Physics

Natural Sciences Division

Physics is the study of the most basic principles of nature that describe the world around us, from subatomic particles, to the motion of everyday objects, to the galaxies and beyond. Courses in physics allow students to develop a sound knowledge of these principles as well as the analytical and experimental techniques necessary to apply them to a broad range of theoretical and experimental problems. A physics degree is excellent preparation for graduate school in physics and engineering, and for careers in the health sciences and teaching.

Faculty

Benjamin W. Schumacher, Chair, Professor
Hyun Jai Cho, Visiting Assistant Professor
Eric J. Holdener, Assistant Professor
Jan Kmetko, Assistant Professor
Frank C. Peiris, Associate Professor
Timothy S. Sullivan, Professor
Paula C. Turner, Associate Professor

Emeritus Faculty

Thomas B. Greenslade Jr., Professor Emeritus
John D. Idoine, Professor Emeritus
Franklin Miller Jr., Professor Emeritus

The Physics Curriculum

The Department of Physics offers three options for students wishing to begin their exploration of physics.

Students who want a less mathematical approach to interesting subfields of physics should consider PHYS 104 (Einstein); PHYS 106 (Astronomy: Planets and Moons); PHYS 107 (Astronomy: Stars and Galaxies); PHYS 108 (Geology); or PHYS 109 (Origins). These courses are suitable for diversification in the sciences and are accessible to any Kenyon student. All contain some laboratory sessions in which students gain experience with the phenomena discussed in lectures. Usually, one or two such courses are offered each year.

The second option is PHYS 130 and 135 (General Physics I and II). PHYS 130 and 135 constitute a general survey of physics designed primarily for students who will take only one year of physics. Corequisite courses PHYS 141 and PHYS 146 are weekly laboratories closely tied to lecture material; they make extensive use of computers for data acquisition and analysis.

The third option is PHYS 140 (Classical Physics) and PHYS 145 (Modern Physics), which, together with PHYS 240 (Fields and Spacetime), form a calculus-based introduction to the fundamentals of physics. These courses cover much the same material as PHYS 130 and PHYS 135, but are more analytical and treat topics in greater depth. PHYS 140 and PHYS 145 are particularly suitable for students who plan to take more physics or upper-level chemistry or mathematics courses. PHYS 140 and 145 are required for all physics courses with numbers above 220. They require concurrent enrollment in, or credit for, calculus. For first-year students who have had any physics laboratory experience in high school, PHYS 110 (First-Year Seminar in Physics) is required as a corequisite to PHYS 140. (For first-year students who have not had any physics laboratory component in high school or who are just starting their study of physics in college, PHYS 141 is the required corequisite class.) For upper-class students, co-enrollment in PHYS 141 is required for PHYS 140. For the second semester, co-enrollment in PHYS 146 is required for enrollment in PHYS 145 for all students. PHYS 141 and PHYS 146 are weekly laboratories, closely tied to lecture material; they make extensive use of computers for data acquisition and analysis.

Students who have an unusually strong background in high school physics, including quantitative laboratory exercises, and mathematics, or who receive high scores on the Advanced Placement C-level Physics Examination, should consider beginning their study of physics with PHYS 240 (Fields and Spacetime) and the corequisite laboratory course, PHYS 241. Placement in this course is determined in consultation with the instructor and chair of the department. A student choosing this option should consider taking PHYS 110 (First-Year Seminar in Physics) as well.

Requirements for the Major

The minimum requirements for a major in physics consist of the following:

- PHYS 140; 110 or 141; 145; 146; 240; 241; 245; 270. PHYS 130 and 135 may be substituted for PHYS 140 and 145 with permission of the department chair.
- One unit of experimental physics including both PHYS 380 and 385, the rest being chosen from among PHYS 381, 382, 386, and 387.
- One unit of theoretical physics selected from PHYS 340, 350, 355, 360, 365, 370, or 375; including at least one of PHYS 340, 350, or 360.
- One-half additional unit selected from experimental or theoretical physics courses numbered above 320.
- MATH 111, 112, and 213, or equivalent; and either MATH 224 or 333.

Students of the classes of 2011 and 2012 may substitute PHYS 280 and 281 (1.5 unit total) for PHYS 380, 381 and 382 (1.5 unit total) and may substitute PHYS 246 (0.25 unit) for PHYS 270 (0.5 unit) in the above requirements.

