Physics

Website: http://physics.wustl.edu/graduate

Courses

PHYSICS 5000 Independent Work
Prerequisites: senior standing and apply for approval using the Physics independent study web form https://physics.wustl.edu/independent-study. Program and credit to be determined; maximum 6 units.
Credit 6 units.
Typical periods offered: Fall, Spring

PHYSICS 5001 Physical Science in 12 Problems
Exercises related to general chemistry, classical mechanics, quantum mechanics, statistical mechanics, thermodynamics, and kinetics, will be solved with numerical software. Each exercise will be accompanied by a lecture, a software template solving a problem and presenting a related take-home problem. The software will allow us to focus on, and treat in a transparent fashion, physical problems without the unworldly idealizations and contrivances found in textbooks. Prerequisites: Chem 106/112A and/or Physics 192/194, and prior or concurrent enrollment in either Chem 401 or Phys 217. The lectures will be in-person however a complete set of taped lectures will also be available. A remote help session will be scheduled at a mutually agreed to time. There are no quizzes, exams or a final.
Credit 1 unit. A&S IQ: NSM Art: NSM

PHYSICS 5010 Theoretical Physics
The first part of a two-semester course reviewing the mathematical methods essential for the study of physics. Theory of functions of a complex variable, residue theory; review of ordinary differential equations; introduction to partial differential equations; integral transforms. Prerequisite: undergraduate differential equations (Math 217), or permission of instructor.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5011 Mechanics
Motion of a point particle, rotational motion, oscillation, gravitation and central forces, Lagrangian and Hamiltonian formulation. Prerequisite: Prerequisite: Physics 191 - 192 or Phys 193 - 194 or Physics 197-198 or Phys 205 - 206, Math 217, or permission of instructor.
Credit 3 units. A&S IQ: NSM Art: NSM

PHYSICS 5020 Methods of Theoretical Physics II
Continuation of Phys 501. Introduction to function spaces; self-adjoint and unitary operators; eigenvalue problems, partial differential equations, special functions; integral equations; introduction to group theory. Prerequisite: Phys 501, or permission of instructor.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5021 Electricity and Magnetism I
Starting from Coulomb's law, the Biot-Savart law, and Faraday's law, the electrical and magnetic fields are defined and applied. Maxwell's equations are derived and their consequences, such as electromagnetic waves and relativity, are explored. Prerequisites: Prerequisite: Physics 191 - 192 or Phys 193 - 194 or Physics 197-198 or Phys 205 - 206., Math 217, or permission of instructor.
Credit 3 units. A&S IQ: NSM, AN Art: NSM BU: SCI

PHYSICS 5022 Electricity and Magnetism II
The second course in a two part series covering the classical theory of electricity and magnetism leading to the derivation and application of Maxwell's equation. Topics in electrodynamics including Faraday's law, the displacement current and Maxwell's equations in vacuum and in matter are covered. Electromagnetic waves and radiation, special relativity and relativistic electrodynamics will also be discussed. Prerequisites: Phys 421, Graduate Student standing or permission of instructor.
Credit 0 units.

PHYSICS 5027 Introduction to Computational Physics
What does it mean to solve a research problem using a computer? What is the difference between someone ran a simulation and an interesting research result? And what skills does it take? Familiarity with a programming language is, of course, essential, but that is only the beginning. This course will focus on the methodology of computational research, touching also on topics in numerical analysis, statistics and visualization. The format will combine lectures and hands-on experience, with emphasis on research-style small-group projects. Prerequisites:Prerequisite: Physics 191 - 192 or Phys 193 - 194 or Physics 197-198 or Phys 205 - 206, Calculus, and familiarity with a programming language.
Credit 3 units. A&S IQ: NSM Art: NSM
Typical periods offered: Fall

PHYSICS 5030 Advanced Math Methods for Physicist & Engineers I
The first semester of a two semester course presenting an organized approach to solving hard problems approximately; a self contained and general examination of asymptotics and perturbation theory; local and global analysis of differential and difference equations, summation methods, Pade theory, asymptotic expansion of integrals; emphasis calculational rather than theoretical. Continued in Physics 504. Prerequisite: Physics 501 or an elementary knowledge of differential equations and complex variables.
Credit 3 units.

