Science

The Science Department's primary mission is to provide for all students a foundation of excellence in the study of science. Whether as scientists or as scientifically literate citizens, Exonians must be well-prepared to enter a world of increasing social and technological complexity. In order to assist students in reaching this goal, the science curriculum is designed to offer students a variety of opportunities to engage with the world around them—in the classroom, in the laboratory, and in field work.

Hands-on learning, both collaborative and individual, is at the heart of our course of instruction. The department considers the laboratory and the field to be its Harkness table, and students will have extensive practical experience. Therefore, classrooms in the Phelps Science Center and in the Grainger Observatory include both laboratory and discussion space. The department has integrated technology into the curriculum in a variety of guises, all designed to place the tools for discovery directly into the hands of the students.

The Science Department believes that successful scientific inquiry requires the integration of observational ability, quantitative skills, and analytical thinking; in all courses, students will be challenged to reason creatively and to think critically.

In keeping with the program broadly outlined above, the Phillips Exeter Academy Science Department strongly encourages students to take all three basic courses—biology, chemistry and physics—as a minimal preparation for college.

Biology

LABORATORY POLICY FOR BIOLOGY

Laboratory work is an essential and integral part of the biology curriculum in the Science Department. The proximity to local ponds, rivers, and the coast allows students to collect and observe representative organisms from those habitats for observation in the laboratory. Behavior, feeding strategies, and structural modifications as they apply to function are studied in these organisms. In addition, observation of preserved specimens and observation of dissection is required of those enrolled in biology courses at the Academy.

BIO110/120/130: AN INTRODUCTION TO BIOLOGY

Biology 110 introduces cell structure and function leading to a study of human anatomy and physiology. Basic physical and chemical principles critical to cell structure and function are also studied. Biology 120 completes the study of human anatomy and physiology. The remainder of the term is devoted to a study of genetics (classical and molecular), nucleic acids and evolution. Biology 130 surveys the various kingdoms of living organisms and ecology. *Open to Juniors. Five class periods per week.*

BIO210/220/230: PRINCIPLES OF BIOLOGY

This course follows the same sequence of topics as does Biology 110/120/130 but uses a different textbook. After completing this three-term sequence, students will have covered the topics examined in the SAT II test in biology. Not open to students who have completed the Biology 110/120/130 sequence. *Open to Lowers, Uppers and Seniors. Five class periods per week.*

BIO320: HUMAN PHYSIOLOGY

Biology 320 examines how the human body functions. The complexity of and interactions between different systems will be explored. Extensive laboratory investigations, including a mammalian dissection, computer applications, and project work comprise a significant part of the course. Prerequisite: one year of introductory biology. *Open to Uppers and Seniors (Lowers with departmental permission). Three class periods and one double class period per week.* ***Offered: Winter Term.***

BIO321: ANIMAL BEHAVIOR

This course is an introduction to the study of animal behavior. It explores the development, cause, evolutionary origin, and function of a host of behaviors, such as sexual behavior, communication, dominance, territoriality, and learning. Weekly laboratory work and field trips involve the observation of and experimentation with animals, including fish, bees, crayfish, birds, buffalo, donkeys and more. Prerequisite: *Open to Uppers and Seniors (Lowers with departmental permission) who have taken one year of introductory biology. Three class periods and one double class period per week.* ***Offered: Spring Term.***

BIO331: ORNITHOLOGY

This course emphasizes field identification of locally common species and habitats. Spring migrants are the focus of the course, along with winter finches and waterfowl which may have lingered in the Exeter area. The course utilizes a systems approach to the biology of birds, with investigations into their life histories, ecology, evolution, and behavior. *Prerequisite: one year of introductory biology. Open to Uppers and Seniors (Lowers with departmental permission). Three class periods and one double class period per week.* ***Offered: Spring Term.***

BIO341: ECOLOGY

This course considers the range of interactions between the organism and its total environment. The emphasis is on biological ecology. Topics considered include population dynamics, the ecological community, the ecosystem, material cycling, energy flow, and succession. Field trips to different ecosystems complement the laboratory work. *Prerequisite: One year of introductory biology. Open to Uppers and Seniors (Lowers with departmental permission). Three class periods and one double class period per week.* ***Offered: Fall Term.***

