# Physical Sciences

There are many different ways of obtaining knowledge. Knowledge in physics and chemistry is essentially linked to experimental work in the lab. Through the continual process of analyzing experiment in terms of theory and of testing theory through the discovery of new phenomena, some of the most far-reaching, universal, and magnificent discoveries about the nature of the world have been made. Observational sciences, such as astronomy or geology, create knowledge and discover truth in a related, but different, fashion. In these sciences the goal is to learn about majestic themes such as the nature of the Earth, the solar system, or indeed the universe itself. Such knowledge is gained not primarily in the lab using equipment and samples that are interchangeable, but rather through observations on a single sample that is too big, too old, too distant, and too unique to duplicate: namely, the Earth and the cosmos themselves. Field trips or telescopic observations allow one to observe what happened. The data collected are then interpreted in light of other observations. But one can never redo the entire experiment again and recreate the planets and the galaxies. Mathematics provides a third, nonempirical, form of knowing along with a crucial tool for formulating and analyzing the discoveries of the other sciences. All of these disciplines strive for a knowledge that is of a different nature than that found in humanistic or social scientific discourse. One aspect of the general education courses in the physical sciences is to introduce the student to these different ways of knowing and these different visions of truth.

The physical sciences sequences (along with the first half of the natural sciences sequence) provide a way for students in the humanities and social sciences to meet the general education requirement in the physical sciences. There are several sequences in the physical sciences, each of which introduces a different discipline and different aspects of scientific knowledge.

## Courses: Physical Sciences (phsc)

### *General Education Sequences*

Either of the two-course sequences PHSC 11100-11200 and PHSC 11900-12000 satisfies the general education requirement. In addition, any two-quarter sequence assembled from PHSC 10900, 11000, 13400, 13500, or 13600 will satisfy the requirement. The general education requirement in the physical sciences must be completed in the first two years. The listings below identify several possible combinations.

Along with one of these two-quarter sequences, students must register for at least two quarters of an approved biological sciences sequence and at least one quarter of an approved mathematical science. A sixth quarter must be taken in any one of the three areas: physical science, biological science, or mathematical science. NOTE: To receive general education credit for calculus, two quarters must be taken; this will count as two quarters towards meeting the general education requirement in the sciences.

**10900-11000. Science and the Earth.** *PQ: MATH 10600, or placement in MATH 13100 or higher. Open only to first- and second-year students and first-year transfer students. Taking these courses in sequence is not required.*

**10900. Ice-Age Earth.** We examine the cause and effects of Earth's great ice ages, and use the knowledge so gained as a means to inform ourselves about the stability of Earth's climate system and its relationship to the life of humankind. The ice age also serves as the starting point for the exploration of Earth's history through deep time undertaken in PHSC 11000. Our study begins with the history of how the ice age was discovered (i.e., through the analysis of landforms and sediments). We move on to consider the ways in which modern, post mid-twentieth century nuclear chemistry allows the creation of a detailed history of Earth's paleoclimate from deep-sea sediments and ice cores. We consider the astronomical hypothesis for ice-age cycles, and conclude that some as yet unknown "climatic signal amplifier" (e.g., natural variations of atmospheric greenhouse gasses) is needed to explain the wide degree of climate variation during the past million years. We conclude with an analysis of the interaction between ice-age climate change and our species, both at an animalistic level and at an advanced technological level. The lab exercises deal with topographic maps that depict glacial landforms in various national parks such as Yosemite National Park in California and Glacier National Park in Montana. We also explore the glacial landforms in the Chicago vicinity through topographic maps and a day-long field trip. A day-long weekend field trip to ice-age sites is required. If a weekend date is not possible, the field trip will be run on the Wednesday prior to Thanksgiving recess. Students who register for this class must arrange to attend the field trip at one of the offered dates. *D. Rowley. Not offered 2010-11. L.*