Additional physics courses are encouraged. A student preparing for graduate study in physics should enroll in several advanced physics courses in addition to the minimum requirements and is encouraged to take further work in mathematics and chemistry. A student preparing for graduate study should expect to average about 2.25 units per semester. Care should be taken to satisfy the College's graduation requirement to take nine units outside of the major department.

Note: All courses in physics numbered above 220 have as prerequisites PHYS 140 and 145 and MATH 111 and 112, unless otherwise noted. PHYS 141, 146, 241, and courses numbered 380-387 are laboratory courses involving substantial experimental work.

Senior Exercise

The Senior Exercise includes the presentation of a talk on a topic in physics at a department colloquium and a comprehensive written exam in physics.

Honors

Honors work in physics involves directed research on a specific topic in experimental, theoretical, or computational physics, culminating in a written thesis, an oral presentation at a departmental colloquium, and an examination by an outside specialist.

Requirements for the Minor

The department offers two minors, physics and astronomy. Students considering one of these minors should work with a faculty member in the physics department as the minor is being planned, since some courses are not offered every year.

Requirements for the Physics Minor

The program for a minor in physics consists of the following:

- PHYS 140; 110 or 141; 145; 146; 240; 241. PHYS 130 and 135 may be substituted for 140 and 145 with permission of the department chair.
- One additional unit selected from physics courses numbered above 220.

This minor is open to students with all majors, but may be especially attractive to students in disciplines that have strong ties to physics, such as chemistry, mathematics, and biology. Other combinations of introductory courses may also be acceptable. Note: All courses in physics numbered above 220 have as prerequisites PHYS 140, 141, 145, 146, and MATH 111 and 112, unless otherwise noted.

Requirements for the Astronomy Minor

The program for a minor in astronomy consists of the following:

- PHYS 130 and 135 or 140 and 145; 110 or 141; 146; 106; 107.

- An additional .5 unit selected from all physics courses (see suggestions below).

There are several options for the choice of the fifth course. PHYS 240, 241 (Fields and Spacetime) and PHYS 245, 246 (Oscillations and Waves) provide further experience with the foundations of physics (note that these two courses have prerequisites in mathematics). PHYS 270 provides an introduction to computational physics. Students with interests in instrumentation can choose PHYS 380, 381. and 382 (Electronics). Other options may include independent study and special topics courses related to astronomy. Note that College rules prohibit a student from receiving a minor in the same department as his or her major. Thus, a physics major may not elect to minor in astronomy.

Physics Courses

PHYS 104 Einstein

Credit: .5 unit **QR**

A hundred years ago, Albert Einstein helped to launch a far-reaching revolution in physics. His relativity theories are justly famous; but he also made amazing discoveries about quantum mechanics and the statistical properties of matter and radiation. This course will focus on Einstein's life, his scientific contributions, and his role in the creation of modern physics. We will find that his insights are significant, not just for microscopic particles or distant galaxies, but for the phenomena of everyday life. Lectures, discussions, and readings (including Einstein's own works) will be supplemented by laboratory experiments (at times to be arranged). The course will have some mathematical content—simple algebra and geometry—but should be accessible to any Kenyon student. No prerequisites.

PHYS 106 Astronomy: Planets and Moons

Credit: .5 unit

This course, designed primarily for non-science majors, gives an introduction to the modern understanding of the solar system, including planets, moons, and smaller bodies (asteroids, comets, meteorites). Topics include planetary interiors, surface modification processes, planetary atmospheres, and the evolution of the solar system. Students will also attend evening laboratory sessions utilizing a variety of methods for exploring space-science topics, including telescopic observations, computer simulations, and laboratory exercises. No prerequisites.

PHYS 107 Astronomy: Stars and Galaxies

Credit: .5 unit **QR**

Accessible to all students, this course surveys current knowledge of the physical nature of stars and galaxies. Topics include the sun and other stars, the evolution of stars, interstellar matter, the end products of stellar evolution (including pulsars and black holes), the organization of stellar systems such as clusters and galaxies, and the large-scale structure of the universe itself. Evening laboratory sessions will include telescopic observation, laboratory investigations of light and spectra, and computer modeling and simulation exercises. No prerequisites.

