

## **PHY Physics**

Note: It is assumed that all prerequisites include, in addition to any specific course listed, the phrase "or equivalent," or "consent of instructor."

### **PHY 105 PHYSICS AND ASTRONOMY TODAY. (1)**

This course is intended for freshmen and others who wish to find out what physics is and how it relates to other fields of study. It is especially useful for physics majors or for those considering physics as a major or minor. One demonstration lecture per week presented by various members of the physics faculty. May only be taken on a pass/fail basis.

### **PHY 120 HOW THINGS WORK. (3)**

The close relationship between physical science, technology and our everyday lives will be illuminated by examination of the technology we purchase and use and by observations of natural phenomena we can make using only the informed mind and eye.

### **PHY 130 PHYSICS OF ENERGY. (3)**

Energy sources, such as fossil fuels; nuclear, solar and hydro electric power are discussed in the context of the basic laws of physics which govern their uses and limitations. Concepts covered include kinetic and potential energy, heat, radiation, and mass-energy equivalence. Credit is not given to students who already have credit for PHY 201, 211, or 231.

### **PHY 151 INTRODUCTION TO PHYSICS. (3)**

A lecture demonstration course covering the mechanics of solids, liquids, gases, heat, and sound. Credit is not given to students who already have credit for PHY 201, 211 or 231. Prereq: Two years of high school algebra or MA 108R.

### **PHY 152 INTRODUCTION TO PHYSICS. (3)**

A lecture demonstration course covering electricity, magnetism, optics, atomic and nuclear physics. Credit is not given to students who already have credit for PHY 203, 213 or 232. Prereq: Two years of high school algebra or MA 108R.

### **PHY 153 LABORATORY FOR MIDDLE SCHOOL TEACHERS. (1)**

Laboratory to accompany PHY 151-152 with experiments and exercises designed especially for students preparing to be middle school teachers. Laboratory, two hours per week. Prereq: PHY 151; coreq: PHY 152.

### **PHY 160 PHYSICS AND ASTRONOMY FOR ELEMENTARY TEACHERS. (3)**

Course sequence (GLY 160-PHY 160 six credit hours) in physical science for prospective elementary teachers. The sequence addresses basic concepts of earth science, astronomy and physics appropriate for elementary teachers and is taught with an emphasis on inquiry-based, laboratory activities. PHY 160 includes the basics of the motion of objects, astronomy by sight, electrical circuits, magnetism and the behavior of light. Lecture, one hour; laboratory, five hours per week.

#PHY 170 BLACK HOLES AND TIME TRAVEL. (3)

The course will discuss basic concepts in physics prior to the 20th century and the backdrop to the emergence of the Special Theory of Relativity. Elements of Special and General Relativity will be discussed at a non-technical level. These concepts will be used to explain how very massive stars inevitably collapse to form black holes. Their observational signatures will be discussed. The work of Hawking leading to the prediction that black holes emit faint radiation will be explained. Finally, the possibility of existence of wormholes leading to time travel will be explored.

PHY 210 SPECIAL LABORATORY  
FOR GENERAL PHYSICS PHY 201. (1)

Special laboratory for students who have completed PHY 201 and later determine that they need an accompanying laboratory. Laboratory, two hours per week. Prereq: PHY 201.

PHY 211 GENERAL PHYSICS. (5)

First part of a two-semester survey of classical and modern physics, focusing on the motion of solids and fluids as governed by Newton's Laws and by the conservation laws of energy, momentum, and angular momentum. Lecture, two hours; recitation, two hours; laboratory, two hours. Credit is not given to students who already have credit for PHY 231 and 241. Prereq: A working knowledge of algebra and trigonometry as obtainable in MA 109 and MA 112, or as demonstrated by an ACT math score of 25 or higher.

PHY 212 SPECIAL LABORATORY  
FOR GENERAL PHYSICS PHY 203. (1)

Special laboratory for students who have completed PHY 203 and later determine that they need an accompanying laboratory. Laboratory, two hours per week. Prereq: PHY 203.

PHY 213 GENERAL PHYSICS. (5)

Continuation of PHY 211, covering electrostatics, de circuits, magnetism, Maxwell's Equations, electromagnetic radiation, light and some modern physics. Lecture, two hours; recitation, two hours; laboratory, two hours. Credit is not given to students who already have credit for PHY 232 and 242. Prereq: PHY 211 or equivalent.

