

PHYSICAL SCIENCES

General education courses in the Physical Sciences benefit from a rich tradition of scientific discovery at the University of Chicago. The late University of Chicago professor and Nobel laureate Subrahmanyan Chandrasekhar, who predicted the existence of black holes based on theoretical considerations, described well the importance of science in our lives when he said, "Science is a perception of the world around us. Science is a place where what you find in nature pleases you."

Under the designation PHSC, the Physical Sciences Collegiate Division offers several sequences of courses from the Astronomy and Astrophysics, Chemistry, Geophysical Sciences, and Physics Departments, tailored to provide an interesting and useful education for non-scientists in their goal of satisfying their general education requirement in the physical sciences. The goal of general education in the physical sciences is to engender in the student the ability to understand and assess our understanding of the physical world. One can argue that the fundamental tenet of liberal education at the University of Chicago is to cultivate an appreciation for critical inquiry and the basis for judgement. The physical sciences contribute to this mission in teaching the principles of experimentation, observation, and the principles of scientific inquiry. Chemistry and physics are advanced through laboratory experiments that study the structure of nature and build models which we extrapolate from those observations. Astronomy and geophysical sciences develop methods to make inferences about the world around us based on observations which cannot always be recreated in a laboratory.

While the Departments of Mathematics, Statistics, and Computer Science do not offer PHSC courses, these subjects are strongly connected to the physical sciences. Mathematics is the language of science and the only known way to make quantitative assessments about the experiments. Statistics teaches us how to interpret experimental results and how to assess a level of confidence in the conclusions derived from them, while computer science enables us to analyze large and complex data and simulate physical processes whose properties cannot be determined mathematically. The techniques developed and applied to scientific inquiry provide valuable tools to the basis of inquiry in any field, and indeed in our lives in general.

Students are required to take an approved two course sequence in the physical sciences to satisfy the general education requirement. This requirement may be met by taking an introductory sequence in Chemistry, Geosciences, or Physics, or by taking any acceptable pairing of Physical Sciences (PHSC) courses, which generally have a broader focus than the disciplinary sequences. Students are required to complete the general education sequence in the physical sciences during the first two years.

GENERAL EDUCATION SEQUENCES FOR SCIENCE MAJORS

The following introductory sequences may be used to satisfy the general education requirement in the physical sciences for all students, although these tend to be taken by sciences majors or by students who have a particular need for science (namely, premeds). The sequences are:

CHEM 10100-CHEM 10200

CHEM 11100-CHEM 11200*

CHEM 12100-CHEM 12200

GEOS 13100-GEOS 13200

PHYS 12100-PHYS 12200*#

PHYS 13100-PHYS 13200

PHYS 14100-PHYS 14200*

*For information, see the Placement Tests (<http://collegecatalog.uchicago.edu/thecollege/examinationcreditandtransfercredit/>) and Advanced Placement Credit (<http://collegecatalog.uchicago.edu/thecollege/examinationcreditandtransfercredit/>) sections elsewhere in this catalog.

#PHYS 12100 has the prerequisite of CHEM 11300 or CHEM 12300.

PHYSICAL SCIENCES COURSES FOR NON-SCIENCE MAJORS

There are several sequences in the physical sciences, each of which introduces a different discipline and different aspects of scientific knowledge. Physical Sciences (PHSC) courses fall mainly into four general categories that we might conveniently label as "**Physics**," "**Astronomy and Astrophysics**," "**Geosciences**," and "**Chemistry**." As a general rule, courses from two different categories may not be combined to satisfy the two-quarter general education requirement in the physical sciences. It is strongly recommended that the general education sequence in the physical sciences be completed in the first two years. Some PHSC courses restrict registration for students beyond the second year.

Students who seek to deviate from the combinations identified here must submit a petition to the master of the Physical Sciences Collegiate Division. Email the completed petition to the College Academic Advising office at collegeadvising@uchicago.edu, (collegeadvising@uchicago.edu) addressed to Stuart Kurtz, PSCD Master.

The PHSC courses in the **Physics** category are PHSC 11100-11200 Modern Physics I-II, PHSC 11400-11500 Life in the Universe I-II, PHSC 11600-11700 Physics for Future Presidents I-II, and PHSC 11800 Physics and Contemporary Architecture. The approved sequences among these courses are listed below. Other sequences are not permitted.

PHSC 11100-PHSC 11200

PHSC 11400-PHSC 11500

PHSC 11600-PHSC 11700

PHSC 11800-PHSC 11600

PHSC 11800-PHSC 11700

PHSC 11800-PHSC 12600

PHSC 11800-PHSC 13400/PHSC 13410

Students wishing to take a three-quarter Physical Sciences sequence may combine PHSC 11600-11700 with any other Physical Sciences core courses except PHSC 11100.

