, rigid body rotation, and deterministic chaos. Basic notions of elasticity theory and fluid dynamics.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 503: Methods of Mathematical Physics I

A selection of mathematical techniques useful for physicists. Topics are selected from: linear algebra, complex variables, differential equations, asymptotic analysis, special functions, boundary value problems, integral transforms, perturbation theory as applied to linear and nonlinear systems. This course should be taken by entering graduate students seeking enrichment in these areas.

Fall and Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 504: Computational Methods in Physics and Astrophysics

An introduction to procedural and object-oriented programming in a high-level language such as C++ or modern Fortran with examples and assignments consisting of rudimentary algorithms for problems in physics and astronomy. Students will use the UNIX/Linux operating system to write programs and manage data, and the course will include an introduction to parallel computing and good programming practices such as version control and verification. The course will prepare students for courses in algorithms and methods that assume a knowledge of programming.

Fall or Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 505: Classical Electrodynamics

Electrostatics and Magnetostatics in vacuum and medium; Green's functions; Maxwell's equations and gauge invariance; Electromagnetic wave propagation; Radiation, scattering, interference, and diffraction; Special relativity; Radiation by relativistic charges; Additional topics as time permits. Three lecture hours plus two recitation hours per week.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 510: Introduction to Nonlinear Dynamics

This course concentrates on developing the tools used to analyze models of dynamical systems associated with physical phenomena, such as coupled electrical mechanical, chemical and biological oscillators, amplitude equations, symplectic maps, etc. There is a discussion of the basic theorems, as well as methods used to derive perturbation solutions for differential equations and maps using the method of normal forms.

Fall or Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 511: Quantum Mechanics I

First course in a two-part sequence. Topics include basic quantum physics and mathematical apparatus; application to one dimensional examples and simple systems. Symmetries, angular momentum, and spin. Additional topics as time permits.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 512: Quantum Mechanics II

Second course in a two-part sequence, covering variational principles, perturbation theory, relativistic quantum mechanics, quantization of the radiation field, many-body systems. Application to atoms, solids, nuclei and elementary particles, as time permits.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 514: Current Research Instruments

In a series of distinct units, various members of the experimental research faculty describe the nature of their work, explain the major principles of their laboratory instruments, discuss how these instrument systems function, and conduct tours of their laboratories showing the apparatus in action. The student becomes familiar with most of the experimental research instrumentation in the department.

Fall or Spring, 3 credits, S/U grading

PHY 515: Methods of Experimental Research I

An experimental course required for all graduate students. The goal of the course is to provide firsthand experience with the nature of experimental work. For students oriented toward theory, the course gives a background for reading and evaluating experimental papers. The course is based on classic measurements in nuclear, particle, atomic, condensed matter physics, and astronomy. Students can gain experience in handling cryogenic liquids, vacuum systems, lasers, pulse counting and coincidence methods, resonance measurements, and electronic instrumentation, such as lock-in amplifiers, particle detectors, coincidence counters, computer control, etc. Numerical analysis of data, presentation of results in written, graphic, and oral form, and meaningful comparison of experiments and theory are part of the course. Working alone or with, at most, one partner, each student must do one experiment from each of four different groups.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 517: Laboratory Course in Astronomical Techniques

A course designed to introduce the theory, design, and operation of modern astronomical instrumentation and to familiarize the student with the use of telescopes. Current astronomical techniques will be discussed with emphasis on methods of observational measurements and reduction of data. Emphasis is given on optical techniques appropriate for wavelengths shorter than one micron. Extensive laboratory and observing exercises may be expected.

Spring, alternate years, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 518: Applications of Synchroton Radiation

An introduction to the principles of synchrotron radiation is followed by a series of lectures given by graduate faculty and guest lecturers with expertise in using synchrotron radiation for research in physics, chemistry, materials science, biology and medicine. Most of these presentations are followed by hands-on experience with synchrotron instrumentation at Brookhaven National Laboratory. Access to user facilities, including safety requirements, preparation of user proposals, user training and other issues, and also covered.

