**Physics (PHY)**

**Courses**

**PHY 005 Concepts In Physics 4 Credits**
Fundamental discoveries and concepts of physics and their relevance to current issues and modern technology. For students not intending to major in science or engineering. Lectures, demonstrations, group activities, and laboratories using modern instrumentation and computers. This is a non-calculus course; no previous background in physics is assumed. Three class meetings and one laboratory period per week.

*Attribute/Distribution: NS*

**PHY 009 Introductory Physics I Completion 1-2 Credits**
For students who have Advanced Placement or transfer credit for 2 or 3 credits of PHY 11. The student will be scheduled for the appropriate part of PHY 11 to complete the missing material. The subject matter and credit hours will be determined by the Physics Department for each student. Students with AP Physics C credit for mechanics will take the thermodynamics and kinetic theory part of PHY 11 for one credit. Consent of department required.

*Prerequisites:* MATH 021 or MATH 031 or MATH 051 or MATH 076 or MATH 075

*Can be taken Concurrently:* MATH 021, MATH 031, MATH 051, MATH 076, MATH 075

**PHY 010 General Physics I 4 Credits**
Statics, dynamics, conservation laws, thermodynamics, kinetic theory of gases, fluids. Primarily for architecture, biological science, earth and environmental science students.

*Prerequisites:* MATH 021 or MATH 031 or MATH 051 or MATH 076 or MATH 075

*Can be taken Concurrently:* MATH 021, MATH 031, MATH 051, MATH 076, MATH 075

**PHY 011 Introductory Physics I 4 Credits**
Kinematics, frames of reference, laws of motion in Newtonian theory and in special relativity, conservation laws, as applied to the mechanics of mass points; temperature, heat and the laws of thermodynamics; kinetic theory of gases. Two lectures and two recitations per week.

*Prerequisites:* MATH 021 or MATH 031 or MATH 051 or MATH 076 or MATH 075

*Can be taken Concurrently:* MATH 021, MATH 031, MATH 051, MATH 076, MATH 075

**PHY 012 Introductory Physics Laboratory I 1 Credit**
A laboratory course taken concurrently with PHY 10 or 11. Experiments in mechanics, heat, and DC electrical circuits. One three-hour laboratory period per week.

*Prerequisites:* PHY 010 or PHY 011

*Can be taken Concurrently:* PHY 010, PHY 011

**PHY 013 General Physics II 3 Credits**
A continuation of PHY 10, primarily for biological science and earth and environmental science students. Electrostatics, electromagnetism, light, sound, atomic physics, nuclear physics, and radioactivity.

*Prerequisites:* (PHY 010 or PHY 011) and (MATH 021 or MATH 031 or MATH 051)

*Can be taken Concurrently:* MATH 021, MATH 031, MATH 051

**PHY 019 Introductory Physics II Completion 1-2 Credits**
For students who have Advanced Placement or transfer credit for 2 or 3 credits of PHY 21. The student will be scheduled for the appropriate part of PHY 21 to complete the missing material. The subject matter and credit hours will be determined by the Physics Department for each student. Students with AP Physics C credit for electricity and magnetism will take the optics and modern physics part of PHY 21 for one credit. Consent of instructor required.

*Prerequisites:* (PHY 010 or PHY 011) and (MATH 022 or MATH 032 or MATH 052)

*Attribute/Distribution: NS*

**PHY 021 Introductory Physics II 4 Credits**
A continuation of PHY 11. Electrostatics and magnetostatics; DC circuits; Maxwell’s equations; waves; physical and geometrical optics; introduction to modern physics. Two lectures and two recitations per week. May not be taken by students who have previously completed PHY 23.

*Prerequisites:* (PHY 010 or PHY 011) and (MATH 022 or MATH 032 or MATH 052)

**PHY 022 Introductory Physics Laboratory II 1 Credit**
A laboratory course to be taken concurrently with PHY 13 or 21. One three-hour laboratory period per week.

*Prerequisites:* (PHY 012) and (PHY 021 or PHY 013 or PHY 023)

*Can be taken Concurrently:* PHY 021, PHY 013, PHY 023

**PHY 023 Introductory Physics II with Relativity 4 Credits**
A version of PHY 021 for students interested in majoring in physics or astrophysics, or students with a strong interest in related fields. It is well-suited for students with PHY 011 AP credit, or with PHY 021 AP credit who wish to replace that course with a more sophisticated version. The theory of electricity and magnetism is developed from a modern point of view, emphasizing the utility of electric and magnetic fields in the context of special relativity.

*Prerequisites:* (PHY 010 or PHY 011) and (MATH 022 or MATH 032 or MATH 052)

*Attribute/Distribution: NS*

**PHY 031 Introduction to Quantum Mechanics 3 Credits**
Experimental basis and historical development of quantum mechanics; the Schroedinger equation; one-dimensional problems; angular momentum and the hydrogen atom; many-electron systems; spectra; selected applications. Three lectures per week.

