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 cosmos themselves. Field trips or telescopic observations allow one to observe what happened. The data collected is 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 sequences) provide a way for students in the humanities and social sciences to meet the general education requirement in the physical sciences. There are four sequences in the physical sciences, each of which introduces a different discipline and different aspects of scientific knowledge.

Courses

General Education Sequences

The first two quarters of each sequence listed below meets the two-quarter general education requirement in the physical sciences. The general education requirements in physical sciences must be completed in the first two years.

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 get 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. Must be taken in sequence.*

10900. Ice-Age Earth. We study the ice age as a means of understanding the varied processes that determine the stability of the Earth's climate system. The ice age is also the most distinguished event of recent geologic time, and 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. The lab exercises come in two parts. One deals with computer-aided analysis of the climate system. The other deals with topographic maps. The second part includes analysis of glacial land forms in various national parks such as Yosemite National Park in California and Glacier National Park in Montana. We also explore the glacial land forms 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. Exceptions required to accommodate schedule conflicts with sports events will not be considered. D. MacAyeal. Autumn. L.*

11000. Environmental History of the Earth. *PQ: PHSC 10900.* 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. *S. Kidwell. 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. A student who has previously taken PHSC 10900 may complete the general education requirement in the physical sciences by taking PHSC 13400. Note, however, that PHSC 13400 has limited enrollment. 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.*

10900. Ice-Age Earth. We study the ice age as a means to an understanding of the varied processes that determine the stability of the Earth's climate system. The ice age is also the most distinguished event of recent geologic time, and 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. Next, we explore the nature of glacier flow, glacier mass balance, and the landforms that are created by glaciers both today and in the past. The terrestrial and marine record of climate change is then investigated to set the stage for the most important part of the course: an investigation of theories for the glacial cycle of Earth's climate system. The lab exercises come in two parts. One deals with computer-aided analysis of the climate system. The other deals with topographic maps. The second part includes analysis of glacial land forms in various national parks such as Yosemite National Park and Glacier National Park. We also explore the glacial land forms in the Chicago vicinity through topographic maps and a field trip. *A day-long weekend field trip to ice-age sites near Chicago is required; requests for exceptions to accommodate schedule conflicts with sports events will not be considered. D. MacAyeal. Autumn. L.*

13400. Global Warming: Understanding the Forecast. (=ENST 12300, GEOS 13400, NTSC 12300) *PQ: PHSC 10900 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; and an examination of the records of recent and past climates such as the glacial world and Eocene and Oligocene warm periods. *D. Archer, R. Pierrehumbert. Spring. L.*

13400-13500. The Science of Global Environmental Change. *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor. Courses have limited enrollment.* In this two-course sequence, fundamental chemistry and physics are used to study the major issues associated with global change occurring in the Earth's atmosphere. The factors that make the planet habitable for life, and how that environment is changing, are considered. This sequence differs from PHSC 10900-11000 and 10900-13400 in that its focus is more directed toward present and future climate, and the processes that determine present-day environmental quality.

13400. Global Warming: Understanding the Forecast. (=ENST 12300, GEOS 13400, NTSC 12300) *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor; 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; and an examination of the records of recent and past climates such as the glacial world and Eocene and Oligocene warm periods. *D. Archer. R. Pierrehumbert. Spring. L.*

13500. Atmospheric Chemistry and Air Quality. (=ENST 12100, NTSC 12100) *PQ: MATH 10600, or placement in MATH 13100 or higher, or consent of instructor.* This course considers: (1) the chemical, physical, and radiative processes that determine the composition of the atmosphere, and (2) the effects that increasing global industrialization and agriculturization are having upon the atmosphere. Particular attention is given to stratospheric ozone depletion, the chemistry of the global troposphere, the quality of urban air throughout the world, and the formation of acid precipitation. The extent to which locally-released pollutants affect the atmosphere on a global scale is addressed. *J. Frederick. Autumn. 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 course presents an introduction to Newton's laws, with special emphasis on their consequences for the motion of the planets and stars. The course also includes a discussion of wave motion as applied to sound, water, and light, and treatment of some basic aspects of special relativity. *M. Oreglia. Autumn. L.*

11200. Foundations of Modern Physics II. *PQ: PHSC 11100.* With the advent of quantum mechanics, physicists were forced to abandon the classical laws of Newton and adopt a completely new philosophy concerning the laws of physics. In this course, we explore the philosophy of quantum mechanics, including such novel concepts as the quantization of energy, the indeterminacy of physical events, and fields. We also examine systems where quantum mechanical effects are not subtle, such as the substructure of common matter and high-energy particle collisions. *D. Müller. Winter. L.*

11900-12000; or 11900-12000-12700. Introduction to Astrophysics. *PQ: MATH 10600, or placement in MATH 13100 or higher. Must be taken in sequence.* Students wishing to take a two-quarter physical science core should register for 11900-12000. Those wishing to take a third quarter may extend this by taking 12700. PHSC 11900 will be taught in Autumn and Winter Quarters, and 12000 will be taught in Winter and Spring Quarters.