PHYSICS 5035 Nuclear and Radiochemistry Lab
Application of radiochemistry to problems in chemistry, physics, and nuclear medicine, with emphasis on particle detectors and experimental techniques. Prerequisites: 3 units of physical chemistry or quantum mechanics, or permission of instructor. Five hours of laboratory a week.
Credit 3 units. A&S IQ: NSM Art: NSM

PHYSICS 5036 Introduction to the Atomic Nucleus
Introduction to the interaction of radiation with matter, the production and decay of radioactive nuclides, the structure and properties of nuclei, and various applications of nuclear science (including nuclear power) are all presented. Same as L31 436 and Lo7 436.
Credit 3 units. A&S IQ: NSM Art: NSM

PHYSICS 5040 Advanced Math Methods for Physicist & Engineers II
A continuation of Physics 503. A general presentation of perturbation theory. Matched asymptotic expansions. Boundary layer theory, WKB theory, multiple scale analysis. Variational methods, integral equations.
Credit 3 units.

PHYSICS 5050 Classical Electrodynamics I
Classical electromagnetism via Maxwell's equations. Electric and magnetic fields from static charge and current distributions. Mathematical techniques for solving electrostatic and magnetostatic problems. Electrostatic and magnetostatic forces and energies.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5054 Physics of Living Systems
Credit 0 units.

PHYSICS 5060 Classical Electrodynamics II
Time-varying electric and magnetic fields. Electromagnetic waves and radiation; simple antennas. Waveguides and effects of dispersion. Retardation effects and special relativity.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5063 Statistical Mechanics and Thermodynamics
Basic methods of classical and quantum statistical mechanics, thermodynamics, and transport theory. Prerequisite: Phys 217 or permission of instructor.
Credit 3 units. A&S IQ: NSM, AN Art: NSM

PHYSICS 5068 Introduction to Quantum Information
Same as L31 3068. Students enrolled in L31 5068 will complete an independent research project under the instructor's supervision is required.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5070 Classical Mechanics
The culminating achievements in this classical discipline are presented: the Lagrangian and Hamiltonian formulation of the equations of motion, action principles and the Hamilton-Jacobi equation. Applications to constrained systems, many-body systems, continuous systems and classical fields are included. Perturbation theory and general relativity are discussed briefly.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5071 Quantum Mechanics
Origins of quantum theory, wave packets and uncertainty relations, Schroedinger's equation in one dimension, step potentials and harmonic oscillators, eigenfunctions and eigenvalues, Schroedinger's equation in three dimensions, the hydrogen atom, symmetry, spin and the periodic table, approximation methods for time independent problems, quantum statistics. Prerequisite: Math 217, Physics 217, or permission of instructor.
Credit 3 units. A&S IQ: NSM Art: NSM

PHYSICS 5072 Solid State Physics
Crystal structures, binding energies, thermal properties, dielectrics, magnetism, free electron theory of metals, band theory, semiconductors, defects in solids. Prerequisite: Phys 471.
Credit 3 units. A&S IQ: NSM Art: NSM

PHYSICS 5074 Introduction to Particle Physics
Introduction to the standard model of particle physics, including symmetries, conservation laws, the weak interaction, the strong interaction, quark confinement, and some more exotic ideas such as grand unified theories. Prerequisite: Phys 217.
Credit 3 units. A&S IQ: NSM, AN Art: NSM

PHYSICS 5078 From Black Holes to the Big Bang
An introduction to general relativity. The goal will be to illustrate important features of general relativity without the full-blown mathematics of Einstein's equations by restricting attention to spherically symmetric spacetimes. Topics will include: principle of equivalence; curved spacetime; spherical stars and black holes; the Big Bang model, observational cosmology. Prereq: Physics 411 or permission of instructor.
Credit 3 units. A&S IQ: NSM Art: NSM

