PHYSICS (PHY)

Physics (PHY) Courses

PHY 5103. Classical Mechanics I. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Newtonian mechanics, Lagrangian and Hamiltonian dynamics, dynamics of rigid bodies, central force problem and orbital dynamics, symmetries and conservation laws, relativistic dynamics. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 5203. Electrodynamics I. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Electrostatics and magnetostatics; boundary value problems, Maxwell's equations; plane waves; wave guides diffraction; multipole radiation. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 5303. Statistical Mechanics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Thermodynamics, equilibrium statistical mechanics, Boltzmann equation and the collision operator, moments of the Boltzmann equations, the Navier-Stokes equations, introduction to nonequilibrium concepts, ensembles, classical and quantum gases, statistical physics of solids. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 5403. Quantum Mechanics I. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Linear vector spaces and linear operators. Postulates. Hilbert space formulation, the Schrödinger equation and one-dimensional problems, the hydrogen atom, symmetries, rotational invariance and angular momentum, spin, system with N-degrees of freedom. (Formerly PHY 6003. Credit cannot be earned for both PHY 5403 and PHY 6003.) This course has Differential Tuition. Course Fee: GS01 $90.

PHY 6103. Classical Mechanics II. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing, PHY 5103, or consent of instructor. Canonical transformations. Hamilton-Jacobi theory, nonlinear dynamics and chaos, instabilities, pattern formation, the three-body problem, dust, planets, and planetary systems, continuous systems. This course has Differential Tuition. Course Fee: GS01 $90; LRS1 $46.20; STSI $21.60.

PHY 6123. Plasma Physics and Magnetohydrodynamics (MHD). (3-0) 3 Credit Hours.
Prerequisite: Graduate standing, PHY 5103 and PHY 5203, or consent of instructor. Plasma equations, magnetohydrodynamics (MHD), waves and instabilities in two-fluid model, Vlasov and Fokker-Planck equations, Landau damping, turbulence in plasmas, radiation in plasmas, quasi-linear theory, wave-particle interaction, kinetic theory in space plasmas. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 6133. Introduction to Scientific Writing. (3-0) 3 Credit Hours.
Methods to overcome resistance to writing and approach to become productive scientific writers. Writing methods and techniques for manuscript, dissertation, thesis preparation. Fundamentals of funding proposal writing. Critical reading and reviewing. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 6203. Electrodynamics II. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing, PHY 5203, or consent of instructor. Relativistic formulation of Maxwell equations, radiation from moving charges, collisions of charged particles, radiation damping, introduction to plasmas, and magnetohydrodynamics. This course has Differential Tuition. Course Fee: GS01 $90; LRS1 $46.20; STSI $21.60.

PHY 6303. Quantum Mechanics II. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing, PHY 5303 and PHY 5403, or consent of instructor. Variational and WKB methods. Time-independent and time-dependent perturbation theory. Scattering theory. Path integration formulation. Introduction to relativistic quantum mechanics and the Dirac equation. This course has Differential Tuition. Course Fee: GS01 $90; LRS1 $46.20; STSI $21.60.

PHY 6313. Solid State Physics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Lattice vibrations and thermal properties of solids; band theory of solids, transport properties of metals and semiconductors; optical properties; magnetic properties; magnetic relaxation; superconductivity, elementary excitations: phonons, electrons, spin waves; interactions: phonon-phonon, electron-electron, electron-phonon, theory of metals and semiconductors, transport theory; and optical properties. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 6323. Nonlinear Optics and Lasers. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Topics to be discussed in this course will include Gaussian beam optics, interaction of electromagnetic radiation with matter, semi-classical laser theory, experimental laser systems, nonlinear optical susceptibilities, harmonic generation, wave mixing, electro-optic and acousto-optic effects, coherent transient effects, optical breakdown, and laser plasma interactions. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 6403. Fundamentals of Space Physics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. The Sun, solar models, solar and stellar winds, heliosphere and astrospheres, synthesis of elements in the Sun and stars, solar system composition and cosmic abundances, terrestrial magnetosphere, ionosphere and thermosphere, comparative planetary magnetospheres and atmospheres. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 6413. Fundamentals of Astronomy. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Photometry, stellar models, variable stars, white dwarfs, neutron stars, supernovae, cosmic rays, galaxies and galactic structure, and introduction to cosmology. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 6503. Mathematical Physics I. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Linear algebra, ordinary and partial differential equations, special functions, eigenvalue problems, complex analysis, group theory. This course has Differential Tuition. Course Fee: GS01 $90; LRS1 $46.20; STSI $21.60.

