# PHYSICS (PH-GY)

**PH-GY 955X READINGS IN APPLIED PHYSICS (1-4 Credits)**
*Typically offered occasionally*
These guided studies courses in physics are supervised by faculty member. | Prerequisite: Graduate Physics advisor approval. Note: Course may be repeated for additional credit.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** Yes

**PH-GY 996X MS Project in Applied Physics (1-9 Credits)**
*Typically offered occasionally*
This project course in applied physics is supervised by a faculty member. A written project proposal and final report must be submitted to the department chair and the advisor, and may be extended to a thesis with the project advisor's recommendation. | Prerequisite: Advisor Approval
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** Yes

**PH-GY 997X MS THESIS IN APPLIED PHYSICS (1-9 Credits)**
*Typically offered occasionally*
Independent research project performed under guidance of thesis advisor. Bound thesis volume and oral defense in presence of at least three faculty members. Continuous registration with total 9 credits required.
**Grading:** Satisfactory/Unsatisfactory
**Repeatable for additional credit:** Yes

**PH-GY 999X PHD DISSERTATION IN APPLIED PHYSICS (3-9 Credits)**
*Typically offered occasionally*
An original investigation in some branch of physics, which may serve as basis for the PhD degree, is performed under the direction of a member of the department. The number of research credits registered for each semester should realistically reflect the time devoted to research. | Prerequisites: Passing grade in RE-GY 9990 PhD Qualifying Exam, degree status and graduate advisers and research director's consent.
**Grading:** Satisfactory/Unsatisfactory
**Repeatable for additional credit:** Yes