BIO342: HUMAN POPULATIONS AND RESOURCE CONSUMPTION: IMPLICATIONS FOR SUSTAINABILITY

In this course students consider human impact on the environment. Issues of human population, demography, and carrying capacity will be explored in relationship to the world's food resources and urban land use and management. Some of the consequences of the most basic decisions we make as humans – how many babies should we have, what do we eat, and where do we live will be considered. The legal, ethical, economic and political aspects of these topics will be an integral part of the course. Lab work as well as the completion of a local service-learning project will be required. *Prerequisite: One year of introductory biology. Open to Uppers and Seniors (Lowers with departmental permission). Five class periods/week.* ***Offered: Winter Term.***

BIO351: EVOLUTION

Students will read Weiner's Pulitzer-prize-winning book, *The Beak of the Finch* for its excellent examples of evolutionary changes that are being observed and measured today. Then Sean Carroll's new text on Evo-Devo, *Endless Forms Most Beautiful*, will help students understand how changes in development occur and how those changes lead directly to new physical characteristics in organisms. For the first time, scientists understand how eggs become embryos which then become ordered bodies. This process of animal development turns out to have such amazing similarities between all members of the animal kingdom that a common descent from an ancestor that lived 600 million years ago is the only possible explanation. Labs will range from fossil examinations to a Polymerase Chain Reaction exercise to the production of stone tools. *Prerequisite: One year of introductory biology. Open to Uppers and Seniors. Five class periods per week.* ***Offered: Winter Term.***

BIO360: BIOCHEMISTRY AND HUMAN NUTRITION

This course explores the chemistry, digestion, and functions of carbohydrates, proteins, fats, water, vitamins, and minerals in the human body. The importance of adequate personal nutrition for optimal performance as an adolescent is stressed. Special considerations include world hunger, sports nutrition, eating disorders, drug-nutrient interactions, weight control, and the relationship between nutrition and disease. Students will apply the scientific method and develop skills in personal diet selection, consumerism, and in evaluating controversial nutrition issues in the literature. Laboratory investigations will focus on the biological chemistry of foods and will also require use of the Academy's personal computers. *Prerequisite: One year of introductory biology or one year of introductory chemistry. Open to Uppers and Seniors (Lowers with departmental permission). Five class periods per week.* ***Offered: Fall and Winter Terms.***

BIO361: MARINE BIOLOGY

The relationships and interactions between marine organisms and their environment are studied in class and in the field. Field trips to estuarine and rocky intertidal habitats allow students to become familiar with organisms and to employ techniques often used by marine biologists. *Prerequisite: One year of introductory biology. Open to Uppers and Seniors (Lowers with departmental permission). Three class periods and one double class period per week.* ***Offered: Fall and Spring Terms.***

BIO371: INTRODUCTORY GENETICS I

This course considers the classical and contemporary views of the nature, transmission, and function of the hereditary material. Laboratory investigations in plant and animal genetics supplement class discussion. *Prerequisite: One year of introductory biology. Open to Uppers and Seniors (Lowers with departmental permission). Three class periods and one double class period per week.* ***Offered: Fall Term.***

BIO372: MOLECULAR GENETICS

This course examines the biochemistry of the gene in greater detail and considers the underlying principles of recombinant DNA technology. Because DNA science is experimental, much of the time available in this course will be devoted to laboratory work learning techniques of DNA isolation, analysis, and manipulation. *Prerequisite: Biology 371. Open to Uppers and Seniors (Lowers with departmental permission). Three class periods and one double class period per week.* ***Offered: Winter Term.***

BIO410/420/430: ADVANCED BIOLOGY

This sequence of three courses is the equivalent of an introductory college course. Biology 410 studies principles of biological chemistry, cytology, and cellular energy transformations. Biology 420 studies molecular genetics, heredity, and evolution. Biology 430 studies taxonomy and systematics, ecology, and population dynamics. Independent laboratory work is an integral part of the course. After completing this three-term sequence, students will be prepared to write the Advanced Placement Examination in biology. *Prerequisite: One year of introductory biology and one year of introductory chemistry. Open to Uppers and Seniors. Five class periods per week.*

