DEPARTMENT OF PHYSICS AND ASTRONOMY

Sanjay V. Khare, Chair
Rupali Chandar, Associate Chair
Scott A. Lee, Undergraduate and Honors Adviser, both Physics and Astronomy
Song Cheng, Graduate Program Director
Sanjay V. Khare, Coordinator, Minor in Renewable Energy

Degrees Offered

The Department of Physics and Astronomy offers courses of study leading to the Bachelor of Science degree in physics, the Bachelor of Arts in physics and the Bachelor of Arts in astronomy.

Advanced Placement

- Students with a score of 3, 4 or 5 on the Physics B test will receive credit for PHYS 2070 and PHYS 2080.
- Students with a score of 3, 4 or 5 on the Physics C Mechanics test will receive credit for PHYS 2130;
- Students with a score of 3, 4 or 5 on the Physics C Electricity and Magnetism test will receive credit for PHYS 2140.

Degrees Offered


ASTR 1010 Survey Of Astronomy
[3 credit hours (3, 0, 0)]
Not for major credit; not open to science majors; no credit after 2010, 2020. General astronomy, including appearance of the sky and nature and evolution of the Earth, Moon, solar system, stars, galaxies and the Universe.
Term Offered: Spring, Summer, Fall
Core Natural Sciences, Trans Mod Natural Science

ASTR 2010 Solar System Astronomy
[3 credit hours (3, 0, 0)]
A quantitative introduction to the contents, origin and evolution of the solar system, as revealed by recent advances in space exploration. High school mathematics at the level of graphs, algebra and elementary logarithms is required.
Term Offered: Fall
Core Natural Sciences, Trans Mod Natural Science

ASTR 2020 Stars, Galaxies, And The Universe
[3 credit hours (3, 0, 0)]
A quantitative introduction to the nature and evolution of stars, galaxies and the universe, as revealed by observation and physical theory. High school mathematics at the level of graphs, algebra and elementary logarithms is required.
Term Offered: Spring
Core Natural Sciences, Trans Mod Natural Science

ASTR 2050 Elementary Astronomy Laboratory
[1 credit hour (0, 2, 0)]
Laboratory exercises and observational measurements in elementary astronomy. Two hours laboratory per week. (not for major credit)
Term Offered: Spring, Fall
Core Natural Sciences, Trans Mod Natural Science

ASTR 2310 Mars
[3 credit hours (3, 0, 0)]
The history of observations of Mars, information gathered during the space program, potential for human exploration and colonization and related contemporary science fiction. High school algebra and graphs will be used.
Prerequisites: ASTR 1010 with a minimum grade of D- or ASTR 2010 with a minimum grade of D-

ASTR 2320 Life In The Universe
[3 credit hours (3, 0, 0)]
The astronomical factors involved in the emergence of life in the universe, the search for extraterrestrial intelligence and the likelihood of advanced civilizations in the Galaxy. May be offered as writing intensive.
Prerequisites: ASTR 1010 with a minimum grade of D- or (ASTR 2010 with a minimum grade of D- and ASTR 2020 with a minimum grade of D-)
Term Offered: Fall

ASTR 2330 Black Holes, General Relativity And The Big Bang Theory
[3 credit hours (3, 0, 0)]
Descriptive discussion of the theory of general relativity, the final states of stellar evolution, black holes and history of the universe from the big bang through the formation of the solar system. May be offered as writing intensive.
Prerequisites: ASTR 1010 with a minimum grade of D- or ASTR 2010 with a minimum grade of D-
Term Offered: Fall

ASTR 2340 New Frontiers In Astronomy
[3 credit hours (0, 0, 3)]
Descriptive treatment of recent developments in astronomy from spacecraft, such as the Hubble Space Telescope, or from the newest, very large ground based telescopes. May be offered as a writing intensive.
Prerequisites: ASTR 1010 with a minimum grade of D- or ASTR 2010 with a minimum grade of D-
Term Offered: Spring
ASTR 3880 Foundations of Astronomy
[4 credit hours (4, 0, 0)]
Positional Astronomy and Time; Telescopes and Optics; Detection and Characterization of Light (Imaging, Photometry and Spectroscopy); Data Reduction and Measurements; Fundamental Techniques of Astronomy (Parallax, Magnitudes, Interstellar Extinction, Doppler Shift and Spectral Line Widths, Stellar Classification, Color-Magnitude and Color-Color Diagrams, Lightcurves, and Redshifts); Measuring Properties of Stars, Star Clusters, Galaxies, and the Universe.
Prerequisites: ASTR 2020 with a minimum grade of D- and PHYS 3310 with a minimum grade of D- and MATH 3610 with a minimum grade of D-