**PH-GY 5343 Physical Basis of Nanotechnology (3 Credits)**
This course focuses on the underlying physical basis of nanotechnology. Introduction to nanotechnology, examples of nanoscale systems. Systematics in miniaturization from the mm to the nm scale. Limits to miniaturization. Quantum concepts and elementary Schrodinger theory. Quantum effects in the behavior of chemical matter. Examples of self-assembled nanosystems from nature and from contemporary industrial products. | Prerequisite: PH-UY 2004 or PH-UY 2033
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 5443 PHYSICAL TECHNIQUES AND APPLICATION OF NANOTECHNOLOGY (3 Credits)**
This course focuses on physical techniques and applications of nanotechnology. Scanning probe microscopes for observation and fabrication. Photolithographic methods of patterning, deposition techniques. Dense memory based on arrays of cantilevers. Magnetic Tunnel Junctions as elements of magnetic disc memory read heads and in Magnetic Random Access Memory. Nanoscale high-electric-field devices. Nanoscale confinement techniques and devices. Applications of carbon nanotubes and semiconductor nanowires. Assembly methods for nanoscale objects. | Prerequisite: PH-UY 2004 or PH-UY 2033
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 5473 Modern Optics (3 Credits)**
The course covers the physics of optics, using both classical and semi-classical descriptions. Topics include the classical and quantum interactions of light with matter. Diffraction of waves and wave packets by obstacles. Fourier transform optics, holography, Fourier transform spectroscopy. Coherence and quantum aspects of light. Geometrical optics. Matrix optics. Crystal optics. Introduction to electro-optics and nonlinear optics. | Prerequisites: MA-UY 2122 and PH-UY 3234 equivalents.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 5481 MODERN OPTICS LAB (1 Credit)**
The modern optics laboratory includes experimental investigations into laser modes, velocity of light by time-of-flight, Fourier optics, holography, Fourier transform spectroscopy, crystal optics and nonlinear optics. | Corequisite: PH-UY 5473 or equivalent.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 5493 Physics of Nanoelectronics (3 Credits)**
*Typically offered occasionally*
This course covers limits to the ongoing miniaturization (Moore's Law) of the successful silicon-device technology imposed by physical limitations of energy dissipation, quantum tunneling and discrete quantum electron states. Quantum physical concepts and elementary Schrodinger theory. Conductance quantum and magnetic flux quantum. Alternative physical concepts appropriate for devices of size scales of 1 to 10 nanometers, emphasizing role of power dissipation. Tunnel diode, resonant tunnel diode, electron wave transistor; spin valve, tunnel valve, magnetic disk and random access memory; single electron transistor, molecular crossbar latch, quantum cellular automata including molecular and magnetic realizations. Josephson junction and "rapid single flux quantum" computation. Photo- and x-ray lithographic patterning, electron beam patterning, scanning probe microscopes for observation and for fabrication; cantilever array as dense memory, use of carbon nanotubes and of DNA and related biological elements as building blocks and in self-assembly strategies. | Prerequisites: PH-UY 2023
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 5543 Physics of Nanomaterials and Graphene (3 Credits)**
An introductory graduate course for science and engineering students on the basic properties, preparations and applications of Nanomaterials and Graphene. This course will emphasize forms of carbon, including graphitic carbon composites that are a leading structural material in aircraft; and diamond, carbon black, activated charcoal, carbon nanotubes and graphene. Review of the Schrodinger equation as applied to carbon atoms, to diamond, to graphite and to graphene. Trigonal planar bonding as distinguished from tetrahedral bonding. Methods of making graphene including chemical vapor deposition, exfoliation of graphite. Application of graphene as transparent conductor in solar cells and opto-electronic devices. | Prerequisites: PH-UY 2033 or Graduate Standing.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 5553 Physics of Quantum Computing (3 Credits)**
*Typically offered occasionally*
This course explores limits to the performance of binary computers, traveling salesman and factorization problems, security of encryption. The concept of the quantum computer based on linear superposition of basis states. The information content of the qubit. Algorithmic improvements enabled in the hypothetical quantum computer. Isolated two-level quantum systems, the principle of linear superposition as well established. Coherence as a limit on quantum computer realization. Introduction of concepts underlying the present approaches to realizing qubits (singly and in interaction) based on physical systems. The systems in present consideration are based on light photons in fiber optic systems; electron charges in double well potentials, analogous to the hydrogen molecular ion; nuclear spins manipulated via the electron-nuclear spin interaction, and systems of ions such as Be and Cd which are trapped in linear arrays using methods of ultra-high vacuum, radiofrequency trapping and laser-based cooling and manipulation of atomic states. Summary and comparison of the several approaches. | Prerequisites: PH-UY 2023
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 5663 Physics of Alternative Energy (3 Credits)**
*Typically offered occasionally*
The course examines non-petroleum sources of energy including photovoltaic cells, photocatalytic generators of hydrogen from water, and nuclear fusion reactors. The advanced physics of these emerging technical areas are introduced in this course. Semiconductor junctions, optical absorption in semiconductors, photovoltaic effect. Energy conversion efficiency of the silicon solar cell. Single crystal, polycrystal, and thin film types of solar cells. Excitons in bulk and in confined geometries. Excitons in energy transport within an absorbing structure. Methods of making photocatalytic surfaces and structures for water splitting. Conditions for nuclear fusion. Plasmas and plasma compression. The toroidal chamber with magnetic coils as it appears in recent designs. Nuclear fusion by laser compression (inertial fusion). Small scale exploratory approaches to fusion based on liquid compression and electric field ionization of deuterium gas. | Prerequisites: PH-UY 2004 or PH-UY 2033
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6153 THEORETICAL MECHANICS I (3 Credits)**
Principles of particle and rigid body dynamics. Lagrange's equations. Small vibrations of coupled systems, normal modes of oscillation. | Prerequisites: Graduate standing, or for undergraduates, PH-UY 2104 or equivalent and physics graduate advisor's approval.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6163 THEORETICAL MECHANICS II (3 Credits)**
Hamiltonian mechanics. Transformation theories of mechanics including the Poisson Bracket and Hamilton-Jacobi formulations. Lagrangian formulation of mechanics of continuous media. | Prerequisite: PH-GY 6153.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No
**Prerequisites:** PH 6153.