The PHSC courses in the **Geosciences** category are PHSC 10100 Origin and Evolution of the Solar System and the Earth, PHSC 10800 Earth as a Planet: Exploring Our Place in the Universe, PHSC 11000 Environmental History of the Earth, PHSC 11900 Getting Something For Nothing, PHSC 13400 Global Warming: Understanding the Forecast and PHSC 13140 Global Warming: Understanding the Forecast (flipped version), and PHSC 13600 Natural Hazards. The only approved sequences among these courses are listed below. The courses in these sequences can be taken in any order. Below is a summary of approved courses:

PHSC 10100-PHSC 11000

PHSC 10100-PHSC 11900

PHSC 10100-PHSC 13400/PHSC 13410

PHSC 10800-PHSC 11000

PHSC 10800-PHSC 11900

PHSC 10800-PHSC 13400/PHSC 13410

PHSC 10800-PHSC 13600

PHSC 11000-PHSC 11900

PHSC 11000-PHSC 13400/PHSC 13410

PHSC 11000-PHSC 13600

PHSC 11900-PHSC 13400/PHSC 13410

PHSC 11900-PHSC 13600

PHSC 12300-PHSC 13400/PHSC 13410

PHSC 13400/PHSC 13410-PHSC 13600

Under no circumstances may a student receive credit for both PHSC 10100 and PHSC 10800.

There is one sequence of PHSC courses with a focus on **Chemistry**, PHSC 12100 Chemistry in Everyday Media, PHSC 12200 The Chemistry of Food and Cooking, PHSC 12300 Chemistry for an Alternative Energy Economy, PHSC 12400 The Chemistry of Big Problems, PHSC 12500 Molecular Mechanisms of Human Disease, and PHSC 12900 The Chemistry of Artist's Materials. PHSC 12100 and PHSC 12300 are no longer being offered and are listed as reference points for students who may have taken these courses.

PHSC 12200-PHSC 11700

PHSC 12200-PHSC 12400

PHSC 12200-PHSC 12500

PHSC 12200-PHSC 12900

PHSC 12200-PHSC 13400/PHSC 13410

PHSC 12200-PHSC 13600

PHSC 12400-PHSC 12500

PHSC 12400-PHSC 12900

PHSC 12500-PHSC 12900

Students who have credit for CHEM 10100, 11100, or 12100 by either taking the course or by AP credit (for CHEM 11100) and do not wish to take CHEM 10200, 11200, or 12200 may complete the general education requirement with any of the following courses offered by the Department of Chemistry.

PHSC 12200

PHSC 12400

PHSC 12500

PHSC 12900

Several sequences are available that pair **Geosciences** and **Astronomy and Astrophysics** courses. The approved sequences are PHSC 10800 Earth as a Planet: Exploring Our Place in the Universe + PHSC 12720 Exoplanets, PHSC 10100 The Origin and Evolution of the Solar System and the Earth + PHSC 12720 Exoplanets, and PHSC 10800 Earth as a Planet: Exploring Our Place in the Universe + PHSC 12710 Galaxies.

PHSC 10100-PHSC 12720

PHSC 10800-PHSC 12710

PHSC 10800-PHSC 12720

Students who wish to take a three-quarter sequence may enroll accordingly: PHSC 12700 Stars (Autumn Quarter) + PHSC 10100 The Origin and Evolution of the Solar System and the Earth (Winter Quarter) + PHSC 12720 Exoplanets (Spring Quarter).

PHSC 12700-PHSC 10100-PHSC 12720

The on-campus PHSC courses in the **Astronomy and Astrophysics** category are PHSC 12600 Matter, Energy, Space, and Time, PHSC 12610 Black Holes, PHSC 12620 The Big Bang, PHSC 12700 Stars, PHSC 12710 Galaxies, and PHSC 12720 Exoplanets. PHSC 12600-12610-12620 is a logical progression that applies physical principles based on terrestrial experiments to the cosmos at large. Similarly, PHSC 12700-12710-12720 is a logical progression that concerns observed properties of important classes of astronomical objects. Thus, a two-quarter sequence can be built most naturally from 12600 + 12610 or 12600 + 12620, and similarly from 12700 + 12710, 12700 + 12720 or 12710 + 12720. It is also possible to make two-quarter sequences from 12600 + 12710 (galaxies are an example of structure that evolved from early conditions), from 12700 + 12610 (black holes are an end state of stellar evolution), and from PHSC 12600 + 12700.

PHSC 12600 must be taken as the prerequisite before PHSC 12610 or PHSC 12620. Either PHSC 12700 or PHSC 12710 can be taken as the prerequisite before PHSC 12720. Three-quarter sequences may be created by adding any third of the six courses, subject to prerequisite restrictions. The approved sequences among these courses are:

PHSC 12600-PHSC 12610

PHSC 12600-PHSC 12620

PHSC 12600-PHSC 12700

PHSC 12600-PHSC 12710

PHSC 12700-PHSC 12710

PHSC 12700-PHSC 12720

PHSC 12700-PHSC 12610

PHSC 12710-PHSC 12720

Every Spring Quarter a three-course Astronomy program (<http://study-abroad.uchicago.edu/programs/paris-astronomy/>) is offered in Paris, composed from the PHSC courses numbered in the 12600s and 12700s that are offered on campus. The Astronomy program in Paris satisfies the general education requirement in the physical sciences.

PHSC course electives that fit into the Astronomy and Astrophysics category are numbered in the 18000s. These courses may only be used as a third physical sciences general education course and may be combined with any acceptable two-quarter sequence, including those outside of the Astronomy and Astrophysics category.

Note on General Education in the Sciences:

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 sciences, biological sciences, or mathematical sciences. (If the mathematical sciences requirement is met by taking calculus, two quarters must be taken.)

