

# PHYSICS (PHYS)

## PHYS 5210 Theoretical Mechanics

[3 credit hours (3, 0, 0)]

Kinematics and dynamics of particles and rigid bodies. Lagrangian and Hamiltonian equations of motion.

**Term Offered:** Fall

## PHYS 5230 Classical Electricity And Magnetism I

[3 credit hours (3, 0, 0)]

Electrostatics: the equations of Laplace and Poisson-Maxwell's equations and their solutions.

**Term Offered:** Fall

## PHYS 5240 Electricity And Magnetism II

[3 credit hours (3, 0, 0)]

Maxwell's equations and their solutions; electromagnetic radiation.

**Prerequisites:** PHYS 5230 with a minimum grade of D-

**Term Offered:** Spring

## PHYS 5310 Quantum Mechanics

[3 credit hours (3, 0, 0)]

Formalism and applications of quantum mechanics: Hilbert space, time independent and time-dependent perturbation theories, atomic and molecular structure and spectra, and scattering theory.

**Term Offered:** Spring

## PHYS 5510 Condensed Matter Physics

[3 credit hours (3, 0, 0)]

Crystal lattices and structures, reciprocal lattice and kinematical diffraction theory. Survey of binding in crystals. Lattice dynamics and phonons. Thermodynamic, electronic, and optical properties of insulators, semiconductors, metals and alloys.

**Term Offered:** Spring, Fall

## PHYS 5620 The Physics Of Lasers

[3 credit hours (3, 0, 0)]

Longitudinal and transverse coherence, stimulated emission, optical pumping, resonator structures, Q-switching, mode-locking and laser systems (gas, dye, diode, doped insulator and free electron lasers).

## PHYS 5800 Astronomy In The Planetarium

[3 credit hours (3, 0, 0)]

Theory and practice of astronomical outreach programming. Sky and calendar, mythology, constellations, astrophysics, buying and using small telescopes, operating and maintaining planetarium projectors, sky simulation software, projects and program production.

## PHYS 5810 Astrophysics I

[3 credit hours (3, 0, 0)]

Spherical coordinate systems, astronomical time, celestial mechanics, the solar system and planetary physics, photometry, radiative transfer, stellar spectra and classification, binary stars and stellar masses.

**Term Offered:** Fall

## PHYS 5820 Astrophysics II

[3 credit hours (3, 0, 0)]

Stellar structure and evolution, close binaries, origin of the elements, the sun, variable stars, star clusters, the interstellar medium, the Milky Way Galaxy, stellar statistics, galaxy structure and evolution, cosmology.

**Prerequisites:** PHYS 5810 with a minimum grade of D-

**Term Offered:** Spring

## PHYS 5880 Astrophysics Laboratory

[3 credit hours (1, 5, 0)]

Astronomical, optical and electronic principles of operation of a modern astronomical observatory. Observing with the 1-meter telescope of Ritter Observatory, reduction, analysis and interpretation of astronomical spectra, Six hours laboratory per week.

**Corequisites:** PHYS 5810

**Term Offered:** Fall

## PHYS 5900 Research Techniques In Physics And Astronomy

[1-6 credit hours (0, 0, 0)]

Research work under the guidance of a member of the graduate faculty. Designed to prepare the student to propose and carry out the thesis research required for the M.S. degree.

**Term Offered:** Summer

## PHYS 5950 Education Workshop In The Physical Sciences

[1-4 credit hours (0, 0, 0-4)]

For teachers in grades K-12. Introduction to modern physical science concepts suitable for classroom use; lecture and laboratory. Not acceptable for physics degree program.

## PHYS 6010 Physics And Astronomy Colloquium

[2 credit hours (2, 0, 0)]

Topical lectures by visiting and local professionals.

**Term Offered:** Spring, Fall

## PHYS 6020 Physics And Astronomy Journal Seminar

[1 credit hour (0, 0, 1)]

Literature review seminar.

**Term Offered:** Spring, Fall

## PHYS 6130 Computational Physics For Research

[3 credit hours (3, 0, 0)]

Software packages for display and analytic manipulation, numerical methods for linear and non-linear systems of differential equations, matrix algebra, and the Schrodinger equation. Vector and parallel processing.

## PHYS 6140 Fundamentals Of Modern Physics

[3 credit hours (3, 0, 0)]

An intensive course which reviews the fundamentals of atomic, statistical and condensed matter physics. Provides a common foundation for entering graduate students for succeeding courses in physics and astronomy.