PHY 6513. Mathematical Physics II. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing, PHY 6503, or consent of instructor. Advanced topics in mathematical physics, topology, functional analysis, differentiable manifolds, Lie groups and algebras, and cohomology theory. This course has Differential Tuition. Course Fee: GS01 $90; LRS1 $46.20; STSI $21.60.

PHY 6523. Computational Physics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing, PHY 5103 and PHY 5203, or consent of instructor. Introduction to numerical techniques for solving physics problems, theory of computation and applications to various branches of physics, sample problems might include chaotic motion and nonlinear dynamics, plasmas, particle trajectories, Monte Carlo simulations, dynamical and statistical descriptions of many-body problems, hyperbolic, parabolic, and elliptic differential equations and solution techniques, stability analysis. This course has Differential Tuition. Course Fee: GS01 $90; LRS1 $46.20; STSI $21.60.

PHY 6623. Space Physics Laboratory. (1-6) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Vacuum systems, detectors, charged and neutral particle instruments, magnetic and electric field instruments, imagers (optical, UV, X-ray), instrument control and on-board data processing systems, spacecraft systems, data processing and analysis. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 6953. Independent Study. (0-0) 3 Credit Hours.
Prerequisite: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the degree. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 6961. Comprehensive Examination. (0-0) 1 Credit Hour.
Prerequisite: Approval of the appropriate Graduate Program Committee to take the Comprehensive Examination. Credit does not count toward total required hours for the M.S. degree. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination). This course has Differential Tuition. Course Fee: GS01 $30.

PHY 6983. Master's Thesis. (0-0) 3 Credit Hours.
Prerequisite: Permission from the Graduate Advisor of Record and thesis director. Thesis research preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7001. Directed Research. (0-0) 1 Credit Hour.
Prerequisite: Graduate standing or consent of instructor. The directed research course may involve either a laboratory or a theoretical problem. Normally a written report is required. This course may be repeated for credit, but not more than 6 hours will apply to the Master's degree, or 18 hours toward the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 $30.

PHY 7002. Directed Research. (0-0) 2 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. The directed research course may involve either a laboratory or a theoretical problem. Normally a written report is required. This course may be repeated for credit, but not more than 6 hours will apply to the Master's degree, or 18 hours toward the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 $60; LRS1 $30.80; STSI $14.4.

PHY 7003. Directed Research. (0-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. The directed research course may involve either a laboratory or a theoretical problem. Normally a written report is required. This course may be repeated for credit, but not more than 6 hours will apply to the Master's degree, or 18 hours toward the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7013. Research Seminar. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. Formal presentations of research by outside authorities, as well as current research seminars presented by faculty, visiting lecturers, and Ph.D. candidates. May be repeated for credit. The grade report for this course is either "CR" (satisfactory participation in the seminar) or "NC" (unsatisfactory participation in the seminar). This course may include a written component. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7101. Doctoral Research. (0-0) 1 Credit Hour.
Prerequisite: Permission from the Graduate Advisor of Record and dissertation director. Doctoral research and preparation in the chosen area of concentration. May be repeated for credit, but not more than 21 hours will apply to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 $30.

PHY 7102. Doctoral Research. (0-0) 2 Credit Hours.
Prerequisite: Permission from the Graduate Advisor of Record and dissertation director. Doctoral research and preparation in the chosen area of concentration. May be repeated for credit, but not more than 21 hours will apply to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 $60.

PHY 7103. Doctoral Research. (0-0) 3 Credit Hours.
Prerequisite: Permission from the Graduate Advisor of Record and dissertation director. Doctoral research and preparation in the chosen area of concentration. May be repeated for credit, but not more than 21 hours will apply to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7111. Doctoral Dissertation. (0-0) 1 Credit Hour.
Prerequisite: Permission from the Graduate Advisor of Record and dissertation director. Preparation and writing of the Doctoral dissertation. May be repeated for credit, but not more than 12 hours will apply to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 $30.

PHY 7112. Doctoral Dissertation. (0-0) 2 Credit Hours.
Prerequisite: Permission from the Graduate Advisor of Record and dissertation director. Preparation and writing of the Doctoral dissertation. May be repeated for credit, but not more than 12 hours will apply to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 $60; LRS1 $30.80; STSI $14.40.