Chemistry

CHE210/220/230: AN INTRODUCTION TO PHYSICAL CHEMISTRY

This course is designed to foster deductive reasoning, creativity, and cooperative learning. Thereafter, the course continues to be laboratory based. Topics include atomic and molecular structure, states of matter, chemical and physical behavior of elements and compounds, solution chemistry, kinetics, equilibrium, thermochemistry and electrochemistry. Mathematical modeling and computer software are used to extend the range of discussions. After completing this three-term sequence, students will be prepared to write the SAT II test in chemistry. *Mathematics co-requisite: For Chemistry 210, Lowers must be concurrently enrolled in Mathematics 220, Transition II, or higher; Uppers must be concurrently enrolled in Math 310, Transition III, or higher. Open to Lowers, Uppers, and Seniors. Five class periods per week.*

CHE319/329/339: ACCELERATED INTRODUCTORY CHEMISTRY

This course is designed for those students who have not had a previous full-year, laboratory-based chemistry course, but who would like to enroll in an accelerated one-year course that covers the topics on the Advanced Placement Exam. Because this course covers two years of chemistry in three terms, students should expect that this course will progress at a more rapid pace and demand a greater degree of independent study than the typical one-year science course. Students wishing to enroll

in Chemistry 319 are expected to demonstrate a high level of proficiency in both mathematics and in physics and must complete an application in order to be considered for the course. The Science Department will review applications and select those who are qualified for enrollment. Application forms and further information are available from the Science Department Head. *Prerequisite: A full-year laboratory physics course. Open to Lowers, Uppers, and Seniors. Five class periods per week.*

CHE343: CHEMISTRY OF THE ENVIRONMENT

This advanced course investigates the chemical principles that underlie current environmental issues. Students will study the chemistry of the natural environment (atmosphere, soil, and water) and develop skills necessary to analyze alterations that human beings have made. Specific topics include ozone layer depletion, acid rain, the greenhouse effect, photochemical smog, toxic organic pollutants, and heavy metal contamination. Laboratory work will include field sampling and will emphasize the methods required to make accurate measurements of both background and elevated levels of chemical substances in the environment. *Prerequisite: One year of introductory chemistry. Open to Uppers and Seniors. Three class periods and one double class period per week.* ***Offered: Spring Term.***

CHE381: ADVANCED TOPICS IN CHEMISTRY: NUCLEAR AND ORGANIC CHEMISTRY

In this advanced course, students will explore two different fields of chemistry, each with applications that greatly affect the environment and the quality of human life. Students will have the opportunity to study nuclear reactions, the design of nuclear power plants and the history and development of nuclear weapons, as well as the safety and waste management issues raised by nuclear materials and recent global concerns of nuclear terrorism. While studying organic chemistry students will learn the names, structures, and reactivity of the functional groups found in organic molecules, polymers and biomolecules. They will be engaged in extensive laboratory investigations as they synthesize and test a wide variety of compounds, including oil of wintergreen, aspirin, rubber, plexiglass R, polyurethane foam, nylon, soap, and porphyrin rings. *Prerequisite: One year of introductory chemistry and one year of introductory biology. Students who have completed one year of advanced or accelerated Chemistry may also take this course. Open to Uppers and Seniors. The course meets five class periods per week.* ***Offered: Winter Term.***

CHE410/420/430: ADVANCED CHEMISTRY

This sequence of three courses is the equivalent of an introductory college course. The sequence begins with a review of basic chemistry and chemical reactions, and moves quickly to cover topics of thermochemistry, atomic structure, nuclear chemistry, bonding, states of matter, equilibria, kinetics, and electrochemistry. Independent laboratory work is an integral part of this course. After completing this three-term sequence, students will be prepared to write the Advanced Placement Examination in chemistry. *Prerequisite: One year of introductory chemistry and one year of introductory physics. Introductory physics can be taken concurrently with advanced chemistry. Open to Uppers and Seniors. Five class periods per week.*