**Term Offered:** Fall

## PHYS 6180 Advanced Atomic And Nuclear Physics Laboratory

[2-3 credit hours (0, 0-6, 0)]

Experiments in nuclear, atomic, and condensed matter physics, such as gamma-ray and X-ray spectroscopies, beta and alpha particle spectroscopies, NMR, ESR, Mossbauer effect, neutron shielding, detectors and electronics, and atomic emission spectroscopy. One four-hour lab and one hour lecture per week.

**Prerequisites:** PHYS 6140 with a minimum grade of D-

**Term Offered:** Spring

## PHYS 6220 Classical Mechanics

[3 credit hours (3, 0, 0)]

Advanced classical mechanics, including the variational principles, Lagrange and Hamilton mechanics, and linear and nonlinear systems.

**Term Offered:** Fall

**PHYS 6250 Classical Electrodynamics I**

[3 credit hours (3, 0, 0)]

Solutions to Poisson's equation in Cartesian, spherical and cylindrical coordinates with Dirichlet, Neuman and mixed boundary conditions. Maxwell's equations and their solutions applied to waveguides and nonlinear materials.

**Term Offered:** Spring**PHYS 6260 Classical Electrodynamics II**

[3 credit hours (0, 0, 3)]

Solutions to the wave equation with time dependent source terms, energy loss from high energy charged particles in dense materials, special relativity, classical field theory, invariant Lagrangians and conserved quantities.

**Prerequisites:** PHYS 6250 with a minimum grade of D-**Term Offered:** Fall**PHYS 6280 Photovoltaic Materials And Device Physics Laboratory**

[3 credit hours (0, 3, 0)]

Fabrication and characterization of solar cell materials and devices, addressing materials science and physics of substrate preparation, absorber and window deposition processes, metal contact formation, and measurement of physical properties. One four-hour lab and one-hour lecture per week.

**Prerequisites:** PHYS 6140 with a minimum grade of D- and PHYS 7140 with a minimum grade of D-**Term Offered:** Fall**PHYS 6320 Quantum Mechanics I**

[3 credit hours (3, 0, 0)]

Quantum theory and its application to physical problems. Topics include dynamics in the Schrodinger and Heisenberg pictures, invariance principles and angular momentum theory, perturbation theory, the variational method.

**Term Offered:** Fall**PHYS 6330 Quantum Mechanics II**

[3 credit hours (3, 0, 0)]

The quantum theory of scattering, electromagnetic interactions, quantization of the electromagnetic field and introduction to the Dirac equation.

**Term Offered:** Spring**PHYS 6450 Statistical Mechanics**

[3 credit hours (3, 0, 0)]

A fundamental quantum-mechanical development of statistical thermodynamics. Non-interacting and weakly interacting many-particle systems in the classical and quantum regimes, with applications to various fields of physics.

**Term Offered:** Spring**PHYS 6490 Current Issues In Theoretical Physics**

[3 credit hours (3, 0, 0)]

Problems in theory relative to the research programs pursued at the University.

**PHYS 6520 Condensed Matter Physics I**

[3 credit hours (3, 0, 0)]

A study of the electromagnetic, thermal and elastic properties of condensed matter through the quantum-mechanical treatment of the electrons and elementary excitations.

**Prerequisites:** PHYS 6330 with a minimum grade of D-**PHYS 6530 Condensed Matter Physics II**

[3 credit hours (3, 0, 0)]

A survey of condensed matter phenomena of interest to experimentalists, as elucidated by theory.

**Prerequisites:** PHYS 6330 with a minimum grade of D-**PHYS 6540 Structure, Defects And Diffusion**

[4 credit hours (4, 0, 0)]

A generic materials science approach to the study of crystalline structure, defects (point, line and planar) in crystalline materials, and the mechanisms and kinetics of diffusion in the condensed state.

**Term Offered:** Fall**PHYS 6550 Thermodynamics And Phase Transformations In Condensed Systems**

[4 credit hours (4, 0, 0)]

A materials science approach to the thermodynamics of condensed state equilibria and phase transformation kinetics.

**Prerequisites:** PHYS 6450 with a minimum grade of D-**Term Offered:** Spring**PHYS 6630 Semiconductors I**

[3 credit hours (3, 0, 0)]

Review of modern theory of solids. Semiconducting and metallic materials. Semiconductor devices including p-n junctions and solar cells.