**PH-GY 6243 ELECTROMAGNETIC THEORY I (3 Credits)**
Electro- and Magneto-statics. Boundary value problems in three dimensions. Green's functions and multipole expansions. Polarization and magnetization. Scalar and vector potentials and gauges. Maxwell's equations. | Prerequisites: Graduate Standing, or for Undergraduates, PH-UY 3234 or equivalent and Physics Graduate Advisor approval.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6253 ELECTROMAGNETIC THEORY II (3 Credits)**
Electromagnetic waves. Propagation in free space and in dielectric and conducting media. Polarization, dissipation and dispersion. Guided waves and cavities. Special Relativity. Scattering. | Prerequisites: PH-GY 6243 Electromagnetic Theory I
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6403 Physical Concepts of Polymer Nanocomposites (3 Credits)**
*Typically offered occasionally*
This course presents fundamental aspects of polymer nanocomposites and updates on recent advancements and modern applications. Topics include nanostructured materials; assembly at interfaces; interactions on surfaces; properties of polymer nanocomposites; reliability; nanodevices.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6513 Introduction to Solid-State Physics I (3 Credits)**
Phenomena and theory of physics of crystalline solids. Topics from thermal, magnetic, electrical and optical properties of metals, insulators and semiconductors. | Prerequisite: PH-UY 2344 or equivalent.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6523 Introduction to Solid-State Physics II (3 Credits)**
Phenomena and theory of physics of crystalline solids. Topics from thermal, magnetic, electrical and optical properties of metals, insulators and semiconductors. | Prerequisite: PH-GY 6513
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6553 ADVANCED QUANTUM COMPUTING (3 Credits)**
Advanced topics in quantum computation are explored. | Prerequisites: PH-GY 5553.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6633 STATISTICAL MECHANICS I (3 Credits)**
Equilibrium distributions. Relationships to laws of thermodynamics. Quantum effects. Maxwell-Boltzmann, Fermi-Dirac, Bose-Einstein distributions. Applications to bulk properties phenomena using Boltzmann transport equation. | Prerequisites: PH-UY 4364 or PH-GY 6673
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6643 STATISTICAL MECHANICS II (3 Credits)**
Micro-, macro-, and grand-canonical ensembles and principles of classical statistical mechanics. Condensation phenomena. Treatment of fluctuation and transport phenomena. Density matrix formalism of quantum statistical mechanics. Many-body problems. | Prerequisites: PH-GY 6633.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6673 QUANTUM MECHANICS I (3 Credits)**
*Typically offered occasionally*
Quantum mechanics with applications to atomic systems. The use of Schrodinger's equations. Angular momentum and spin. Semi-classical theory of field-matter interaction. | Prerequisites: MA-UY 2114, PH-UY 3234 equivalents.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 6683 QUANTUM MECHANICS II (3 Credits)**
*Typically offered occasionally*
Quantum mechanics with applications to atomic systems. The use of Schrodinger's equations. Angular momentum and spin. Semi-classical theory of field-matter interaction. | Prerequisites PH-GY 6673.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** No

**PH-GY 8013 Selected Topics in Advanced Physics (3 Credits)**
*Typically offered occasionally*
Current or advanced topics of particular interest to graduate students are examined. Subject matter is determined each year by students and faculty. The course may be given in more than one section. Consult department office for current offerings. | Note: this course is not offered every semester.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** Yes

**PH-GY 8023 Selected Topics in Advanced Physics (3 Credits)**
Current or advanced topics of particular interest to graduate students are examined. Subject matter is determined each year by students and faculty. The course may be given in more than one section. Consult department office for current offerings. | Note: this course is not offered every semester.
**Grading:** Grad Poly Graded
**Repeatable for additional credit:** Yes

**PH-GY 9531 GRADUATE SEMINAR I (1.5 Credits)**
*Typically offered occasionally*
Students presenting current topics in Physics in a seminar setting to other students and supervising faculty. Topics chosen by the student with guidance from faculty.
**Grading:** Grad Poly Pass/Fail
**Repeatable for additional credit:** No

**PH-GY 9541 GRADUATE SEMINAR II (1.5 Credits)**
*Typically offered occasionally*
Students presenting current topics in Physics in a seminar setting to other students and supervising faculty. Topics chosen by the student with guidance from faculty.
**Grading:** Grad Poly Pass/Fail
**Repeatable for additional credit:** No