PHY 7113. Doctoral Dissertation. (0-0) 3 Credit Hours.
Prerequisite: Permission from the Graduate Advisor of Record and dissertation director. Preparation and writing of the Doctoral dissertation. May be repeated for credit, but not more than 12 hours will apply to the Doctoral degree. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7403. Topics in Biophysics and Biomedical Physics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor; Topic 2 prerequisite: Completion of Topics class in Biophysical Chemistry. May be repeated for credit as topics vary. Topics may include the following: Topic 1: Biophysical Chemistry. Molecular structure of biological systems, energetics and entropy, relationship between structure and function of proteins and nucleic acids, structure prediction, role of hydration. Topic 2: Biomolecular Spectroscopy. Introduction to traditional and modern optical spectroscopic techniques to the study of biological molecules. Physical basis of absorption, fluorescence, circular dichroism, and FTIR spectroscopy. Introduction to time resolved techniques (time-correlated single photon counting, transient absorption spectroscopy). Photoacoustic calorimetry, near-field scanning optical microscopy, atomic force microscopy, small angle X-ray and neutron scattering. Topic 3: Biophotonics. Optical methodologies for imaging, diagnosis, and therapy in biology and medicine. Review of basic elements of optics and optical sources, lasers and light-emitting solid state devices, in the context of biomedical applications. Dosimetry, tissue optics, and the principles of laser-tissue interaction. Current medical uses of lasers, along with their scientific and technical foundations. Topic 4: Biomedical Physics. Use of fundamental physical laws and experimental techniques to numerous biomedical fields such as applications of lasers to ophthalmology, lithotripsy, and dentistry will be covered. Topic 5: Chemical Physics of Biophysical Processes. Transition and reaction pathways, transition state theory approach, transition path sampling approach, atomistic models of biomolecules and their visualizations, modern techniques of molecular dynamics. This course has Differential Tuition. Course Fee: GS01 $90; LRS1 $46.20; STSI $21.60.

PHY 7503. Topics in Experimental Physics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. May be repeated for credit as topics vary. Topics may include the following: Topic 1: Microstructural and Physical Property Characterizations. Diffraction physics, X-ray diffraction, electron microscopy, Raman spectroscopy, Rutherford Backscattering Spectrum, transport property characterization, microwave property measurements, dielectric and piezoelectric property measurements, and optical property measurements. Topic 2: Nonlinear Optics. Quantum optics, light scattering, ultra-fast photonics, fiber optics, lasers, electromagnetically-induced transparency, incoherent interactions, photonic band gaps. Topic 3: Waves in Complex Media. Transport in random and periodic materials and structures, closed and open systems, diffusion and wave localization, photonic band gaps. Topic 4: Physics of Thin Films and Applications. Vacuum physics and technology, fundamentals of physical and chemical depositions, kinetic and dynamic growth theory, rf/dc sputtering, MBE, etc. Topic 5: Molecular Physics and Fundamentals of Spectroscopy. Molecular electronic states, rotation vibration and potential curves of diatomic molecules, spectra of diatomic molecules, rotations and vibration of polyatomic molecules, electronic states of polyatomic molecules, spectra of polyatomic molecules, perturbations in molecular spectra, molecules and clusters, experimental techniques in molecular physics. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7603. Topics in Condensed Matter Physics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. May be repeated for credit as topics vary. Topics may include the following: Topic 1: Advanced Condensed Matter Physics. Second quantization for bosons and fermions, phonons and phonon-phonon interactions, Bloch electrons and band theory, density functional theory, electron-phonon interactions, superconductivity, critical phenomena, quantum fluids, spin glasses, quantum wells and quantum dots, quantum Hall effect. Topic 2: Nanophysics. Quantum nature of the nanostructure, quantum confinement in low-dimensional systems; single electron phenomena and electron states in nanotubes, interference in diffusive transport, nonequilibrium transport and nanodevices. Introduction to nanofabrication and cross-roads between nanotechnology and biotechnology; nanostructure transmission including quantized conductance and transport. Topic 3: Group Theory Applications in Condensed Matter. Tensors, matrices, point group, space group, and color group representations for symmetry in ferroelectric states and magnetic states, phase transitions, etc. Topic 4: Surface and Interface Physics. Thermodynamics of multicomponent systems for surface and interface segregation, crystal surface and interface structures and energy, adsorption and nucleation, electronic surface states, scanning probe microscopy, collective phenomena at interfaces, junction and heterostructures. Topic 5: Stochastic Processes in Physical and Chemical Systems. Stochastic Langevin dynamics, quantum Langevin dynamics, electronic transport and noise characteristics in nanostructures, diffusion and crystal growth, chemical reactions, statistical mechanics of laser systems. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7703. Topics in Space Physics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. May be repeated for credit as topics vary. Topics may include the following: Topic 1: Heliospheric Physics. The connection between the Sun and solar wind. Formation of transient events such as Coronal Mass Ejections (CMEs), co-rotating interaction regions, solar energetic particles, plasma waves, pickup ions and mass loading, anomalous cosmic rays, heliospheric boundaries and interaction with the local interstellar medium, energetic neutral atoms (ENAs). Topic 2: Magnetospheric Physics. Earth's bow shock, magnetopause, magnetotail, plasma sheet, ring current and plasmasphere. Current systems, reconnection, magnetospheric storms and substorms, ionospheric interactions, aurora borealis. The geocorona and ENA emissions. Topic 3: Data Analysis Techniques in Space Physics. Space instrumentation and datasets, measurement processes, performance and instrument limitations, data interpretation, statistical data analysis, time series data analysis, Fourier wavelet analysis, correlation and regression, multi-spacecraft data analysis, minimum variance analysis, numerical modeling and simulations. Topic 4: Planetary Science. Planets, planetary atmospheres, and planetary magnetospheres. Planetary formation, composition, dynamics, end evolution of the solar system. Comparative planetology, interplanetary dust, comets, asteroids, and Kuiper belt objects. Extra-solar planets, astrobiology, exobiology, and the search for life beyond Earth. This course has Differential Tuition. Course Fee: GS01 $90; DL01 $75.