GENERAL EDUCATION COURSES

PHSC 10100. Origin and Evolution of the Solar System and the Earth. 100 Units.

This course examines the physical and chemical origins of planetary systems, the role of meteorite studies in this context, and a comparison of the Earth with neighboring planets. It then turns to chemical and physical processes that lead to internal differentiation of the Earth. Further topics include the thermal balance at the Earth's surface (glaciation and the greenhouse effect), and the role of liquid water in controlling crustal geology and evolution. (L) Note: This course includes a lab section, but the labs can be done at home at any time with no need for specialized equipment.

Instructor(s): A. Davis Terms Offered: Winter

Note(s): Under no circumstances may a student receive credit for both PHSC 10100 and PHSC 10800.

PHSC 10800. Earth as a Planet: Exploring Our Place in the Universe. 100 Units.

This course explores the diversity of bodies in our Solar System, and the physical and chemical processes that have shaped them over their histories. We will also discuss how these studies have carried us away from an Earth-centered view of the universe to one where Earth is just one of billions of planets that exist in our galaxy. Topics to be covered include: early observations of the Solar System and the laws of planetary motion, the formation and evolution of the Moon, the structure and geophysical evolution of the planets, and the search for habitable environments outside of Earth.

Instructor(s): F. Ciesla Terms Offered: Autumn

Note(s): Under no circumstances may a student receive credit for both PHSC 10100 and PHSC 10800.

PHSC 11000. Environmental History of the Earth. 100 Units.

This course considers how physical and biological processes determine environmental conditions at the surface of the Earth, and how environments have changed over the 4.5 billion-year history of Earth. Topics include the methods of historical inference in geology; major transitions in the history of life, including the origin of life, the evolution of oxygen-producing photosynthesis, the origin of animals, and the series of massive extinctions that have repeatedly re-set ecosystems both on land and in the sea; and ecosystem evolution, including the environmental effects of human evolution. Labs involve hands-on study of rock and fossil specimens, and analysis and interpretation of datasets drawn from the scientific literature and/or faculty research programs.

Instructor(s): M. Webster; S. Kidwell Terms Offered: Spring

Note(s): Due to significant overlap of course content, students may register for only one of PHSC 11000, BIOS 12117, or GEOS 13900/BIOS 13123

PHSC 11100. Modern Physics I: Modern Physics in the Everyday World. 100 Units.

This course will introduce key concepts in classical and quantum physics and will relate them to things we encounter every day, such as lasers, microwaves, and magnetic levitation. It will also discuss some of the recent developments in chaos, nanotechnology, and quantum computing, and how they will change the world we live in. (L)

Note(s): Must be taken with PHSC 11200

PHSC 11200. Modern Physics II: Paradoxes in Modern Physics. 100 Units.

Physics advancements are often the result of conflict between, on the one hand, existing ideas and speculations, and on the other, observations and measurements. In this course, we explore historical and modern paradoxes in physics including quantum phenomena, elementary particle physics, and others. We match common sense and sensibility with scientific abstraction to broaden our understanding of the physical world.

Prerequisite(s): PHSC 11100

Note(s): Must be taken with PHSC 11100

PHSC 11400-11500. Development of Life on Earth; Extraterrestrial Life.

TBD

PHSC 11400. Life in the Universe I: Development of Life on Earth. 100 Units.

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. (L)

PHSC 11500. Life in the Universe II: Extraterrestrial Life. 100 Units.

Building upon the topics in PHSC 11400, this course goes on to consider what the laws of physics have 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. (L)

Prerequisite(s): PHSC 11400

PHSC 11600. Physics for Future Presidents: Fundamental Concepts and Applications. 100 Units.

This algebra-based course presents an introduction to many of the foundational concepts of physics with applications to modern society. These concepts include energy and power, heat, sound, gravity, electromagnetism and light, nuclear physics and radioactivity, and Newton's laws.

Instructor(s): TBD Terms Offered: Autumn

Prerequisite(s): none

Note(s): PHSC 11600-11700 is an approved two-quarter sequence which will satisfy the general education requirement in the physical sciences. core requirement.

PHSC 11700. Physics for Future Presidents: Energy and Sustainability. 100 Units.

This course treats both the past and future of how the principles that govern the conversion of energy to useful work have impacted and will impact civilization. The principles of kinetic, potential, thermal, mechanical, and nuclear energies will be considered in the contexts of societal issues such as energy sustainability, modern technologies, war, information, food, and health.

Instructor(s): Peter Littlewood Terms Offered: Winter

Prerequisite(s): none

Note(s): PHSC 11600-11700 is an approved two-quarter sequence which will satisfy the general education requirement in the physical sciences.

PHSC 11800. Physics and Contemporary Architecture. 100 Units.

Architectural structures form the built environment around us and in many ways create the backbone of our civilization. They push the limits of form and function on the largest human scales, often leading to iconic masterpieces that symbolize the aesthetics as well as the technical achievements of a period. Many architectural advances have been made possible by breakthroughs in the science of materials, which then led to innovation in construction and fabrication techniques. This course will introduce the physics principles that have enabled some of the most innovative architecture of our time. This course will take key ideas and tools from physics and demonstrate their power and relevance in a broader context familiar from everyday experience. The course will challenge students to recognize physics concepts in the built structures that make up the urban environment we live in. Chicago is a most appropriate place for this study; it was the birthplace of the first skyscraper, and ever since it has played an internationally celebrated role in pushing the limits of the architectural state of the art. A long succession of renowned Chicago architects and structural engineers has turned this city into a premier laboratory for architectural innovation. Against this backdrop, the course will show how science, and physics in particular, delivers the conceptual foundations that drive current directions in architecture and open up new opportunities.