ASTR 4800 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.
Prerequisites: ASTR 1010 with a minimum grade of D- or ASTR 2010 with a minimum grade of D- or ASTR 2020 with a minimum grade of D-

ASTR 4810 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.
Prerequisites: ASTR 3880 with a minimum grade of D-
Term Offered: Fall

ASTR 4820 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: ASTR 4810 with a minimum grade of D-
Term Offered: Spring

ASTR 4880 Astrophysical Measurements
[3 credit hours (1, 6, 0)]
Astronomical, optical and electronic principles of operation of a modern astronomical observatory. Observing with the 1 meter telescope of Ritter Observatory, introduction to reduction, analysis and interpretation of astrophysical data. Six hours laboratory per week. May be offered as writing intensive.
Prerequisites: ASTR 3880 with a minimum grade of D-
Term Offered: Fall

PHYS 1050 The World Of Atoms
[3 credit hours (3, 0, 0)]
The atomic structure of matter and the ideas of quantum physics. The sizes of objects from galaxies to nucleons. Molecules, solids, the wave nature of the electron, quarks and gluons.
Core Natural Sciences

PHYS 1300 Physics In Everyday Life
[3 credit hours (3, 0, 0)]
Not for major credit. Selected subjects of current interest, with their relation to the principles and concepts of physics. Content may vary from year to year. No special science or mathematics background needed.
Term Offered: Fall
Core Natural Sciences

PHYS 1310 Physics Of Music And Sound
[3 credit hours (3, 0, 0)]
Term Offered: Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 1320 Jurassic Physics
[3 credit hours (3, 0, 0)]
Not for major credit. Mechanics, energy, sound and thermodynamics of dinosaurs. The physics of vision and hearing. Fluids and flight. Radioactivity. Climate and the effects of an asteroid collision with the Earth.
Term Offered: Spring
Core Natural Sciences

PHYS 1330 Physics Of Light And Color
[3 credit hours (3, 0, 0)]
Not for major credit. Physics of light and human vision. Atmospheric phenomena, images, depth perception, color analysis, pigments and dyes, color perception, the physics of art, the reproduction of color, thin film interference and holography.
Term Offered: Spring
Core Natural Sciences, Trans Mod Natural Science

PHYS 1340 The Nature Of Science
[3 credit hours (2, 2, 0)]
An interdisciplinary course that discusses major scientific discoveries, the role of hypothesis testing in science, the use of mathematics in science; data presentation; and moral and ethical issues that stem from science.
Core Natural Sciences

PHYS 1750 Introduction To Physics
[4 credit hours (4, 0, 0)]
Not for major credit. High school mathematics including plane geometry, trigonometry and two years of algebra is strongly recommended. Fundamental laws of nature pertaining to mechanics, thermodynamics, waves, electricity, magnetism, optics, atoms and particles.
Term Offered: Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 1910 Frontiers Of Physics And Astronomy
[3 credit hours (3, 0, 0)]
An examination of our current understanding of the physical world at the conceptual level. Topics may include the ultimate structure of matter, quantum theory, relativity, astrophysics, cosmology and contemporary applications.
Term Offered: Fall