PHYS 108 Geology

Credit: .5 unit

As an introduction to the geosciences designed for all students, this course surveys a wide range of physical geology topics. Our initial coverage of minerals and rocks, the basic building blocks of the world around us, includes discussions of the environments in which they form and the major processes operating in these environments. Hands-on exercises are designed to aid in the identification of these basic components of the Earth and to teach students how to recognize clues to their formation. Students will use this knowledge in a series of self-guided on-campus "field trips." Our coverage of plate tectonics includes discussions of the major evidence in support of this grand unifying theory of geology, including seismicity and earthquakes, volcanism and plutonic activity, orogenesis and structural geology, and geomagnetism and paleogeographic reconstruction. We will establish these ideas in a global context and apply them to the geologic history of the North American continent. Requirements include laboratory exercises, on-campus field trips, at least one off-campus field trip, and small group projects. No prerequisites.

PHYS 109 Origins

Credit: .5 unit

Around us we see a vast, expanding universe of galaxies. The galaxies are composed of stars around some of which orbit planets. At least one of these planets in the universe is inhabited by an astoundingly complex set of living things. Where did all this come from? This course presents an overview of the formation and evolution of the universe, the solar system, planet Earth, and life on our planet. Lectures and readings will be supplemented by astronomical observations, computer simulations, and laboratory experiments (at times to be arranged.) The course has no prerequisites and is accessible to any Kenyon student.

PHYS 110 First-Year Seminar in Physics

Credit: .25 unit **QR**

The goal of this seminar is to explore a specific topic in physics that is of current significance as well as challenging to first-year students. Generally, the topics will be varied from year to year, and in the past, the seminar has explored topics such as material science, nanoscience, astrophysics, particle physics, biological physics, and gravitation. In addition to introducing the fundamental physics related to these topics, the course will expose students to recent developments, as the topics are often closely related to the research area of faculty teaching the seminar. The seminar meets once per week for lectures, discussions, laboratory experiments, and computer exercises. It is open only for first-year students who are concurrently enrolled in or have placed out of PHYS 140 (Classical Physics). It fulfills the concurrent laboratory requirement of PHYS 140 and serves as a solid preparation for PHYS 145 (Introduction to Experimental Physics II).

PHYS 130 General Physics I

Credit: .5 unit **QR**

This course is the first course in a one-year introductory physics sequence. Topics include Newtonian mechanics, work and energy, wave phenomena, fluids, and thermodynamics. When possible, examples will relate to life-science contexts. The course will be taught using a combination of lectures, in-class exercises, homework assignments, and examinations. A knowledge of calculus is not required. Prerequisites: high-school algebra and trigonometry. Co-requisite: PHYS 141.

PHYS 135 General Physics II

Credit: .5 unit **QR**

This course focuses on a wide variety of physics topics relevant to students in the life sciences. Topics include electricity and magnetism, geometrical and physical optics, atomic physics, X-rays, radioactivity, and nuclear physics. When possible, examples will relate to life-science contexts. The course will be taught using a combination of lectures, in-class exercises, homework assignments, and examinations. Prerequisites: PHYS 130. Co-requisite: PHYS 146.

PHYS 140 Classical Physics

Credit: .5 unit **QR**

This lecture course is the first in a three-semester, calculus-based introduction to physics. Topics include the kinematics and dynamics of particles and solid objects, work and energy, linear and angular momentum, and gravitational, electrostatic, and magnetic forces. PHYS 140, 145, and 240 are recommended for students who may major in physics, and are also appropriate for students majoring in other sciences and mathematics. The course will be taught using a combination of lectures, in-class exercises, homework assignments, and examinations. Prerequisite: trigonometry. Co-requisite: (first year students) PHYS 110; (upperclass students) PHYS 141; and MATH 111 or 112 taken concurrently, or equivalent. (While calculus is a co-requisite, we will develop the necessary mathematical tools in our lectures as well.) PHYS 140 is open only to first- and second-year students.

PHYS 141 Introduction to Experimental Physics I

Credit: .25 unit **QR**

This laboratory course meets one afternoon each week and is organized around weekly experiments that demonstrate the phenomena of classical mechanics, including projectile motion, rotation, electrical circuits and fields, and conservation of energy and momentum. Lectures cover the theory and instrumentation required to understand each experiment. Experimental techniques emphasize computerized acquisition and analysis of video images to study motion. Students are introduced to computer-assisted graphical and statistical analysis of data as well as the analysis of experimental uncertainty. Enrollment is limited to sixteen students in each section. Co-requisite: PHYS 130 or 140.