*Prerequisites:* (PHY 013 or PHY 021 or PHY 023) and MATH 205

**PHY 032 Introductory Physics Laboratory II 1 Credit**
A laboratory course taken concurrently with PHY 13 or 21. One three-hour laboratory period per week.

**PHY 102 Introductory Physics Laboratory I 1 Credit**
A laboratory course taken concurrently with PHY 10 or 11. Experiments in mechanics, heat, and DC electrical circuits. One three-hour laboratory period per week.

*Prerequisites:* PHY 010 or PHY 011

*Can be taken Concurrently:* PHY 010, PHY 011

**PHY 103 General Physics II 3 Credits**
A continuation of PHY 10, primarily for biological science and earth and environmental science students. Electrostatics, electromagnetism, light, sound, atomic physics, nuclear physics, and radioactivity.

*Prerequisites:* (PHY 010 or PHY 011) and (MATH 021 or MATH 031 or MATH 051)

**PHY 120 Physics of Medical Imaging: Ultrasound and Radiography 2 Credits**
An introduction and analysis of the physical principles and effects that underlay medical imaging techniques such as those using ultrasound, x-rays or other high-energy radiation. The course will serve as an introduction to intermediate quantum physics and electromagnetism concepts and discuss the effects and data collection techniques that ultimately allow to create an image that a physician can interpret for clinical purposes.

*Prerequisites:* PHY 021 or PHY 013

*Attribute/Distribution: NS*

**PHY 121 Physics of Medical Imaging: Ultrasound and Radiography, Supplement 1 Credit**
A supplementary course taken concurrently with PHY 120 [Physics of Medical Imaging: Ultrasound and Radiography]. Themes pertaining ultrasound and radiography will be covered more in depth, like for example: SPECT- and PET-scans, Beam forming and phased arrays, Dosimetry, Image formation (Radon transform and projection slice theorem).

*Prerequisites:* PHY 021 or PHY 013

**PHY 205 Physical Science 3 Credits**
A continuation of PHY 10, for students majoring in science or engineering. Lectures, demonstrations, group activities, and laboratories using modern instrumentation and computers. This is a non-calculus course; no previous background in physics is assumed. Three class meetings and one laboratory period per week.

*Attribute/Distribution: NS*

**PHY 206 Physical Science Laboratory 1 Credit**
A laboratory course taken concurrently with PHY 205. Experiments in mechanics, heat, and DC electrical circuits. One three-hour laboratory period per week.

*Prerequisites:* PHY 010 or PHY 011

*Can be taken Concurrently:* PHY 010, PHY 011

**PHY 210 Introductory Physics Laboratory I 1 Credit**
A laboratory course to be taken concurrently with PHY 21. Two lectures and two recitations per week.

*Prerequisites:* MATH 021 or MATH 031 or MATH 051 or MATH 076 or MATH 075

**PHY 211 Introductory Physics II 4 Credits**
A continuation of PHY 20. Electrostatics and magnetostatics; DC circuits; Maxwell’s equations; waves; physical and geometrical optics; introduction to modern physics. Two lectures and two recitations per week.

**PHY 212 Introductory Physics Laboratory II 1 Credit**
A laboratory course to be taken concurrently with PHY 21. Two lectures and two recitations per week.

**PHY 213 Introductory Physics III 4 Credits**
A continuation of PHY 21, primarily for biological science and earth and environmental science students. Electrostatics, electromagnetism, light, sound, atomic physics, nuclear physics, and radioactivity.

**PHY 220 Introductory Physics IV 4 Credits**
A continuation of PHY 21, primarily for biological science and earth and environmental science students. Electrostatics, electromagnetism, light, sound, atomic physics, nuclear physics, and radioactivity.

**PHY 221 Introductory Physics V 4 Credits**
A continuation of PHY 21, primarily for biological science and earth and environmental science students. Electrostatics, electromagnetism, light, sound, atomic physics, nuclear physics, and radioactivity.
PHY 122 Physics of Medical Imaging: Magnetic Resonance 2
Credits
An introduction and analysis of the physical principles and effects
that underlay medical imaging techniques based on nuclear magnetic
resonance, such as MRI (Magnetic Resonance Imaging). The course
will serve as an introduction to intermediate/advanced quantum
physics and electromagnetism concepts and discuss the effects and
data collection techniques that ultimately allow to create an image that
a physician can interpret for clinical purposes.
Prerequisites: PHY 021 or PHY 013
Attribute/Distribution: NS