PHYSICS 5080 Artificial Intelligence and Machine Learning Methods With Applications to Physics
The course will introduce key ideas of AI and machine learning from a statistical physics perspective. Essentials of statistical distributions, kernel methods, neural networks, large language models, diffusion models, and many other tools will be presented from this physics based approach. Students will apply these techniques to problems in physics. Apart from the very first assignments, nearly all homework problems will assume the use of Python. If you do not know Python, there will be an additional very brief introduction to Python that the instructor will give in addition to the course lectures. Prerequisites: Graduate Student standing or L24 132 (Calculus III) and L24 429 (Linear Algebra)
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5090 Nonlinear Dynamics
The course will treat the theoretical foundations of nonlinear dynamics, and its applications to phenomena in diverse fields including physics, biology, and chemistry. Topics will include phase plane analysis, stability analysis, bifurcations, chaos, and iterated maps. Prerequisites: knowledge of multivariate calculus and ordinary differential equations at the level of Mathematics 217; and Physics 117-118 (mechanics at the level of 411 is desirable but not essential).
Credit 3 units.
Typical periods offered: Fall, Spring

PHYSICS 5230 Quantum Mechanics I
Provides a rigorous introduction to quantum mechanics with an emphasis on formalism. The course begins with review of the theory of linear (state) vector spaces and the quantum theory of measurement. Topics covered include dynamics of quantized systems, the quantum theory of angular momentum, density matrix formalism, and advanced topics in quantum measurement theory.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5240 Quantum Mechanics II
Review of wave mechanics, scattering theory. Measurement algebra and the foundations of nonrelativistic quantum theory. Mathematical techniques for solution, perturbation theory. Applications to atomic, molecular, nuclear, and solid state problems. Introduction to relativistic quantum theory and quantized wave fields.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5290 Statistical Mechanics
Gibbs' formalism of statistical mechanics and applications to thermodynamics. Quantum statistical mechanics and degenerate matter. General theory of equilibrium including phase transitions and critical phenomena. Interacting particles including non-ideal gases, ferromagnetism, and superconductivity. Transport theory, irreversible processes.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5300 Advanced Topics in Statistical Mechanics
Critical phenomena and renormalization group theory: scaling, universality, exact solutions, series expansions, computer simulations, e-expansion. Role of solitons and instantons in phase transitions. Quantum fluids: superfluidity and superconductivity. Linear response theory and disordered systems.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5321 Electronic Laboratory
Credit 3 units.

PHYSICS 5322 Physical Measurement Laboratory
A variety of classical and modern experiments in physics, including five experiments in nuclear radiation. Use of computers in experiment control, data acquisition, and data analysis. Development of skills in writing lab notebooks and formal reports and giving short oral presentations on experiments. Two laboratory periods each week. Prerequisite: Physics 217 or permission of instructor; junior or senior level standing
Credit 3 units. A&S IQ: NSM, AN, WI Art: NSM BU: SCI

PHYSICS 5330 Planets and Life in the Universe
In this course, we will explore the history, methods, outcomes, and broad impacts of exoplanet research and how these are connected to our search for life beyond planet Earth. Following an engaging contextual introduction at the beginning of the lectures, topics will be presented with an accessible mathematical treatment (e.g., geometrical derivations of the two-body transit problem). Prerequisite: Physics 191 and 192 or Physics 193 and 194.
Credit 3 units. A&S IQ: NSM, AN Art: NSM
Typical periods offered: Fall