PHYS 145 Modern Physics

Credit: .5 unit **QR**

This lecture course, a continuation of the calculus-based introduction to physics, focuses on the physics of the twentieth century. Topics include geometrical and wave optics, special relativity, photons, photon-electron interactions, elementary quantum theory (including wave-particle duality, the Heisenberg uncertainty principle, and the time-independent Schrodinger equation), atomic physics, solid-state physics, nuclear physics, and elementary particles. PHYS 145 is recommended for students who may major in physics, and is also appropriate for students majoring in other sciences or mathematics. The course will be taught using a combination of lectures, in-class exercises, homework assignments, and examinations. Prerequisite: PHYS 140 and MATH 111 (or permission of the instructor). Co-requisite: PHYS 146 and MATH 112 taken concurrently (or permission of the instructor). Open only to first- and second-year students.

PHYS 146 Introduction to Experimental Physics

Credit: .25 unit **QR**

This laboratory course is a co-requisite for all students enrolled in PHYS 135 or 145. The course meets one afternoon each week and is organized around weekly experiments demonstrating the phenomena of waves, optics, x-rays, and atomic and nuclear physics. Lectures cover the theory and instrumentation required to understand each experiment. Experimental techniques include the use of lasers, x-ray diffraction and fluorescence, optical spectroscopy, and nuclear counting and spectroscopy. Students are introduced to computer-assisted graphical and statistical analysis of data, as well as the analysis of experimental uncertainty. Enrollment is limited to sixteen students in each section. Prerequisite: PHYS 110 or 141. Co-requisite: PHYS 135 or 145.

PHYS 210 Intermediate Seminar in Physics

Credit: .25 unit

See the course description for PHYS 110. This course will cover the same material but in greater depth, using physics learned in previous courses. This course will meet once each week for a combination of lectures, discussion of assigned readings, small group problem-solving sessions, demonstrations, and experimental work. Prerequisites: one year of introductory physics at the college level. PHYS 210 may be repeated, as topics vary from year to year.

PHYS 218 Dynamical Systems in Scientific Computing

Credit: .5 unit **QR**

The advent of widespread computing power has led to a revolution in our understanding of the natural world. Using computer models, scientists in all disciplines have been able to explore systems that are mathematically intractable. Surprising commonalities among systems have been discovered that have led to new ways of classifying phenomena and to a strong interdisciplinary perspective. In this class, students will get hands-on experience in numerical exploration using new techniques applied to many areas of science. Students will write programs to solve ordinary differential equations and to model electrical circuits, orbital motion, and chemical reaction rates. In every case, students will implement these techniques in a programming language and build their programming skills. Prerequisites: MATH 118 or demonstrated competence in programming in some high-level language.

PHYS 219 Complex Systems in Scientific Computing

Credit: .5 unit **QR**

The underlying laws governing nature are usually fairly simple, yet the phenomena of nature are often extremely complex. How can this happen? In this course we discuss several definitions of "complexity" and use computers to explore how simple rules can give rise to complex behavior. We will construct cellular automata and related models to simulate a variety of systems: the growth of random fractals, the spread of forest fires, magnetic materials near phase transitions, the statistics of avalanches, the movements of flocks of birds, and even the formation of traffic jams. A number of common ideas and characteristics will emerge from these explorations. Since the computer is our primary tool, some knowledge of computer programming will be required. Prerequisite: MATH 218 or permission of the instructor.

PHYS 240 Fields and Spacetime

Credit: .5 unit **QR**

This lecture course is the third semester of the calculus-based introductory sequence in physics, which begins with PHYS 140 and PHYS 145. Topics covered include electric charge, electric and magnetic fields, electrostatic potentials, Ampere's law, electromagnetic induction, Maxwell's equations in integral form, electromagnetic waves, the postulates of the special theory of relativity, relativistic kinematics and dynamics, and the connections between special relativity and electromagnetism. This course may be an appropriate first course for particularly strong students with advanced placement in physics; such students must be interviewd by and obtain permission from the chair of the physics department. Prerequisites: PHYS 140 and 110 (or 141) or equivalent, and MATH 111. Co-requisite: PHYS 241.

