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, 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 Kenyon College faculty voted to change from Kenyon units to semester hours. This change will go into effect for all students who start at the College in the fall of 2024. Both systems will be used throughout the course catalog with the Kenyon units being listed first.

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 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, cold atom physics, gravitation, astrophysics and particle physics. PHYS 131, co-requisite to PHYS 140 for upper-class 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, may want to consider beginning their study of physics with PHYS 240 (plus PHYS 141 as their co-requisite lab course) in the first semester, followed by PHYS 145 and 146 in the second semester. Such preparation includes a high score on the Advanced Placement C-level physics examination, experience with quantitative laboratory measurement, significant use of calculus in high school physics and placement into

Calculus III. 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 and do not intend to major in physics or pursue 3-2 engineering 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 100 (QR), 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 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.

Upper-class 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 136. Entry into PHYS 130 and 135 requires sophomore standing; no first-year students will be admitted to these courses. Co-requisite laboratory courses must be taken in the same semester as the associated survey course.

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 2.5 units/20 semester hours per semester. Care should be taken to satisfy the College's graduation requirement to take 9 units/72 semester hours 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 the purpose of pre-engineering course work.

All courses in physics numbered above 220 have as prerequisites PHYS 140 and 145 and MATH 111 and 112, unless otherwise noted. PHYS 131, 136, 141, 146, 241 and courses numbered 380–387 are laboratory courses involving substantial experimental work.

Requirements for the Major

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

- PHYS 140: Classical Physics
- PHYS 141: First-Year Seminar in Physics
- PHYS 145: Modern Physics
- PHYS 146: Modern Physics Lab
- PHYS 240: Fields and Spacetime

- PHYS 241: Fields and Spacetime Laboratory
- PHYS 245: Oscillations and Waves
- PHYS 270: Introduction to Computational Physics
- In extraordinary circumstances, PHYS 130, 131 and 135, 136 may be substituted for PHYS 140, 141 and 145, 146 with permission of the department chair.
- Four courses of experimental physics:
    - PHYS 380: Introduction to Electronics
    - PHYS 385: Advanced Experimental Physics 1
    - Two courses chosen from:
        - PHYS 381: Projects in Electronics 1
        - PHYS 382: Projects in Electronics 2
        - PHYS 386: Advanced Experimental Physics 2
        - PHYS 387: Advanced Experimental Physics 3
- Two courses of theoretical physics:
    - PHYS 340: Classical Mechanics
    - PHYS 345: Astrophysics and Particles
    - PHYS 350: Electricity and magnetism
    - PHYS 355: Optics
    - PHYS 360: Quantum Mechanics
    - PHYS 365: Quantum Mechanics II
    - PHYS 370:Thermodynamics and Statistical Mechanics
    - PHYS 375: Condensed Matter Physics
    - At least one of:
        - PHYS 340: Classical Mechanics
        - PHYS 350: Electricity and Magnetics
        - PHYS 360: Quantum Mechanics
- Additional .5 units/4 semester hours selected from experimental or theoretical physics courses numbered above 320.
- MATH 111, 112 and 213, or equivalent; and any 0.5 units/4 semester hour course numbered MATH 220 or above. In rare cases, other courses may satisfy the requirement with department approval.

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, 131 or 141, 145, 146, 240 and 241. PHYS 130 and 135 and their co-requisite labs may be substituted for 140 and 145 with permission of the department chair.

- Additional 1 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:

- 1 unit/8 semester hours of 100-level courses that cover topics in astronomy from among PHYS 101, 105, 106, 107 and 109;
- A year of introductory physics with lab: PHYS 130 and 135 or 140 and 145; 131 or 141; 136 or 146.
- An additional 0.5 units/4 semester hours selected from all physics courses (see suggestions below).

There are several options for 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 270 explores 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 Capstone

The Senior Capstone includes the presentation of a talk on a topic in physics at a department colloquium and a set of gateway examinations in physics.

More information about the Senior Capstone 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 in Physics

A Certain Slant on Light

PHYS 100 Credits: 0.5/4 QR

For many centuries, both scientists and artists have pondered the myriad compositions of light, including rainbows, shadows, colors and mirages. While the beauty of these phenomena is fascinating, it is also rewarding to grapple with the underlying theory that explains them. In this course, students explore how light can be modelled as a ray, wave or particle, and use these ideas to explain concepts such as reflection, refraction, scattering, diffraction and absorption. Several in-class laboratory exercises strengthen the conceptual understanding of light. Throughout the course, the focus is to explain various phenomena, ranging from fiber-optic technology to pointillism. A final project, which synthesizes the conceptual understanding of light, is required, and students are encouraged to follow their interests, through various forms, in order to fulfill it. While the course has some mathematical content -- simple algebra and geometry -- it is open to any student and does not count toward the physics major. No prerequisite.