Spring, 1-3 credits, S/U grading

PHY 521: Stars

A study of the atmospheres, interiors, and evolution of stars. The contact between theory and observations is emphasized. Stellar atmospheres in hydrostatic and radiative equilibrium described. Models for the calculation of stellar spectra are discussed. Stellar winds are studied. Next, theoretical studies of stellar interiors and evolution, including equations of state, energy transport, and nuclear energy generation, are developed. Structures of main sequence, red giant, pre-main sequence, and white dwarves are studied and compared to observations. The evolution of single stars up to supernovae and the peculiar evolution of close binary systems are also studied.

Fall, alternate years, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 522: Interstellar Medium

A study of the interstellar medium with emphasis on physical processes. Topics include kinetic theory, equation of transfer, spectral lines, non-thermal emission, ionization effects of dust, and formation and spectroscopy of molecular clouds. The components of the interstellar medium and the interactions between them are discussed in detail, as well as the process of star formation.

Spring, alternate years, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 523: Galaxies

A basic course on the observational and theoretical aspects of the content, morphology, kinematics, and dynamics of galaxies. Topics include the size, shape, and location of the sun in the Milky Way; stellar populations; the disk and spheroidal components; galactic rotation; distance determination in the Milky Way and to external galaxies; galaxy classification and the Hubble Law. Theoretical topics center on stellar dynamics, including potential theory; stellar orbits; and spiral structure. The course also includes a brief introduction to cosmology.

Fall, alternate years, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 524: Cosmology

A basic course on cosmology: Hubble expansion, Friedmann universes, age of the universe, microwave background radiation, big-bang nucleosynthesis, inflation, growth of gravitational instabilities and galaxy formation, correlation functions, local density and velocity perturbations, and dark matter.

Prerequisite: PHY 523 or permission of instructor
Spring, alternate years, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 529: Quantum Electronics

Introduction to modern atomic physics for the laser era for graduate students. Emphasis on the interaction between atoms and light, as well as on atomic structure and how it affects this interaction. Modern applications such as laser cooling, atom trapping, precision spectroscopy with frequency comb, quantum information, and others will be discussed. Not for satisfying physics Ph.D. breadth course requirements. Spring every year, 1-3 credits, ABCF grading

1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 534: Radio Astronomy

Topics covered include continuum and spectral-line radio astronomy. Within the Milky Way Galaxy topics include the interstellar medium, the physics and kinematics of molecular clouds, star formation in giant molecular clouds, chemistry of molecular clouds, galactic structure, spiral structure, and pulsars. Extragalactic topics include radio galaxies and jets, radio loud quasars, molecular and atomic gas in galaxies, luminous infrared galaxies, the missing mass problem in spiral galaxies, and cosmic microwave background radiation. Radio astronomy measurement techniques for single telescopes and aperture synthesis techniques are also covered, although the emphasis is on scientific results.

Fall or Spring, alternate years, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 536: The Physics of Free Electron Lasers

The purpose of this course is to introduce the students to the physics of Free Electron Lasers and Synchrotron Radiation. This course is suitable for graduate students who want to learn more about Free Electron Lasers and Synchrotron Radiation physics.

Offered: Summer, 1-2 credits, Letter graded (A, A-, B+, etc.)

PHY 540: Statistical Mechanics

Brief review of thermodynamics, principles of physical statistics, systems of non-interacting particles: Boltzmann, Fermi-Dirac, and Bose-Einstein statistics. Applications to ideal gases, electrons and phonons in solids, and black body radiation. Approximate treatment of non-ideal gases. First-order and second-order phase transitions. Ising model, transfer matrix, and renormalization group approach. Fluctuations in thermal equilibrium, fluctuation-dissipation theorem, brief review of non-equilibrium fluctuations. Basic notions of ergodicity, classical and quantum chaos.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 541: Advanced Statistical Mechanics

Topics are selected from cluster expansions, elementary theory of quantum fluids, phase transitions, transfer matrix, Ising and ferroelectric models, polymers and membranes, disordered systems, and fluctuation and nonequilibrium phenomena.