PHYSICS 5370 Kinetics of Materials
A general discussion of phase formation and phase transformation in solids and liquids. Topics include equilibrium and non-equilibrium thermodynamics, equilibrium and metastable phase diagrams, nucleation and growth, spinodal transformations, diffusion and interface limited processes, shear type transformations and order/disorder transformations. Prerequisite: A background in thermodynamics, statistical mechanics, and solid state physics.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5400 Quantum Theory of Many-Particle Systems
Develops a modern approach to quantitative microscopic description of strongly-interacting quantum many-particle systems, including the helium liquids, nuclear matter, neutron star matter, nuclei, and strongly-coupled electron systems. Emphasis is placed on the method of self-consistent Green's functions. Diagram resummation and field theoretic techniques are introduced. Applications are discussed that cover the Hartree-Fock method for atoms, Bose-Einstein condensation of atoms, etc. The microscopic basis for pairing in superfluids and superconductors is also examined.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5420 Physics of Finite and Infinite Nuclear Systems
Quantum mechanics of finite and infinite systems of protons and neutrons. Interaction between nucleons. Independent-particle model of nuclei and shell structure. Contrast with atomic shell model. Isospin symmetry. Information from weakly and strongly interacting probes of nuclei. Nuclear decay properties and some historical context. Many-particle description of nuclear systems. Single-particle versus collective phenomena. Properties of excited states. Bulk properties of nuclei. Nuclear and neutron matter. Role of different energy scales in determining nuclear properties: influence of long-range, short-range, and medium-induced interactions. Pairing correlations in nuclear systems. Relevance of nuclear phenomena and experiments for astrophysics and particle physics. Prerequisites: Phys 318 or Phys 471, or permission of instructor
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5430 Group Theory and Symmetries in Physics
Symmetries offer beautiful explanations for many otherwise incomprehensible physical phenomena in nature. Group theory is the underlying mathematical framework for studying symmetries, with far-reaching applications in many areas of physics, including solid-state physics, atomic and molecular physics, gravitational physics, and particle physics. We will discuss many of the fascinating mathematical aspects of group theory while highlighting its physics applications. The following topics will be covered: general properties of groups (definition, subgroups and cosets, quotient group, homo- and iso-morphism), representation theory (general group actions, direct sums and tensor products, Wigner-Eckart theorem, Young tablelaux), and discrete groups (cyclicity, characters, examples), Lie groups and Lie algebra (Cartan-Weyl basis, roots and weights, Dynkin diagrams, Casimir operators, Clebsch-Gordan coefficients, classification of simple Lie algebras), space-time symmetries (translation and rotation, Lorentz and Poincare groups, conformal symmetry, supersymmetry and superalgebra), and gauge symmetries (Abelian and non-Abelian, Standard Model, Grand Unified Theories). Interested undergraduates who have taken Physics 217 or similar can register for this course with prior approval.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5460 Galactic Astrophysics
In these lectures, the focus is on the dynamics and statistical mechanics of a collection of stars, which is treated as a collisionless system. The course begins with a discussion of potential theory and proceeds to discuss the density and phase distributions of stars in star clusters and galaxies, thus leading to an understanding of the equilibria and stability of these systems. Topics such as Chandrasekhar's dynamical friction, galaxy formation and dark matter will constitute the final topics of discussion.
Credit 3 units. A&S IQ: NSM Art: NSM BU: SCI