Rocket Science

PHYS 101 Credits: 0.5/4 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 space flight, 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 are several evening and weekend lab sessions, during which we 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. This course does not count toward the physics major. No prerequisite.

Good Nukes, Bad Nukes

PHYS 102 Credits: 0.5/4 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. This course 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 explore radioactive decay, antimatter, transmutation of atoms, nuclear detectors and interactions of radiation with matter. We 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 cover the history of the Manhattan Project and the use of nuclear weapons that brought an end to World War II. The course offers a field trip to at least one significant nuclear site in Ohio. This course is open to any student and does not count toward the physics major. No prerequisite.

Creating with Gadgets

PHYS 103 Credits: 0.25/2

In this course, students 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 is 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 combines laboratory exercises, homework assignments, individual and group project work, and a culminating public presentation. The course does not count toward the physics major. No prerequisite.

Einstein

PHYS 104 Credits: 0.5/4 QR

Over 100 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 focuses on Einstein's life, his scientific contributions and his role in the creation of modern physics. We find that his insights are significant not just for microscopic particles or distant galaxies, but also for the phenomena of everyday life. Lectures, discussions and readings (including Einstein's own works) are supplemented by laboratory experiments. The course has some mathematical content -- simple algebra and geometry -- and is open to any student and does not count toward the physics major. No prerequisite.

Frontiers of Gravity

PHYS 105 Credits: 0.5/4 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 explores 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 are required to meet a few times during the semester for evening laboratories. This course does not count toward the physics major. No prerequisite.

Astronomy: Planets and Moons

PHYS 106 Credits: 0.5/4

This course introduces the modern understanding of the solar system, including planets, moons and smaller bodies (asteroids, comets, meteors). Topics include planetary interiors, surface modification processes, planetary atmospheres and the evolution of the solar system. Evening laboratory sessions utilize a variety of methods for exploring space-science topics, including telescopic observations, computer simulations and laboratory investigations. This course does not count toward the physics major. No prerequisite.

Astronomy: Stars and Galaxies

PHYS 107 Credits: 0.5/4 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 include telescopic observation, laboratory investigations of light and spectra, and computer modeling and simulation exercises. This course does not count toward the physics major. No prerequisite.

Geology

PHYS 108 Credits: 0.5/4

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 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 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. This course does not count toward the physics major. No prerequisite.

Origins

PHYS 109 Credits: 0.5/4

Around us we see a vast, expanding universe of galaxies. The galaxies are composed of stars, some of them orbited by planets. At least one of these planets 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 supplement lectures and readings. This course does not count toward the physics major. No prerequisite.

General Physics I

PHYS 130 Credits: 0.5/4 QR

This course is the first in a one-year introductory physics sequence. Topics include Newtonian mechanics, work and energy, fluids, and electric fields. When possible, examples relate to life science contexts. The course combines lectures, in-class exercises, homework assignments and examinations. Knowledge of calculus is not required. This course does not count toward the physics major. Prerequisite: concurrent enrollment in PHYS 131. Sophomore standing. Offered every fall.

Introduction to Experimental Physics I

PHYS 131 Credits: 0.25/2 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. Except in rare instances, this course does not count toward the physics major. Prerequisite: concurrent enrollment in PHYS 130 (or PHYS 140 for sophomores enrolled in PHYS 140). Offered every fall.

General Physics II

PHYS 135 Credits: 0.5/4 QR

This course is the second in a one-year introductory physics sequence. Topics include wave phenomena, geometrical and physical optics, elementary quantum theory, atomic physics, X-rays, radioactivity, nuclear physics and thermodynamics. When possible, examples relate to life science contexts. The course combines lectures, in-class exercises, homework assignments and examinations. Knowledge of calculus is not required. This course does not count toward the physics major. Prerequisite: PHYS 130 and concurrent enrollment in PHYS 136. Offered every spring.

Introduction to Experimental Physics II

PHYS 136 Credits: 0.25/2

This laboratory course meets one afternoon each week and is organized around weekly experiments that explore the phenomena of waves phenomena, geometrical and physical optics, elementary quantum theory, atomic physics, X-rays, radioactivity, nuclear physics and thermodynamics. Lectures cover the theory and instrumentation required to understand each experiment. Students continue to develop skills in computer-assisted graphical and statistical analysis of data as well as the analysis of experimental uncertainty. This course does not count toward the physics major. Prerequisite: PHYS 131 and concurrent enrollment in PHYS 135. Offered every spring.