Instructor(s): Heinrich M. Jaeger; Sidney Nagel Terms Offered: Spring

Prerequisite(s): Some exposure to high-school physics is recommended

Note(s): The course will consist of two lectures per week plus a weekly hands-on workshop (lab) component.

The Monday lectures will introduce the physics principles to be explored that week. The Thursday lectures will be delivered by distinguished guest speakers, including renowned architects and engineers. These lectures will be public lectures. They will relate to the physics principle introduced that Monday and explore its ramification within the broader context of contemporary architectural practice. The Thursday afternoon workshop component will involve team-based, hands-on construction projects to develop a better understanding and intuition of the physics principles introduced in the lectures and to obtain a sense of their real-life implications. The workshops will also provide an opportunity to interact with the guest lecturers. Attendance at Thursday lectures is required. This course meets the general education requirement in the physical sciences and may be paired with PHSC 11600, 11700, 12600, or 13400 in order to complete the requirement. This course can be taken for credit towards either the general education requirement in the physical sciences or the Architectural Studies minor, but not both. Students intending to receive physical sciences general education credit should register for PHSC 11800; students intending to receive credit towards the Architectural Studies Minor should register for ARCH 11800.

Equivalent Course(s): ARCH 11800, CHST 11800

PHSC 11900. Getting Something for Nothing. 100 Units.

We can learn an incredible amount about the physical world with simple tools of estimation. So-called Fermi problems involve estimating quantities of interest to within an order of magnitude, or factor of 10, on the "back of an envelope." There are learnable techniques that we can use to approach these problems. Developing these skills is incredibly useful for physical scientists because it allows us to quickly estimate whether an idea is worth pursuing with expensive resources and time. More generally, order-of-magnitude estimation can keep you from getting fooled by journalists and politicians, or give you a trading edge in a competitive market. Finally, Fermi problems are common in interviews for jobs in finance, consulting, and software. Students in this course will develop techniques to quickly estimate physical science quantities to within an order of magnitude.

Instructor(s): D. Abbot Terms Offered: Spring. This course will first be offered in Spring 2024.

Note(s): Physical Science Course Pairings (to complete the general education requirements): 1. PHSC 10100. Origin and Evolution of the Solar System and the Earth. 2. PHSC 10800. Earth as a Planet: Exploring Our Place in the Universe. 3. PHSC 11000. Environmental History of the Earth. 4. PHSC 13400. Global Warming: Understanding the Forecast. 5. PHSC 13410. Global Warming: Understanding the Forecast (Flipped Class) 6. PHSC 13600. Natural Hazards.

Equivalent Course(s): GEOS 25600

PHSC 11901. The Physics of Stars. 100 Units.

Understanding how stars work--what makes them shine--is one of the great accomplishments of 20th-century science. The theory of stellar structure allows us to investigate the interiors of stars, even though what we observe is radiation from their outer atmospheres. This theory also helps us determine how old stars are, how they create heavier nuclei from lighter nuclei in their centers, and how they evolve from birth to death, ending as a white dwarf, a neutron star, or a black hole. This course introduces you to the concepts behind and applications of this crucial breakthrough. We will review the physical principles--gravity, pressure, radiation, and how radiation interacts with matter--and apply these principles to further our understanding of stellar structure. We will collect our own measurements of stellar properties, such as the temperatures and luminosities of stars, using robotic telescopes controlled via the internet and those at Yerkes Observatory. (The class will be bussed to Yerkes Observatory, two hours north of Chicago, for an on-site experience there.) Using these and other data, we will test the theory of stellar structure and explore what it can tell us about the universe. While it is not required, students who have taken this course in the past have found it beneficial to bring their own laptops to class if they have them.

Instructor(s): TBD Terms Offered: Summer

Prerequisite(s): Open to high school students only.

PHSC 12200. The Chemistry of Food and Cooking. 100 Units.

The goals of this course are for students to understand the everyday chemistry involved in food and cooking, gain science literacy, and critically evaluate food marketing. The first part of the course will explore the basics of food chemistry, establishing how the structure and properties of water, fats, proteins, and other macromolecules influence our eating and cooking experiences. We will also investigate the chemical components that contribute to color, flavor, and aroma in food. The rest of the course will examine consumer issues related to food science. What do the food labels organic, all-natural, and non-GMO actually mean from a chemistry perspective? What is the science involved in the plant-based meat industry? How can we use chemistry to be a more thoughtful consumer of food? Additional topics will be driven by student interest. The course will include a both a lecture and laboratory component. The laboratory sessions will involve case studies and application of lecture topics in a collaborative environment. Course assignments will include readings, class discussions, written papers, and a final presentation.

Instructor(s): Shaunna McLeod Terms Offered: Spring

Prerequisite(s): Some previous background in Chemistry is recommended

Note(s): In order to complete the Physical Sciences Core Requirement, this course may be paired with: PHSC 11600, PHSC 11700, PHSC 12400, PHSC 12500, PHSC 13400, PHSC 13600

Equivalent Course(s): CHEM 12600

PHSC 12400. The Chemistry of Big Problems. 100 Units.

