



Mission, Vision, Guiding  
Principles

Philosophy

Introduction to the College

Institutional Goals

Calendar

Campus and Accreditation

Student Life

Student Services

Admission to College

Costs and Financial Aid

Special Programs

Academic Regulations

Graduate Program

Programs of Study

Course Descriptions

Minors

Faculty Directory

Staff Directory

Board Of Trustees

Campus Map

**Contact**

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Registrar  
(812) 877- 8438

**Course Descriptions - Physics**

Professors: Basu, Bunch, Ditteon, Duree, Granieri, Joenathan, E. Kirkpatrick, S. Kirkpatrick, Kirtley, Lepkowitz, Letfullin, McInerney, Moloney, Siahmakoun, Syed, Wagner, and Western.

*NOTE:* In courses which include a laboratory, satisfactory completion of the laboratory work is required in order to pass the course.

**PH 111 Physics I 3.5R-1.5L-4C F, W Coreq: MA 111**

Kinematics, Newton's laws of motion, gravitation, Coulomb's law, Lorentz force law, strong and weak nuclear forces, conservation of energy and momentum, relevant laboratory experiments.

**PH 112 Physics II 3.5R-1.5L-4C W, S Pre: PH 111 and MA 111; Co: MA 112**

Torque and angular momentum, oscillations, one-dimensional waves, electric fields and potentials, electric current and resistance, DC circuits, capacitance, relevant laboratory experiments.

**PH 113 Physics III 3.5R-1.5L-4C S, F Pre: PH 112 and MA 112; Coreq: MA 113**

Sources of magnetic fields, Faraday's law, inductance electromagnetic waves, reflection and polarization, geometric and physical optics, introduction to relativity, relevant laboratory experiments.

**PH 215 Introduction to CHAOS 2R-0L-2C W**

What constitutes chaotic behavior, detection of chaos in real systems using phase space plots, Poincare sections, bifurcation plots, power spectra, Lyapunov exponents, and computer simulation of chaotic systems.

**PH 230 Introduction to Astronomy and Astrophysics 3R-3L-4C F Pre: MA 111, and PH 111 or EM 120**

Celestial coordinates; electromagnetic radiation, atomic structure, spectra, blackbody radiation and radiative transfer as they relate to astronomy; telescopes and detectors; structure and evolution of stars; galaxies; cosmology; quantitative observational work using modern telescopes, detectors and software simulations.

**PH 235 Many-Particle Physics 3.5R-1.5L-4C F Pre: PH 111 or Coreq: EM 202; and Coreq: MA 112**

Dynamics of rigid body, harmonic motion; mechanics of fluids; heat, kinetic theory, thermodynamics. Alternate week laboratories.

**PH 241 Physics of Stars 4R-0L-4C W Pre: MA 111, and PH 111 or EM 120**

Binary stars and stellar parameters; stellar spectra; stellar atmospheres; stellar interiors; star formation; stellar evolution; star death; stellar remnants; black holes and binary stars.

**PH 250 Planets and Galaxies 4R-0L-4C S Pre: MA 111, and PH 111 or EM 120**

Overview of planets and planetary science; origin and evolution of the solar system; structure and evolution of galaxies; origin and evolution of the universe; introduction to cosmology.

**PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W Pre: PH 113 and MA 221**

Wave-particle nature of matter and radiation, Bohr model, Schrodinger equation, quantum description of the hydrogen atom, atomic and molecular spectra, and introduction to statistical physics.

**PH 265 Fundamentals of Nuclear Physics and Radiation (odd years) 3R-3L-4C S Pre: PH 112, and MA 221**

Relativity, black-body radiation, the Bohr model, physics of the nucleus, fission and fusion, reactors, nuclear radiation, radiation damage, medical applications.

**PH 270 Special Topics in Physics Credit arranged Pre: Consent of instructor**

Lectures on special topics in physics. Maximum of 4 credits per term.

**PH 290 Directed Research Credit arranged Pre: Consent of instructor**

Research for freshmen and sophomore students under the direction of a physics and

optical engineering faculty member. May earn up to a maximum of 2 credits for meeting the graduation requirements. The student must make arrangements with a physics faculty member for the research project prior to registering for this course.

**PH 292 Physical Optics 3.5R-1.5L-4C F Pre: PH 113**

Electromagnetic waves; interference; optical interferometry; coherence; polarized light; Jones vec-tors/matrices; production of polarized light; birefringence, Fraunhofer diffraction, diffraction gratings.

**PH 302 Biophysics 4R-0L-4C W Pre: PH 113 or consent of instructor**

Biological examples of the interaction of radiation and matter; medical uses of x-rays, nuclear medicine, magnetic resonance imaging, and current applications in biophysics.

**PH 310 Introduction to Relativity 2R-0L-2C F Pre: PH 113 or consent of instructor**

Experimental background of the special theory of relativity, the structure of the theory and its consequences in measurements involving space, time and motion. Relativistic mechanics, relativity and electromagnetism, and applications in modern physics.