**Prerequisites:** PHYS 4510 with a minimum grade of D- and EECS 4400 with a minimum grade of D-**Term Offered:** Fall**PHYS 6640 Fundamentals of Solar Cells**

[3 credit hours (3, 0, 0)]

Worldwide status of Photovoltaics, Semiconductors. P-n junction diodes. Ideal solar cells. Efficiency losses. Single crystals and thin films technologies. PV systems.

**Prerequisites:** PHYS 4510 with a minimum grade of D- and EECS 4400 with a minimum grade of D-**Term Offered:** Spring**PHYS 6690 Current Issues In Optics**

[3 credit hours (3, 0, 0)]

Current research in optics and the optical excitation of material modes.

**PHYS 6710 Atomic Physics**

[3 credit hours (3, 0, 0)]

A study of the fundamental properties of atoms, their theoretical description and experimental measurement. Topics include atomic structure, radiative transitions, external field interactions and atomic collisions.

**Term Offered:** Fall**PHYS 6720 Atomic & Molecular Spectroscopy**

[3 credit hours (3, 0, 0)]

Theory and experimental methods of atomic and molecular spectroscopy. Topics include the theory of interpretation of atomic and molecular spectra and the experimental means to measure the spectra.

**Prerequisites:** PHYS 6710 with a minimum grade of D-**PHYS 6770 Accelerator Physics**

[3 credit hours (3, 0, 0)]

Basic electrodynamic functioning of charged-particle accelerators, particle dynamics of non-relativistic and relativistic accelerators, accelerator applications, static field and dynamic field accelerator designs.

**PHYS 6810 Stellar Astrophysics I**

[3 credit hours (3, 0, 0)]

Stellar atmospheres and their emergent spectra. Physics of radiation, matter and their interaction. Radiative transfer, hydrostatic and radiative equilibrium, convection, line formation and spectral signatures of atmospheric physics.

**Term Offered:** Fall**PHYS 6820 Stellar Astrophysics II**

[3 credit hours (3, 0, 0)]

Stellar structure and evolution. Equation of state, nuclear reactions and nucleosynthesis, stellar formation, evolution and death, enrichment of the interstellar medium, formation of planetary systems, solar physics and helioseismology.

**Term Offered:** Spring**PHYS 6830 Galactic Astronomy I**

[3 credit hours (3, 0, 0)]

Stellar spectra, colors, compositions and ages; star clusters; pulsating stars; calibration of distance indicators. Interstellar dust, interstellar extinction, interstellar gas, nebulae; structure of the interstellar medium.

**Term Offered:** Fall**PHYS 6840 Galactic Astronomy II**

[3 credit hours (3, 0, 0)]

Structure and dynamics of the Galaxy, shocks and explosions, stellar kinematics, galactic rotation, and dynamical and chemical evolution.

**Term Offered:** Spring**PHYS 6940 Industrial Internship**

[1-6 credit hours (1-6, 0, 0)]

Experiential learning in an academic advisor-approved business, industry, or non-profit. Six credits are required for the PSM degree.

**Term Offered:** Spring, Summer, Fall**PHYS 6960 M.s. Thesis Research**

[1-15 credit hours (0, 0, 0)]

Thesis research required for the M.S. degree.

**Term Offered:** Spring, Summer, Fall**PHYS 6980 Special Topics**

[1-4 credit hours (0-4, 0, 0)]

Course reserved for visiting lecturers and topics not covered otherwise.

**Term Offered:** Spring, Summer, Fall**PHYS 6990 Independent Study**

[1-4 credit hours (0, 0, 0)]

**PHYS 7130 Computational Physics For Research**

[3 credit hours (3, 0, 0)]

Software packages for display and analytic manipulation, numerical methods for linear and non-linear systems of differential equations, matrix algebra, and the Schrodinger equation. Vector and parallel processing.

**PHYS 7140 Fundamentals Of Modern Physics**

[3 credit hours (3, 0, 0)]

An intensive course which reviews the fundamentals of atomic, statistical and condensed matter physics. Provides a common foundation for entering graduate students for succeeding courses in physics and astronomy.

**Term Offered:** Fall**PHYS 7180 Advanced Atomic and Nuclear Physics Laboratory**

[2-3 credit hours (0, 0-6, 0)]

Experiments in nuclear, atomic, and condensed matter physics, such as gamma-ray and X-ray spectroscopies, betas and alpha particle spectroscopies, NMR, ESR, Mossbauer effect, neutron shielding, detectors and electronics, and atomic emission spectroscopy. One four-hour lab and one hour lecture per week.