Classical Physics

PHYS 140 Credits: 0.5/4 QR

This lecture course is the first in a three-semester, calculus-based introduction to physics (PHYS 140, 145 and 240). 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 is recommended for students who might major in physics and is appropriate for students majoring in other sciences and mathematics, particularly those who are considering careers in engineering. The course combines lectures, in-class exercises, homework assignments and examinations. This course is required for the physics major. Prerequisite: concurrent enrollment or credit for MATH 111, or equivalent, and concurrent enrollment in PHYS 141 (first-year students) or PHYS 131 (sophomore students). Open only to first-year and sophomore students. Offered every fall.

First-Year Seminar in Physics

PHYS 141 Credits: 0.25/2 QR

This seminar explores a significant current topic in physics that challenges 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 exposes 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. It is required for the physics major. Prerequisite: first-year students who are concurrently enrolled in or have placed out of PHYS 140. Offered every fall.

Modern Physics

PHYS 145 Credits: 0.5/4 QR

This lecture course is the second in a three-semester calculus-based introduction to physics, focusing 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 combines lectures, in-class exercises, homework assignments and examinations. Open only to first-year and sophomore students. This course is required for the physics major. Prerequisite: PHYS 140 and MATH 111 or equivalent and concurrent enrollment in PHYS 146 and MATH 112 or equivalent . Offered every spring.

Modern Physics Lab

PHYS 146 Credits: 0.25/2 QR

This laboratory course is a corequisite for all students enrolled in PHYS 145. The course meets one afternoon each week and is organized around weekly experiments exploring 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. This course is required for

the physics major. Prerequisite: PHYS 131 or 141 and concurrent enrollment in PHYS 145. Offered every spring.

Fields and Spacetime

PHYS 240 Credits: 0.5/4 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. It may be an appropriate first course for particularly strong students with advanced placement in physics and mathematics; such students must be interviewed by and obtain permission from the chair of the physics department. This course is required for the physics major. Prerequisite: PHYS 140 or equivalent and concurrent enrollment in PHYS 241 (upper-class students) or PHYS 141 (first-years) and MATH 213 or equivalent. Offered every fall.

Fields and Spacetime Laboratory

PHYS 241 Credits: 0.25/2 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. This course is required for the physics major. Prerequisite: PHYS 146 and concurrent enrollment in PHYS 240. Offered every fall.

Oscillations and Waves

PHYS 245 Credits: 0.5/4 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. This course is required for the physics major. Prerequisite: PHYS 145 and 240. Offered every spring.

Introduction to Computational Physics

PHYS 270 Credits: 0.5/4 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 introduces students to a variety of computational methods, which could include the methods of computational physics, numerical integration, numerical solutions of differential equations, Monte Carlo techniques and discrete Fourier transforms. Students learn to implement these techniques in the computer language C, a widely used high-level programming language in computational physics. For some techniques, students may also learn implementations in the computer language Python. In addition, the course expands students' capabilities in using a symbolic algebra program (Mathematica) to aid in theoretical analysis and in scientific visualization. This course is required for the physics major. Prerequisite: PHYS 240 and MATH 112 or equivalent. Offered every spring.

Classical Mechanics

PHYS 340 Credits: 0.5/4 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 is spent understanding an alternate description to that of the Newtonian picture: the Lagrange-Hamilton formulation. The course also covers the topics of motion in a central field, classical scattering theory, motion in non-inertial reference frames and dynamics of rigid body rotations. This counts toward the theoretical elective for the major. Prerequisite: PHYS 245 and MATH 213. Offered every other fall.

Astrophysics and Particles

PHYS 345 Credits: 0.5/4 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 covers 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. This counts toward the theoretical elective for the major. Prerequisite: PHYS 350. Offered every other spring.

Electricity and Magnetism

PHYS 350 Credits: 0.5/4 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 revisit Maxwell's equations and consider the physics of time-dependent fields and the origin of electromagnetic radiation. Other topics 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. This counts toward the theoretical elective for the major. Prerequisite: PHYS 245 and MATH 213. Offered every other fall.

Optics

PHYS 355 Credits: 0.5/4 QR

The course begins with a discussion of the wave nature of light. The remainder 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. This counts toward the theoretical elective for the major. Prerequisite: PHYS 350. Offered every other spring.

Quantum Mechanics

PHYS 360 Credits: 0.5/4 QR

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

Quantum Mechanics II

PHYS 365 Credits: 0.5/4 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. This counts toward the theoretical elective for the major. Prerequisite: PHYS 360. Offered every other spring.

Thermodynamics and Statistical Mechanics

PHYS 370 Credits: 0.5/4 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 (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. This counts toward the theoretical elective for the major. Prerequisite: PHYS 245 and MATH 213. Offered every other fall.

Condensed Matter Physics

PHYS 375 Credits: 0.5/4 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 includes 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 are 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. This counts toward the theoretical elective for the major. Prerequisite: PHYS 360. Offered every other spring.

