PHYSICS

REQUIREMENTS

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, computational 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, law and teaching.

THE CURRICULUM

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

1. Students interested in exploring physics as a potential major or minor field of study should begin by taking PHYS 140 and 141 and PHYS 145 and 146 in their first year. Together with PHYS 240 and 241, these courses form a calculus-based introduction to physics particularly suitable for students who plan to take upper-level courses in physics, chemistry and/or mathematics. PHYS 140 and 145 require concurrent enrollment in or credit for Calculus I and II, respectively, and each has a co-requisite laboratory course. PHYS 141, corequisite to PHYS 140 for first-year students, is a weekly seminar open only to first-year students enrolled in PHYS 140 or holding credit for an equivalent course. It introduces students to laboratory work in physics in the context of one of the subdisciplines of physics pursued by faculty members in the department. Recent seminar topics have included nanoscience, biological physics, gravitation, astrophysics and particle physics. PHYS 131, corequisite to PHYS 140 for upperclass students, and PHYS 146 are weekly laboratories, closely tied to lecture material; they make extensive use of computers for data acquisition and analysis.
2. First-year students who have unusually strong physics preparation from high school, including a high score on the Advanced Placement C-level Physics Examination, experience with quantitative laboratory measurement, significant use of calculus in their high school physics course and placement into Calculus III, may want to consider beginning their study of physics with PHYS 240 (plus PHYS 141 as their corequisite lab course), in the first semester, followed by PHYS 145 and 146 in the second semester. Placement into PHYS 240 is determined in consultation with the instructor and chair of the department.
3. Students who desire a more qualitative approach to physics can choose from an array of courses designed to engage learners in the physics relevant to various interesting subfields of the discipline. Recent course offerings in this series have included: PHYS 101 (QR); PHYS 102 (QR); PHYS 103; PHYS 104 (QR); PHYS 105 (QR); PHYS 106; PHYS 107 (QR); PHYS 108 and PHYS 109. These courses are suitable for diversification in the sciences and are accessible to any Kenyon student regardless of class year or prior preparation. Those including the QR designation also satisfy the College's quantitative reasoning requirement, making regular, weekly use of numerical, statistical and/or graphical techniques to help students explore the material in quantitative ways. 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 semester.

Upperclass students seeking a one-year survey of physics with laboratory should take PHYS 130 and 135 and the co-requisite laboratory courses, PHYS 131 and 146. Entry into PHYS 130 and 135 requires sophomore standing; no first-year students will be admitted to these courses.

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 two-and-a-half (2.25) units per semester. Care should be taken to satisfy the College's graduation requirement to take nine (9) units outside of the major department.

A student preparing for graduate or second bachelor's degree work in engineering will need to complete a year of chemistry with lab as well as MATH 333. Note that MATH 224 does not substitute for MATH 333 for purpose of pre-enginering coursework.

All courses in physics numbered above 220 have as prerequisites PHYS 140 and 145 and MATH 111 and 112, unless otherwise noted. PHYS 131, 141, 146, 241, and courses numbered 380-387 are laboratory courses involving substantial experimental work.

REQUIREMNTS FOR THE MAJOR

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

- PHYS 140; 141; 145; 146; 240; 241; 245. In extraordinary circumstances, PHYS 130, 131, and 135 may be substituted for PHYS 140, 141, and 145 with permission of the department chair.
- One (1) unit of experimental physics including both PHYS 380 and 385, the rest being chosen from PHYS 381, 382, 386 and 387.
- One (1) unit of theoretical physics selected from PHYS 340, 345, 350, 355, 360, 365, 370 or 375, including at least one of PHYS 340, 350 or 360.
- Half (.5) unit of computational physics chosen from PHYS 218 or PHYS 270. (Note that PHYS 218 has a prerequisite of SCMP 118 and is not offered every year.)
- Half (.5) 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.

REQUIREMENTS FOR THE MINORS

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; 131 or 141; 145; 146; 240; 241. PHYS 130 and 135 may be substituted for 140 and 145 with permission of the department chair.
- One (1) additional unit selected from physics courses numbered above PHYS 220 (Note: All courses in physics numbered above 220 have as prerequisites PHYS 140 and 145 and MATH 111 and 112, unless otherwise noted).