PHY 228 OPTICS, RELATIVITY AND THERMAL PHYSICS. (3)

A lecture and problems course covering the principles of geometrical optics, special relativity, and thermal physics. Prereq or concur: MA 114.

PHY 231 GENERAL UNIVERSITY PHYSICS. (4)

First part of a two-semester survey of classical physics. Consequences of the principles of mechanics are developed conceptually, analytically and quantitatively. Lecture, three hours; recitation, one hour per week. Prereq or concur: MA 113.

PHY 232 GENERAL UNIVERSITY PHYSICS. (4)

A general course covering electricity, magnetism, electromagnetic waves and physical optics. Lecture, three hours; recitation, one hour per week. Prereq: PHY 231; concur: MA 213.

PHY 241 GENERAL UNIVERSITY  
PHYSICS LABORATORY. (1)

A laboratory course offering experiments in mechanics and heat, framed in a small group environment that requires coordination and team work in the development of a well-written lab report. Prereq or concur: PHY 231.

PHY 242 GENERAL UNIVERSITY  
PHYSICS LABORATORY. (1)

A laboratory course offering experiments in electricity, magnetism, and light, framed in a small group environment that requires coordination and team work in the development of a well written lab report. Prereq: PHY 241; concur: PHY 232.

PHY 306 THEORETICAL METHODS OF PHYSICS. (3)

A lecture and problems course on the applications in physics of vector calculus, Fourier series and transforms, special functions and asymptotic forms. Prereq or concur: MA 214.

PHY 335 DATA ANALYSIS FOR PHYSICISTS. (1)

An integrated lecture and demonstration computational laboratory course in the theory and techniques of data analysis and error propagation. An emphasis is given to applications common to physical sciences: curve fitting, statistical methods of data analysis, systematic uncertainties, and both independent and correlated errors in several variables. Prereq: PHY 242. (Same as STA 335.)

PHY 361 PRINCIPLES OF MODERN PHYSICS. (3)

An introduction to the foundations of quantum mechanics and selected topics in atomic, nuclear, particle, solid state, and statistical physics. Prereq: MA 213; PHY 232 or, with consent of instructor, PHY 213.

PHY 395 INDEPENDENT WORK IN PHYSICS. (1-3)

Students may select an approved topic for study under the direction of a faculty member. May be repeated to a maximum of 12 credits. Prereq: Major and a standing of 3.0 in the department.

PHY 401G SPECIAL TOPICS IN PHYSICS AND  
ASTRONOMY FOR ELEMENTARY, MIDDLE SCHOOL  
AND HIGH SCHOOL TEACHERS. (1-4)

Selected topics in physics and astronomy of special interest to teachers will be discussed. When the course is offered, a specific title with specific credits, the number of hours in lecture-discussion and laboratory will be announced. Lecture/discussion, two-four hours; laboratory, zero-four hours. May be repeated to a maximum of eight credits. Prereq: Open only to elementary, middle school and high school teachers.

PHY 402G ELECTRONIC INSTRUMENTATION  
AND MEASUREMENTS. (3)

Elementary treatment of electronic circuits emphasizing laboratory work. Topics include AC circuits, filters, theory and operation of transistors and other semiconductor devices and a simple treatment of operational amplifiers. Lecture, two hours per week; laboratory, three hours per week. Prereq: PHY 242 or EE 305 or consent of instructor. (Same as EE 402G.)

PHY 404G MECHANICS. (3)

A lecture and problem course covering the fundamental laws of mechanics. Topics include Newton's Laws, Kepler's Laws, oscillatory motion and an introduction to Lagrangian methods. Prereq: PHY 232, or with permission of Director of Undergraduate Studies, PHY 213; concur: MA 214.

PHY 416G ELECTRICITY AND MAGNETISM. (3)

First of two lecture and problem courses covering: the theory of electrostatic fields in the presence of conductors and dielectric materials, magnetic fields due to steady currents in the presence of magnetic materials, electromagnetic induction, and electromagnetic fields due to time-varying currents. Prereq: PHY 308, MA 214. MA 432G recommended.

PHY 417G ELECTRICITY AND MAGNETISM. (3)

Second of two lecture and problem courses covering: the theory of electrostatic fields in the presence of conductors and dielectric materials, magnetic fields due to steady currents in the presence of magnetic materials, electromagnetic induction, and electromagnetic fields due to time-varying currents. Prereq: PHY 416G.