PHYS 2010 Technical Physics I
[0-5 credit hours (0-4, 0-2, 0)]
Topics include measurement, statics, Newton’s laws, friction, work, energy, power, impulse and momentum, and simple machines. Includes integrated laboratory.
Prerequisites: MATH 1340 with a minimum grade of D- or MATH 1330 with a minimum grade of D-
Term Offered: Spring, Fall
Core Natural Sciences, Trans Mod Natural Science
PHYS 2020 Technical Physics II
[0-5 credit hours (0-4, 0-2, 0)]
Topics include thermodynamics, electricity, and magnetism, electromagnetic radiation, optics, atomic and nuclear physics. Includes integrated laboratory.
Prerequisites: MATH 1340 with a minimum grade of D- or MATH 1330 with a minimum grade of D-
Term Offered: Spring, Summer, Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 2070 General Physics I
[5 credit hours (3, 2, 0)]
Calculus not required. Mechanics of energy and motion, gravitation, harmonic motion, fluids, heat, entropy and the laws of thermodynamics. Four hours lecture and discussion, two hours laboratory per week.
Prerequisites: (MATH 1320 with a minimum grade of D- and MATH 1330 with a minimum grade of D-) or MATH 1340 with a minimum grade of D- or MATH 1750 with a minimum grade of D- or MATH 1850 with a minimum grade of D-
Term Offered: Spring, Summer, Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 2080 General Physics II
[5 credit hours (3, 2, 2)]
Calculus not required. Electricity and magnetism, capacitors and inductors, electromagnetic waves, optics, atomic physics, nuclear physics, and elementary particles. Four hours lecture and discussion, two hours laboratory per week.
Prerequisites: PHYS 2070 with a minimum grade of D-
Term Offered: Spring, Summer, Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 2100 Physics With Calculus
[2 credit hours (2, 0, 0)]
A bridge course for students wishing to continue in physics after taking PHYS 2070-2080. The application of calculus and elementary differential equations in various physical contexts. No credit for students who take PHYS 2130-2140.
Prerequisites: PHYS 2080 with a minimum grade of D- and MATH 1860 with a minimum grade of D- or PHYS 2080 with a minimum grade of D- and MATH 1840 with a minimum grade of D- or PHYS 2080 with a minimum grade of D- and MATH 1880 with a minimum grade of D- or PHYS 2080 with a minimum grade of D- and MATH 1930 with a minimum grade of D-
Term Offered: Spring, Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 2130 Physics For Science And Engineering Majors I
[5 credit hours (4, 2, 1)]
Calculus based general physics. Mechanics of motion and energy, rotation, gravitation, harmonic motion, waves, fluids and the laws of thermodynamics. Five hours lecture and discussion, two hours laboratory per week.
Prerequisites: MATH 1830 (may be taken concurrently) with a minimum grade of C or MATH 1850 (may be taken concurrently) with a minimum grade of C or MATH 1920 (may be taken concurrently) with a minimum grade of C
Term Offered: Spring, Summer, Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 2140 Physics For Science And Engineering Majors II
[5 credit hours (4, 2, 1)]
Calculus based general physics. Electricity and magnetism, capacitors and inductors, electromagnetic oscillations, Maxwell's equations and electromagnetic radiation, optics, images, interference, and diffraction. Five hours lecture and discussion, two hours laboratory per week.
Prerequisites: PHYS 2130 with a minimum grade of D-
Term Offered: Spring, Summer, Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 3150 Methods Of Theoretical Physics
[3 credit hours (3, 0, 0)]
Basic theoretical methods of physics. Topics include mechanical oscillations, wave propagation, electromagnetic fields, symm and eigenfunctions. Emphasis is on techniques that are common to many areas of physics and astrophysics.
Prerequisites: (MATH 1890 with a minimum grade of D- and MATH 2850 with a minimum grade of D- and PHYS 2140 with a minimum grade of D-)
Term Offered: Spring, Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 3180 Intermediate Laboratory
[3 credit hours (0, 3, 0)]
Physical measurements laboratory related to the development of modern physics, emphasizing techniques such as electronics, computer-aided experimental control and data acquisition, and data analysis. May be offered as writing intensive.
Prerequisites: PHYS 2140 with a minimum grade of D- or PHYS 2100 with a minimum grade of D-
Term Offered: Spring
Core Natural Sciences, Trans Mod Natural Science

PHYS 3310 Modern Physics I
[3 credit hours (3, 0, 0)]
Quantum mechanics: atomic and molecular structure and spectra.
Prerequisites: (PHYS 2140 with a minimum grade of D- and MATH 1840 with a minimum grade of D- or (PHYS 2140 with a minimum grade of D- and MATH 1860 with a minimum grade of D- or (PHYS 2140 with a minimum grade of D- and MATH 1880 with a minimum grade of D- or (PHYS 2140 with a minimum grade of D- and MATH 1930 with a minimum grade of D-
Term Offered: Fall
Core Natural Sciences, Trans Mod Natural Science

PHYS 3320 Modern Physics II
[3 credit hours (3, 0, 0)]
Quantum statistics, applications of quantum mechanics and quantum statistics in laser physics and solid state physics, nuclear physics.
Term Offered: Spring
Core Natural Sciences, Trans Mod Natural Science

