PHYSICS

Physics is the study of how the world works: from fiber optic communications to the CCD chips in your phone; from bridges to radio antennas; from subatomic particles to stars and galaxies; physicists study it all.

The educational objectives of the Department of Physics are:

1. To train students to become critically thinking problem solvers.
2. To prepare students for entrance into and successful completion of a graduate education in physics or related fields.
3. To prepare students for entrance into the technological and non-technical work forces.

To accomplish these objectives, physics students are guided to an understanding of physical laws and their applications; students are trained to think logically and develop their problem-solving abilities; students develop experimental skills and become knowledgeable in the use of instrumentation; and students receive instruction in advanced mathematical and analytical techniques and in the use of computers and microprocessors. The applied component of the physics curriculum focuses on laser technology, applications in biology and medicine, and nanotechnology and materials science. Students learn the fundamental physical processes that constitute the basis of modern technology and engineering. Student research is highly encouraged. Students have opportunities to work with our faculty members on research ranging from biophotonics, astronomy, to high energy physics. Students are required to complete Senior Capstone Project which is an integrative project, chosen by our students and executed with the help of a faculty mentor. Here, students will apply their classroom knowledge to concrete challenges at the forefront of physics. Past capstones, for example, have ranged from quantum computing, to detecting early-stage cancer, to monitoring the earth's ionosphere using low-frequency radio receivers. Physics majors automatically earn a minor in mathematics.

Whether your interest is teaching high school, working in a high-tech company, or continuing on to graduate school and a research career, our combination of a solid classroom foundation and student research will give you an outstanding starting point for your future career. Physics graduates can pursue graduate studies in any sub-field of physics and related fields such as engineering, follow industrial careers in research and development in corporate or industrial environments, or pursue professional careers in such fields as physics, engineering, computer science, finance, medicine, biology, architecture, patent/high-tech law, and science teaching, just to name a few.

Programs

- Physics Major (https://catalog.fairfield.edu/undergraduate/arts-sciences/physics/bs-physics)
- Physics Minor (https://catalog.fairfield.edu/undergraduate/arts-sciences/physics/minor-physics)

Courses

PS 0071 Physics of Light and Color **3 Credits**
Attributes: EDCG Educational Studies Cognate
This course, intended for students who are not majoring in the physical sciences, covers the particle-wave duality of light and the relationship of light to other electromagnetic waves. Additional topics include polarization, vision, color and the perception of color, optical phenomena in nature and in biological systems, color and light in art, simple optical instruments, sources of light and their spectra, lasers, and holography.

PS 0076 Physics of Sound and Music **3 Credits**
Attributes: EDCG Educational Studies Cognate
Designed for the non-science major, this course examines the physical principles in the production of sound, with an emphasis on sound produced by musical instruments. Topics include the nature of wave motion as produced by vibrating strings and organ pipes, harmonic content, musical scales and intervals, and the mechanism of the hearing process. The course applies concepts to the construction and characteristics of musical instruments and to the design of auditoriums and concert halls.

PS 0077 Science and Technology of War and Peace: The Way Things Work **3 Credits**
Attributes: EDCG Educational Studies Cognate
Designed for the non-science major, this course includes critical discussion and descriptive exposition of the swords and plowshares dilemma, of the concept that science and technology have been used to build up - and tear down - civilization, and of the forces of civilization driving and being driven by the dual nature of our technological heritage. The course begins with the first lever and club and ends with laser surgery and Star-Wars lasers, taking a historical and a thematic approach where appropriate. The course describes, in the simplest terms, the way important real devices (television, telephones, lasers, gas turbines, thermonuclear weapons, etc.) work, examining their illustration of and limitations by scientific principles at a qualitative level. The course also considers the technical future from a past, present, and future perspective, asking: What can, could, didn't, might, and can we not do? The course illustrates the moral and ethical implications of science where appropriate. Knowledge of no more than high school algebra is required.

PS 0078 The Nature of the Universe **3 Credits**
This course, intended for non-science majors, reviews the scientific field of cosmology, or the nature of the physical universe, from a historical perspective. Beginning with the ancients, the course traces the development of cosmological principles through the Greek and Egyptian era of Aristotle, C. Ptolemy, and others; the 16th and 17th centuries of Copernicus, Galileo, and Newton; and the cosmology of the 20th century based upon Einstein's theories of relativity coupled with several fundamental observations. This leads to an examination of the current model of the universe, which is based upon the Big Bang theory.

PS 0087 Fundamentals of Astronomy **3 Credits**
This course introduces students who are not majoring in science to the principal areas, traditional and contemporary, of astronomy. Traditional topics include a historical background to astronomy, telescopes, the sun, the moon, the major and minor planets, comets, and meteors. After discussing these subjects in detail, the course covers areas appropriate to modern astronomy such as the composition and evolution of stars, star clusters, quasars, pulsars, black holes, and cosmological models.