PHY 422 COMPUTATIONAL PHYSICS LABORATORY (3)

An introductory laboratory and lecture course covering the application of numerical methods to the solution of problems encountered in mechanics and electrostatics. Lecture, one hour; laboratory, four hours per week. Prereq: PHY 404G or equivalent.

PHY 472G INTERACTION OF RADIATION WITH MATTER. (3)

Basic aspects of the interaction of ionizing radiation with matter. Bohr atom, atomic spectra, radioactivity, energetics of decay. Sources of radiation, penetration of charged particles, electromagnetic radiation, and neutrons through matter; excitation and ionization processes; selected nuclear reactions; basic radiation detection and dosimetry. Prereq: PHY 213 or 232; MA 114 (may be taken concurrently); or equivalent. (Same as RM 472G.)

PHY 477 PHYSICS AND ASTRONOMY SEMINAR. (1)

Reports and discussion on student research projects and research topics from the literature of physics and astronomy. May be repeated to a maximum of two credits. Prereq: PHY 361, COM 199 or equivalent.

PHY 495 SENIOR THESIS. (3)

With mentoring from faculty member(s), advanced undergraduate students propose and execute an independent research project. A final report will be written and a presentation will be made in a forum such as a professional meeting, a student group such as a regional or national Society of Physics Students meeting, or a small group of faculty. May be repeated to a maximum of six credits. Prereq: Advanced standing.

PHY 504 ADVANCED MECHANICS. (3)

A continuation and extension of PHY 404G. Includes dynamics of a particle, rigid bodies, Lagrange's equations, constrained motions, and oscillations. Prereq: PHY 404G, MA 214.

PHY 506 METHODS OF THEORETICAL PHYSICS I. (3)

The course and its sequel (MA/PHY 507) are designed to develop, for first-year graduate students, familiarity with the mathematical tools useful in physics. Topics include curvilinear coordinates, infinite series, integrating and solving differential equations of physics, and methods of complex variables. Work with Green's functions, eigenvalues, matrices and the calculus of variations are included as a part of MA/PHY 506 and 507. Prereq: PHY 404G or equivalent. (Same as MA 506.)

PHY 507 METHODS OF THEORETICAL PHYSICS II. (3)

Continuation of MA/PHY 506. Fourier and Laplace Transforms, the special functions (Bessel, Elliptic, Gamma, etc.) are described. Work with Green's functions, eigenvalues, matrices and the calculus of variations are included as a part of MA/PHY 506 and 507. Prereq: MA/PHY 506. (Same as MA 507.)

PHY 520 INTRODUCTION TO QUANTUM MECHANICS. (3)

A lecture and problem course providing an introduction to the concepts and formalism of quantum mechanics. Primary emphasis is on the Schrodinger equation and its applications including the simple harmonic oscillator, the square well, the hydrogen atom, orbital and spin angular momenta, matrix representation of two level systems. Prereq: PHY 361, MA 214; recommended: MA 322.

PHY 522 THERMODYNAMICS  
AND STATISTICAL PHYSICS. (3)

Temperature, heat, and entropy, and the Laws of Thermodynamics, as applied to simple systems. Introduction to statistical mechanics and the description of thermodynamic quantities in terms of ensemble averages. Prereq: PHY 361 and MA 214.

PHY 524 SOLID STATE PHYSICS. (3)

Introductory solid state physics with emphasis on the properties of electrons in crystals; crystal structure, crystal diffraction, reciprocal lattice, lattice vibrations and phonons, free electron theory, energy bands in solids, semiconductors. Prereq: PHY 520, or consent of instructor. Engineering standing required for EE 524. (Same as EE 524.)

PHY 525 CONDENSED MATTER PHYSICS. (3)

Optical, magnetic, and transport properties of metals, semiconductors, superconductors, and dielectrics; cooperative phenomena and phase transitions. Prereq: PHY 524 or consent of instructor.

PHY 530 EXPERIMENTAL PHYSICS:  
OPTICS AND SPECTROSCOPY. (2)

An advanced laboratory dealing with the wave nature of light, optical systems, interference, diffraction, polarization and spectroscopy. Prereq: PHY 335, PHY 361, and PHY 308.