PHY 7803. Topics in Theoretical Physics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. May be repeated for credit as topics vary. Topics may include the following: Topic 1: General Relativity. Special relativity, tensor analysis, Einstein field equations, the Schwarzschild solution, Newtonian limit, orbits, black holes, gravitational waves. Introduction to cosmology. Topic 2: Advanced Condensed Matter Physics. Quantum theory of many-body systems, Green's functions at zero and finite temperatures, electron-phonon interactions. Topic 3: Introduction to Quantum Field Theory. Canonical field quantization, path integral quantization, Feynman diagrams, basics of renormalization, introduction to quantum electrodynamics. Topic 4: Gauge Theories. Basics of field quantization and Feynman rules, renormalization group, quantum electrodynamics, quantum chromodynamics spontaneous symmetry breaking, electroweak theory. Additional topics may include topological solitons, effective Lagrangians, unified theories, and introduction to supersymmetry. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7903. Topics in Astrophysics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. May be repeated for credit as topics vary. Topics may include the following: Topic 1: Stellar Astrophysics. Advanced discussion of one or more topics from: stellar structure, physics of accretion disks, physics of star formation and the interstellar medium, structure of collapsed stars and supernova remnants, radiative transport and photoionization. Topic 2: Galactic and Extragalactic Astrophysics. Density wave theory and structure of spiral galaxies. Active galaxies, clusters of galaxies, large-scale structure. Topic 3: Cosmology. Basics of general relativity. The cosmological principle and Friedmann models, thermal history of the universe, structure formation, the cosmic microwave background, baryonic structures formation, dark matter and dark energy, particle physics and the early universe, inflationary cosmology. Topic 4: Astrobiology. Conditions necessary for life, extra-solar planets, discovery strategies and techniques for extrasolar planets and results to date. Basic stellar evolution and nucleosynthesis impacts on development of life on Earth. Topic 5: Astrophysics Fluid Dynamics. Lagrangian, Eulerian, and smooth-particle formulations, rotation, vorticity, circulations, convection, magnetohydrodynamics, shocks, stellar rotation, photon fluid dynamics, relativistic fluids, mass transfer. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7973. Special Topics in Physics. (3-0) 3 Credit Hours.
Prerequisite: Graduate standing or consent of instructor. An organized course offering the opportunity for specialized study which may not normally or not often be available as part of the regular course offerings. May be repeated for credit as topics vary. This course has Differential Tuition. Course Fee: GS01 $90.

PHY 7983. Current Topics in Physics. (3-0) 3 Credit Hours.
Research and critical analysis of the relevant current research literature in relevant Physics topics. Analysis and discussion of ongoing research projects. May be repeated for credit as topics vary. This course has Differential Tuition. Course Fee: GS01 $90.