**11000. Environmental History of the Earth.** Topics emphasize how geologic history has determined the physical and biological environments we experience on Earth today. In other words, we learn how the long-term processes of Earth history have shaped the surface and interior of the Earth, and have determined the diversity of life on the planet as seen both in the present day and in the fossil record. *Spring. L.*

**10900-13400. Past and Future Climate of Earth.** *PQ: MATH 10600, or placement in MATH 13100 or higher. Open only to first- and second-year students and first-year transfer students. Taking these courses in sequence is not required.* This sequence is recommended for students wishing to focus on global climate change. PHSC 10900 introduces the geological evidence for climate change in the past (i.e., the ice age); and PHSC 13400 examines the mechanisms of this climate change and introduces forecasts of future climate change associated with industrial and agricultural activity.



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**13400. Global Warming: Understanding the Forecast.** (=ENST 12300, GEOS 13400) *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor required; some knowledge of chemistry or physics helpful.* This course presents the science behind the forecast of global warming to enable the student to evaluate the likelihood and potential severity of anthropogenic climate change in the coming centuries. It includes an overview of the physics of the greenhouse effect, including comparisons with Venus and Mars; an overview of the carbon cycle in its role as a global thermostat; predictions and reliability of climate model forecasts of the greenhouse world. *D. Archer. Autumn, Spring. L.*

**11100-11200. Foundations of Modern Physics I, II.** *PQ: MATH 10600, or placement in MATH 13100 or higher. Must be taken in sequence.*

**11100. Foundations of Modern Physics I.** This algebra-based course presents an introduction to Newton's laws of mechanics, including a study of planetary motion. The course also discusses wave motion as applied to sound and light. It concludes with an introduction to the special theory of relativity, in which the Newtonian concepts of space and time are reconsidered. *Autumn. L.*

**11200. Foundations of Modern Physics II.** *PQ: PHSC 11100.* With the advent of quantum mechanics, physicists found a successful alternative to Newton's laws for explaining atomic phenomena. In doing so, a completely new philosophy concerning the laws of physics had to be adopted. In this course, we explore the basic tenets of quantum mechanics, and consider the quantization of energy, the indeterminacy of physical events, and other concepts unique to the quantum view of nature. *Winter. L.*

**11400-11500. Life in the Universe.** *PQ: MATH 10600, or placement into MATH 13100 or higher. Both offered in Summer Quarter, PHSC 11400 and 11500 are one-quarter courses that must be taken in sequence.* This sequence treats our current understanding of the role that the laws of physics play in the development, existence, and persistence of life in the universe. The main goal of this sequence is for students to learn about these laws within the overarching context of this theme. The subject matter includes all the major branches of physics and certain aspects of cosmology, stellar evolution, and planetary science, as well as chemical and biological evolution. *D. Reid. Summer. L.*

**11400. Development of Life on Earth.** Starting with the big bang theory of the early universe, students study how the laws of physics guided the evolution of the universe through the processes most likely to have produced life on earth as it exists today. Physics topics include the fundamental interactions and the early universe; nuclear, atomic, and molecular structure; Newton's laws and the formation of stars, galaxies, and planetary systems; thermonuclear fusion in stars; the physical origin of the chemical elements; the laws of electricity and magnetism and electromagnetic radiation; the laws of thermodynamics; atmospheric physics; and physical processes on primordial earth.

**11500. Extraterrestrial Life.** Building upon the topics in PHSC 11400, this course goes on to consider what the laws of physics has to say about life elsewhere in the universe. We begin with an analysis of the prospects for life on other bodies in the solar system, especially Mars. This is followed by a treatment of the physics behind the search for extraterrestrial intelligence and the feasibility of human interstellar and intergalactic spaceflight. We conclude with a critical examination of speculative ideas in the popular media such as the suggestion that the universe itself is a living organism. Physics topics include extended applications of topics from PHSC 11400, optics and electromagnetic communication, rocket propulsion and advanced propulsion systems, theories of special and general relativity, quantum physics, complexity, and emergence.