Fall, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 542: Fundamentals of Accelerator Physics and Technology with Simulations and Measurements Lab

This course is an introduction to the underlying principles and uses of the nearly 14,000 particle accelerators that are used worldwide in medicine, industry, and scientific research. The course is suitable for senior undergraduate and entry-level graduate students in physics and engineering or students from other fields with a particular interest in accelerator-based science.

Summer, 1-2 credits, Letter graded (A, A-, B+, etc.)

PHY 543: Superconducting RF for High-Energy Accelerators

This graduate level course covers application of superconducting radio frequency (SRF) technology to contemporary high-# accelerators: storage rings, pulsed and CW linacs, including energy recovery linacs (ERLs). The course will address physics and engineering aspects of using SRF in accelerators. It will cover beam-cavity interactions issues specific to superconducting cavities, a systems approach to designing SRF systems and engineering of superconducting cavity cryomodules. The course is intended for graduate students pursuing accelerator physics and graduate engineers and physicists who want to familiarize themselves with superconducting RF systems.

Fall, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 546: Python for Scientific Computing

Python has seen wide adoption in the scientific community for data analysis, simulation, prototyping and visualization. It provided a simple, yet powerful means to build applications. This seminar introduces python and its use in scientific computing. Students will learn the standard python libraries for array manipulation, visualization, numerical analysis and symbolic mathematics, as well as how to interface python with other languages, build applications, and good software engineering practices (including version control and testing). Students are encouraged to share examples for their discipline

0-1 credits, Letter graded (A, A-, B+, etc.)

PHY 551: Nuclear Physics I

Nucleon structure, conservation laws and the static quark model; nuclear force and the two nucleon system; bulk properties of nuclear matter, charge distribution, spin, isospin, mass, alpha decay, nuclear fission; electromagnetic and weak interaction; collective motion;

microscopic models of the nucleus; nuclear matter under extreme conditions, high rotational states, heavy ion physics at RHIC, nuclear astrophysics.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 552: Nuclear Physics II

Nucleon-nucleon scattering and effective range approximation; the nucleon-nucleon interaction calculated from meson exchange; effective forces between nucleons in nuclei and nuclear matter; the renormalization group approach to these interactions; Fermi-liquid theory of the nuclear many-body problem; thermodynamics of hadrons at high temperature; RHIC physics with heavy ions including transition from hadrons to quark gluon plasma, restoration of chiral symmetry, equation of state, initial conditions, thermodynamics of hadrons at high temperature.

1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 554: Fundamentals of Accelerator Physics

History of accelerators, basic principles including centre of mass energy, luminosity, accelerating gradient; Characteristics of modern colliders: RHIC, LEP, LHC, b-factories; Transverse motion, principles of beam cooling, Strong focusing, simple lattices; Circulating beams, synchrotron radiation; Longitutdinal dynamics; Non-linearities and resonances; Radio Frequency cavities, superconductivity in accelerators; Applications of accelerators: light sources, medical uses, Future Accelerators: eRHIC, ILC, neutrino factories, muon collider, laser plasma acceleration.

Offered
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 555: Solid-State Physics I

This course concentrates on the basic notions of solid state physics, treated mostly within the single-particle approximation. Main topics include: crystal lattices and symmetries, reciprocal lattice and state counting, phonons, electron energy band theory, bonding and cohesion (semi-quantitatively), electron dynamics and electron transport in metals and semiconductors, screening, optical properties of solids, and an introduction to superconductivity and magnetism.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 556: Solid State Physics II

The course focuses on the many-particle aspects of solid state physics addressing classical topics such as superconductivity and the transport properties of disordered conductors, as well as more modern subjects including the fractional quantum Hall effect, dissipative quantum mechanics, and problems of mesoscoptic physics. Both phenomenological and theoretical descriptions are discussed.

Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 557: Elementary Particle Physics

Introduction to elementary particle physics. Symmetries and invariance in particle physics. The properties of particles in terms of quarks and leptons and their interactions. An introduction to the electroweak and for strong interactions. Interactions at high energies. Interactions between particles and matter, experiments in particle and experimental results. Survey of particle accelerators.