PHYS 3400 Physical Principles Of Energy Sources For Humans
[3 credit hours (3, 0, 0)]
This course will involve the study of various conventional and unconventional sources of energy for human consumption. Past, present, and future energy sources will be examined on scientifically established principles and data.
Prerequisites: PHYS 2140 with a minimum grade of D- or PHYS 2080 with a minimum grade of D- and CHEM 1240 with a minimum grade of D-
Term Offered: Spring
Core Natural Sciences, Trans Mod Natural Science
PHYS 3410 Thermal Physics  
[3 credit hours (3, 0, 0)]  
Statistical mechanics, kinetic theory and thermodynamics from a unified microscopic point of view, with applications to a variety of topics from different areas of physics.  
**Prerequisites:** PHYS 3310 with a minimum grade of D-  
**Term Offered:** Spring

PHYS 3610 Optics And Lasers  
[3 credit hours (3, 0, 0)]  
Electromagnetic theory, ray and wave optics including matrix methods, polarization, interference, diffraction, basic laser physics and survey of current laser systems.  
**Prerequisites:** PHYS 2140 with a minimum grade of D-  
**Term Offered:** Spring, Fall

PHYS 4130 Computational Physics  
[3 credit hours (3, 0, 0)]  
Working knowledge of computer operations and programming required. Numerical accuracy, advanced programming, graphics and spreadsheet packages, numerical techniques for differentiation, integration, matrices, solving differential equations and eigenvalue problems.

PHYS 4210 Theoretical Mechanics  
[3 credit hours (3, 0, 0)]  
Statics and dynamics of particles, work, energy, Lagrange equations of motion, small oscillations, dynamics of rigid bodies  
**Prerequisites:** (PHYS 2140 with a minimum grade of D- and MATH 1890 with a minimum grade of D-) or (PHYS 2140 with a minimum grade of D- and MATH 2860 with a minimum grade of D-) or (PHYS 2140 with a minimum grade of D- and MATH 2860 with a minimum grade of D-)  
**Term Offered:** Fall

PHYS 4230 Electricity And Magnetism I  
[3 credit hours (3, 0, 0)]  
The mathematical formulation of electrostatic and magnetostatic fields, potential theory solution of boundary value problems, method of images, dielectric and magnetic materials.  
**Prerequisites:** (PHYS 2140 with a minimum grade of D- and MATH 1890 with a minimum grade of D-) or (PHYS 2140 with a minimum grade of D- and MATH 2860 with a minimum grade of D-) or (PHYS 2140 with a minimum grade of D- and MATH 2860 with a minimum grade of D-)  
**Term Offered:** Fall

PHYS 4240 Electricity And Magnetism II  
[3 credit hours (3, 0, 0)]  
Maxwell's field equations, production and propagation of electromagnetic waves, solution of boundary value problems with application to the laws of optics and guided waves.  
**Prerequisites:** PHYS 4230 with a minimum grade of D-  
**Term Offered:** Spring

PHYS 4310 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.  
**Prerequisites:** (PHYS 3310 with a minimum grade of D- and MATH 2860 with a minimum grade of D-) or (PHYS 3310 with a minimum grade of D- and MATH 1890 with a minimum grade of D-) or (PHYS 3320 with a minimum grade of D- and MATH 2890 with a minimum grade of D-)  
**Term Offered:** Spring

PHYS 4400 Principles and Varieties of Solar Energy  
[3 credit hours (3, 0, 0)]  
Types and extent of solar energy used in human society including: photosynthesis, photovoltaic, solar thermal, and concentrating solar electric; scope of the necessary energy storage and long distance electricity transmission.  
**Prerequisites:** CHEM 1240 with a minimum grade of D- and PHYS 2080 with a minimum grade of D- and PHYS 3400 with a minimum grade of D-  
**Term Offered:** Spring

PHYS 4430 Physics Applications in Medicine I  
[3 credit hours (3, 0, 0)]  
Physical concepts as applied to medicine including: mechanics, exponential growth, statistical physics, fluid transport, and electricity and magnetism. This is a companion course to PHYS 4440.  
**Prerequisites:** (PHYS 2080 with a minimum grade of D- or PHYS 2140 with a minimum grade of D-) and (MATH 1760 with a minimum grade of D- or MATH 1840 with a minimum grade of D-) or (MATH 1760 with a minimum grade of D- or MATH 1840 with a minimum grade of D- or MATH 1860 with a minimum grade of D-)  
**Term Offered:** Spring