**11900-12000 or 11900-12000-12800. Introduction to Astrophysics.** *PQ: MATH 10600, or placement in MATH 13100 or higher. Must be taken in sequence.* PHSC 11900 will be taught in Autumn and Winter Quarters, and 12000 will be taught in Winter and Spring Quarters. The sequence 11900-12000-12800 will be offered to students in the Paris study abroad program in Spring Quarter.

**11900. Stellar Astronomy and Astrophysics.** This course explores the observational and theoretical bases for our present understanding of the structures and evolution of stars. After a brief introduction to descriptive astronomy and a survey and interpretation of the relevant observations, we develop the theoretical principles governing the physical properties and dynamics of stars. Subsequently, we apply such observational and theoretical methods to studies of the formation of stars and their planetary systems, the life and death of stars, and the formation of the chemical elements. This course also will be offered to students in the Paris study abroad program in Spring Quarter. *R. Rosner, Autumn; D. Hooper, Winter. L: A. Kravtsov, Autumn; P. Privitera, Winter.*

**12000. The Origin of the Universe and How We Know.** *PQ: PHSC 11900 or consent of instructor.* The universe is made of galaxies, which are made of aggregates of stars. Stellar aggregates allow us to map the positions of the galaxies in the universe. Studies of galaxy motions and of supernovae allow us to explore the nature of space to the edge of the visible universe. Our description of space allows us to build falsifiable models of cosmology, the origin of all that exists. The course consists of exploring how we know what we know about cosmology and why our perceptions have gradually changed over 2000 years. The fundamental theories and observations on which our knowledge rests are explored in detail. This course also is offered to students in the Paris study abroad program in Spring Quarter. *M. Gladders, Winter; J. Carlstrom, Spring. L: P. Privitera, Winter; E. Kibblewhite, Spring.*



**12800. European Astronomy and Astrophysics.** *PQ: PHSC 12000 or consent of instructor, and enrollment in the Paris study abroad program.* Modern astronomy was born in Europe in the sixteenth and seventeenth centuries, led by Nicolaus Copernicus of Poland, who simplified the description of the solar system by moving the Sun to the center of the Universe. The Italian, Galileo Galilei, first pointed a telescope at the sky in 1609 and discovered the moons of Jupiter, sunspots, the stellar composition of the Milky Way, and craters on the Moon. Tycho Brahe of Denmark studied planetary motions in great detail, allowing Johannes Kepler of Germany to define the principles of the orbits of the planets by 1615. Isaac Newton of England discovered the laws of gravity and of motion, and built the reflecting telescope later in the seventeenth century. By 1774, French astronomer Charles Messier began the explosion of our current knowledge of the Universe when he catalogued what are now known to be other galaxies. Building upon this history, this course also explores recent developments in European astronomical and astrophysical technology that allows a modern exploration of the deepest regions of the Universe using a wide range of telescopes. This course is offered only in Paris in Spring Quarter. *P. Privitera. Spring.*

**13400-13500. The Science of Global Environmental Change.** *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor. Open only to first- and second- year students and first-year transfer students. Enrollment limited. Taking these courses in sequence is not required.*

**13400. Global Warming: Understanding the Forecast.** (=ENST 12300, GEOS 13400) *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor required; some knowledge of chemistry or physics helpful.* This course presents the science behind the forecast of global warming to enable the student to evaluate the likelihood and potential severity of anthropogenic climate change in the coming centuries. It includes an overview of the physics of the greenhouse effect, including comparisons with Venus and Mars; an overview of the carbon cycle in its role as a global thermostat; predictions and reliability of climate model forecasts of the greenhouse world. *D. Archer. Autumn, Spring. L.*

**13500. Chemistry and the Atmosphere.** (=ENST 12100) *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor.* This course focuses on aspects of chemistry as they apply to the Earth's atmosphere.