PHYSICS 5470 Intro to Elementary Particle Physics
An introduction to the standard model of elementary particle physics. The non-Abelian SU() X SU(2) X U (1) gauge theory and its relation to phenomenology and experiments.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5490 Solid State Physics I
Quantum theory of phonons in solids, thermodynamical properties, band theory of solids, free-electron and tight-binding approaches to electronic structure.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5500 Solid State Physics II
Band magnetism and local moments, Ising models, electron-electron and electron-phonon interactions, superconductivity.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5510 Relativistic Quantum Mechanics
Introduction to Quantum Field Theory using simple 1-dimensional and/or scalar field examples. Canonical quantization and path integrals; Feynman diagrams; Lorentz group; discrete symmetries; LSZ theorem. Introduction to regularization and renormalization.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5520 Relativistic Quantum Field Theory
Continuation of Phys 551. Path integral quantization of spin 1/2 and spin 1 fields. Quantum electrodynamics. Ward identities and renormalization. Computation of the electron anomalous magnetic moment and the Lamb shift. Non-Abelian gauge theories and their quantization. Quantum chromodynamics and asymptotic freedom. Spontaneous symmetry breaking and the Standard Model.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5560 Stellar Astrophysics
In the second semester, the focus is on the dynamics and statistical mechanics of a collection of stars which is treated as a collisionless system. The course begins with a discussion of potential theory and proceeds to discuss the density and phase space distributions of stars in star clusters and galaxies, thus leading to an understanding of the equilibria and stability of these systems. Topics such as Chandrasekhar's dynamical friction and dark matter will constitute the final topics of discussion. This course is also available for advanced undergraduates, with the prerequisites as noted. Prerequisites: Physics 411, 421, and 463, or permission of the instructor.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5570 Gravitation and Cosmology
Special relativity, equivalence principle, and fundamental experiments. Mathematics of curved spacetime. General structure of Einstein's equations. Observational tests. Applications of general relativity, relativistic stellar structure, gravitational collapse and black holes.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5580 Relativistic Astrophysics
Applications of general relativity to astrophysics and cosmology. Relativistic stars, gravitational collapse and black holes; generation, propagation and detection of gravitational radiation. Cosmology, the Standard Model; physical processes in the early universe and the microwave background. Inflationary scenario. Origin of galaxies and large-scale structure. Gravitational lenses. Credit 3 units.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5590 Testing Fundamental Physics With Astronomical Observations
Astronomical observations allow us to test fundamental physics laws under more extreme conditions than possible in terrestrial laboratories. In some important cases (i.e. cosmology), astronomical observations present the only way to gather empirical evidence and to formulate and subsequently test the theories. In this one-semester course, we start with a brief summary of the current theoretical framework that is used to explain the cosmos: the theory of General Relativity and the Standard Model of particle physics. Subsequently, we introduce current astronomical observatories and discuss which fundamental physics laws they can probe. We include a detailed discussion of theoretical ideas which are being probed, and avenues for developing more precise tests with future experiments. This class is designed to be highly relevant for theoretical and experimental researchers. Previous exposure to the theory of General Relativity and quantum field theories is beneficial but not required.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5600 X-Ray and Gamma-Ray Astrophysics
The final semester will provide an up to date coverage of x-ray and gamma-ray astronomy and astrophysics. Generation and observational techniques of energetic radiations from accreting neutron stars and black holes, supernova and supernova remnants, active galactic nuclei, interstellar and intergalactic matter, as well as related physics and model building will be discussed. The course will thus explore the most energetic phenomena in the universe and will also provide insight into diverse topics ranging from planetary exploration to dark matter and cosmology. This course is also available for advanced undergraduates, with the prerequisites as noted in 476/576.
Credit 3 units.
Typical periods offered: Fall

PHYSICS 5630 Topics in Theoretical Biophysics
Application of a range of physical models to biological systems. Topics include protein folding, self-assembling molecular systems, and mechanical properties of biological materials. Background material will be provided but some exposure to statistical mechanics or thermodynamics is necessary.
Credit 3 units.
Typical periods offered: Spring

PHYSICS 5650 Magnetism and Superconductivity: Basics and Applications
Fundamental and applied aspects of magnetism and superconductivity in solids. The magnetic state in transition metal, rare earth and actinide systems. Exotic forms of magnetism. Conventional, high-Tc, fullerene and organic superconductors. Josephson effect. Bose-Einstein condensation. Coexistence of magnetism and superconductivity. Applications include: SQUID sensors, permanent and superconducting magnets, bubble memories, and magnetic cooling. Prerequisite: Physics 472 or permission of instructor.
Credit 3 units.