**PH 314 Theoretical Mechanics I 4R-0L-4C S, Arranged Pre: PH 111, PH 235, MA 222**

Statics and dynamics of particles and systems of particles, including rigid bodies. Conservation of energy, linear and angular momentum. Central forces. Lagrangian and Hamiltonian equations of motion. Vibrations.

**PH 315 Theoretical Mechanics II 4R-0L-4C W, Arranged Pre: PH 314**

Statics and dynamics of rigid bodies. Lagrangian treatment of rigid body dynamics. Euler method of rigid body dynamics. Small oscillations about positions of equilibrium and about steady motion. Statics and dynamics of deformable bodies. Computational analysis of mechanical systems.

**PH 316 Electric and Magnetic Fields 4R-0L-4C F Pre: PH 113, MA 222**

Maxwell's equations in integral and point form, vector calculus; electric field and potential, electric fields in matter, boundary conditions; the magnetic field.

**PH 317 Electromagnetism 4R-0L-4C W Pre: PH 316**

Further methods in electrostatics, Poisson's equation; magnetostatics, the vector potential; electromagnetic induction; magnetic properties of matter; further applications of Maxwell's equations, properties of electromagnetic radiation.

**PH 322 Celestial Mechanics and Solar System Physics 4R-0L-4C S (alternate with PH240) Pre: PH 112 or PH 265**

Equation of motion of the two-body problem and their integrals; artificial satellites, orbit theory and perturbation theory; physical properties of the planets and their satellites, the sun and interplanetary space, and the origin of the solar system.

**PH 325 Advanced Physics Laboratory I 2R-6L-4C S Pre: PH 255 or PH 265**

Introduction to the methods of experimental physics; topics may include error analysis, component fabrication, transducers, ac circuits, operational amplifiers, electrical signal conditioning, and automated data acquisition.

**PH 327 Thermodynamics and Statistical Mechanics 4R-0L-4C S (odd years) Pre: PH 235 or consent of instructor**

First, second, and third laws of thermodynamics. Ideal gases, real gases, liquids, solids, change of phase. The Joule-Thompson effect, adiabatic demagnetization. Kinetic theory of gases, classical and quantum statistical mechanics.

**PH 330 Material Failure 3R-3L-4C W (odd years) Pre: PH 113**

Physical principles of instrumentation used for material failure analysis, including light microscopy, electron microscopy, and spectroscopy. Laboratory includes experiments and case studies using these instruments.

**PH 401 Introduction to Quantum Mechanics 4R-0L-4C W Pre: PH 255, or PH 113 and PH 265**

Review of wave-particle experiments, atomic model, Bohr theory, deBroglie's hypothesis. Uncertainty principle, Schroedinger equation, quantum mechanical operators and stationary states, quantization and role of angular momentum.

**PH 402 Introduction to Atomic Physics 4R-0L-4C S (odd years) Pre: PH 401**

Solutions of Schroedinger equation, perturbation theory, applications to one electron system. Quantum numbers, spin and magnetic moments, multi-electron systems including LS coupling. Zeeman effect, transition rates, hyperfine structure, X-rays.

**PH 404 Acoustics 4R-0L-4C W (odd years) Pre: PH 113, and MA 222**

Harmonic motion, waves on strings, membranes, eigenfunctions and eigenvalues; waves in rods and fluids; behavior of waves at interfaces; radiation from vibrating piston; resonators, absorption.

**PH 405 Semiconductor Materials and Devices I 3R-3L-4C F Pre: PH 113 or PH 255 or PH 265**

Material structure electronic levels and energy bands; semiconductor doping; optical and electronic material characteristics; p-n junction and diode characteristics; bipolar junction transistor; basics of device fabrication. Laboratories on X-ray and Scanning Electron Microscope investigations, device characteristics and a three-week design project on production and testing of thin films.

**PH 406 Semiconductor Materials and Devices II 3R-3L-4C W Pre: PH 405 or ECE 250**

Metal-semiconductor interfaces; photoresist and photolithography; thin film deposition; design and fabrication of semiconductor diodes; characterization of process diodes and transistors; MOSFETS; optoelectronic devices and lasers. Laboratory is a design project, the production and characterization of a diode, bipolar transistor and MOSFET. The project is a team exercise.

**PH 407 Solid State Physics 4R-0L-4C S (even years) Pre: PH 255 or PH 265**

Selected topics in the field are discussed in detail; e.g., crystal structures, lattice vibrations and electronic band structure; electrical, optical and thermal properties of solids and semi-conductors; and the properties of materials at very low temperatures.

**PH 408 Microsensors 3R-3L-4C S Pre: JR or SR standing, and consent of instructor**

Introduction to solid state materials and conventional silicon processing. Measurement of signals from resistance- and capacitance-based transducers; sensor characteristics, calibration and reliability. Examples of microsensors: thermal, radiation, mechanical, chemical, optical fibers, and biological.

**PH 410 Introduction to MEMS: Fabrication and Applications 3R-3L-4C S Pre: JR or SR standing**

Properties of silicon wafers, wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor.

**PH 411 Advanced MEMS: Modeling and Packaging 3R- 3L- 4C F Pre: PH 410 or equivalent**

Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, and physics.

