PHY 501: Classical Mechanics
Analytical classical mechanics including Lagrangian and Hamiltonian formulations and the Hamilton-Jacobi 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.

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.

PHY 505: Classical Electrodynamics I
First course in a two-part sequence. Electrostatics and magnetostatics in vacuum and matter; electromagnetic induction, Maxwell’s equations and gauge invariance; electromagnetic waves. Additional topics as time permits. Vector analysis, eigenfunction expansions and Green functions will be introduced and used.

PHY 506: Classical Electrodynamics II
Second course in a two-part sequence. Maxwell’s equations are applied to electromagnetic waves in materials and at interfaces between media. Electromagnetic radiation by moving charges. Special relativity. Additional topics as time permits.

PHY 507: Laboratory Course in Experimental Instruments
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.

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.

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.

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.

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.

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.

PHY 517: Laboratory Course in Astronomical Techniques
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.

PHY 518: Applications of Synchrotron Radiation
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
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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.

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.

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.

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

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.

PHY 540: Statistical Mechanics

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. Prerequisite: PHYS 540.

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.

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.

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.

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 mesoscopic Hall effects. Both phenomenological and theoretical descriptions are discussed.

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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.)
Fall, 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 spectroscopy, coherent transients, etc.
Spring, 3 credits, Letter graded (A, A-, B+, 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.)
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.)
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.)
Fall, 3 credits, Letter graded (A, A-, B+, etc.)

PHY 574: Quantum Physics 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.
Fall or Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)

PHY 575: 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.)

PHYS 578: Quantum Physics for Teachers
The concepts, historical development and mathematical methods of quantum mechanics. Topics include Schrödinger'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.)
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.
Fall or Spring, 1-3 credits, Letter graded (A, A-, B+, etc.)

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.
Fall and Spring, 1-18 credits, Letter graded (A, A-, B+, etc.)

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.
Fall and Spring, 0-2 credits, Letter graded (A, A-, B+, etc.)

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

PHY 601: 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 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 gauge 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.)

PHY 622: String Theory I
This course is intended for graduate students who have familiarity with gauge & 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

PHY 623: String Theory II
This course is intended for graduate students who have familiarity with gauge & 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

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.
1-3 credits, S/U grading

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

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

Fall and Spring, 1 credit, S/U grading

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

Fall and Spring, 1 credit, S/U grading

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.

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

Fall or Spring, 1 credit, S/U grading

PHY 670: Seminar in Theoretical Physics

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

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

PHY 672: Seminar in Elementary Particle Physics

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

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

PHY 674: Seminar in Nuclear Physics

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

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

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

PHY 678: Atomic, Molecular and Optical Physics Seminar

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

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

PHY 680: Special Topics in Theoretical Physics

Fall and Spring

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

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

PHY 681: Special Topics in Statistical Mechanics

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

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

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.

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

PHY 683: Special Topics in Astronomy

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

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

PHY 684: Special Topics in Nuclear Physics

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

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

PHY 685: Special Topics in Mathematical Physics

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

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

PHY 686: Special Topics in Elementary Particles

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

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

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.)

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

PHY 688: Special Topics in Astrophysics

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

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

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.

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

PHY 698: Colloquium

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

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

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.

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

Fall, 1-9 credits, S/U grading

PHY 700: Dissertation Research off Campus - Domestic
Prerequisite: Must be 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. All international students must enroll in one of the graduate student insurance plans and should be advised by an International Advisor.

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

Fall, 1-9 credits, S/U grading

PHY 701: Dissertation Research off Campus - International
Prerequisite: Must be 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 be covered by another insurance plan they must file a waiver by second week of classes. The charge will only be removed if other plan is deemed comparable.

All international students must receive clearance from an International Advisor.

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

PHY 800: SUMMER RESEARCH

May be repeated for credit.