Earth and Planetary Science

EPS310: EARTH SYSTEMS

This course will study the complex interconnected systems (e.g., lithosphere, hydrosphere, atmosphere, and biosphere) of our planet Earth. Students will develop an understanding of the basic workings of the Earth from its origin to the present, and will investigate the scientific basis for some of today's most pressing challenges, such as global climate change and the search for newer and safer energy resources. Selected topics will include plate tectonics, the rock cycle, geologic time, the formation of the Appalachians, natural hazards (i.e., earthquakes, volcanoes, and tsunamis), global climate change and the challenge of finding and managing energy resources. Laboratory work, including local field trips and inquiry-based exercises using authentic maps and data bases (e.g., NOAA and USGS), will complement classroom discussion. *Prerequisite: One year of physics or chemistry. Open to Uppers and Seniors. Three class periods and one double class period per week.* ***Offered Fall and Spring Terms.***

Environmental Science

BIO341: ECOLOGY

BIO342: HUMAN POPULATIONS AND RESOURCE CONSUMPTION: IMPLICATIONS FOR SUSTAINABILITY

CHE343: CHEMISTRY OF THE ENVIRONMENT

After completing all three courses, students will be prepared to write the Advanced Placement Examination in Environmental Science. Courses can be taken in any sequence.

Physics

PHY201/202/203: AN INTRODUCTION TO PHYSICS

This course investigates the topics of Newtonian mechanics: motion, force, energy and momentum conservation; and topics in the physics of optics, waves, electricity and magnetism. Students will use both qualitative and quantitative methods to develop understanding of these fundamental concepts. Laboratory activities are a major component of the course, which satisfies the physical science requirement. This course assumes proficiency in basic algebraic skills. (Students wishing to prepare for the SAT II test will be better served in the PHY 210/220/230 sequence.) *Five class periods per week.*

PHY208/209: AN INTRODUCTION TO PHYSICS

These courses are designed for students who have demonstrated unusual ability for and interest in physics. They cover material similar to that covered in Physics 202 and 203, but do so more quickly, more mathematically, and with greater depth. These courses prepare students for the Advanced Physics sequence. *Open to students who have been recommended by their Physics 201 or 202 instructor. Five class periods per week.* ***Offered: Winter and Spring Terms.***

PHY210/220/230: PRINCIPLES OF PHYSICS

This introductory physics course covers a similar sequence of topics as does Physics 201/202/203, but uses a higher-level textbook and assumes a greater mathematical competence (see prerequisites). After taking this three-term sequence, students will be prepared for the majority of topics that appear on the SAT II test in physics. *Prerequisite for Physics 210: Successful completion of Mathematics 230 or a physics placement test. Open to Lowers, Uppers, and Seniors (Juniors by departmental permission). Students who have taken PHY201/202/203 or 208/209 may not take this sequence. Five class periods per week.*

PHY310: MODERN PHYSICS

In the early 20th century, two major scientific revolutions drastically altered our understanding of Nature: quantum mechanics and Einstein's theories of special and general relativity. These will be the main themes of this course, along with occasional excursions into nuclear and particle physics topics. Students will perform and analyze experiments to measure the speed of light; the mass, charge, and wave nature of the electron; as well as the quantization of energy. In situations less conducive to hands-on work, data from historical experiments or computer simulations will be provided for analysis. This course picks up where a rigorous, yearlong introductory physics course leaves off. Proficiency in algebra, along with competence in the basic physics principles of motion, force, energy, gravitation, electricity, magnetism, waves, and light, will be expected. *Prerequisite: One year of physics. Open to Uppers and Seniors (Lowers with departmental permission). Five class periods per week.* ***Offered: Fall Term.***

PHY350: ROBOTICS

Students in this course will learn to use a microcomputer to control output devices and interpret input sensors. Students will complete a series of small projects that will culminate with a working autonomous robot. The initial focus of the course requires students to build and analyze several micro-controlled devices. Students will learn fundamental engineering skills such as programming the microcomputer and building simple electronic circuits. The middle portion of the course will feature the construction of an autonomous robot that uses a microcomputer and several sensors to make navigational decisions. The final weeks of the course will require students to independently research, design, and implement a system or systems that will increase the capabilities of their robot. *Prerequisite: One year of physics or departmental permission. Previous experience in electronics and/or computer science is recommended, but not required. Open to Uppers and Seniors. Three class periods and one double class period per week.* ***Offered: Spring Term.***