PHY 123 Physics of Medical Imaging: Magnetic Resonance,
Supplement 1 Credit
A supplementary course taken concurrently with PHY 122 [Physics
of Medical Imaging: Magnetic Resonance]. Themes pertaining
magnetic resonance will be covered more in depth, like for example:
Fourier analysis in spectroscopy, Advanced techniques in magnetic
resonance (fMRI, DTI, mMRI, ...).
Prerequisites: PHY 021 or PHY 013
Corequisites: PHY 122
Attribute/Distribution: NS

PHY 212 Electricity and Magnetism I 3 Credits
Electrostatics, magnetostatics, and electromagnetic induction.
Prerequisites: (PHY 021 or PHY 013 or PHY 023) and MATH 205
Can be taken Concurrently: MATH 205
Attribute/Distribution: NS

PHY 213 Electricity and Magnetism II 3 Credits
Maxwell’s equations, Poynting’s theorem, potentials, the wave
equation, waves in vacuum and in materials, transmission and
reflection at boundaries, guided waves, dispersion, electromagnetic
field of moving charges, radiation, Lorentz invariance and other
symmetries of Maxwell’s equations.
Prerequisites: PHY 212

PHY 215 Classical Mechanics I 4 Credits
Kinematics and dynamics of point masses with various force
laws; conservation laws; systems of particles; rotating coordinate
systems; rigid body motions; topics from Lagrange’s and Hamilton’s
formulations of mechanics; continuum mechanics.
Prerequisites: (PHY 021 or PHY 013 or PHY 023) and MATH 205
Can be taken Concurrently: MATH 205
Attribute/Distribution: NS

PHY 220 Advanced Physics Laboratory I 3 Credits
In a lab/lecture format, students learn basic elements needed for
experimental, observational and computational work in physics,
astrophysics and other technical areas. This course and its
continuation as PHY 221 include topics such as electronics, optics,
vacuum systems, data acquisition and analysis, curve fitting, scientific
computing, interfacing of computers to experiments, and modern
machining. These methods will be utilized in the examination of
various physical systems, e.g., atomic and molecular spectroscopy,
astronomical observations, condensed-matter phenomena, and
others.
Prerequisites: (PHY 021 or PHY 023) and PHY 022 and CSE 002
Attribute/Distribution: NS

PHY 221 Advanced Physics Laboratory II 2 Credits
This is a continuation of PHY 220.
Prerequisites: (PHY 021 or PHY 023) and PHY 022 and PHY 220
Attribute/Distribution: NS

PHY 272 Special Topics In Physics 1-4 Credits
Selected topics not sufficiently covered in other courses.
Repeat Status: Course may be repeated.

PHY 273 Research 2-3 Credits
Participation in current research projects being carried out within the
department.
Repeat Status: Course may be repeated.
Attribute/Distribution: NS

PHY 300 Apprentice Teaching 1-4 Credits

PHY 332 (ASTR 332) High-Energy Astrophysics 3 Credits
Observation and theory of X-ray and gamma-ray sources, quasars,
pulsars, radio galaxies, neutron stars, black holes. Results from
ultraviolet, X-ray and gamma-ray satellites. Generally offered in the
spring of odd-numbered years.
Prerequisites: (PHY 021 or PHY 023) and (MATH 023 or MATH 033)
Can be taken Concurrently: MATH 023, MATH 033
Attribute/Distribution: NS

PHY 340 Thermal Physics 3 Credits
Basic principles of thermodynamics, kinetic theory, and statistical
mechanics, with emphasis on applications to classical and quantum
mechanical physical systems.
Prerequisites: (PHY 013 or PHY 021 or PHY 023) and (MATH 023 or
MATH 032 or MATH 052)
Attribute/Distribution: NS

PHY 342 (ASTR 342) Relativity and Cosmology 3 Credits
Special and general relativity. Schwarzschild and Kerr black holes.
Super massive stars. Relativistic theories of the origin and evolution of
the universe. Generally offered in the spring of even-numbered years.
Prerequisites: (PHY 021 or PHY 023) and (MATH 023 or MATH 033)
Can be taken Concurrently: MATH 023, MATH 033
Attribute/Distribution: NS

PHY 348 Plasma Physics 3 Credits
Single particle behavior in electric and magnetic fields, plasmas
as fluids, waves in plasmas, transport properties, kinetic theory of
plasmas, controlled thermonuclear fusion devices. Must have senior
standing or consent of the department chair.
Prerequisites: (PHY 021 or PHY 023) and MATH 205
Attribute/Distribution: NS

PHY 352 Modern Optics 3 Credits
Paraxial optics, wave and vectorial theory of light, coherence and
interference, diffraction, crystal optics, and lasers.
Prerequisites: MATH 205 and (PHY 213 or ECE 203)
Can be taken Concurrently: PHY 213, ECE 203
Attribute/Distribution: NS