Fall or Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 558: Physical Biology

Topics of this course include but are not limited to: Time and space in cells; Structural basis of biology; Molecular solvation and lattice models; Chemical potential; Electrostatics, potentials, dipoles, electrochemical potentials[Poisson-Boltzmann and Born models; Acids, bases and salts; Intermolecular potentials and force fields; Phase transitions; Lattice and Ising models; Adsorption; Binding polynomials; Binding cooperativity; Semigrand ensemble, molecular machines; Molecular motors, energy conversion and transduction; Polymer theory; Flory-Huggins; Random flights; Elasticity; Helix-coil theory; Collapse transitions; Protein folding equilibria; Protein folding kinetics; Sequence space; Protein evolution; Protein elasticity and biological mechanics of proteins; Biophysics of the cell; Proteome stabilities, aggregation, kinetics.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 559: Biological Dynamics and Networks

This course will provide a solid foundation in key theoretical concepts for the study of dynamics in biological systems and networks at different scales ranging from the molecular level to metabolic and gene regulatory networks. Topics of this course include but are not limited to: Physical kinetics; Diffusion/Smoluchowskii; Random flights; Waiting times; Poisson; Brownian ratchets; Chemical kinetics; Transition states; Stability, bifurcations, pattern development; Noise in cells: intrinsic and Extrinsic; Feedback; Biological Osciillators; Recurrence, period doubling, chaos; Networks; Topologies; Degree distribution, betweenness; Models of nets: Erdos-Renyi, scale-free, social, Watts-Strogatz, agents; Robustness, highly-optimized tolerance, bowties, epidemics; Biological networks: Protein-protein nets, regulatory and metabolic nets; Known biological circuits and their behaviors; How networks evolve: Preferential attachment, rewiring; Power laws; Fluxed through networks; Information and communication, entropy; Metabolic flux analysis; Artificial and Natural selection for traits; Darwinian evolution; Population dynamics.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 561: Biology for Physical Scientists

Topics of this course include but are not restricted to: Overview of living things; Six kingdoms, animal phyla. Physiology and organs; Chemistry of life; Noncovalent interactions; Hydrogen bonds; Solvation; Biochemistry: reactions, catalysis, ATP amino acids, nucleic acids, lipids; Cell structures: Nucleus, mitochondria, chromosomes, membranes; Basic paradigm: DNA makes RNA makes protein; How cell machines and circuits work; Cell cycle; The processes of evolution; Genetics and heredity; Diseases: how biological systems fail; How drugs are discovered; Tight-binding inhibitors; Antibodies; Current research: Cell division and cancer, genomics, bioinformatics, high throughput sequencing, systems and synthetic biology.

Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 562: Lasers and Modern Optics

Introduction to the theory of lasers including resonance conditions, normal modes, optical cavities and elementary quantum mechanics. Description of types of lasers, methods of control, limitations of power, precision, wavelength, etc. Applications to research and industry. Throughout the course, there will be many problems that involve writing computer programs to solve simple differential equations and model different aspects of laser operation. Not for satisfying physics Ph.D. breadth course requirements.

Fall, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 564: Advanced Accelerator Physics

Types and Components of Accelerators, Relativistic Mechanics and EM for Accelerators, Accelerator Hamiltonian and N-dimensional phase space, Poincare diagrams, Lie algebras and symplectic maps and matrices; exact parameterization of linear motion in accelerators; matrix functions, Sylvester's formula; non-linear effects, Collective instabilities & Landau Damping, Radiation damping and Excitation, natural Emittance; Spin motion in accelerators.

1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 565: Quantum Electronics I: Atomic Physics

Quantum electronics is a synthesis of quantum physics and electrical engineering, and is introduced in two independent semesters. A description of simple atoms and molecules and their interaction with radiation includes atoms in strong and/or weak external fields, two-photon spectroscopy, superradiance, Rydberg states, lasers and laser spec-troscopy, coherent transients, etc.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 566: Quantum Electronics II: Quantum Optics

Quantum electronics is a synthesis of quantum physics and electrical engineering, and is introduced in two independent semesters. This course focuses on the quantum properties of light. The quantized electromagnetic field and its correlations are used to understand nonclassical states from various sources such as two-level atoms and nonlinear systems interacting with radiation fields.