This course will discuss the chemistry of big problems that impact human life and society, such as the future accessibility of personal genetic sequence information, genetically modified organisms, or plastics and polymers and alternative sources of energy. We will use each of these topics as a window to grasp the underlying chemistry, reaction mechanisms, analytical methods, and quantitative chemical principles applied to major scientific issues that impact the world around us. Relevant examples will be considered in a discussion-oriented format to bring out chemical and analytical principles associated with big problems. The course will have a classroom lecture component as well as a laboratory component. The laboratory component will involve case studies and problem solving by application of analytical principles and independent work or teams of students.

(L)

Instructor(s): Y. Krishnan Terms Offered: Autumn

Prerequisite(s): Some previous background in Chemistry is recommended.

Note(s): Note(s): In order to satisfy the general education requirements in the physical sciences PHSC 12400 may be combined with PHSC 12300 Chemistry for an Alternative Energy Source or PHSC 12500 Molecular Mechanisms of Human Disease. If a student does not wish to continue with CHEM 10100 Introductory General Chemistry, CHEM 11100 Comprehensive General Chemistry, or CHEM 12100 Honors General Chemistry sequence, they may take PHSC 12400 as the second course.,

Equivalent Course(s): CHEM 12400

PHSC 12500. Molecular Mechanisms of Human Disease. 100 Units.

This course will examine the molecular basis for a few specific instances of human disease. We will use each of these molecular case studies as a vehicle to demonstrate quantitative chemical principles such as thermodynamics, chemical equilibrium, chemical kinetics, diffusive dynamics, and DNA damage and repair. The goal of the course will be to use well-understood biological and medical examples to illustrate chemical principles and to give students a toolbox and techniques to understand molecular systems more broadly. The course will have a classroom lecture component as well as a laboratory component. The laboratory component

will involve specific case studies and mechanistic proposals that represent exploratory independent work by teams of students. (L)

Instructor(s): G. Engel Terms Offered: Spring

Prerequisite(s): Some previous background in Chemistry recommended

Note(s): Note(s): In order to satisfy the general education requirements in the physical sciences PHSC 12500 may be combined with PHSC 123 Chemistry for an Alternative Energy Source or PHSC 12400 The Chemistry of Big Problems, If a student does not wish to continue with CHEM 10100 Introductory General Chemistry, CHEM 11100 Comprehensive General Chemistry, or CHEM 12100 Honors General Chemistry sequence, they may take PHSC 12500 as the second course.

Equivalent Course(s): CHEM 12500

PHSC 12600. Matter, Energy, Space, and Time. 100 Units.

A comprehensive survey of how the physical world works, and how matter, energy, space, and time evolved from the beginning to the present. A brief survey of the historical development of mathematics, physics, and astronomy leads to a conceptual survey of the modern theory of the physical universe: space and time in relativity; the quantum theory of matter and energy; and the evolution of cosmic structure and composition. The major theme of this course is the understanding of all nature, from the prosaic to the exotic, using powerful quantitative theory grounded in precise experiments. Although quantitative analysis will be an important part of the course, students will not be expected to employ mathematics beyond algebra. (L)

Instructor(s): Paolo Privitera Terms Offered: Autumn

Equivalent Course(s): ASTR 12600

PHSC 12610. Black Holes. 100 Units.

The past decade has seen the stunning discovery of gravitational waves from black holes merging together, allowing physical theory to be tested in the most exotic and extreme environment in the universe. Black holes are mathematically the most perfectly understood of any physical structure, but their visible effects can be extraordinarily complex. This course will survey the physics of space and time; the nature of black holes, neutron stars, and white dwarf stars; their effects on surrounding matter and light; the astrophysical contexts in which they are observed; and frontier areas of research. The development of Albert Einstein's theory of General Relativity will be placed in historical context, including a review of observational confirmation of predictions of the theory. Experimental work will include use of a robotic telescope to observe circumstances related to extreme gravity, such as supernovae and the centers of giant galaxies that harbor super-massive black holes. Quantitative analysis will be an important part of the course, but mathematics beyond algebra will not be required. (L)

Instructor(s): Fausto Cattaneo (Summer Quarter); Rich Kron (Winter Quarter) Terms Offered: Summer Winter.

Summer Quarter instructor is Fausto Cattaneo.

Prerequisite(s): PHSC 12600 or PHSC 12700

Equivalent Course(s): ASTR 12610

PHSC 12620. The Big Bang. 100 Units.

The Big Bang model describes the Universe on the largest scales and its evolution from the earliest observationally accessible times through the formation of the complex world we live in today. This powerful framework allows us to interpret a wide range of observations and to make detailed and precise predictions for new experiments. The key motivating observations include the expansion of the Universe and how it has changed with time; the existence of radiation indicating a hot and dense early phase; the abundance of the light elements; and how matter is organized over a wide range of physical scales. The model naturally incorporates dark matter and dark energy, two surprising and poorly understood components that govern the growth of structure over time. The course will explore the history of scientific cosmology and the evidence for the Big Bang model, its consequences for the earliest moments after the Big Bang, and its predictions for the eventual fate of the Universe. Labs will include a hands-on measurement of the relic cosmic microwave background radiation from the early universe and the use of astronomical data to verify key discoveries in the history of Big Bang cosmology. Quantitative analysis will be an important part of the course, but prior experience with mathematics beyond algebra will not be required. (L)

Instructor(s): John Carlstrom Terms Offered: Spring

Prerequisite(s): PHSC 12600

Equivalent Course(s): ASTR 12620

PHSC 12700. Stars. 100 Units.