The first half considers atmospheric structure and fundamental chemical principles, while the second half presents examples of chemical systems that operate in the atmosphere. Topics include the chemical composition of the atmosphere, the structure of atoms and molecules, the nature of chemical reactions, the interaction of solar radiation with atmospheric gases, the properties of the water molecule, formation of an ozone layer, and the chemistry of urban air pollution. *J. Frederick. Autumn. L.*

**13400-13600. Environment and Society.** *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor. Open only to first- and second- year students and first-year transfer students. Enrollment limited. Taking these courses in sequence is not required.*

**13400. Global Warming: Understanding the Forecast.** (=ENST 12300, GEOS 13400) *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor required; some knowledge of chemistry or physics helpful.* This course presents the science behind the forecast of global warming to enable the student to evaluate the likelihood and potential severity of anthropogenic climate change in the coming centuries. It includes an overview of the physics of the greenhouse effect, including comparisons with Venus and Mars; an overview of the carbon cycle in its role as a global thermostat; predictions and reliability of climate model forecasts of the greenhouse world. *D. Archer. Autumn, Spring. L.*

**13600. Natural Hazards.** This course presents the current understanding of high-impact weather and geologic events and an introduction to risk assessment and mitigation. Topics include an overview of geography, statistics, and societal impacts of the world's natural hazards; physics and forecasts of hurricanes, extratropical cyclones, tornadoes, earthquakes, tsunamis, volcanic eruptions, droughts, floods, wildfires, and landslides; climate change and weather events; quantifying risks; and successful examples of community- and national-level disaster prevention programs. *N. Nakamura. Winter. L.*

**13500-11000. The Earth's Chemical and Physical Environments.** *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor. Open only to first- and second-year students and first-year transfer students. Taking these courses in sequence is not required.* This sequence considers fundamental principles that determine the chemical composition of the Earth's atmosphere (Winter) and then proceeds to examine the evolution of the surface and interiors of the Earth over geologic history (Spring).

**13500. Chemistry and the Atmosphere.** (=ENST 12100) This course focuses on aspects of chemistry as they apply to the Earth's atmosphere. The first half considers atmospheric structure and fundamental chemical principles, while the second half presents examples of chemical systems that operate in the atmosphere. Topics include the chemical composition of the atmosphere, the structure of atoms and molecules, the nature of chemical reactions, the interaction of solar radiation with atmospheric gases, the properties of the water molecule, formation of an ozone layer, and the chemistry of urban air pollution. *J. Frederick. Autumn. L.*



**11000. Environmental History of the Earth.** Topics emphasize how geologic history has determined the physical and biological environments we experience on Earth today. In other words, we learn how the long-term processes of Earth history have shaped the surface and interior of the Earth, and have determined the diversity of life on the planet as seen both in the present day and in the fossil. *Spring. L.*

***Elective Courses***

*Any of the following can be used only as a third course in physical sciences to meet the general education requirement (of six courses total in the biological, physical, and mathematical sciences).*

**18100. The Milky Way.** (=ASTR 18100) *PQ: Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.* In this course, we study what is known about our galaxy, the Milky Way. We discuss its size, shape, composition, location among its neighbors, motion, how it evolves, and where we are located within it, with an emphasis on how we know what we claim to know. *N. Gnedin. Spring. L.*

**18200. The Origin and Evolution of the Universe.** (=ASTR 18200) *PQ: Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.* This course discusses how the laws of nature allow us to understand the origin, evolution, and large-scale structure of the universe. After a review of the history of cosmology, we see how discoveries in the twentieth century (i.e., the expansion of the universe and the cosmic background radiation) form the basis of the hot Big Bang model. Within the context of the Big Bang, we learn how our universe evolved from the primeval fireball. *A. Olinto. Autumn.*

**18300. Searching between the Stars.** (=ASTR 18300) *PQ: Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.* With the advent of modern observational techniques (e.g., radio, satellite astronomy), it has become possible to study free atoms, molecules, and dust in the vast space between the stars. The observation of interstellar matter provides information on the physical and chemical conditions of space and on the formation and evolution of stars. *D. Harper. Winter.*