PHYSICS 5680 Astrostatistics
The course will be centered on astrostatistics and explore fundamental concepts in statistics and computer science, using astrophysics as the basis of application. The course will introduce the essential principles and techniques of astrostatistics, equipping students with the necessary tools to analyze and interpret data from various astrophysical phenomena, while the methods covered will also apply to problems outside of astronomy.
Credit 0 units.

PHYSICS 5760 Astrophysics
This is the first of a four-semester course in astrophysics, with two semesters of classical astrophysics of stars and stellar systems, followed by two semesters of high energy astrophysics of cosmic rays, radio, x-ray and gamma-ray astronomies. Each of these is a self-contained course and may be attended by advanced undergraduates and graduate students. In the first semester we discuss observations of stars; stellar populations; physical processes in stars; birth, evolutions, and death of stars; energy generation; nucleosynthesis; variable stars; supernovae; collapsed objects; solar neutrinos; helioseismology; and selected topics in galactic astrophysics, cosmology and exobiology. Additional reading assignments for students registered for 576. Prerequisites: Physics 411, 421, and 463, or permission of the instructor.
Credit 3 units.

PHYSICS 5810 Critical Analysis of Scientific Data
Data science is most commonly associated with topics in computer science. But efficient algorithms, specific software packages, neural nets, etc., are only tools, and are easily misused. In a research setting, working with data is primarily an exercise in critical thinking. The purpose of this interactive, hands-on course is to learn from mistakes by making them in a safe environment. After covering/reviewing probability theory; Bayesian inference; elements of information theory and random matrix theory, the course will focus on case studies of real-world biological data, such as quantitative imaging data, nextgeneration sequencing (metagenomics), and neural recordings. These modules will involve critical reading of research papers and working through puzzle-based assignments. The primary modules will be supplemented by shorter presentations on topics chosen by students. Fair warning: this is explicitly NOT a course on big data or machine learning, although students may choose to explore some of these topics in their presentations (required for credit). Experience with MatLab or Python strongly encouraged or will need to be acquired during the course. Open to undergraduates with prior programming experience and a quantitative background (Phys 197/198, Math 203 or similar; contact instructor if unsure). Experience with data or statistics not required. Course mimics a research environment and undergraduates considering an academic research track especially encouraged. Graduate students required to pick an advance topic.
Credit 3 units.

Typical periods offered: Fall, Spring

PHYSICS 5820 Research Seminar
Designed to introduce students to current developments in physics and to research carried out by faculty. Topics vary each year. Each member of the department addresses issues in their particular specialty. Required of all majors and first-year graduate students. Undergraduates are advised to take this seminar in their junior year.
Credit 1 unit.

Typical periods offered: Fall

PHYSICS 5830 Grant Proposal Writing and Research Project Development
Introduction to grant proposal writing. Students will develop a research project and write a graduate student fellowship application based on that project. As part of the fellowship application the student will develop all supporting documents necessary for the application (i.e. curriculum vitae, budget, etc.). Twice during the course students will make an oral presentation of their project in order to get feedback from faculty and other students.
Credit 1 unit.

PHYSICS 5840 Computational Methods
This course provides an introduction to the computational techniques that are most widely used in both theoretical and experimental research in physics. Each lecture will use a realistic research problem to introduce the algorithms, software packages and numerical techniques that will be used by the students to develop a solution on the computer. Topics include Monte Carlo techniques, symbolic analysis with Mathematica, data acquisition software used in the laboratory, the numerical solution of quantum mechanical problems, and an introduction to general purpose frameworks based on Python. Prerequisites: Prior of concurrent enrollment in L31 471 or L31 422 or permission of the instructor.
Credit 1 unit.

Typical periods offered: Spring

PHYSICS 5860 Commercialization of Science and Technology
Commercialization of Science and Technology is an interdisciplinary course that investigates the issues and decisions that inventor/scientists, engineers, and entrepreneurs encounter when taking early stage scientific discoveries from the laboratory to applied use. The course employs case studies, invited speakers, and team projects to engage graduate and professional students in interdisciplinary collaboration, idea generation and the feasibility of applying scientific discoveries in commercial marketplaces. Participants learn about the basics of commercialization and entrepreneurship and how these relate to their personal goals and scientific interests. The course is ideal for anyone interested in working as an academic, chief scientist, entrepreneur, manager, consultant, or investor.
Credit 3 units.