This minor is open to students with all majors, but it 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.

Requirements for the Astronomy Minor

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

- Both 100-level survey courses in astronomy: PHYS 106 and 107;
- A year of introductory physics with lab: PHYS 130 and 135 or 140 and 145; 131 or 141; 146.
- An additional half (.5) unit selected from all physics courses (see suggestions below).

There are several options for the choice of the fifth course. While any of the 100-level courses could be used, specific intermediate courses accessible upon completion of the introductory sequence with lab are also good choices. For example, PHYS 240 and 241 provide further experience with the foundations of physics. PHYS 218, 219 and 270 explore computational approaches to problem solving using examples from astronomy, physics and other sciences. Other options may include individual study and special topics courses related to astronomy.

Note: College policy prohibits 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.

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.

More information about the Senior Exercise in physics is available on the department website.

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.

More information about honors work in physics is available on the department website.

COURSES

PHYS 101 ROCKET SCIENCE

Credit: 0.5 QR

"Rocket science" may be proverbial as a complex subject impossible for the ordinary person to understand, but in fact its essential principles are entirely accessible to any Kenyon student. Our course explores the basic concepts of rocket propulsion and spaceflight, including Newton's laws of motion, ballistics, aerodynamics, the physics and chemistry of rocket motors, orbital mechanics and beyond. Simple algebra, numerical calculations and data analysis help us apply the principles to real situations. We also delve into the history of astronautics, from the visionary speculations of Tsiolkovsky and Goddard to the missiles and space vehicles of today. Finally, we take a look at some of the developments in technology and space exploration that may lie just around the corner. In addition to the regular class meeting, there will be several evening and weekend lab sessions, during which we will design, build, test and fly model rockets powered by commercial solid-fuel engines. A willingness to build upon high school science and mathematics is expected. No prerequisite.

PHYS 102 GOOD NUKES, BAD NUKES

Credit: 0.5 QR

Nuclear power produces needed energy, but nuclear waste threatens our future. Nuclear weapons make us strong, but dirty bombs make us vulnerable. Nuclear medicine can cure us, but nuclear radiation can kill us. Radiocarbon dating tells us about the past, but it can challenge religious faith. "Good Nukes, Bad Nukes" is designed to give each student the scientific knowledge necessary to understand and participate in public discussions of nuclear issues. The concepts include classification of nuclei, the types of energy (radiation) released in nuclear reactions, the interactions of that radiation with matter, including human health effects, and the design of nuclear reactors and nuclear weapons. Hands-on demonstrations and experiments will explore radioactive decay, antimatter, transmutation of atoms, nuclear detectors and interactions of radiation with matter. We will apply the core concepts to understanding contemporary issues, such as electric power generation using nuclear energy, including its environmental effects; advances in nuclear medicine; the challenges of preventing nuclear weapons proliferation; the threat of "dirty bombs"; and dating the universe. We also will cover the history of the Manhattan Project and the use of nuclear weapons that brought an end to World War II. The course will offer a field trip to at least one significant nuclear site in Ohio. This course is designed to be accessible to any student. No prerequisite.

PHYS 103 CREATING WITH GADGETS

Credit: 0.25

In this course, students will learn to use motors, relays, microcontrollers and electronic components to design and build computer-controlled devices, small robots and interactive gizmos increasingly employed in projects by artists, designers and scientists. The primary tool will be the Arduino open source microcontroller environment. Developed for use by designers, artists and hobbyists, the Arduino environment provides a wide array of options for implementing automation and interaction between a physical device and its environment. It is used in applications ranging from interactive installation art to smart home technologies and hardware control in scientific applications. The course will combine laboratory exercises, homework assignments, individual and group project work, and a culminating public presentation. No prerequisite.

PHYS 104 EINSTEIN

Credit: 0.5 QR

Over one hundred years ago, Albert Einstein helped 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. The course will have some mathematical content, simple algebra and geometry, but should be accessible to any student. No prerequisite.