PHYS 4440 Physics Applications in Medicine II  
[3 credit hours (3, 0, 0)]  
Physical concepts as applied to medicine including: detectors, feedback and control, signal analysis, atomic physics, high energy particles, nuclear medicine, treatment and imaging devices. Prerequisite: PHYS 4430.  
**Prerequisites:** PHYS 4430 with a minimum grade of D-  
**Term Offered:** Spring

PHYS 4510 Physics Of Condensed Matter  
[3 credit hours (3, 0, 0)]  
Crystal lattices and structures, reciprocal lattice and kinematical diffraction theory, binding in crystals, lattice dynamics and phonons, thermodynamic, electronic, and optical properties of insulators, semiconductors, metals and alloys.  
**Prerequisites:** (PHYS 3310 with a minimum grade of D- and PHYS 3410 with a minimum grade of D-)  
**Term Offered:** Spring, Fall

PHYS 4580 Molecular And Condensed Matter Laboratory  
[3 credit hours (1, 4, 0)]  
Experiments in molecular and condensed matter physics. Measurements and analysis based on techniques such as film thickness and surface morphology. X-ray diffraction, optical absorption, four-point probe and Hall measurements. One four-hour lab and one-hour lecture per week. May be offered as writing intensive.  
**Prerequisites:** PHYS 3310 with a minimum grade of D-  
**Term Offered:** Fall

PHYS 4620 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).  
**Prerequisites:** PHYS 3310 with a minimum grade of D-
PHYS 4780 Atomic And Nuclear Physics Laboratory
[3 credit hours (1, 4, 0)]
Detectors and electronics, gamma-ray and X-ray spectrosopies, beta and alpha particle spectrosopies, nuclear magnetic resonance, gratin and interferetometric spectrosopy, laser applications, and solar atomic spectrosopy. One four-hour lab and one-hour lecture per week. May be offered sd writing intensive.
Prerequisites: PHYS 3310 with a minimum grade of D-
Term Offered: Spring

PHYS 4910 Research Problems-Physics And Astronomy
[1-3 credit hours (0, 3-9, 0)]
Individual experimental or theoretical projects selected with the approval of the department.
Term Offered: Spring, Summer, Fall

PHYS 4920 Senior Capstone Project
[1 credit hour (0, 0, 1)]
Required senior capstone project for all physics and astronomy majors. The topics may involve physics/astronomy research, physics/astronomy education, research in a related field with an emphasis on physics/astronomy, internships with companies or other institutions with an emphasis on physics/astronomy. Students should register for this course in the closest spring semester prior to graduation.
Prerequisites: PHYS 4950 with a minimum grade of D-

PHYS 4940 Internship in Renewable Energy
[1-4 credit hours (0, 0, 3-12)]
Experiential learning in an advisor-approved business, non-profit, or academic organization. Maximum of three hours may count toward minor. Credit hours 1-4; may be repeated once for credit
Prerequisites: PHYS 3400 with a minimum grade of D-
Term Offered: Spring, Summer, Fall

PHYS 4950 Undergraduate Professional Development Seminar
[1 credit hour (1, 0, 0)]
Selected topics on professional development as it applies to junior / senior level physics or astronomy major undergraduates. Specific emphasis will be on topics relevant to near-term professional goals of students (graduate school applications, job interviews, career pathways, CV/resume, professional presentation skills, and ethical research).

PHYS 4980 Special Topics In Physics
[1-4 credit hours (1-4, 0, 0)]
Individual or small group study of selected topics not covered in regular undergraduate courses.
Term Offered: Spring, Summer, Fall

Honors in Physics and Astronomy

Qualified juniors and seniors may be invited to work for the citation “honors in physics and astronomy.”

1. Admission: The Honors Program in the department of physics and astronomy is open to physics majors and may be taken concurrently with College Honors. Admission to the program is based upon the student’s academic achievement (at least a 3.0 GPA overall; at least a 3.3 GPA in the major), recommendations of previous instructors and an interview with the departmental honors officer. A petition for entrance into the program normally should be made before the end of the sophomore year.

2. Requirements: In order to remain in the program and graduate with departmental honors, the students must maintain at least a 3.0 cumulative GPA and at least a 3.3 GPA in the major. In addition to the normal requirements for a physics undergraduate major, the student must successfully complete six hours of physics with honors in courses numbered above 3320, six hours of math chosen from MATH 2860 and other math courses above the 3000 level. A written Honors Thesis and an oral presentation of the thesis work are required.

1 ASTR 4810, ASTR 4820 may count toward this requirement.