PHYS 241 Fields and Spacetime Lab

Credit: .25 unit **QR**

This lecture and laboratory course is required for all students enrolled in PHYS 240 and is a prerequisite for all physics courses numbered above 241. The course is organized around experiments demonstrating various phenomena associated with electric and magnetic fields. Lectures cover the theory and instrumentation required to understand each experiment. Laboratory work emphasizes computerized acquisition and analysis of data, the use of a wide variety of modern instrumentation, and the analysis of experimental uncertainty. Prerequisite: PHYS 140 and 110 or 141 or equivalent. Co-requisite: PHYS 240.

PHYS 245 Oscillations and Waves

Credit: .5 unit **QR**

The topics of oscillations and waves serve to unify many subfields of physics. This course begins with a discussion of damped and undamped, free and driven, and mechanical and electrical oscillations. Oscillations of coupled bodies and normal modes of oscillations are studied along with the techniques of Fourier analysis and synthesis. We then consider waves and wave equations in continuous and discontinuous media, both bounded and unbounded. The course may also treat properties of the special mathematical functions that are the solutions to wave equations in non-Cartesian coordinate systems. Prerequisite: PHYS 240 or equivalent or permission of instructor. Co-requisites: MATH 213.

PHYS 246 Oscillations and Waves Laboratory

Credit: .25 unit **QR**

This laboratory course is required for all students enrolled in PHYS 245. The course is organized around experiments demonstrating oscillations and waves in mechanical, acoustical, and electrical systems. Lectures cover the theory and instrumentation required to understand each experiment. Laboratory work emphasizes computerized acquisition and analysis of data, the use of a wide variety of modern instrumentation, and the analysis of experimental uncertainty. Co-requisite: PHYS 245.

PHYS 270 Introduction to Computational Physics

Credit: .5 unit **QR**

As modern computers become more capable, a new mode of investigation is emerging in all science disciplines: the use of the computer to model the natural world and solving the model equations numerically rather than analytically. Thus, computational physics is assuming a co-equal status with theoretical and experimental physics as a way to explore physical systems. This course will introduce the student to the methods of computational physics, numerical integration, numerical solutions of differential equations, Monte Carlo techniques, and others. Students will learn to implement these techniques in the computer language Fortran, the most widely used high-level programming language in computational physics. In addition, the course will expand students' capabilities in using a symbolic algebra program (Mathematica) to aid in theoretical analysis and in scientific visualization. Prerequisites: PHYS 240 and Math 112. Offered every year.

PHYS 280 Electronics

Credit: .25 unit **QR**

This lecture course covers the physics behind modern electronic components, such as field-effect transistors and operational amplifiers, as well as the design and analysis of digital and analog circuits. Prerequisites: PHYS 145 and MATH 112. Co-requisite: PHYS 281.

PHYS 281 Electronics Laboratory

Credit: .5 unit **QR**

This laboratory course is required for the physics major and is a prerequisite for PHYS 481. The course meets for two afternoons each week and is organized around experiments in which students design, test, and analyze both digital and analog electronic circuits. Students will become familiar with the use of a wide variety of electronic devices, including logic gates, analog-to-digital converters, field-effect transistors, and operational amplifiers. The course will emphasize the use of computers to analyze and control electronic circuits and scientific instrumentation. Independent laboratory projects allow students to combine and expand upon what they have learned to create new circuits of their own design. Co-requisite: PHYS 280.

PHYS 340 Classical Mechanics

Credit: .5 unit **QR**

This lecture course begins by revisiting most of the Newtonian mechanics learned in introductory physics courses but with added mathematical sophistication. A major part of the course will be spent in understanding an alternate description to that of the Newtonian picture: the Lagrange-Hamilton formulation. The course will also cover the topics of motion in a central field, classical scattering theory, motion in non-inertial reference frames, and dynamics of rigid body rotations. Prerequisites: PHYS 245 and MATH 213.

PHYS 350 Electricity and Magnetism

Credit: .5 unit

In this course we develop further the basic concepts of electricity and magnetism previously discussed in Fields and Spacetime (PHYS 240) and introduce mathematical techniques for analyzing and calculating static fields from source distributions. These techniques include vector calculus, Laplace's equation, the method of images, separation of variables, and multipole expansions. We will then revisit Maxwell's equations and consider the physics of time-dependent fields and the origin of electromagnetic radiation. Other topics to be discussed include the electric and magnetic properties of matter. This course provides a solid introduction to electrodynamics and is a must for students who plan to study physics in graduate school. Prerequisites: PHYS 240, PHYS 245, and MATH 213 (may be taken concurrently).