PHY 355 Nonlinear Optics 3 Credits
This course will introduce the fundamental principles of nonlinear
optics. Topics include nonlinear interaction of optical radiation with
matter, multi-photon interactions, electro-optics, self and cross phase
modulation, and the nonlinear optical susceptibilities that describe all
these effects in the mainframe of electromagnetic theory.
Prerequisites: PHY 031 and (PHY 213 or ECE 203)
Can be taken Concurrently: PHY 213, ECE 203
Attribute/Distribution: NS

PHY 362 Atomic and Molecular Structure 3 Credits
Review of quantum mechanical treatment of one-electron atoms,
electron spin and fine structure, multi-electron atoms, Pauli principle,
Zeeman and Stark effects, hyperfine structure, structure and spectra
of simple molecules.
Prerequisites: PHY 031 or CHM 341
Attribute/Distribution: NS

PHY 363 Physics of Solids 3 Credits
Introduction to the theory of solids with particular reference to the
physics of metals and semiconductors.
Prerequisites: (PHY 031 or MAT 316 or CHM 341) and PHY 340
Can be taken Concurrently: PHY 340
Attribute/Distribution: NS

PHY 364 Nuclear and Elementary Particle Physics 3 Credits
Models, properties, and classification of nuclei and elementary
particles; nuclear and elementary particle reactions and decays;
radiation and particle detectors; accelerators; applications.
Prerequisites: PHY 031 and MATH 205
Attribute/Distribution: NS
PHY 365 Physics Of Fluids 3 Credits
Concepts of fluid dynamics; continuum and molecular approaches; waves, shocks and nozzle flows; nature of turbulence; experimental methods of study.
Prerequisites: (PHY 212 or ECE 202) and (PHY 340 or ME 104)
Can be taken Concurrently: PHY 212, ECE 202, PHY 340, ME 104
Attribute/Distribution: NS

PHY 366 Introduction to String Theory 3 Credits
Introduction to string theory for upper-level undergraduates and beginning graduate students. Building on Einstein’s theory of general relativity and quantum theory, this course covers the fundamentals of string theory and the latest developments. Advanced topics such as D-branes, non-perturbative dualities and holography will also be covered. The course content is appropriate to students who have a working knowledge of quantum mechanics and special relativity, and have had some exposure to general relativity. Instructor permission required in lieu of Phy 362/369.
Prerequisites: PHY 031 and PHY 215 and (PHY 362 or PHY 369)
Can be taken Concurrently: PHY 369
Attribute/Distribution: NS

PHY 369 Quantum Mechanics I 3 Credits
Prerequisites: PHY 031 and MATH 205 and PHY 215
Can be taken Concurrently: PHY 215
Attribute/Distribution: NS

PHY 372 Special Topics In Physics 1-3 Credits
Selected topics not sufficiently covered in other courses.
Repeat Status: Course may be repeated.
Attribute/Distribution: NS

PHY 380 Introduction to Computational Physics 3 Credits
Prerequisites: MATH 205
Can be taken Concurrently: MATH 205
Attribute/Distribution: NS

PHY 382 Physics of Cells 3 Credits
This course focuses on the physical principles underlying the organization of living cells, which spans several orders of magnitude in length and time. It provides an introduction to biological physics and relevant concepts of soft-matter physics. Topics include: self-organization of filamentous and motor proteins of the cytoskeleton that determine cell shape and motion; the plasma membrane as a fluid responsive to environmental and biochemical signals; biological waves and pattern formation; mathematical modeling of biological systems; experimental methods and image analysis.
Prerequisites: (PHY 010 or PHY 011) and (PHY 013 or PHY 021)
Attribute/Distribution: NS

PHY 388 Honors Project 1-8 Credits
Repeat Status: Course may be repeated.

PHY 420 Mechanics 3 Credits
Includes the variational methods of classical mechanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi Theory.

PHY 421 Electricity & Magnetism I 3 Credits
Electrostatics, magnetostatics, Maxwell’s equations, dynamics of charged particles, multipole fields.

PHY 422 Electricity & Magnetism II 3 Credits
Electrodynamics, electromagnetic radiation, physical optics, electrodynamics in anisotropic media. Special theory of relativity.
Prerequisites: PHY 421
PHY 482 Applied Optics 3 Credits
Review of ray and wave optics with extension to inhomogenous media, polarized optical waves, crystal optics, beam optics in free space (Gaussian and other types of beams) and transmission through various optical elements, guided wave propagation in planar waveguides and fibers (modal analysis), incidence of chromatic and polarization mode dispersion, guided propagation of pulses, nonlinear effects in waveguides (solitons), periodic interactions in waveguides, acousto-optic and electro-optics.
Prerequisites: PHY 352

PHY 490 Thesis 1-6 Credits

PHY 491 Research 3 Credits
Research problems in experimental or theoretical physics.

PHY 492 Research 3 Credits
Continuation of PHY 491.
Repeat Status: Course may be repeated.

PHY 499 Dissertation 1-15 Credits
Repeat Status: Course may be repeated.