PS 0089 Physics of Sport **3 Credits**
Attributes: EDCG Educational Studies Cognate
This course introduces concepts from science, particularly physics, by using illustrations from a wide variety of sports. For example, it explains why a baseball curves, why gears work on a bike, the speeds obtainable by a windsurfer or skier or tennis ball or arrow, how scuba divers survive, and a wide variety of other sports phenomena from football, golf, skiing, climbing, sailing, skating, baseball, scuba, fishing, sky-diving and so forth. The association of sports with motion, forces, and energy is explained by scientific reasoning and analysis. The course includes a small laboratory/experiential component that illustrates the scientific method, where various examples of sports are made quantitative, using readily available equipment.

PS 0093 Energy and Environment **3 Credits**
Attributes: EDCG Educational Studies Cognate, EVME Environmental Studies Major Elective, EVNS Environmental Studies: Natural Science, EVPE Environmental Studies Elective
This course introduces students not majoring in the natural sciences to topics relating to work, energy, and power, and explores many of the environmental consequences resulting from our use of energy. The course examines the finite nature of fossil fuels as well as many alternative energy sources including solar energy; wind, tidal, and geothermal energy; nuclear fission; and nuclear fusion. Students use arithmetic and simple algebra.

PS 0115 General Physics I **3 Credits**
Prerequisite: MA 0145 or higher (concurrency allowed).
This introductory course - for students concentrating in physics, mathematics, chemistry, or engineering - covers mechanics, heat, and fluid dynamics. It also includes rigorous mathematical derivations using integral and differential calculus. Topics include velocity and acceleration, Newton's laws of motion, work, energy, power momentum, torque, vibratory motion, elastic properties of solids, fluids at rest and in motion, properties of gases, measurement and transfer of heat, and elementary thermodynamics.

PS 0115L General Physics I Lab **1 Credit**
Fee: $60 Science Lab Fee
Corequisite: PS 0115.
This lab course engages students in experimental measurements spanning the areas of mechanics and thermal stresses on matter, with the objective of training students in experimental measurements, data manipulation and analysis, error analysis, deductive thinking, and instrumentation, providing depth to students' understanding of the phenomena taught in PS 115. Specific experimental measurements include accelerated motion, periodic motion, gravitational force, ballistics, conservation of energy and momentum, rotational dynamics, and measurements of the coefficient of linear expansion and the heat of fusion. Students complete a weekly lab report.

PS 0116 General Physics II **3 Credits**
Prerequisites: MA 0146 or higher (concurrency allowed); PS 0115.
This continuation of PS 0115 covers electricity and magnetism, light and optics, and sound. Topics include magnetism and electricity; simple electric circuits; electrical instruments; generators and motors; characteristics of wave motion; light and illumination; reflection; refraction, interference; polarization of light, color, and the spectrum; and production and detection of sound waves.

PS 0116L General Physics II Lab **1 Credit**
Fee: $60 Science Lab Fee
Corequisite: PS 0116.
This laboratory provides students with a greater understanding of electromagnetic phenomena, wave phenomena, and optics, and supports PS 116. Measurements of microscopic quantities, like the charge and mass of the electron, give students an opportunity to explore the structure of matter. Other experiments involve the physics of electrical currents, electric properties of bulk matter, magnetic fields and their effect on beams, wave phenomena, and the nature of light and its interaction with optical materials. This course trains students in experimental measurements, data manipulation and analysis, error analysis, deductive thinking, and instrumentation. Students complete a weekly lab report.

PS 0204L Modern Experimental Methods Lab **2 Credits**
Fee: $60 Science Lab Fee
Prerequisite: PS 0285.
This course offers lab experience in modern experimental methods and techniques. It involves lab investigation of fundamental concepts in modern physics including atomic, nuclear, solid-state, X-ray, acoustic, superconductivity, and quantum physics. Lab procedures emphasize hands-on work with basic experimental equipment such as vacuum systems, power supplies, electronics and instrumentation, detectors, diagnostic techniques, computer interfaces, data acquisition and control, hardware and software, etc. This lab course gives students maximum opportunity to work on their own with minimum supervision.

PS 0206L Modern Optics Lab **1 Credit**
Fee: $60 Science Lab Fee
Prerequisite: PS 0222 (concurrency allowed).
In this lab course, student experiments include measurement of the photoelectric effect, electro-optic phenomena, diffraction phenomena, spectroscopy, interferometry, interference effects, and optical heterodyning. Students may - and are encouraged to - develop relevant experiments. The course requires comprehensive lab reports.