Elements such as carbon and oxygen are created in fusion reactions at high temperatures and pressures in the deep interiors of stars, conditions that naturally arise in stars like the Sun. This course will outline the physical principles at work and the history of the development of the key ideas: how nuclear physics and the theory of stellar interiors account for how stars shine, why they live for such long times, and how the heavy elements in their cores are dispersed to form a new generation of stars. Gravity assembles stars out of more diffuse material, a process that includes the formation of planetary systems. The course shows how, taken together, these physical processes naturally lead to the ingredients necessary for the emergence of life, namely elements like carbon, nitrogen, and oxygen, and planets in stable orbits around long-lived stars. The course features quantitative analysis of data; any tools needed beyond pre-calculus algebra will be taught as part of the course. (L)

Instructor(s): Fausto Cattaneo (Summer Quarter); Damiano Caprioli (Autumn Quarter) Terms Offered: Autumn Summer. Summer Quarter instructor is Fausto Cattaneo.

Equivalent Course(s): ASTR 12700

PHSC 12710. Galaxies. 100 Units.

Galaxies have been called island universes, places where stars are concentrated, where they are born, and where they die. The study of galaxies reaches back to the Renaissance; Galileo Galilei first pointed a telescope skyward in 1610 and confirmed a then 2000 year-old Greek conjecture about the nature of our own galaxy -- the Milky Way. This course will use extensive modern observational data from a wide range of telescopes to trace the modern picture for the formation and evolution of galaxies and the stars in them. Galaxies will then be used as markers of yet larger scale structures, in order to explore the influence of gravity over cosmic time. The object of study in this course is galaxies, and the narrative arc traced through that extensive data and understanding will highlight our profound discovery that most of the mass in galaxies (and the Universe as a whole) is in fact an exotic form of matter -- dark matter -- that we cannot directly see. Quantitative analysis will be an important part of the course in both laboratory work and lectures, but mathematics beyond algebra and some geometric understanding will not be required. This course will feature several observationally-oriented labs that will allow students to directly experience how some of the modern understanding of galaxies has arisen. (L)

Instructor(s): Jeff McMahon Terms Offered: Winter

Prerequisite(s): PHSC 10800, PHSC 12600 or PHSC 12700. PHSC 12710 can be taken as the first course in a sequence combined with PHSC 12720.

Equivalent Course(s): ASTR 12710

PHSC 12720. Exoplanets. 100 Units.

The discovery of planets in orbit around other stars is one of the newest developments in astronomy, which set off a race to characterize these "exoplanetary" systems. The architectures of planetary systems are set by the formation of the parent star and its protoplanetary disk, but they also encode subsequent evolution. We are now able to place our Solar System into the context of other worlds, and we find some aspects familiar and other aspects quite alien. A challenging next step is to find planets like the Earth in orbit around stars like the Sun. This course will review the techniques for discovery of planets around other stars, what we have learned so far about exoplanetary systems, and the driving questions for the future, including the quest for habitable environments elsewhere. Although quantitative analysis will be an important part of the course, students will not be expected to employ mathematics beyond algebra. (L)

Instructor(s): Jacob Bean Terms Offered: Winter

Prerequisite(s): PHSC 10800, PHSC 10100, PHSC 12700 or PHSC 12710.

Equivalent Course(s): ASTR 12720

PHSC 12900. The Chemistry of Artists' Materials. 100 Units.

The goal of this course is to understand the fundamentals of molecular structure as applied to dyes, pigments, and other materials used in art and crafts. Students will gain general scientific literacy skills and engage with fundamental laboratory techniques in an inherently interdisciplinary way. The first part of the course will delve into molecular structure of organic dyes and inorganic pigments as well as principles behind how visible light interacts with these compounds to produce the colors we see. The fundamental set of techniques used to probe and explore these processes is called spectroscopy; these techniques will play a large role in the laboratory component. Throughout the rest of the course, a number of case studies of these principles will be investigated, including natural v. synthetic dyes and historical dye extraction processes, conservation and restoration of fine art, pigments and materials used in pottery, and the chemistry of stained glass. Additional topics will be driven by student interest. Course assignments will include readings, class discussions, homework sets, lab reports, and a final written paper

Instructor(s): Lant, Hannah Terms Offered: Autumn

Note(s): PHSC 12200 The Chemistry of Food and Cooking PHSC 12400 The Chemistry of Big Problems, and PHSC 12500 Molecular Mechanisms of Human Disease. Students who have credit for CHEM 10100, 11100, or 12100 by either taking the course or by AP credit (for CHEM 11100) and do not wish to take CHEM 10200, 11200, or 12200 may complete the general education requirement with any of the PHSC courses offered by the Department of Chemistry.

Equivalent Course(s): CHEM 12900

PHSC 13400. Global Warming: Understanding the Forecast. 100 Units.