PHYS 355 Optics

Credit: .5 unit **QR**

The course begins with a discussion of the wave nature of light. The remainder of the course is concerned with the study of electromagnetic waves and their interactions with lenses, apertures of various configurations, and matter. Subjects include the properties of waves, reflection, refraction, interference, and Fraunhofer and Fresnel diffraction, along with Fourier optics and coherence theory. Prerequisite: PHYS 350 or consent of the instructor.

PHYS 360 Quantum Mechanics

Credit: .5 unit **QR**

This course presents an introduction to theoretical quantum mechanics. Topics to be covered include wave mechanics, the Schrodinger equation, angular momentum, the hydrogen atom, and spin. Prerequisites: PHYS 245 and MATH 221.

PHYS 365 Atomic and Nuclear Physics

Credit: .5 unit **QR**

This course covers applications of quantum mechanics to atomic, nuclear, and molecular systems. Topics to be covered include atomic and molecular spectra, the Zeeman effect, nuclear structure and reactions, cosmic rays, scattering, and perturbation theory. Prerequisite: PHYS 360.

PHYS 370 Thermodynamics and Statistical Mechanics

Credit: .5 unit **QR**

This introduction to thermodynamics and statistical mechanics focuses on how microscopic physical processes give rise to macroscopic phenomena; that is, how, when averaged, the dynamics of atoms and molecules can explain the large-scale behavior of solids, liquids, and gases. We extend the concept of conservation of energy to include thermal energy, or heat, and develop the concept of entropy for use in determining equilibrium states. We then apply these concepts to a wide variety of physical systems, from steam engines to superfluids. Prerequisite: PHYS 240.

PHYS 375 Condensed Matter Physics

Credit: .5 unit **QR**

Modern field theories may find their inspiration in the quest for understanding the most fundamental forces of the universe, but they find crucial tests and fruitful applications when used to describe the properties of the materials that make up our everyday world. In fact, these theories have made great strides in allowing scientists to create new materials with properties that have revolutionized technology and our daily lives. This course will include: crystal structure as the fundamental building block of most solid materials; how crystal lattice periodicity creates electronic band structure; the electron-hole pair as the fundamental excitation of the "sea" of electrons; and Bose-Einstein condensation as a model for superfluidity and superconductivity. Additional topics will be selected from the renormalization group theory of continuous phase transitions, the interaction of light with matter, magnetic materials, and nano-structures. There will be a limited number of labs, at times to be arranged, on topics such as crystal growth, X-ray diffraction as a probe of crystal structure, specific heat of metals at low temperature,; and spectroscopic ellipsometry. Prerequisite: PHYS 245.

PHYS 380 Introduction to Electronics

Credit: .25 unit **QR**

This course will build upon the foundation developed in PHYS 240 and 241 for measuring and analyzing electrical signals in DC and AC circuits, introducing you to many of the tools and techniques of modern electronics. Familiarity with this array of practical tools will prepare you well for engaging in undergraduate research opportunities as well as laboratory work in graduate school or industry settings. You will learn to use oscilloscopes, meters, LabView, and various other tools to design and characterize simple analog and digital electronic circuits. The project-based approach used in this and associated courses (PHYS 381, PHYS 382) fosters independence and creativity, while the hands-on nature of the labs and projects will help you build practical experimental skills including schematic and spec sheet reading, soldering, interfacing circuits with measurement or control instruments, and trouble-shooting problems with components, wiring, and measurement devices. In each of these three courses, you will practice documenting your work thoroughly, by tracking your work in your lab notebook with written records, diagrams, schematics, data tables, graphs, and program listings. You will also engage in directed analysis of the theoretical operation of components and circuits through lab notebook explanations, worksheets, and occasional problem sets, and in each course you may be asked to research and present to the class a related application of the principles you learn during your investigations. This course is required as part of the one unit of upper-level experimental physics coursework to complete the major in physics. Prerequisites: PHYS 240, PHYS 241.

PHYS 381 Projects in Electronics 1

Credit: .25 unit **QR**

In this course, you will explore circuit design and analysis for active and passive analog element circuits, from the physics of the components (semiconductor diodes, transistors) to the behavior of multi-stage circuits. Experiments will include voltage source and current source power supplies, transistors, gain and isolation amplifier designs, and frequency-sensitive feedback networks. Prerequisite: PHYS 380 (may be taken concurrently). Offered every other year.