**PH 425 Advanced Physics Laboratory II 0R-8L-4C W Pre: PH 325**

Selected experiments in various areas of physics, with primary emphasis on nuclear physics and a significant independent student project

**PH 437/ECE 480 Introduction to Image Processing 3R-3L-4C S Pre: MA 222, and JR/SR or Graduate standing**

Basic techniques of image processing. Discrete and continuous two dimensional transforms such as Fourier and Hotelling. image enhancement through filtering and histogram modification. Image restoration through inverse filtering. Image segmentation including edge detection and thresholding. Introduction to image encoding. Integral laboratory.

**PH 440 X-rays and Crystalline Materials 2R-6L-4C S (even years) Pre: PH 255 or PH 265**

X-ray emission, absorption, fluorescence, and diffraction. Methods of analyzing crystalline solid materials. Applications in solid-state physics, materials science, chemistry, metallurgy, and biology.

**PH 460 Directed Study Credit arranged Pre: Consent of instructor**

Permits study in an area of physics not available in regular course offerings. Maximum of 4 credits per term.

**PH 470 Special Topics in Physics 2-4 Credits Pre: Consent of instructor**

Lectures on special topics in physics.

**PH 480 Seminar 0C Arranged**

Lectures by staff, students, and outside speakers on topics of special interest.

**PH 490 Directed Research Credit arranged Pre: Consent of instructor**

Research for junior and senior students under the direction of a physics and optical engineering faculty member. May earn a maximum of 8 credits between PH 290 and PH 490 for meeting graduation requirements. Maximum of 4 credits per term. The student must make arrangements with a physics and optical engineering faculty member for the research project prior to registering for this course.

**PH 497, PH 498, PH 499 Senior Thesis 2C F,W,S Pre: Consent of PHOE faculty**

Literature search, research proposal preparation, and laboratory project work. This sequence is designed to result in a completed senior thesis.

**GRADUATE COURSES**

*Note:* SR/GR standing is required for enrolling in the following 500-level courses.

**PH 505 Semiconductor Materials and Devices I 3R-3L-4C F Pre: PH 113 or PH 255 or PH 265**

Material structure electronic levels and energy bands; semiconductor doping; optical and electronic material characteristics; p-n junction and diode characteristics; bipolar junction transistor; basics of device fabrication. Laboratories on X-ray and Scanning Electron Microscope investigations, device characteristics and a three-week design project on production and testing of thin films. Students must do additional project work on a topic selected by the instructor.

**PH 506 Semiconductor Materials and Devices II 3R-3L-4C W Pre: PH 405 or ECE 250**

Metal-semiconductor interfaces; photoresist and photolithography; thin film deposition; design and fabrication of semiconductor diodes; characterization of process diodes and transistors; MOSFETS; optoelectronic devices and lasers. Laboratory is a design project, the production and characterization of a diode, bipolar transistor and MOSFET. The project is a team exercise. Students must do additional project work on a topic selected by the instructor.

**PH 508 Microsensors 3R-3L-4C S Pre: JR or SR standing, and consent of instructor**

Introduction to solid state materials and conventional silicon processing. Measurement of signals from resistance- and capacitance-based transducers; sensor characteristics, calibration and reliability. Examples of microsensors: thermal, radiation, mechanical, chemical, optical fibers, and biological. Students must do additional project work on a topic selected by the instructor.

**PH 510 Introduction to MEMS: Fabrication and Applications 3R-3L-4C S Pre: JR or SR standing**

Properties of silicon wafers, wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Students must do additional project work on a topic selected by the instructor.

**PH 511, ME 519, ECE 519, CHE 519, BE 519, CHEM 411 Advanced MEMS: Modeling and Packaging 3R-3L-4C F Pre: PH 410 or equivalent**

Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, and physics. Students must do additional project work on a topic selected by the instructor.

**PH 512 Methods of Mathematical Physics 4R-0L-4C Arranged**

Ordinary and partial differential equations, linear vector spaces, matrices, tensors. Sturm-Liouville theory and eigenvalue problems, special functions, function of a complex variable, theory of groups, linear integral equations.

**PH 514 Quantum Mechanics 4R-0L-4C Arranged**

Development of quantum mechanical theory to the present time. Examples from spectroscopy, chemistry, nuclear physics.

**PH 530 Advanced Acoustics 4R-0L-4C Arranged Pre: PH 404**

Waves in solids, electrostatics and piezoelectric sound transducers, ultrasonics. Architectural acoustics. Underwater sound.

**PH 537/ECE 582 Advanced Image Processing 3R-3L-4C Pre: CSSE 220 or ME 323 or ECE 380 or consent of instructor; MA 221**

Introduction to color image processing and image recognition. Morphological methods,

feature extraction, advanced segmentation, detection, recognition and interpretation. Integral laboratory. Same as ECE 582.

**PH 538 Introduction to Neural Networks 3R-3L-4C Arranged Pre: SR/GR standing**

Classifiers, linear separability. Supervised and unsupervised learning. Perceptrons. Back-propagation. Feedback networks. Hopfield networks. Associative memories. Fuzzy neural networks. Integral laboratory.