Fall, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 570: Introductory Physics Revisited for Teachers

This seminar allows students to explore the fine points of topics normally covered in high school physics. Not for PhD credit.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 571: Electromagnetic Theory for Teachers

The course reviews vector calculus and develops Maxwell's equations relating electric and magnetic fields to their sources. Applications for time-independent fields are developed for solving boundary value problems and the interactions of fields in bulk matter. An oral presentation of a relevant topic suitable for a high-school class is required. Not for PhD credit.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 573: Mechanics for Teachers

The Newtonian formulation of classical mechanics is reviewed and applied to more advanced problems than those considered in introductory physics. The Lagrangian and Hamiltonian methods are then derived from the Newtonian treatment and applied to various problems. An oral presentation of a relevant topic suitable for a high-school class is required. Not for PhD credit.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 576: Thermodynamics and Statistical Mechanics for Teachers

This course consists of two parts. Those relations among the properties of systems at thermal equilibrium that are independent of a detailed microscopic understanding are developed by use of the first and second laws of thermodynamics. The concepts of temperature, internal energy and entropy are analyzed. The thermodynamic potentials are introduced. Applications to a wide variety of systems are made. The second portion of the course, beginning with the kinetic theory of gases, develops elementary statistical mechanics, relates entropy and probability, and treats simple examples in classical and quantum statistics. An oral presentation of a relevant topic suitable for a high-school class is required. Not for PhD credit.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 577: Physical and Mathematical Foundations of Quantum Mechanics for Teachers

Physical and mathematical foundations of quantum mechanics. Maxwell waves and their properties: intensity, energy density, and momentum density. Planck-Einstein relation between energy and frequency for light quanta. De Broglie relation between momentum and wavelength. Number density and probability density of photons. One-photon quantum mechanics, with Maxwell field as wave function. Diffraction phenomena. Uncertainty relation between wavelength and position, hence between momentum and position. In addition to the requirements for the undergraduate course PHY 307, students taking this course must prepare and present a talk on quantum physics suitable for a general (non-physics) adult audience. This course cannot be taken for credit toward the PhD degrees in Physics. Approval of the Program Director is required for taking this course for credit toward a Master Degree.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 578: Quantum Physics for Teachers

The concepts, historical development and mathematical methods of quantum mechanics. Topics include Schroedinger's equation in time-dependent and time-independent forms, and one- and three-dimensional solutions, including the treatment of angular momentum and spin. Applications to simple systems, especially the hydrogen atom, are stressed. An oral presentation of a relevant topic suitable for a high school class is required. Not for PhD credit.

Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 579: Special Topics for Teachers

Topics of current interest to high school teachers are discussed in order to bring the teachers up to date on the latest developments in various areas of research. Examples could include the standard model of particle physics, nanofabrication techniques, atomic force microscopy, etc. Not for PhD credit.

Fall or Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 580: Special Research Projects

Research under the direction of a faculty member. Not open to Ph.D. candidates.

Fall and Spring, 1-18 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 582: Optics Rotation

Optical science students experience three to eight week periods in each of several appropriate research groups. At the end of each period a report is required that describes the topics studied or project done. May not be taken for credit more than two semesters.

Fall and Spring, 0-2 credits, Letter graded (A, A-, B+, etc.)
May be repeated 2 times FOR credit.

PHY 584: Rotation in Physical Biology

A two-semester course in which students spend at least 8 weeks in each of three different laboratories actively participating in the research of faculty associated with the Laufer Center. At least one of the rotations must be in experimental physical biology. Participants will give a research talk at the end of each eight week period.

Fall and Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 585: Special Study

Reading course in selected topics.

Fall and Spring, 1-18 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 595: Master's Degree Thesis Research

Independent research for Master's degree students. Open only to those approved by individual faculty for thesis work. This course also includes a minimum of two hours person to person discussion of ethics and conduct in research and scholarship which addresses among others integrity in scholarship, academic honesty, authorship, plagiarism, mentoring and collaborations. These topics will be illustrated with case studies and issues that arise in current research projects.