PHY381: ELECTRONICS

This introduction to electronics is a hands-on, project-oriented course. Students will build a variety of simple devices including timing circuits, alarms, flashers, amplifiers, and counters. By designing, building, and analyzing these circuits, students will gain a firsthand knowledge of a variety of basic electronic components including resistors, capacitors, switches, relays, transformers, diodes, transistors, and op amps. *Prerequisite: One year of physics or departmental permission. Open to Uppers and Seniors. Three class periods and one double class period per week.* ***Offered: Winter Term.***

PHY391: ASTRONOMY I

This introductory course emphasizes the observational aspects of astronomy. Topics include the relationship between the earth and the sky, the exploration of the solar system, the nature and distribution of stars and galaxies, and the origin of the universe. Practical work is done at Grainger Observatory, located on the Exeter campus. Students use a variety of telescopes at the Observatory to make their own observations and measurements. *Prerequisite: one year of physics or chemistry. Open to Uppers and Seniors (Lowers with departmental permission).* ***Offered: Fall, Winter and Spring Terms.***

PHY392: ASTRONOMY II

This course examines selected topics of special interest in astronomy and astrophysics, including variable stars and binary star systems, stellar spectra and photometry, astrophotography, and solar-system studies. Students use the full range of equipment at Grainger Observatory, located on the Exeter campus, and pursue independent projects of their own choice. *Prerequisite: Astronomy I or departmental permission. Open to Uppers and Seniors (Lowers with departmental permission).* ***Offered: Winter Term.***

PHY393: OBSERVATIONAL ASTRONOMY

This course provides students who have successfully completed an introductory course in astronomy with the skills necessary to participate in and contribute to observational programs in astronomy. The course emphasizes the practical and computational skills used to make precise measurements of astronomical phenomena. Students work at Grainger Observatory, located on the Exeter campus, and study the work in progress at other observatories and research centers. *Prerequisite: Astronomy I. Open to Uppers and Seniors (Lowers with departmental permission).* ***Offered: Spring Term.***

PHY410/420/430: ADVANCED PHYSICS

This three-term sequence is taken as a second year of physics. In the first term, an emphasis is placed on synthesizing a variety of fundamental topics into a coherent whole. Topics include linear and rotational kinematics, dynamics including torque, energy conservation, linear and angular momentum conservation, and gravitation. Students will study a number of complex situations, performing in-depth laboratory experiments, and calculus-based theoretical analysis. In the second term, students study electricity and magnetism—making extensive use of experimental results and of calculus—with electric field and potential being the unifying concepts. In the third term, students finish the study of magnetism, including Maxwell's Equations. Finally, they study oscillatory phenomena including both mechanical and electrical systems. After taking this three-term sequence, students will be able to take the Physics C Advanced Placement Examinations in Mechanics and Example. *Prerequisite: One year of introductory physics and concurrently enrolled in Math 430, or one year of introductory physics and concurrently enrolled in Math 420, with permission of the chair of the science department. Open to Uppers and Seniors (Lowers with departmental permission).* ***Five class periods per week.***

PHY530: QUANTUM MECHANICS

This course seeks to outline the mathematical underpinnings of the present theory of the microscopic world. Beginning with a brief review of the dilemmas faced by physics at the turn of the 20th century, we will examine solutions to the Schrödinger equation and their interpretations as wave functions of probability. Various model systems will be studied: bound states of the "particle-in-a-box," the harmonic oscillator, the hydrogen atom, as well as unbound examples of quantum mechanical tunneling and reflection of free electrons. If time permits, we will examine the description and consequences of the electron's "spin" on the structure and stability of matter. A final project will involve creating a spreadsheet/computer program to solve quantum mechanical problems numerically. The mathematics required is a familiarity with integral calculus, infinite series, and elementary differential equations at the Math 450 level. *Prerequisites: Phys. 310, Phys. 420 and Math 450 or permission of the instructor.* ***Offered: Spring Term.***