DOCTOR OF PHILOSOPHY IN PHYSICS

The Doctor of Philosophy in Physics program is designed to provide students with advanced graduate training in physics, which will prepare them for scientific careers in academe, as well as industry. The strength of the department lies in solid state physics, semiconductor physics, materials science, theoretical physics, laser remote sensing, computational physics, and instrumentation. A student with only a Bachelor's Degree may qualify for a straight PH.D program which carries 48 units of coursework, 3 units of seminar and 12 units dissertation. A student with a degree of M.S. Physics may qualify for the regular Ph.D. program requiring 27 units of coursework to be programmed by the Physics Department Graduate Committee based on courses taken during the M.S. Physics, 3 units of seminar and 12 units of dissertation.

Program Requirements

Straight PhD Program:

Advance Academic Writing	(6 units)
Basic Courses	9 units
Major Courses	18 units
Elective Courses	21 units
Seminar	3 units
Comprehensive Examination	0 unit
Dissertation	12 units
Total	**63 units**

Regular PhD Program:

Advance Academic Writing	(6 units)
Basic Courses	6 units
Major Courses	3 units
Elective Courses	21 units
Seminar	3 units
Comprehensive Examination	0 unit
Dissertation	12 units
Total	**45 units**

Course Description

Advance Academic Writing Courses:

Advanced Technical Reading and Writing I (ENG501M)
3 units
The first part of an intensive English academic reading and writing course, focuses on the review of basic reading and writing skills and their application in the preparation of short academic papers such as definitions and descriptions, and non-prose forms. It emphasizes the mastery of active reading strategies, the effective use of rhetorical and organizational features of academic writing, and proper documentation.

Advanced Technical Reading and Writing II (ENG502M)
3 units
The second part of the intensive English academic reading and writing course, focuses on the writing of data commentary and the various parts of a research report, with emphasis on the different rhetorical moves and the linguistic features that realize these moves. The course continues to emphasize the observance of integrity in writing and research.

Refresher Courses:

Basic Mathematical Methods of Physics I (PHY501D)
3 units
A refresher course on mathematical physics covering topics in vector algebra, vector calculus, curvilinear coordinate systems, linear algebra and introductory tensor algebra.

Basic Mathematical Methods of Physics II (PHY503D)
3 units
A refresher course on mathematical physics covering topics in complex analysis, the Sturm-Liouville theory, and special functions.

Basic Classical Mechanics (PHY505D)
3 unit
A refresher course on classical mechanics which includes Newton's laws of motion, conservation laws, Lagrangian dynamics, central forces, and harmonic oscillators.

Basic Electricity and Magnetism (PHY507D)
3 units
A refresher course on electricity and magnetism covering electrostatics, magnetostatics, and Maxwell's equations.

Basic Modern Physics (PHY509D)
3 units
A refresher course on modern physics covering the historical development of quantum mechanics, special relativity, Schrodinger's Equation, and the basic notions of spin and atomic orbitals.

Basic Quantum Mechanics (PHY513D)
3 units
A refresher course on quantum mechanics including such topics as Schrodinger equation, piece wise constant potentials, harmonic oscillators, the hydrogen atom, and matrix mechanics.

Basic Statistical Mechanics (PHY515D)
3 units
A refresher course on statistical mechanics including topics on the theory of probability, thermodynamics, partition functions, statistical thermodynamics, and quantum statistics.

Basic Experimental Methods of Physics (PHY517D)
3 units
A refresher course on experimental methods of physics, covering experiments in modern physics, electricity and magnetism, and optics.

Basic Wave Mechanics and Optics (PHY519D)
3 units
Mechanical waves; electromagnetism waves; reflection; refraction; interference; diffraction; polarization; lasers.

Basic Courses:

History and Philosophy of Science and Mathematics (PHY551D)
3 units
A course on the history of science and mathematics with emphasis on the significant contributions of people who have laid the foundations of science and mathematics, the philosophy of science with concentration on the conceptualization and methodology of science; elements of scientific thought; and the relation of science to other fields; religion, literature, politics and other social sciences.