PHY 535 EXPERIMENTAL PHYSICS:  
ATOMIC AND NUCLEAR. (2)

An advanced laboratory course in which students will study atoms and nuclei with the goals of both illustrating the quantum mechanical behavior of these systems and learning modern laboratory techniques. Measurements include: the charge and mass of the electron, Planck's constant, interference of x-rays and matter waves, Bragg and Compton scattering, and nuclear decay correlations. Four hours of laboratory per week. Prereq: PHY 361, PHY 335.

**PHY 545 RADIATION HAZARDS AND PROTECTION. (3)**

An analysis of common radiation hazards encountered in medicine, research, industry, and the environment. Regulations and procedures for the safe use of ionizing and nonionizing radiations. Lecture, two hours; laboratory, two and one-half hours. Prereq: PHY/RM 472G or consent of instructor. (Same as RM/RAS 545.)

**PHY 546 GENERAL MEDICAL  
RADIOLOGICAL PHYSICS. (3)**

The uses and dosimetric aspects of radiation in medicine will be analyzed, including many basic applications in the fields of diagnostic radiology physics, therapy physics, and nuclear medical physics. Prereq or concur: RM/PHY 472G or consent of instructor. (Same as RM/RAS 546.)

**PHY 554 FUNDAMENTALS OF ATOMIC PHYSICS. (3)**

A continuation of introductory quantum mechanics with application to atomic systems. Topics include angular momentum, perturbation theory, variational principles, interaction of radiation with matter, atomic spectra and the Zeeman and Stark effects. Prereq: PHY 520.

**PHY 555 FUNDAMENTAL NUCLEAR PHYSICS. (3)**

Topics covered include nuclear systematics, the nucleon-nucleon-interaction, nuclear models, radioactivity, nuclear reactions, fission and fusion. Prereq: PHY 520.

**PHY 556 FUNDAMENTAL PARTICLE PHYSICS. (3)**

Introduction to elementary particle physics. Topics include: particle interactions and families, the quark model, symmetries and conservation laws, particle reactions and decays, quark dynamics, and elements of quantum chromodynamics and electroweak interactions. Prereq: PHY 520.

**PHY 567 INTRODUCTION TO LASERS AND MASERS. (3)**

Basic principles of laser action, atomic transitions; population inversion; two- and three-level systems; optical resonators; pumping methods; applications. Prereq: Engineering upper division status or consent of instructor. (Same as EE 567.)

**PHY 570 SEMINAR ON TEACHING PHYSICS. (1)**

A seminar course for teaching assistants focused on developing the art and science of teaching physics. Journal articles, books and other texts will be studied to serve as sources of discussion about the teaching and learning activities in the Department of Physics and Astronomy. Prereq: Consent of instructor.

**PHY 571 SEMINAR ON TEACHING  
PHYSICS LABORATORIES. (1)**

A seminar course for teaching assistants focused on developing the art and science of teaching physics laboratories. Journal articles, books and other texts will be studied to serve as sources of discussion about the teaching and learning activities in the laboratory classes in the Department of Physics and Astronomy. Prereq: Consent of instructor.

PHY 591 ASTROPHYSICS I - STARS. (3)

The physics of stars from star formation to stellar death. Topics include stellar structure and evolution, energy generation and transport, the later stages of stellar evolution and stellar remnants. Prereq: PHY 361, PHY 416G, PHY 417G or consent of instructor. (Same as AST 591.)

PHY 592 ASTROPHYSICS II – GALAXIES  
AND INTERSTELLAR MATERIAL. (3)

The physics of galaxies and of the interstellar medium. Topics include galaxy formation, evolution and interaction, phases of the interstellar medium, and physical processes in the interstellar medium. Prereq: PHY 361, PHY 416G, PHY 417G or consent of instructor. (Same as AST 592.)

PHY 600 SELECTED TOPICS  
IN ADVANCED PHYSICS. (2-3)

An advanced seminar course on topics related to departmental research programs. Topics may include astrophysics, atomic physics, condensed matter physics, nuclear physics and particle physics. May be repeated to a maximum of nine hours. Prereq: Consent of instructor.

PHY 611 ELECTROMAGNETIC THEORY I. (3)

A lecture and problem course treating electrostatics, boundary conditions, potential problems, energy in electric and magnetic fields, magnetic materials and Maxwell's equations. Prereq: PHY 416G; MA 214.