1-18 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 598: Graduate Seminar I

Special research topics centered on monographs, conference proceedings, or journal articles. Topics include solid-state physics, atomic physics, quantum optics and applications of synchroton radiation. Required for all first-year graduate students.

Fall and Spring, 0-1 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 599: Graduate Seminar II

Special research topics centered on monographs, conference proceedings, or journal articles. Topics include elementary particles, nuclear physics, galactic and extragalactic astronomy, and cosmology and accelerator physics. Required for all first-year graduate students.

Fall and Spring, 0-1 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 600: Practicum in Teaching

This course provides hands-on experience in teaching. Activities may include classroom teaching, preparation and supervision of laboratory experiments, exams, homework assignments, and projects.

Fall and Spring, 0-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 601: Group Theory for Physicists

This course provides an introduction to group theory and discusses topics that are important for applications in physics. Topics that will be discussed include but are not restricted to the following: finite groups, Lie groups, Lie algebras, Clifford algebras, Cartan generators, Dynkin diagrams, Young tableaux, noncompact groups such as the Poincar\'e group, invariant measures and coset manifolds. Additional topics such as Kac-Moody algebras, Virasoro algebras, symmetric spaces, supergroups and their invariant measure may be discussed as well. PS. The accent on the "e" of Poincare is and acute accent denoted by\' Offered Fall or Spring

1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 604: Computational Methods in Physics and Astrophysics II

This course discusses numerical methods used in physics and astrophysics. Topics include but are not limited to the following: Numerical integration and differentiation, differential equations, interpolation, root-finding, linear algebra, eigenvalues, Fourier transforms, Monte Carlo methods, hyperbolic and parabolic partial differential equations, parallel computing. All methods will be illustrated by examples from physics or astrophysics. Familiarity with Computational Methods in Physics and Astrophysics (PHY 504) is assumed.

1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 610: Quantum Field Theory I

Quantization of relativistic fields: Lorentz and gauge symmetries, relativistic spin, the S-matrix and scattering; the standard model; perturbation theory, renormalization and effective field theories; path integrals and relations to condensed matter physics.

Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 611: Quantum Field Theory II

Quantization of relativistic fields: Lorentz and gauge symmetries, relativistic spin, the S-matrix and scattering; the standard model; perturbation theory, renormalization and effective field theories; path integrals and relations to condensed matter physics.

Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 612: Theoretical Particle Physics

Applications of quantum field theory to interactions between elementary particles. Topics are chosen from perturbative quantum chromodynamics, the standard electro-weak model, lattice field theory, grand unified models, supersymmetry, and current research problems.

Fall, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 613: Advanced Particle Theory

This course is a continuation of PHY 612 and prepares students for research in theoretical particle physics. Topics that will be discussed include the properties of Quantum Chromodyanamics, Electorweak Symmetry Breaking, Cabbibbo-Kobayahi-Maskawa quark mixing, Effective Field theory, Neutrino masses, the hierarchy problems, dark matter, early universe cosmology and primordial nucleosynthesis. Physics beyond the standard model will be discussed as well including models of quark and lepton masses, grand unified theories and baryon number violation. Semesters Offered: Spring and

Fall, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 620: Modern General Relativity

General theory of relativity; tensor analysis, Einstein's field equations, experimental tests, black holes, gravitational waves, cosmology. May also include topics such as spinor methods, conformal invariance, and introduction to string theory or supergravity.

Fall or Spring, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 621: Advanced Quantum Field Theory

Proofs of renormalizability and unitarity on non-Abelian guage theories using modern methods of Becchi-Rouet-Store-Tyutin (BRST) symmetry; descent equations for anomalies; classical instantons and their quantum corrections, including integration over zero modes; background field methods, other topics if time permits. PHY 610/611 or equivalent is prerequisite.

Fall or Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated 2 times FOR credit.

PHY 622: String Theory I

This course is intended for graduate students who have familiarity with guage & quantum field theory. Topics will be selected from: Free bosonic & spinning strings and heterotic & Green-Schwarz superstrings; conformal field theory; tree-level and one-loop amplitudes; partition functions; spacetime supersymmetry and supergravity; compactification & duality; winding & Kaluza-Klein modes; 11-dimensional supergravity; branes in supergravity; D-branes in string theory; T-duality; M-theory; complex geometry and Calabi-Yau manifolds; string field theory; other advanced topics if time permits. PHY 610/611 or equivalent is prerequisite.