Fundamental Statistics and Statistical Mechanics I (PHY619D)
3 units
Thermodynamics of phase transitions; the Ginzburg-Landau theory; critical exponents; review of probability theory; master equation; the Fokker-Plank equation; random walk and the diffusion equations; probability density and Liouville's equation, ergodic theory, mixing flow; equilibrium statistical mechanics; equilibrium statistical mechanics; equilibrium, fluctuations and critical exponents.

Computational Methods of Physics (PHY639D)
3 units
Numerical methods; introduction to linear and dynamic programming; principles of simulation and modeling; computer languages for numerical solutions and algebraic manipulations.

Major Courses:

Classical Mechanics I (PHY601D)
3 units
Introduction to dynamic systems, Hamiltonian dynamics, variational principles, canonical transformations, Hamilton-Jacobi theory, classical permutation theory, advanced linear dynamics, and classical field theory.

Classical Electrodynamics I (PHY605D)
3 units
The microscopic Maxwell equations; electrostatics in vacuum and in dielectrics; stationary currents and magnetostatics; conservation theorems for the electromagnetic field; plane electromagnetic waves; wave guide and resonant cavities.

Classical Electrodynamics II (PHY607D)
3 units
Electromagnetic multiple radiation; principles of special relativity; covariant formulation of electrodynamics; radiation from moving charges; brevnsstrahlung; relativistic dynamics of charges and fields; classical electron theory; and magnetohydrodynamics.
Prerequisite : Classical Electrodynamics I

Quantum Mechanics I (PHY609D)
3 units
Linear vector spaces representation theory; general formulations; simple quantum mechanical systems; quantum dynamics; and path integral methods.

Quantum Mechanics II (PHY611D)
3 units
Symmetries; stationary-state perturbation theory; time-dependent perturbation theory; and collision theory.
Prerequisite : Quantum Mechanics I

Classical & Quantum Field Theory (PHY721D)
3 units
A first course on field theory covering canonical transformations, Lagrangian and Hamiltonian formulations for continuous systems and fields, special theory of relativity, dynamics of relativistic particles, electromagnetic fields, Klein-Gordon equation, Dirac equation, canonical quantization, path integration, perturbation theory, renormalization, symmetries and gauge fields, and spontaneous symmetry breaking.
Prerequisite : Classical Mechanics, Classical Electrodynamics I, and Quantum Mechanics II

Elective Courses:

Advanced Atomic and Molecular Physics (PHY703D)
3 units
Selected advanced topics of current interest in atom and molecular physics.
Prerequisite: Atomic and Molecular Physics II

Advanced Low Temperature Physics (PHY637D)
3 units
Selected advanced topics of current interest in superconductivity and superfluidity.
Prerequisite : Low-Temperature Physics II

Advanced Plasma Physics (PHY709D)
3 units
Selected advanced topics of current interest in plasma physics
Prerequisite : Plasma Physics II

Advanced Quantum Electronics I (PHY675D)
3 units
Selected advanced topics in laser physics such as advanced laser systems; optical detectors and modulators; optical fibers and optical communication; optelectronic devices; and integrated optics.
Prerequisite : Laser Physics I

Advance Quantum Electronics II (PHY677D)
3 units
Selected advanced topics of current interest in non-linear optics and quantum optics.
Prerequisite : Advanced Quantum Electronics I

Advanced Quantum Mechanics I (PHY613D)
3 units
Formal scattering theory; relativistic quantum mechanics; Feynman calculational techniques; and Feynman graphs.
Prerequisite : Quantum Mechanics II

Advanced Quantum Mechanics II (PHY615D)
3 units
Quantum theory of many-body systems using the methods of second quantization, Feynman graphs, Green functions, and other techniques.
Prerequisite : Advanced Quantum Mechanics I