The future of human civilization depends on its ability to avoid, or adapt to, climate change associated with fossil-fuel (carbon) emissions. With so much at stake, it is important that citizens of the world understand the science which forms the foundation of what is understood about global climate change. The learning objectives of this course are to develop understanding of: (1) the historical and pre-historical records of global climate change, (2) the Earth's carbon budget, (3) how the greenhouse effect determines temperature in Earth's atmosphere and at the land and sea surface, (4) how climate projections are made, and (5) how present-day activities, both in the scientific research realm and in the socio-economic/political realm are shaping what will happen in the future. Course activity is partitioned into lectures (given by the course instructor), weekly laboratory-section activity (run by graduate teaching assistants), outside reading, and occasional homework. Assessment leading to a course grade will focus primarily on student performance in completing laboratory exercises and on a midterm and final exam. (L)

Instructor(s): D. MacAyeal Terms Offered: Autumn

Equivalent Course(s): ENSC 13400, ENST 12300, GEOS 13400

PHSC 13410. Global Warming: Understanding the Forecast (Flipped Class) 100 Units.

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; predictions and reliability of climate model forecasts of the greenhouse world. This course is part of the College Course Cluster program, Climate Change, Culture, and Society. This course covers the same material as PHSC 13400, but is organized using a flipped classroom approach in order to increase student engagement and learning.

Instructor(s): D. Abbot Terms Offered: Autumn Spring

Prerequisite(s): Some knowledge of chemistry or physics helpful.

Equivalent Course(s): ENSC 13410, GEOS 13410, ENST 13410

PHSC 13600. Natural Hazards. 100 Units.

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 and wildfires; climate change and extreme weather events; quantifying and managing risks. (L)

Instructor(s): N. Nakamura Terms Offered: Winter

ELECTIVE COURSES

Courses numbered 18xxx 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). Courses numbered 2xxxx do not satisfy the general education requirement in physical sciences.

PHSC 18000. The Search for Extraterrestrial Life. 100 Units.

The origin of life is one of the biggest questions of modern science. While substantial progress has been made in understanding how life arose on our planet, such research represents just a single case study in how life originates and evolves. This course covers the search for life beyond Earth from the planets and moons of the Solar System to planets orbiting other stars and intelligent life that may have left its mark on macroscopic scales. The discovery of life beyond Earth would be transformative for our understanding of humanity's place in the universe. A range of ongoing and planned experiments have the potential to detect or put strong constraints on the existence of life during the next few decades. This class will mix traditional lectures with flipped classroom problem-solving sessions.

Instructor(s): Jacob Bean Terms Offered: Autumn. NOT OFFERED IN 2023-2024

Note(s): Can be used as a third course in physical sciences to meet the general education requirement (of six courses total in the biological, physical, and mathematical sciences). Not recommended for students who have taken ASTR/PHSC 12720 Exoplanets.

Equivalent Course(s): ASTR 18000

PHSC 18100. The Milky Way. 100 Units.

Within a largely empty universe, we live in a vast stellar "island" that we call the Milky Way. As we survey the stellar and interstellar components of the Milky Way—the distribution and motions of stars and interstellar gas, and how these dynamic, ever-changing components interact with each other during their life cycles inside the Milky Way—we will follow the path of ancient astronomers, wonder at their mistakes and prejudices, and form our own understanding.

Instructor(s): Nick Gnedin Terms Offered: Spring. NOT OFFERED IN 2023-2024

Prerequisite(s): Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics. Can be used as a third course in physical sciences to meet the general education requirement (of six courses total in the biological, physical, and mathematical sciences).

Equivalent Course(s): ASTR 18100

PHSC 18200. The Origin and Evolution of the Universe. 100 Units.

This course provides a comprehensive introduction to modern cosmology for students wishing to delve deeper into the subject than PHSC 12620 (which is not a prerequisite) but at a similar mathematical level. It will discuss how the fundamental laws of physics allow us to understand the origin, evolution, and large-scale structure of the universe. After a brief review of the history of cosmology, the course will cover the expansion of the universe, Newtonian cosmology, Einstein's Special and General Relativity, black holes, dark matter, dark energy, the Cosmic Microwave Background radiation, Big Bang nucleosynthesis, the early universe, primordial inflation, the origin and evolution of large-scale structure in the universe, and cosmic surveys that are probing inflation and cosmic acceleration.

Instructor(s): Edward Kolb Terms Offered: Winter

Prerequisite(s): Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics. Can be used as a third course in physical sciences to meet the general education requirement (of six courses total in the biological, physical, and mathematical sciences).

Equivalent Course(s): ASTR 18200

PHSC 18800. Philosophical Problems in Cosmology. 100 Units.

In this course, we will undertake a comparison of the philosophical underpinnings of the Aristotelian and Copernican cosmologies, including a comparison of mechanistic and teleological approaches to the natural

world. The epistemological foundations of the scientific method, in particular as applied to cosmology (from Galileo to the modern context) will be examined, as will positivist vs. realistic outlooks on cosmology. (For example, what does science say-or not say-about the inside of a black hole, or the space beyond the Hubble horizon?) We will ponder questions such as: Do the epistemological foundations of science require us to be able to repeat relevant experiments? If so, does this disqualify cosmology as a science? If not, why? Might our universe be part of a computer simulation? What information could possibly convince us that this is true or false?