Fall or Spring, 1-3 credits, S/U grading
May be repeated for credit.

PHY 623: String Theory II

This course is intended for graduate students who have familiarity with guage & quantum field theory. Topics will be selected from: free bosonic & spinning strings and heterotic & Green-Schwarz superstrings; conformal field theory; tree-level and one-loop amplitudes; partition functions; spacetime supersymmetry and supergravity; compactification & duality; winding & Kaluza-Klein modes; 11-dimensional supergravity; branes in supergravity; D-branes in string theory; T-duality; M-theory; complex geometry and Calabi-Yau manifolds; string field theory; other advanced topics if time permits. PHY 610/611 or equivalent is prerequisite.

Fall or Spring, 1-3 credits, S/U grading
May be repeated for credit.

PHY 655: Advanced Graduate Seminar in Theoretical Physics

A weekly seminar on advanced theoretical concepts. The discussion starts with a graduate student presentation and it is conducted under the guidance of a faculty supervisor.

1-3 credits, S/U grading
May be repeated for credit.

PHY 664: Astronomy Journal Club

Presentation of preliminary research results and current research problems by students and faculty. Required every semester of all astronomy graduate students.

0-1 credits, S/U grading
May be repeated for credit.

PHY 665: Journal Club in Computational Biology

The goal of this course is for students to hone critical reading and analytic skills through discussions of literature in the area of Computational Biology. Participants take turn being a "discussion leader" who informally guides the group through a peer-reviewed manuscript for which all Journal Club members will have to read in advance of the meeting. Meetings in the Spring semester will include in Person Training (IPT) in Responsible conduct of Research and Scholarship (RCRS) on topics that comprise (1) Integrity in Scholarship, (2) Scientific Misconduct, (3) Mentoring, (4) Ownership and Authorship, (5) Plagiarism, (6) Data Management, (7) Journalism and Science, (8) Human Subjects, and (9) Laboratory Animals.

0-1 credits, S/U grading
May be repeated for credit.

PHY 666: Cool Stars

A weekly seminar concentrating on observational and theoretical studies of cool stars and related objects. Emphasis is on ongoing research and recent results in this area. Speakers include faculty, students, and visitors. Topics anticipated in the near future include results from the Hubble Space Telescope and ROSAT. Students registering for one credit will be expected to present at least one seminar.

Fall and Spring, 0-1 credits, S/U grading
May be repeated for credit.

PHY 668: Seminar in Astronomy

A weekly series of research seminars presented by visiting scientists as well as by the faculty. Required every semester of all astronomy graduate students.

Fall and Spring, 0-1 credits, S/U grading
May be repeated for credit.

PHY 669: Nuclear Astrophysics Seminar

A weekly seminar concentrating on topics in nuclear astrophysics, including dynamics of supernova collapse, structure and evolution of neutron stars, equation of state, the role of neutrinos in nucleosynthesis, etc.

0-1 credits, S/U grading
May be repeated for credit.

PHY 670: Seminar in Theoretical Physics

Fall and Spring, 0-1 credits, S/U grading
May be repeated for credit.

PHY 672: Seminar in Elementary Particle Physics

Fall and Spring, 0-1 credits, S/U grading
May be repeated for credit.

PHY 673: Seminar in Cosmology

This seminar discusses current topics in cosmology. Each semester consists of a formal talk followed by an informal discussion of active areas of cosmology research.

Fall and Spring, 0-1 credits, S/U grading
May be repeated for credit.

PHY 674: Seminar in Nuclear Physics

Fall and Spring, 0-1 credits, S/U grading

PHY 676: Seminar in Solid-State Physics

Fall and Spring, 0-1 credits, S/U grading
May be repeated for credit.

PHY 678: Atomic, Molecular and Optical Physics Seminar

Fall and Spring, 0-1 credits, S/U grading
May be repeated for credit.