PHYS 105 FRONTIERS OF GRAVITY

Credit: 0.5 QR

Gravity is at once the most familiar and most mysterious of the basic forces of nature. It shapes the formation, structure and motion of stars, galaxies and the cosmos itself. Also, because gravity affects everything, it enables us to investigate parts of the universe that are otherwise invisible to us. This course will explore the role of gravity in a few vibrant areas of contemporary astrophysics: the search for planets beyond our solar system, the discovery of giant black holes in the nuclei of galaxies, the generation and detection of gravitational waves and the evidence for dark matter and dark energy in our universe. In addition to the scheduled class lectures and discussions, students will be required to meet a few times during the semester for evening laboratories. No prerequisite.

PHYS 106 ASTRONOMY: PLANETS AND MOONS

Credit: 0.5

This course introduces 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. Evening laboratory sessions will utilize a variety of methods for exploring space-science topics, including telescopic observations, computer simulations and laboratory investigations. No prerequisite.

PHYS 107 ASTRONOMY: STARS AND GALAXIES

Credit: 0.5 QR

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 prerequisite.

PHYS 108 GEOLOGY

Credit: 0.5

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 prerequisite.

PHYS 109 ORIGINS

Credit: 0.5

Around us we see a vast, expanding universe of galaxies. The galaxies are composed of stars, some of which planets orbit. 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. Astronomical observations, computer simulations and laboratory experiments will supplement lectures and readings. No prerequisite.

PHYS 130 GENERAL PHYSICS I

Credit: 0.5 QR

This course is the first course in a one-year introductory physics sequence. Topics include Newtonian mechanics, work and energy, fluids, and electric fields. 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. Knowledge of calculus is not required. Prerequisite: sophomore standing. Corequisite: PHYS 131. Offered every fall semester.

PHYS 131 INTRODUCTION TO EXPERIMENTAL PHYSICS I

Credit: 0.25 QR

This laboratory course meets one afternoon each week and is organized around weekly experiments that explore the phenomena of classical mechanics and electromagnetism, including motion, forces, fluid mechanics, 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. Corequisite: PHYS 130 (or PHYS 140 for sophomores enrolled in PHYS 140). Offered every fall semester.

PHYS 135 GENERAL PHYSICS II

Credit: 0.5 QR

This course focuses on a wide variety of physics topics relevant to students in the life sciences. Topics include wave phenomena, geometrical and physical optics, elementary quantum theory, atomic physics, X-rays, radioactivity, nuclear physics 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. Prerequisite: PHYS 130. Corequisite: PHYS 146. Offered every spring semester.

PHYS 140 CLASSICAL PHYSICS

Credit: 0.5 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 might major in physics, and they also are appropriate for students majoring in other sciences and mathematics, particularly those who are considering careers in engineering. The course will be taught using a combination of lectures, in-class exercises, homework assignments and examinations. Corequisite: MATH 111, if not previously taken, and PHYS 141 (first-year students) or PHYS 131 (upperclass students). Open only to first-year and sophomore students. Offered every fall semester.

PHYS 141 FIRST YEAR SEMINAR IN PHYSICS

Credit: 0.25 QR

This seminar will explore a significant current topic in physics that will challenge first-year students. The topic varies from year to year; in the past, the seminar has explored such topics such nanoscience, astrophysics, particle physics, biological physics and gravitation. In addition to introducing the fundamental physics connected with 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 one evening a week for lectures, discussions, laboratory experiments and computer exercises. This course fulfills the concurrent laboratory requirement of PHYS 140 and serves as solid preparation for PHYS 146. Prerequisite: Open only to first-year students who are concurrently enrolled in or have placed out of PHYS 140, including those first-years who enroll in PHYS 240. Offered every fall semester.