**Prerequisites:** PHYS 6140 with a minimum grade of D- or PHYS 7140 with a minimum grade of D-**Term Offered:** Spring**PHYS 7220 Classical Mechanics**

[3 credit hours (3, 0, 0)]

Advanced classical mechanics, including the variational principles, Lagrange and Hamilton mechanics, and linear and nonlinear systems.

**Term Offered:** Fall**PHYS 7250 Classical Electrodynamics I**

[3 credit hours (3, 0, 0)]

Solutions to Poisson's equation in Cartesian, spherical and cylindrical coordinates with Dirichlet, Neuman and mixed boundary conditions. Maxwell's equations and their solutions applied to waveguides and nonlinear materials.

**Term Offered:** Spring**PHYS 7260 Classical Electrodynamics II**

[3 credit hours (3, 0, 0)]

Solutions to the wave equation with time dependent source terms, energy loss from high energy charged particles in dense materials, special relativity, classical field theory, invariant Lagrangians and conserved quantities.

**Prerequisites:** PHYS 6250 with a minimum grade of D- or PHYS 7250 with a minimum grade of D-**Term Offered:** Fall**PHYS 7280 Photovoltaic Materials And Device Physics Laboratory**

[3 credit hours (0, 3, 0)]

Detailed fabrication and characterization of solar cell materials and devices, addressing materials science and physics of substrate preparation, absorber and window deposition processes, metal contact formation, and measurement of physical properties. One four-hour lab and one-hour lecture per week.

**Prerequisites:** PHYS 6140 with a minimum grade of D- and PHYS 7140 with a minimum grade of D-**Term Offered:** Fall**PHYS 7320 Quantum Mechanics I**

[3 credit hours (3, 0, 0)]

Quantum theory and its application to physical problems. Topics include dynamics in the Schrodinger and Heisenberg pictures, invariance principles and angular momentum theory, perturbation theory, the variational method.

**Term Offered:** Fall**PHYS 7330 Quantum Mechanics II**

[3 credit hours (3, 0, 0)]

The quantum theory of scattering, electromagnetic interactions, quantization of the electromagnetic field and introduction to the Dirac equation.

**Term Offered:** Spring

**PHYS 7450 Statistical Mechanics**

[3 credit hours (3, 0, 0)]

A fundamental quantum-mechanical development of statistical thermodynamics. Non-interacting and weakly interacting many-particle systems in the classical and quantum regimes, with applications to various fields of physics.

**Term Offered:** Spring**PHYS 7520 Condensed Matter Physics I**

[3 credit hours (3, 0, 0)]

A study of the electromagnetic, thermal and elastic properties of condensed matter through the quantum-mechanical treatment of the electrons and elementary excitations.

**Prerequisites:** PHYS 6330 with a minimum grade of D-**PHYS 7530 Condensed Matter Physics II**

[3 credit hours (3, 0, 0)]

A survey of condensed matter phenomena of interest to experimentalists, as elucidated by theory.

**Prerequisites:** PHYS 6330 with a minimum grade of D-**PHYS 7710 Atomic Physics**

[3 credit hours (3, 0, 0)]

A study of the fundamental properties of atoms, their theoretical description and experimental measurement. Topics include atomic structure, radiative transitions, external field interactions and atomic collisions.

**Term Offered:** Fall**PHYS 7720 Atomic & Molecular Spectroscopy**

[3 credit hours (3, 0, 0)]

Theory and experimental methods of atomic and molecular spectroscopy. Topics include the theory of interpretation of atomic and molecular spectra and the experimental means to measure the spectra.

**Prerequisites:** PHYS 6710 with a minimum grade of D-**PHYS 7810 Stellar Astrophysics I**

[3 credit hours (3, 0, 0)]

Stellar atmospheres and their emergent spectra. Physics of radiation, matter and their interaction. Radiative transfer, hydrostatic and radiative equilibrium, convection, line formation, and spectral signatures of atmospheric physics.

**Term Offered:** Fall**PHYS 7820 Stellar Astrophysics II**

[3 credit hours (3, 0, 0)]

Stellar structure and evolution. Equation of state, nuclear reactions and nucleosynthesis, stellar formation, evolution and death, enrichment of the interstellar medium, formation of planetary systems, solar physics and helioseismology.