PHY 613 ELECTROMAGNETIC THEORY II. (3)

Continuation and extension of PHY 611. Includes theory of electromagnetic waves and applications to optical phenomena and radiation. Special theory of relativity and the covariant treatment of Maxwell's equations will be discussed. Prereq: PHY 611.

PHY 614 QUANTUM MECHANICS I. (3)

A lecture and problem course dealing with the description of quantum systems in the forms of wave mechanics, matrix mechanics and state vectors. Also includes angular momentum and its addition, and approximation methods for bound states. Prereq: PHY 520.

PHY 615 QUANTUM MECHANICS II. (3)

Continuation of PHY 614 covering time dependent perturbation theory, symmetry and invariance principles, and elementary scattering theory including the method of partial waves. Prereq: PHY 614.

PHY 616 QUANTUM FIELD THEORY I. (3)

An introduction to field theory and many-body theory. Topics include path integral quantization, second quantization, relativistic field theory of bosons and fermions, Green's function and

perturbation theory, field theories on the lattice, renormalization of scalar fields and applications to critical phenomena. Prereq: PHY 615, PHY 632.

PHY 624 CONDENSED MATTER THEORY. (3)

Electron band theory, lattice dynamics, electron-phonon and electron-electron interactions, superconductivity and superfluidity, Fermi liquid theory. Prereq: PHY 524, 614, 632.

PHY 630 TOPICS IN NUCLEAR AND INTERMEDIATE ENERGY PHYSICS (Subtitle required). (3)

A course in nuclear physics, hadron physics and particle physics. Emphasis is placed on topics related to departmental research activities at Jefferson laboratory and elsewhere. Such topics include study of the structure and interactions of hadrons in terms of quarks and gluons. They also include low energy tests of Standard Model predictions. (PHY 630 may be repeated to a maximum of six hours when taken under different subtitles.) Prereq: PHY 629.

PHY 632 STATISTICAL MECHANICS. (3)

A lecture and problem course dealing with the thermal properties of matter from the standpoint of statistical mechanics. Topics include thermodynamic properties, perfect gases, and Fermi-Dirac statistics. Prereq: PHY 504, 520, 522.

PHY 639 PHYSICAL PROCESSES IN ASTROPHYSICS. (3)

A lecture and problem course covering the physical processes encountered in astrophysics. The topics covered will include micro-physical processes in stellar atmospheres and the interstellar medium, high-energy astrophysics, and basic hydrodynamics and shock waves. Prereq: PHY/AST 592 or consent of instructor. (Same as AST 639.)

PHY 716 QUANTUM FIELD THEORY II. (3)

A continuation of PHY 616. Topics include approximation methods in many body theory and applications to condensed matter and nuclear systems, quantum electrodynamics, radiative corrections, Higgs mechanism and applications to particle physics and superconductivity, introduction to non-Abelian gauge fields and the standard model. Prereq: PHY 616.

PHY 748 MASTER'S THESIS RESEARCH. (0)

Half-time to full-time work on thesis. May be repeated to a maximum of six semesters. Prereq: All course work toward the degree must be completed.

PHY 749 DISSERTATION RESEARCH. (0)

Half-time to full-time work on dissertation. May be repeated to a maximum of six semesters. Prereq: Registration for two full-time semesters of 769 residence credit following the successful completion of the qualifying exams.

PHY 768 RESIDENCE CREDIT FOR THE MASTER'S DEGREE. (1-6)

May be repeated to a maximum of 12 hours.

PHY 769 RESIDENCE CREDIT

FOR THE DOCTOR'S DEGREE. (0-12)

May be repeated indefinitely.

PHY 770 COLLOQUIUM. (1)

A weekly meeting of the staff and advanced students for the discussion of recent developments in physics and of work in progress in the department. Credit is given to those who satisfactorily present papers. May be repeated to a maximum of eight credits.

PHY 781 INDEPENDENT WORK IN PHYSICS. (1-9)

May be repeated to a maximum of 18 credits. Prereq: Graduate standing in Physics.

PHY 790 RESEARCH IN PHYSICS. (3)

May be repeated to a maximum of six credits.

PHY 791 RESEARCH IN PHYSICS. (5)

May be repeated to a maximum of 10 credits.