PHYS 145 MODERN PHYSICS

Credit: 0.5 QR

This lecture course is a continuation of the calculus-based introduction to physics, PHYS 140, and focuses on the physics of the 20th 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 Schrödinger equation), atomic physics, solid-state physics, nuclear physics and elementary particles. PHYS 145 is recommended for students who might major in physics and is appropriate for students majoring in other sciences or mathematics, particularly those who are considering careers in engineering. 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 instructor. Corequisite: PHYS 146 and MATH 112 taken concurrently or permission of department chair. Open only to first-year and sophomore students. Offered every spring semester.

PHYS 146 INTRODUCTION TO EXPERIMENTAL PHYSICS

Credit: 0.25 QR

This laboratory course is a corequisite 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. Prerequisite: PHYS 131 or 141. Corequisite: PHYS 135 or 145. Offered every spring semester.

PHYS 219 COMPLEX SYSTEMS IN SCIENTIFIC COMPUTING

Credit: 0.5 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: SCMP 118, PHYS 270 or permission of instructor.

PHYS 240 FIELDS AND SPACETIME

Credit: 0.5 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 include electric charge, electric and magnetic fields, electrostatic potentials, 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 interviewed by and obtain permission from the chair of the Physics Department. Prerequisite: PHYS 140 or equivalent. Corequisite: PHYS 241 (upperclass students) or PHYS 141 (first-years) and MATH 213 or equivalent. Offered every fall semester.

PHYS 241 FIELDS AND SPACETIME LABORATORY

Credit: 0.25 QR

This laboratory course is a corequisite for all upperclass students enrolled in PHYS 240. The course is organized around experiments demonstrating various phenomena associated with the special theory of relativity and 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 141 or equivalent. Corequisite: PHYS 240. Offered every fall semester.

PHYS 245 OSCILLATIONS AND WAVES

Credit: 0.5 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. Offered every spring semester.

PHYS 270 INTRODUCTION TO COMPUTATIONAL PHYSICS

Credit: 0.5 QR

As modern computers become more capable, a new mode of investigation is emerging in all science disciplines using computers to model the natural world and solving model equations numerically rather than analytically. Thus, computational physics is assuming co-equal status with theoretical and experimental physics as a way to explore physical systems. This course will introduce students 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 C, a 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. Prerequisite: PHYS 240 and MATH 112 or permission of instructor. Offered every spring semester.

PHYS 340 CLASSICAL MECHANICS

Credit: 0.5 QR

This 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 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. Prerequisite: PHYS 245 and MATH 213. Offered every other year.

PHYS 345 ASTROPHYSICS AND PARTICLES

Credit: 0.5 QR

From particle accelerators to galaxies and stars to the big bang, high-energy particle physics and astrophysics address the sciences' most fundamental questions. This course will cover topics of contemporary relevance from the combined fields of cosmology, astrophysics, phenomenological particle physics, relativity and field theory. Topics may include the big bang, cosmic inflation, the standard model of particle physics, an introduction to general relativity, and the structure and evolution of stars and galaxies’ stellar structure and galactic evolution. Prerequisite: PHYS 350 or permission of instructor. Offered every other year.

PHYS 350 ELECTRICITY AND MAGNETISM

Credit: 0.5 QR

In this course we develop further the basic concepts of electricity and magnetism previously discussed in 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 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. Prerequisite: PHYS 245 and MATH 213. Offered every other year.

PHYS 355 OPTICS

Credit: 0.5 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. Topics include the properties of waves, reflection, refraction, interference, and Fraunhofer and Fresnel diffraction, along with Fourier optics and coherence theory. Prerequisite: PHYS 350 or permission of instructor. Offered every other year.

PHYS 360 QUANTUM MECHANICS

Credit: 0.5 QR

This course presents an introduction to theoretical quantum mechanics. Topics include wave mechanics, the Schrödinger equation, angular momentum, the hydrogen atom and spin. Prerequisite: PHYS 245 and MATH 213. Offered every other year.

PHYS 365 QUANTUM MECHANICS II

Credit: 0.5 QR

This course extends the formalism of quantum mechanics and applies it to a variety of physical systems. Topics covered may include atomic and molecular spectra, nuclear structure and reactions, NMR, scattering, perturbation theory, quantum optics, open system dynamics and quantum entanglement.