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. *C. Pryke. L: P. Palmer. Autumn. D. York. L: S. Meyer. 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. *P. Vandervoort. L: S. Meyer. Winter. D. Lamb. L: E. Kibblewhite. Spring.*

12700. Planets, Comets, and Asteroids. *PQ: PHSC 12000 or consent of instructor.* Planets have been known since antiquity, but telescopes and now space probes continue to reveal new information. Anyone who has seen a bright comet cannot help but be struck by the strangeness of the sight. The other minor bodies of the solar system, asteroids, are faint; even the brightest was not discovered until well into the telescopic era.

This course follows an historical approach progressing from early views through recent studies of comet Hale-Bopp and anticipating what is to be learned by contemporary space probes. *P. Palmer. Spring. L.*

13200-13300. Paleoclimate, Earth Systems, and the Emergence of Humankind. *PQ: MATH 10600, or placement into MATH 13100 or higher. Must be taken in sequence.*

13200. The Dynamic Environment: Geologic History of Earth's Climate During the Emergence of Humankind. We study the Pleistocene "ice age" as a means to understand the varied processes that determine the stability of the Earth's climate system. The ice age is also the most distinguished event of recent geologic time, and serves as the starting point for the exploration of how Earth's environment has influenced the evolution of hominids and the emergence of the human cultural systems. Our study establishes the background for understanding the various physical systems that maintain Earth's habitability and that created an environment from which humankind's social, cultural, and technological civilization sprang in prehistoric times. We begin by introducing a basic view of Earth's physical systems, including a discussion of geologic time and methods used in geochronometry and in establishing archaeological time. Next, we study the ice-age landforms that allowed humankind to "rediscover" the ice age: a time period (the last 3 million years or so) during which humans emerged as a species and as a cultural entity. We cover the modern tools of isotopic geochemistry that give a record of Earth's paleoclimate. We complete our investigation of ice-age paleoclimate by covering the processes that control Earth's climate system, and by preparing for the second quarter of the sequence during which the co-evolution of human end-of-ice-age climate is studied in detail. The lab exercises come in two parts. One deals with computer aided analysis of the climate system. The other deals with topographic maps. The second part includes analysis of glacial landforms in various national parks such as Yosemite National Park in California and Glacier National Park in Montana. We explore the relationship between humankind, human's cities, and the natural history of ice-age environment through a field trip that tours glacial landforms in Chicago vicinity. *This daylong weekend field trip to ice-age sites near Chicago is required. D. MacAyeal, G. Eshel, T. J. Wilkinson. Winter. L.*

13300. Settlement Systems, the Management of Nature, and the Emergence of Humankind Within a Dynamic Environment. We extend our study begun in PHSC 13200 by focusing on the environmental history of the last 20,000 years and the events that shaped the emergence of human civilizations. Our emphasis is on the interplay between cultural and environmental mechanisms that shape the early development of civilization. Particular attention is given to covering Earth systems (e.g., rivers, subtropical climate, and transgressive sea level changes) that influenced the early urban settlements of the Near East. This regional focus provides an ideal laboratory for the study of human/environmental interactions because it offers an enormous array of data drawn from archaeological and textual studies. These data can be incorporated into an overall social, economic, and environmental analytical framework over long stretches of time. Earth systems studied include rivers, the hydrologic cycle, forest-steppe-desert ecosystems, and climate change in Africa and the Near East. Major themes include dynamic relationships between Earth systems, environment, and early emergent structures of human civilization. Specifically, these themes include rapid population increases and collapse, the rise of early cities, domestication of plants and animals, population movement and diasporas, the Black Sea Flood story, the development of irrigation, geological constraints on agriculture, and the Mississippi Valley floods of 1993 (as an example of such interactions in modern times). Lab exercises examine evidence for ancient sites and landscapes on satellite images as well as simple computer simulation programs that demonstrate two-way interactions between human communities and environment. *Field trips and museum laboratory exercises are assigned in conjunction with the Oriental Institute and the Field Museum. T. J. Wilkinson, D. MacAyeal. Spring. L.*

Elective Courses

The following courses can be used as the sixth quarter to meet the general education requirement in the natural and mathematical sciences.

18100. The Milky Way. (=ASTR 18100) *PQ: Any 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. *K. Cudworth. L: E. Kibblewhite. Spring. Offered 2002-03; not offered 2003-04.*

18200. The Origin and Evolution of the Universe. (=ASTR 18200) *PQ: Any 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 (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. Winter.*

18300. Searching Between the Stars. (=ASTR 18300) *PQ: Any 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.* With the advent of modern observational techniques such as radio and 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. Autumn.*

18500. The Lives and Deaths of Stars. (=ASTR 18500) *PQ: Any 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.* In this course we study the observed properties of stars and the physics that enables us to understand them. Star formation, stellar evolution, and the deaths of stars are discussed. *Offered 2003-04; not offered 2002-03.*