**Term Offered:** Spring**PHYS 7830 Galactic Astronomy I**

[3 credit hours (3, 0, 0)]

Stellar spectra, colors, compositions, and ages; star clusters; pulsating stars; calibration of distance indicators. Interstellar dust, interstellar extinction, interstellar gas, nebulae; structure of the interstellar medium.

**Term Offered:** Fall**PHYS 7840 Galactic Astronomy II**

[3 credit hours (3, 0, 0)]

Structure and dynamics of the Galaxy, shocks and explosions, stellar kinematics, galactic rotation, and dynamical and chemical evolution.

**PHYS 7910 Advanced Research In Physics And Astronomy**

[1-15 credit hours (0, 0, 0)]

Research work under the guidance of a member of the graduate faculty. Designed to prepare the student to propose and carry out the thesis research required for the Ph.D. degree.

**Term Offered:** Spring, Summer, Fall**PHYS 8010 Physics And Astronomy Colloquium**

[2 credit hours (2, 0, 0)]

Topical lectures by visiting and local professionals.

**Term Offered:** Spring, Fall**PHYS 8020 Physics And Astronomy Journal Seminar**

[1 credit hour (0, 0, 1)]

Literature review seminar.

**Term Offered:** Spring, Fall**PHYS 8490 Current Issues In Theoretical Physics**

[3 credit hours (3, 0, 0)]

Problems in theory relative to the research programs pursued at the University.

**PHYS 8540 Structure, Defects And Diffusion**

[4 credit hours (4, 0, 0)]

A generic materials science approach to the study of crystalline structure, defects (point, line and planar) in crystalline materials, and the mechanisms and kinetics of diffusion in the condensed state.

**Term Offered:** Fall**PHYS 8550 Thermodynamics And Phase Transformations In Condensed Systems**

[4 credit hours (4, 0, 0)]

A materials science approach to the thermodynamics of condensed state equilibria and phase transformation kinetics.

**Prerequisites:** PHYS 6540 with a minimum grade of D- or PHYS 8540 with a minimum grade of D-**Term Offered:** Spring**PHYS 8590 Current Issues In Condensed Matter And Material Science**

[3 credit hours (3, 0, 0)]

A survey of various areas in the physics of condensed matter and materials. Content will vary with instructor and from year to year.

**PHYS 8630 Semiconductors I**

[3 credit hours (3, 0, 0)]

Review of modern theory of solids. Semiconducting and metallic materials. Semiconductor devices including p-n junctions and solar cells.

**Prerequisites:** PHYS 4510 with a minimum grade of D- and EECS 4400 with a minimum grade of D-**Term Offered:** Fall**PHYS 8640 Fundamentals of Solar Cells**

[3 credit hours (3, 0, 0)]

Worldwide status of Photovoltaics, Semiconductors. P-n junction diodes. Ideal solar cells. Efficiency losses. Single crystals and thin films technologies. PV systems.

**Prerequisites:** PHYS 4510 with a minimum grade of D- and EECS 4400 with a minimum grade of D-**Term Offered:** Spring**PHYS 8690 Current Issues In Optics**

[3 credit hours (3, 0, 0)]

Current research in optics and the optical excitation of material modes.

**PHYS 8860 General Relativity**

[3 credit hours (3, 0, 0)]

Differential geometry, exterior calculus of tensors, the stress-energy tensor and Einstein field equation, stellar evolution and black holes, gravitational lensing, tests of the theory, and gravitational wave detection.

**Prerequisites:** PHYS 7260 with a minimum grade of D-

**Term Offered:** Fall

**PHYS 8870 Cosmology**

[3 credit hours (3, 0, 0)]

Cosmological solutions for Einstein's field equation, the standard cosmological model, particle physics, nucleosynthesis and the cosmic background radiation. Inflation, dark matter and mass distribution, gravitational evolution, and formation of galaxies.

**Prerequisites:** PHYS 8860 with a minimum grade of D-

**Term Offered:** Spring

**PHYS 8960 Ph. D. Thesis Research**

[1-15 credit hours (0, 0, 0)]

Thesis research required for the Ph.D. degree.

**Term Offered:** Spring, Summer, Fall

**PHYS 8980 Special Topics**

[1-4 credit hours (0-4, 0, 0)]

Course reserved for visiting lecturers and topics not covered otherwise.

**Term Offered:** Spring, Summer

**PHYS 8990 Independent Study**

[1-4 credit hours (0, 0, 0)]