PHYS 370 THERMODYNAMICS AND STATISTICAL MECHANICS

Credit: 0.5 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 245 and MATH 213. Offered every other year.

PHYS 375 CONDENSED MATTER PHYSICS

Credit: 0.5 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 nanostructures. There will be a limited number of labs 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 360. Offered every other year.

PHYS 380 INTRODUCTION TO ELECTRONICS

Credit: 0.25 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 students to many of the tools and techniques of modern electronics. Familiarity with this array of practical tools will prepare students for engaging in undergraduate research opportunities as well as laboratory work in graduate school or industry settings. Students 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 and 382) fosters independence and creativity, while the hands-on nature of the labs and projects will help students build practical experimental skills including schematic and data sheet reading, soldering, interfacing circuits with measurement or control instruments, and troubleshooting problems with components, wiring and measurement devices. In each electronics course, students will practice documenting work thoroughly, by tracking work in lab notebooks with written records, diagrams, schematics, data tables, graphs and program listings. Students 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 students may be asked to research and present to the class a related application of the principles learned during investigations. This course is required as part of the 1 unit of upper-level experimental physics coursework to complete the major in physics. Prerequisite: PHYS 240. This course is offered once a year and runs the first half of the semester only.

PHYS 381 PROJECTS IN ELECTRONICS 1

Credit: 0.25 QR

In this course, students will explore circuit design and analysis for active and passive analog circuit elements, from the physics of the components (semiconductor diodes, transistors) to the behavior of multi-stage circuits. Experiments will explore transistors, amplifiers, amplifier design and frequency-sensitive feedback networks. Prerequisite: PHYS 380 (may be taken in the same semester). This course is offered in alternate years and runs the second half of the semester only.

PHYS 382 PROJECTS IN ELECTRONICS 2

Credit: 0.25 QR

In this course, students will explore applications of integrated circuits (ICs), the fundamental building blocks of electronic devices such as personal computers, smart phones and virtually every other electronic device in use today. Taking a two-pronged approach, the course will include experimentation with basic ICs such as logic gates and timers as well as with multipurpose ICs such as microcontrollers that can be programmed to mimic the function of many basic ICs. Prerequisite: PHYS 380 (may be taken in the same semester). This course is offered in alternate years and runs in the second half of the semester only.

PHYS 385 ADVANCED EXPERIMENTAL PHYSICS 1

Credit: 0.25 QR

This course is an introduction to upper-level experimental physics that will prepare students for work in original research in physics and for work in industry applications of physics. Students will acquire skills in experimental design, observation, material preparation and handling, and equipment calibration and operation. Experiments will be selected to introduce students to concepts, techniques and equipment useful in understanding physical phenomena across a wide range of physics subdisciplines, with the twofold goal of providing a broad overview of several branches of experimental physics and preparing students to undertake any experiments in PHYS 386 and 387. This course is required as part of the 1 unit of upper-level experimental physics coursework to complete the major in Physics. Prerequisite: PHYS 241 and 245. This course is offered once a year and runs the first half of the semester only.

PHYS 386 ADVANCED EXPERIMENTAL PHYSICS 2

Credit: 0.25 QR

In this course students 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 in the same semester). This course is offered in alternate years and runs the second half of the semester only.

PHYS 387 ADVANCED EXPERIMENTAL PHYSICS 3

Credit: 0.25 QR

In this course students 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 in the same semester). This course is offered in alternate years and runs the second half of the semester only.

PHYS 493 INDIVIDUAL STUDY

Credit: 0.25-0.5

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. An individual study course in physics is designed for .25 unit of credit. 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. Because students must enroll for individual studies by the end of the seventh class day of each semester, they should begin discussion of the proposed individual study preferably the semester before, so that there is time to devise the proposal and seek departmental approval before the registrar's deadline. Individual studies do not count towards the QR (quantitative reasoning) requirement. If a student wishes to satisfy the QR requirement through an individual study in physics, they must receive approval through the college petition process.

PHYS 497Y SENIOR HONORS

Credit: 0.5

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

PHYS 498Y SENIOR HONORS

Credit: 0.5

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