Instructor(s): Dan Hooper Terms Offered: Spring

Prerequisite(s): Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics. Can be used as a third course in physical sciences to meet the general education requirement (of six courses total in the biological, physical, and mathematical sciences).

Equivalent Course(s): ASTR 18800, HIPS 18800

PHSC 27010. Histories of Women in Science. 100 Units.

In the mid-1980s, only two female students drew women when asked what a scientist looked like and none of the male students in the study did. Only 8% of STEM workers in 1970 were women; in 2019 that number was still only 27%. This would seem to suggest that the history of women in science is a recent one. Yet historians of science have foregrounded women's involvement in fields ranging from early modern medicine to twentieth century astrophysics. This class introduces students to these histories, investigates how and why science came to be a gendered as male, and asks to what extent gendered values continue to inform modern conceptions scientific achievement or value. In so doing, this course also introduces students to feminist science studies and challenges students to reflect upon their own (gendered) experiences of science. Students are strongly encouraged to develop final research projects that draw upon their own interests, scientific expertise, and linguistic competencies. No prior experience with history is required for this course, although an enthusiasm for history is advised.

Instructor(s): Kristine Palmieri Terms Offered: Winter

Equivalent Course(s): GNSE 37011, HIPS 27011, KNOW 37011, GNSE 23162, CHSS 37011, HIST 27806, ASTR 23700

PHSC 28102. Science Communication: Producing a Science Video Story. 100 Units.

Students will gain skills in oral communication and will apply these skills to produce a TED Talk-style video communicating primary research in a scientific area of the student's choice. The goal is effective, engaging communication of science to a general audience without sacrificing scientific accuracy or complexity. Students will work with faculty to write scripts and design visual and audio elements. The talks will be filmed and edited in collaboration with UChicago Creative, who will assist with visual aids and animation. Students will leave the course with a professionally produced video that they can use to advance their career and promote their topic. While this course naturally follows BIOS 28101, that course is not a pre-requisite.

Instructor(s): P. Mason, S. Serritella Terms Offered: Spring, Spring 2022.

Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence. Third- or fourth-year standing. This course does not satisfy the general education requirement in the physical sciences.

Equivalent Course(s): BIOS 28102, SCPD 11200

PHSC 28104. Science Communication: Crafting a Science Think Piece. 100 Units.

Science think pieces are an important genre of public writing. Think pieces are longform journalism typically ranging between 2,000 and 5,000 words that appear in print and online publications. Readers of all kinds turn to science think pieces to understand critical issues in STEM fields and get a big picture perspective. Science think pieces provide deep context, informed perspective, and expert synthesis of the most recent data and findings. They have the power to shape public opinion and influence science policy. This course guides students through the process of conceiving, developing, pitching, writing, and potentially publishing an engaging and persuasive science think piece. Through reading-inspired group discussions and instructor-led writing projects, the course introduces students to current theories and best practices of science communication as well as everyday processes in science journalism and public-facing science writing. Students will finish the course with a polished science think piece ready for submission to potential venues for publication. No prior knowledge of science communication is required.

Instructor(s): Jordan Bimm Terms Offered: Autumn Winter

Prerequisite(s): Three quarters of physical or biological (including neuroscience) sciences. Third- or fourth-year standing or consent of instructor.

Equivalent Course(s): SCPD 11300

PHSC 28500. Effective Writing in the Sciences. 100 Units.

This course will help undergraduates majoring in the sciences write effectively in major-level coursework and thesis research. The course is in its pilot year; in future years, the course's graduates may be eligible to serve as teaching assistants in it. For this reason, although the course is mostly devoted to scientific writing, it will include a component on how to teach writing, potentially helping undergraduate science students obtain broader impacts opportunities in science communication. Our reading texts will range from lab reports and posters to advanced scientific work such as research articles, review articles, and grant proposals. We'll analyze how these documents are structured, discuss strategies for reading them efficiently, and discuss what makes them succeed (or not). We'll develop strategies for note-taking, drafting, and revision. Our ultimate purposes: communicating complex information clearly, articulating research questions, justifying the plausibility of methods, and explaining how new research contributes to the advancement of a field. All these writing tasks

must ultimately be tailored to meet the needs of the many audiences that working scientists address, including not only researchers in the field but funding agencies, policymakers, and the general public."

Terms Offered: Summer

PHSC 29103. Science Communication: Building a Science Exhibit. 100 Units.

Students will work as a class to create an interactive physical exhibit that communicates a particular scientific topic to the public. The student-created exhibit will be displayed either on campus or across the city of Chicago. We will welcome guest speakers who are experts in data visualization, visual arts, and museum exhibits to demonstrate the variety of ways science can be communicated. Students will also take field trips to the local museums to observe the different ways in which research and science communication work together. Students will critically analyze exhibits, evaluate how exhibits and approaches across the city are similar and different, and reflect on the variety of approaches. An advisory board of researchers from local Chicagoland museums will inform and review the final exhibits.

Instructor(s): P. Mason, S. Serritella Terms Offered: Spring

Prerequisite(s): Third- or fourth-year standing.

Note(s): This course does not meet the requirements for the Biological Sciences major. This course does not satisfy the general education requirement in the physical sciences.

Equivalent Course(s): BIOS 29103