Advanced Quantum Mechanics III (PHY617D)
3 units
Quantum mechanics and group theory including such topics as group representations; the symmetric, permutation, crystallographic, and other finite groups along with their physical applications; the rotation group; introduction to unitary symmetry; and Clebsch-Gordan, Wigner, and Racah algebras.
Prerequisite : Quantum Mechanics II

Advanced Solid State Physics I (PHY629D)
3 units
Selected advanced topics in solid state physics with focus on semiconductors, metals, surfaces and interfaces, thin films, and amorphous materials.
Prerequisite : Solid State Physics II

Advanced Solid State Physics II (PHY631D)
3 units
Selected advanced topics in solid state physics with focus on dielectric materials, magnetic materials, phase transitions, and low-dimensional systems.
Prerequisite : Advanced Solid State Physics I

Advanced Statistical Mechanics (PHY623D)
3 units
Selected advanced topics of current interest in Statistical Mechanics.
Prerequisite : Statistical Mechanics II

Advanced Topics in Gravitation I (PHY689D)
3 units
Selected advanced topics of current interest in general relativity and/or alternative classical theories of gravitation.
Prerequisite : General Relativity II

Advanced Nuclear Physics (PHY671D)
3 units
Selected advanced topics of current interest in nuclear physics.
Prerequisite : Nuclear Physics II

Advanced Topics in Gravitation II (PHY691D)
3 units
Selected advanced topics related to the quantization of the gravitational field and/or unification with other fields.
Prerequisite : Advanced Topics in Gravitation I

Atomic & Molecular Physics I (PHY699D)
3 units
Quantum-mechanical treatment of the structure and interactions of atoms and molecules: complex atomic spectra; Hartree-Fock-Slater menthols; vector coupling; multiplet theory and Racah methods; transition probabilities and selection of rules; molecular rotations and vibrations; and group-theoretic methods in molecular physics.
Prerequisite : Quantum Mechanics I

Atomic & Molecular Physics II (PHY701D)
3 units
Topics to be selected from rotational, vibrational, and electronic spectra of molecules; molecular orbitals; techniques of nuclear magnetic resonance, microwave, electron-spin-resonance, infrared Raman, optical and ultraviolet spectroscopy; applications to stellar spectra; and introduction to the theory of atomic collisions.
Prerequisite : Atomic and Molecular Physics I

Classical Mechanics II (PHY603D)
3 units
Methods of non-linear dynamics, chaotic dynamical systems, strange attractors, routes to chaos, solitary waves and solitons, the methods of inverse scattering, kinks and vortices.
Prerequisite : Classical Mechanics I

Computational Methods of Physics B (PHY641D)
3 units
Special topics in computational methods for Physics.

Condensed Matter Physics (PHY717D)
3 units
It is an introductory course on the quantum-mechanical treatment of the physics of solids and quantum liquids. It begins with discussions on collective excitations and quasiparticles, develops calculational methods such as the Hartree-Fock approximation and the random phase approximation that are appropriate for fermions, the Bogoliubov theory and the Debye model that are appropriate for bosons, develops the one-electron theory to treat metals, insulators and semiconductors, and ends with discussions on density functional theory.
Prerequisites: Classical Mechanics I, Classical Electrodynamics I, Quantum Mechanics I, and Statistical Mechanics I

Current Topics in Particle Theory II (PHY695D)
3 units
Additional current topics in theoretical particle physics.
Prerequisite : Current Topics in Particle Theory I

Elementary Particle Physics I (PHY643D)
3 units
Space-time properties of particles; classification of particles and their symmetries; and properties of particles and their interactions.
Prerequisite : Quantum Mechanics II

Elementary Particle Physics II (PHY645D)
3 units
Selected topics in strong and weak interactions; current-algebra's; dispersion theory; gauge theories; and S-matrix theory.
Prerequisite : Elementary Particle Physics I

Experimental Methods of Physics A (PHY693D)
3 units
Advanced laboratory techniques and instrumentation of quantum electronics and modern optics.