PHYS 382 Projects in Electronics 2

Credit: .25 unit **QR**

In this course, you will investigate the operation of integrated circuit chips (ICs), the fundamental building blocks of electronic devices, from personal computers, cell phones, and iPods to sophisticated control systems in use across the spectrum of research and industry today. Experiments will touch on applications such as counting, timing, multiplexing, analog-to-digital conversion, and instrument control. Prerequisite: PHYS 380 (may be taken concurrently). Offered every other year.

PHYS 385 Experimental Physics

Credit: .25 unit **QR**

This course is an introduction to upper-level experimental physics that will prepare you for work in original research in physics and for work in industry applications of physics. You will acquire skills in experimental design, observation, material preparation and handling, and equipment calibration and operation. The experiments will be selected to introduce you to concepts, techniques, and equipment useful in understanding physical phenomena across a wide range of physics subdisciplines, with the two-fold goal of providing you with a broad overview of several branches of experimental physics and preparing you to undertake any of the experiments found in the successor courses, PHYS 386 and 387. Prerequisites: PHYS 145, PHYS 240, PHYS 241. Offered every year.

PHYS 386 Advanced Experimental Physics 1

Credit: .25 unit **QR**

In this course you will explore fundamental physical interactions between light and matter, such as Compton scattering, Rayleigh and Mie scattering, and matter-antimatter annihilation, while also learning to use common nuclear and optical detection and analysis techniques. Prerequisite: PHYS 385 (may be taken concurrently). Offered every other year.

PHYS 387 Advanced Experimental Physics 2

Credit: .25 unit **QR**

In this course you will probe the structure of solids using X-ray crystallography and atomic force microscopy, study the physical properties of semiconductors, and use the manipulation of magnetic fields to examine the resonant absorption of energy in atoms and nuclei. Prerequisite: PHYS 385 (may be taken concurrently). Offered every other year.

PHYS 480 Research Methods for Experimental Physics

Credit: .25 unit **QR**

This lecture course presents the theory, instrumentation, and statistical analysis of data needed to prepare students for the experiments performed in Experimental Physics (PHYS 481) and gives them experience in presenting physics to their peers. Topics, selected from many fields of physics, are currently drawn from nuclear physics, solid state physics, x-ray physics, Fourier optics, thin-film fabrication and characterization, light scattering, thermodynamics, and nuclear magnetic resonance. Understanding the physics behind the operation of detectors, analog-to-digital converters, and other modern instrumentation is stressed. Co-requisite: PHYS 481 and senior standing.

PHYS 481 Experimental Physics

Credit: .5 unit **QR**

This advanced course in experimental physics includes extensive laboratory work and data analysis. Students will gain experience with nuclear detectors, x-ray diffraction and fluorescence techniques, noise reduction using phase-sensitive detection, computer data acquisition and analysis, and Fourier techniques. Prerequisites: PHYS 245, 280, and 281. Co-requisite: PHYS 480 and senior standing.

PHYS 493 Individual Study

Credit: .25-.5 unit

Individual study courses should supplement, not replace, courses regularly offered by the department. Only in unusual circumstances will the department approve an individual study in which the content substantially overlaps that of a regularly offered course. Individual studies may involve various types of inquiry?reading, problem solving, experimentation, computation, etc. To enroll in individual study, a student must identify a physics faculty member willing to guide the course and work with that professor to develop a description. The description should include: topics and content areas, learning goals, prior coursework qualifying the student to pursue the study, resources to be used (e.g., specific texts, instrumentation), a list of assignments and the weight of each in the final grade, and a detailed schedule of meetings and assignments. The student must submit this description to the Physics Department chair. In the case of a small-group individual study, a single description may be submitted, and all students must follow that plan. The amount of work in an individual study should approximate the work typically required in other physics courses of similar types at similar levels, adjusted for the amount of credit to be awarded. Ordinarily, individual study courses in physics are designed for .25 unit of credit. Students contemplating individual study should plan well in advance, preferably the semester before the proposed project.

PHYS 497Y Senior Honors

Credit: .5 unit

This course offers guided experimental or theoretical research for senior honors candidates. Prerequisite: permission of department chair.

PHYS 498Y Senior Honors

Credit: .5 unit

This course offers guided experimental or theoretical research for senior honors candidates. Prerequisite: permission of department chair.