PS 0212 Circuit Analysis and Analog Systems **3 Credits**
Corequisite: PS 0212L.
Prerequisites: PS 0115, PS 0116.
This course introduces students to the theory and practice of basic electronics and linear/analog circuitry. Topics include Kirchhoff's laws and applications; resistor circuits; concepts of capacitive and inductive reactance; impedance calculation using vector and complex notation; DC, AC, and transient circuit behavior; operation of basic solid state devices (diodes, junction transistors, FETs, SCRs); operational amplifiers; active and passive filters; feedback techniques; and frequency dependent effects. The basic laws and theorems of circuit analysis are introduced.

PS 0212L Circuit Analysis and Analog Systems Lab **1 Credit**
Fee: $60 Science Lab Fee
Corequisite: PS 0212.
Students learn the use of basic laboratory test equipment such as the digital volt-ohm-amp meter, function generator, oscilloscope, and frequency counter. Bread boarding techniques are utilized to assemble and test various linear/analog circuits. Simulation software is introduced.

PS 0215 Computational Physics **3 Credits**
Prerequisites: PS 0115, PS 0116.
In this course students will learn numerical methods to solve scientific problems and to integrate the use of the computer into their research. The course will cover numerical methods to solve integrals, differential equations, partial differential equations, systems of linear equations, and to model random processes. Problems that will be solved in this class include: Laplace equation, chaotic pendulum, Schrodinger's equation, and magnetic and electric field calculations. The programming languages that will be used in this course are high level languages, such as C and C++, whose basic syntax will be taught in class.

PS 0222 Modern Optics **3 Credits**
Corequisite: PS 0206L.
Prerequisite: PS 0285.
Starting with a review of electromagnetic wave theory and the differential wave equation, this course covers the propagation of light from a scattering and an electromagnetic wave phenomena point of view. The course investigates superposition, polarization, interference, and diffraction in detail and discusses the photon theory of light along with the photoelectric effect. The course covers the basic theory of coherence with its contemporary application to lasers and additional selected topics in applied optical devices, stressing the application of theory to devices and observations.

PS 0226 Classical Mechanics **3 Credits**
Prerequisites: PS 0115, PS 0116.
The formulation of classical mechanics represents a major milestone in our intellectual and technological history as the first mathematical abstraction of physical theory from empirical observations. This achievement is rightly accorded to Isaac Newton, who first translated the interpretation of various physical observations into a compact mathematical theory. More than three centuries of experience indicate that mechanical behavior in the everyday domain can be understood from Newton's theories. Topics in this course include elementary dynamics in one and two dimensions, gravitational forces and potentials, free and forced harmonic oscillations, central fields and the motions of planets and satellites, Lagrange's and Hamilton's equations, small oscillations, and normal mode analysis.

PS 0241 Thermal and Statistical Physics **3 Credits**
Prerequisite: PS 0285.
Thermodynamics, viewed primarily as the science that deals with energy transformations and the relationships between properties of systems, is a fairly modern science. As its name implies, thermodynamics deals with heat and power; originally, this now broad subject dealt almost exclusively with heat engines. This course begins with a review of the three fundamental laws of thermodynamics. Additional topics include the kinetic theory of gasses and modern statistical mechanics.

PS 0255 Introduction to Astrophysics **3 Credits**
Prerequisite: PS 0285.
This course is an introduction to modern astronomy and astrophysics. Starting from basic physical principles, we will begin with a number of practical problems in observational astronomy: the location of stars in the sky, optical telescopes and detectors, and measuring the brightness of stars and galaxies. From here, we will go on to discuss the formation, evolution, and death of stars and how these astronomical processes have influenced the world around us. Finally, we will end with a discussion of cosmological evolution from the big bang onward.

PS 0260 Introduction to Biomedical Optics **3 Credits**
Corequisite: MA 0251.
Prerequisite: PS 0116.
This Introduction to Biomedical Optics course provides an opportunity for students to be introduced to an exciting area in biophotonics. It would introduce students to some of the optical methods in non-invasive medical diagnostics and imaging. Students would learn about basics of tissue optics, elastic scattering, absorption, fluorescence and Raman spectroscopies, and photon transport in random media, Monte Carlo simulations, microscopy, ultrafast lasers and detection systems. Applications would include non-invasive detection of cancer, atherosclerosis, and optical tomography.

PS 0271 Electricity and Magnetism I **3 Credits**
Prerequisites: PS 0115, PS 0116, MA 0251.
This lecture course covers the foundations of electric and magnetic phenomena. Topics include electrostatics and the concepts of the electric field, flux, and potential; Coulomb's law and Gauss's law and their applications; vector and scalar fields and vector operators; electric energy of systems of charges; dipole fields and Laplace's equation; moving charges and currents; Ampere's law; and magnetic fields and forces.