PHY 680: Special Topics in Theoretical Physics

Fall and Spring

1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 681: Special Topics in Statistical Mechanics

Fall and Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 682: Special Topics in Solid-State Physics

Fall and Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 683: Special Topics in Astronomy

Fall and Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 684: Special Topics in Nuclear Physics

Fall and Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 685: Special Topics in Mathematical Physics

Fall and Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 686: Special Topics in Elementary Particles

Fall and Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 687: Topics in Biological Physics

The "Topics" courses in the 680 sequence do not have specific description, since the subject matter within the broadly defined topic may change from one semester to the next.

1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 688: Special Topics in Astrophysics

Fall and Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 689: Special Topics in Accelerator Physics

Recently we established the Center for Accelerator Physics with Vladimir Litvinenko appointed as Director (with a shared appointment at BNL), and with a second faculty position in accelerator physics being added in the near future, we expect that the number of students working on accelerator physics will increase significantly and there will be much more demand for courses in this area. For a long time accelerator physics courses have been taught as "PHY 584: Special Topics in Nuclear Physics", but this is improper use of the course listing. The purpose of this course is two-fold. First, it is a special topic course that is taught full time at Stony Brook. Second, it is special topics course which is taught in collaboration with the United States Particle Accelerator School (USPAS), which is taught on a rotating basis at various universities and National Laboratories in the US. If that is the case, students will prepare for the USPAS course during the semester, and will particioate in the USPAS school in the following Winter or Summer break. The grade for the course will be determined by the grade in the USPAS school. Funding to participate in the USPAS course will be provided by USPAS if students are registered for such course at their local university.

1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated 1 times FOR credit.

PHY 689: Special Topics in Accelerator Physics

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1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated 1 times FOR credit.

PHY 690: Special Topics in Atomic and Optical Physics

Fall and Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

PHY 698: Colloquium

Fall and Spring, 0-1 credits, S/U grading
May be repeated for credit.

PHY 699: Dissertation Research on Campus

Independent research for Ph.D. degree candidates. Open only to students who have advanced to candidacy (G5). Major portion of research must take place on SBU campus, at Cold Spring Harbor, or at the Brookhaven National Lab. This course also includes a minimum of two hours person to person discussion of ethics and conduct in research and scholarship which addresses among others integrity in scholarship, academic honesty, authorship, plagiarism, mentoring and collaborations. These topics will be illustrated with case studies and issues that arise in current research projects.

Fall, Spring, and Summer, 1-9 credits, S/U grading
May be repeated for credit.

PHY 700: Dissertation Research off Campus - Domestic

Independent research for Ph.D. degree candidates. Open only to students who have advanced to candidacy (G5). Major portion of research will take place off-campus, but in the United States and/or U.S. provinces. Please note, Brookhaven National Labs and the Cold Spring Harbor Lab are considered on-campus. This course also includes a minimum of two hours person to person discussion of ethics and conduct in research and scholarship which addresses among others integrity in scholarship, academic honesty, authorship, plagiarism, mentoring and collaborations. These topics will be illustrated with case studies and issues that arise in current research projects. All international students must enroll in one of the graduate student insurance plans and should be advised by an International Advisor.

1-9 credits, S/U grading
May be repeated for credit.

PHY 701: Dissertation Research off Campus - International

Independent research for Ph.D. degree candidates. Open only to students who have advanced to candidacy (G5). Major portion of research will take place outside of the United States and/or U.S. provinces. Domestic students have the option of the health plan and may also enroll in MEDEX. International students who are in their home country are not covered by mandatory health plan and must contact the Insurance Office for the insurance charge to be removed. International students who are not in their home country are charged for the mandatory health insurance. If they are to covered by another insurance plan they must file a waiver before the second week of classes. The charge will only be removed if other plan is deemed comparable. This course also includes a minimum of two hours person to person discussion of ethics and conduct in research and scholarship which addresses among others integrity in scholarship, academic honesty, authorship, plagiarism, mentoring and collaborations. These topics will be illustrated with case studies and issues that arise in current research projects. All international students must receive clearance from an International Advisor.

1-9 credits, S/U grading
May be repeated for credit.

PHY 800: SUMMER RESEARCH

May be repeated for credit.