Experimental Methods of Physics B (PHY632D)
3 units
Advanced laboratory techniques and instrumentation of solid state physics and low-temperature physics.

Experimental Methods of Physics C (PHY700D)
3 units
Advanced laboratory techniques and instrumentation of atomic and molecular physics.

Experimental Methods of Physics D (PHY668D)
3 units
Advanced laboratory techniques and instrumentation of nuclear physics.

Experimental Methods of Physics E (PHY710D)
3 units
Advanced laboratory techniques and instrumentation of plasma physics.

Experimental Methods of Physics F (PHY719D)
3 units
Advanced laboratory techniques and instrumentation in a specialized area of experimental physics that is not covered in the other courses.

General Relativity I (PHY647D)
3 units
Manifolds, modern differential geometry and tensor analysis; basic principles of general relativity; Einstein's field equations and their mathematical properties; extract solutions; linearized theory; variational principles and conservation laws; equations of motion; gravitational waves; and experimental test.

General Relativity II (PHY649D)
3 units
Spinor analysis; tetrad calculus, the spin coefficient formulation of general relativity; asymptotic properties of space-time singularities, relativistic cosmology; and other selected topics.
Prerequisite : General Relativity I

Laser Physics I (PHY651D)
3 units
Einstein's theory of light-matter interaction; rate equation; density matrix formalism of quantum mechanics; Maxwell-Schrodinger equations, Maxwell-Bloch equations; steady state behaviors and instabilities of single-mode lasers; optical bistability, multimode laser operation and multimode instabilities; and coherent pulse propagation.
Prerequisite : Quantum Mechanics II

Laser Physics II (PHY653D)
3 units
Quantum theory of radiation; coherent state of radiation; P-representation; squeezed states; quantum Fokker-Plank equation; quantum theory of the laser; photon and photoelectron statistics; quantum mechanical coherence; Langevin's theory of Brownian motion; and Langevin's theory of the laser.
Prerequisite : Laser Physics I

Low Temperature Physics I (PHY633D)
3 units
Properties of superconductors; the London, Ginzburg-Landau and BCS theories of superconductivity; the Josephson effect; and other topics in superconductivity.
Prerequisite : Quantum Mechanics II

Low Temperature Physics II (PHY635D)
3 units
Properties of liquid helium; the Landau, Feynman, and Bogolyubov theories of superfluidity; rotating helium; vortices; Fermi liquid; and other topics in superconductivity.
Prerequisite : Low-Temperature Physics I

Mathematical Methods of Physics A (PHY655D)
3 units
Selected advanced methods in partial different equations and integral equations such as Hilbert-space methods, Green-Function Methods, approximation methods, variational methods, and optimisation methods.

Mathematical Methods of Physics B (PHY657D)
3 units
Structure and representation theory of various Lie groups.

Mathematical Methods of Physics C (PHY659D)
3 units
Selected advanced topics in topology, differential geometry, and related areas of mathematics that are important in contemporary theoretical physics.

Mathematical Methods of Physics D (PHY661D)
3 units
Selected advanced topics in functional analysis, operator algebras, and related areas of mathematics that are important in contemporary theoretical physics.

Mathematical Methods of Physics E (PHY663D)
3 units
Selected topics in non-linear problems such as stability theory; bifurcation theory, asymptotic properties; perturbation methods; numerical methods; and soliton theory and its applications.

Mathematical Methods of Physics F (PHY665D)
3 units
Special topics on the mathematical methods for physicists that are not covered in other courses.