PS 0285 Modern Physics **3 Credits**
Corequisite: MA 0245.
Prerequisites: PS 0115, PS 0116.
This course introduces modern physics, i.e., the physics of the 20th century. The basic ideas that led to the formulation of quantum mechanics together with Einstein's theories of relativity provided a means to explore many new aspects of the physical world. This course examines the discovery of quanta of energy; Einstein's Special Theory of Relativity; the Bohr model of the atom; wave mechanics, angular momentum, and spin; various aspects of quantum mechanics that explain much of the subatomic world; and aspects of atomic and nuclear physics including solid-state physics and superconductivity. The course also examines several of the major experimental observations that support and confirm these new theories.

PS 0371 Electricity and Magnetism II **3 Credits**
Prerequisite: PS 0271.
This lecture course is a continuation of PS 0271, covering additional topics in electric and magnetic phenomena. Topics include Faraday's laws and induced electromotive force; electric and magnetic fields in matter; methods of solving boundary value problems; Maxwell's equations in integral and differential form; electromagnetic radiation and wave propagation; and Einstein's Special Theory of Relativity for electrodynamics.

PS 0386 Quantum Physics **3 Credits**
Prerequisites: MA 0331, PS 0226, PS 0285.
This course introduces students to the physical concepts and mathematical formulations of nonrelativistic quantum mechanics. Topics include the Schrodinger wave equation, Fourier techniques and expectation values, operator formalism, angular momentum, central forces, matrix representations, and approximation methods.

PS 0387 Introduction to Condensed Matter **3 Credits**
Prerequisite: PS 0386.
Condensed matter physics is the study of the condensed phases of matter where atoms and molecules interact strongly and bind together to form solids and fluids governed by the laws of electromagnetism, quantum mechanics, and statistical physics. Condensed matter research forms the largest area of research in physics with applications in chemistry, photonics, semiconductor and material science, and nano-technology. Students will be introduced to several topics including crystal structure, crystal binding, thermal properties based on quantized vibrations (phonons), free-electron Fermi-gas, origin of the energy bands, semi-conductor crystals and superconductivity.

PS 0388 Elementary Particles and Nuclear Physics **3 Credits**
Prerequisite: PS 0386.
This course begins with a review of elementary particles, their properties and classification, and their nuclear and electromagnetic interactions. It proceeds with the study of bound nuclear systems, conditions for nuclear stability, and radioactive decay modes. The course concludes with an examination of particle accelerators and other nuclear experimental facilities.

PS 0390 Special Topics (Shell) **3 Credits**
Prerequisites: PS 0115, PS 0116, PS 0285.
This course covers the following content: condensed matter physics, numerical analysis and computational physics, and wave phenomena and quantum phenomena. Condensed matter topics include mechanical, thermal, and electric properties of matter; magnetism; superconductivity; and magnetic resonance. Topics in numerical analysis and computational physics include solutions of differential equations, boundary value and eigenvalue problems, special functions and Gaussian quadrature, and matrix operations. Topics in wave phenomena include electric and mechanical oscillators, coupled oscillators, transverse and longitudinal waves, waves on transmission lines, and electromagnetic waves. Quantum phenomena include advanced topics in quantum mechanics with applications in the structure of nuclei, atoms, molecules, metals, crystal lattices, semiconductors, and superconductors.

PS 0391 Theoretical/Experimental Capstone **1-4 Credits**
This course provides opportunities for intensive investigation, experimental or theoretical, of selected topics at an advanced level under the guidance of a faculty member. Participation in this course is required of all seniors. Credit by arrangement.

PS 0392 Theoretical/Experimental Capstone **1-4 Credits**
This course provides opportunities for intensive investigation, experimental or theoretical, of selected topics at an advanced level under the guidance of a faculty member. Participation in this course is required of all seniors. Credit by arrangement.

PS 0399 Independent Study **1 or 2 Credits**
This course provides opportunities to physics majors in their junior year, and to sophomores by permission of the department Chair, to pursue independent studies in selected areas of physics, under the mentorship of a faculty member. The course aims to guide students in using the methods of scientific inquiry to explore subjects in an area of mutual interest to the student and teacher. In the process, students will get personal attention and hands-on experience, and will develop further their analytical and experimental skills.

Faculty

Professors

Biselli, *chair*
Winn

Assistant Professors

Das (Visiting)
Nazarian

Assistant Professors of the Practice

Stott

Lecturers

Cordery
Kuhn

Professors Emeriti

Beal
Hadjimichael