PHYSICS 5890 Selected Topics in Physics I
From time to time, additional courses are offered in specialized physics topics of current interest, such as group theory, general relativity, advanced hydrodynamics, boundary-value problems, celestial mechanics, astrophysics, and so on.
Credit 3 units.

Typical periods offered: Fall

PHYSICS 5900 Selected Topics in Physics II
From time to time, additional courses are offered in specialized topics of current interest such as group theory, general relativity, advanced hydrodynamics, boundary-value problems, celestial mechanics, astrophysics, etc.
Credit 3 units.

Typical periods offered: Spring

PHYSICS 5930 Introduction to Methods in Physics
Five hours per week of tutorial training in modern experimental and/or theoretical methods in physics. Instruction by faculty members or, with faculty supervision and assistance, by graduate teaching interns who are enrolled in and earning credit for Phys 597-598.A maximum of 3 units of this course may be counted toward the requirement of 36 units of course credit for the Ph.D. degree.

Credit 3 units.

Typical periods offered: Fall

PHYSICS 5940 Introduction to Methods in Physics
Five hours per week of tutorial training in modern experimental and/or theoretical methods in physics. Instruction by faculty members or, with faculty supervision and assistance, by graduate teaching interns who are enrolled in and earning credit for Phys 597-598. A maximum of 3 units of this course may be counted toward the requirement of 36 units of course credit for the Ph.D. degree.
Credit 3 units.

Typical periods offered: Spring

PHYSICS 5950 Research
The department regularly conducts seminars for review of current progress in research. Fields in which it is active : (a) Space Physics and Astrophysics, (b) Nuclear Physics, (c) Theoretical Physics, (d) Condensed Matter and Magnetic Resonance, (e) Applications of Ultrasound to medical, biological, and physical problems. This course does not count toward the requirement of 36 units of course credit for the Ph.D. degree.
Credit 9 units.

PHYSICS 5960 Research
The department regularly conducts seminars for review of current progress in research. Fields in which it is active : (a) Space Physics and Astrophysics, (b) Nuclear Physics, (c) Theoretical Physics, (d) Condensed Matter and Magnetic Resonance, (e) Applications of Ultrasound to medical, biological, and physical problems.This course does not count toward the requirement of 36 units of course credit for the Ph.D. degree.
Credit 9 units.

PHYSICS 5970 Supervised Teaching of Physics
Supervised instructional experience as graduate teaching intern. Under faculty supervision, a teaching intern may earn credit in Phys 597-598 by (a) instructing graduate students who are taking Phys 593-594, or (b) instructing undergraduates who are taking Phys 241-242 or 341-342, or (c) as a Graduate Teaching Fellow or Assistant, instructing and evaluating work of undergraduate or graduate students in classroom or laboratory physics courses, or (d) instructional activity connected with journal club, group seminars, special short courses, observatory lectures, etc. Five or more contact hours per week with student(s) being instructed plus associated preparation and evaluation.
Credit 1 unit.

Typical periods offered: Fall

PHYSICS 5980 Supervised Teaching of Physics
Supervised instructional experience as a graduate teaching intern. Under faculty supervision, a teaching intern may earn credit in Phys 597-598 by (a) instructing graduate students who are taking Phys 593-594, or (b) instructing undergraduates who are taking Phys 241-242 or 341-342 or 441-442, or (c) as a Graduate Teaching Fellow or Assistant, instructing and evaluating work of undergraduate or graduate students in classroom and laboratory physics courses, or (d) instructional activity connected with journal club, group seminars, special short courses, observatory lectures, etc. Five or more contact hours per week with student(s) being instructed, plus associated preparation and evaluation.
Credit 1 unit.