Introduction to Electronics

PHYS 380 Credits: 0.25/2 QR

This course builds 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 prepares students for engaging in undergraduate research opportunities as well as laboratory work in graduate school or industry settings. Students 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. The hands-on nature of the labs and projects helps 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 practice documenting work thoroughly, by tracking work in lab notebooks with written records, diagrams, schematics, data tables, graphs and program listings. Students also engage in directed analysis of the theoretical operation of components and circuits through lab notebook explanations, worksheets and occasional problem sets. 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 1.00 unit of upper-level experimental physics coursework to complete the major in physics. Prerequisite: PHYS 240. Offered every fall and runs only the first half of the semester.

Projects in Electronics 1

PHYS 381 Credits: 0.25/2 QR

In this course, students 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 explore transistors, amplifiers, amplifier design and frequency sensitive feedback networks. This counts toward the experimental elective for the major. Prerequisite: PHYS 380 (may be taken in the same semester). Offered in alternate years and runs only the second half of the fall semester.

Projects in Electronics 2

PHYS 382 Credits: 0.25/2 QR

In this course, students 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 includes 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. This counts toward the experimental elective for the major. Prerequisite: PHYS 380 (may be taken in the same semester). Offered in alternate years and runs only in the second half of the semester.

Advanced Experimental Physics 1

PHYS 385 Credits: 0.25/2 QR

This course is an introduction to upper-level experimental physics that prepares students for work in original research in physics and for work in industry applications of physics. Students acquire skills in experimental design, observation, material preparation and handling, and equipment calibration and operation. Experiments are 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, 245 and 380. Offered every spring and runs only the first half of the semester.

Advanced Experimental Physics 2

PHYS 386 Credits: 0.25/2 QR

In this course, students 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. This counts toward the experimental elective for the major. Prerequisite: PHYS 385 (may be taken in the same semester). Offered in alternate years and runs only the second half of the spring semester.

Advanced Experimental Physics 3

PHYS 387 Credits: 0.25/2 QR

In this course, students 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. This counts toward the experimental elective for the major. Prerequisite: PHYS 385 (may be taken in the same semester). Offered in alternate years and runs only the second half of the spring semester.

Research in Physics

PHYS 390 Credits: 0.25-0.5/2-4

Section 01 (0.25 units): In this course, students conduct research, synthesize and share experiences, attend professional presentations in the department, and present their research orally and in writing. Students complete three to four hours of independent research per week under the supervision of a faculty member and participate in discussion sections and other commitments as designed by the instructor. This course does not count toward any major requirement. Permission of instructor required. Offered every semester.

Section 02 (0.5 units): This section carries the same requirements as Section 01, except that the time commitment is six to eight hours of individual research per week under the supervision of a faculty member, in addition to participation in other commitments as designed by the instructor. This section represents a significant commitment to a research project. Enrollment

requires consultation with the department chair. This course does not count toward any major requirement. Permission of instructor required. Offered every semester.

Individual Study

PHYS 493 Credits: 0.25-0.5/2-4

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 for approval. 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. Individual study courses should supplement, not replace, courses regularly offered by the department. 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 the semester before, so that there is time to devise the proposal and seek departmental approval. An individual study course in physics is ordinarily designed for 0.25 unit of credit and cannot count towards the QR (quantitative reasoning) requirement unless special arrangements are made with the chair of the department, in consultation with the registrar's office.

Senior Honors

PHYS 497Y Credits: 0.5/4

This course offers guided experimental or theoretical research for senior honors candidates. Students enrolled in this course are automatically added to PHYS 498Y for the spring semester. Permission of instructor and department chair required, as is cumulative GPA above the College-mandated minimum.

Senior Honors

PHYS 498Y Credits: 0.5/4

This course offers guided experimental or theoretical research for senior honors candidates. Permission of instructor and department chair required, as is cumulative GPA above the College-mandated minimum.

Introduction to Topics in Physics

PHYS 95 Credits: 0.25/2

This course will introduce the theory behind concepts covered in the first year of the Kenyon physics curriculum and will enable the performance of experiments in those areas. Topics will include kinematics, dynamics, impulse and momentum, work and energy, electricity, circuits, atomic physics and nuclear physics. The course will be taught using a combination of lectures, labs, in-class exercises, homework assignments and examinations. Seven full (three-hour) labs will be performed along with supporting activities. Lectures cover the theory and instrumentation required to understand each experiment. Students will continue to develop skills in computer-assisted graphical and statistical analysis of data. The final exam will be an in-lab exam similar to those performed during the Kenyon academic year. Knowledge of calculus is not required. Prerequisite: Acceptance into Camp 4. Offered every Camp 4 session.