Modern Optics I (PHY685D)
3 units
Foundations of geometrical optics geometric theory of imaging; geometrical theory of aberrations; theory of interference and interferometers; theory of diffraction; and diffraction theory of aberrations.
Prerequisite : Classical Electrodynamics II

Modern Optics II (PHY687D)
3 units
Theory of electromagnetic propagation in anisotropic media; Jones calculus as applied to birefringent systems; electromagnetic propagation in periodic media; electro-optics; parametric amplification and oscillation; Raman scattering; Brillouin scattering; phase conjugate optics; and introduction to integrated optics.
Prerequisite : Modern Optics I

Nuclear Physics I (PHY667D)
3 units
Nuclear structure; self-consistent fields; shell model; single particle expectations and vibrations, linearization methods; theory of deformed nuclei; pairing in nuclei; and quasi-particles.
Prerequisite : Quantum Mechanics I

Nuclear Physics II (PHY669D)
3 units
Nuclear reactions; optical model; compound nuclear reactions; direct reactions; coupled-channel methods; and other reaction theories.
Prerequisite : Nuclear Physics I

Plasma Physics I (PHY705D)
3 units
Dynamics of charged particles in electromagnetic fields; orbit theory; wave propagation in cold plasmas;magnetohydrodynamics; and hydromagnetic oscillations and stability.

Plasma Physics II (PHY707D)
3 units
Plasma kinetic theory; statistical mechanics of charged particle systems; the BBGKY kinetic theory; the Vlasov equation; and plasma oscillations, and micro instabilities in some thermo-nuclear devices.
Prerequisite : Plasma Physics I

Quantum Electronics (PHY683D)
3 units
An introductory graduate course on quantum electronics covering such topics as quantization of electromagnetic fields, the propagation of optical beams, optical resonators, laser oscillation and laser systems.

Quantum Field Theory II (PHY681D)
3 units
Path integral formulation of gauge theories; perturbative evaluation of gauge theories; some applications of the theory of elementary particles; and current problems.
Prerequisite : Quantum Field theory I

Semiconductor Physics (PHY673D)
3 units
A course on semiconductor physics covering such topics as transport properties, carrier diffusion processes, scattering processes, quantum effects in transport phenomena, and optical properties of semiconductors.
Prerequisite : Solid State Physics I

Solid State Physics I (PHY625D)
3 units
Fundamentals principles of the physics of solid. Topics include periodic structure, lattice waves, electron states, static properties of solids, electron-electron interaction, dynamics of electron in solids.
Prerequisites : Classical Mechanics I, Classical Electrodynamics I, and Statistical Mechanics I

Solid State Physics II (PHY627D)
3 units
Transport and optical properties of solids, Fermi surface, magnetism, superconductivity, amorphous and disordered systems.
Prerequisite : Solid State Physics I

Special Topics in Theoretical Physics (PHY697D)
3 units
Advanced topics in a specialized area of theoretical physics that are not covered in the other courses.

Statistical Mechanics II (PHY621D)
3 units
Elementary transport theory; Onsager's relations; Wiener-Khinchin theorem; fluctuation-dissipation theorem; linear response theory, response theory, thermodynamic stability criteria far from equilibrium; and examples of non-equilibrium phase transitions.
Prerequisite : Statistical Mechanics I

Seminar Courses:

Graduate Physics Seminar I (PHY901D)
1 unit
A graduate seminar course whereby each student is required to attend physics colloquia and conduct a colloquium, discussing at least one recent publication in Physics.

Graduate Physics Seminar II (PHY903D)
2 units
A graduate seminar course whereby each student is required to attend physics colloquia and conduct a colloquium, discussing extensively a recent development in physics.

Research Courses:

Directed Research with laboratory (PHY920D)
0 unit
Preliminary investigation on an original research problem under the supervision of an adviser. The course is designed for students who wish to start research work, but are not yet eligible to enroll in a dissertation course.

Physics Dissertation I to XXII (MTH976D – MTH987D)
12 units
Conduct of an original research under the supervision of an adviser. The course requires the presentation and oral defense of the results of an approved research problem before a panel of examiners as well as the submission of the final bound copies of the dissertation.

Comprehensive Examination:

Each student should have a minimum grade of **75%** percentile score in any two of the four areas (classical mechanics, classical electrodynamics, quantum mechanics, and statistical mechanics) and **50%** percentile score of the remaining two to pass the written comprehensive examination.