

# ASTROPHYSICAL AND PLANETARY SCIENCES

The Department of Astrophysical and Planetary Sciences is one of the few programs that combines both astrophysics and planetary science, providing a unified view of space sciences, the solar system and comparative planetology, stellar and galactic astronomy, and cosmology. Students are given hands-on experience with telescopes, optics, instrumentation, and computer-image processing and modeling.

For further information concerning undergraduate studies, contact the undergraduate program assistant.

**Course code for this program is ASTR.**

## Bachelor's Degree

- Astrophysical and Planetary Sciences - Bachelor of Arts (BA) (<https://catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/astrophysical-planetary-sciences/astrophysical-planetary-sciences-bachelor-arts-ba/>)

## Minor

- Astrophysical and Planetary Sciences - Minor (<https://catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/astrophysical-planetary-sciences/astrophysical-planetary-sciences-minor/>)

## Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Baker, Daniel N. ([https://experts.colorado.edu/display/fisid\\_103264/](https://experts.colorado.edu/display/fisid_103264/))  
Distinguished Professor; PhD, University of Iowa

Bally, John ([https://experts.colorado.edu/display/fisid\\_105710/](https://experts.colorado.edu/display/fisid_105710/))  
Professor Emeritus; PhD, University of Massachusetts at Amherst

Begelman, Mitchell C. ([https://experts.colorado.edu/display/fisid\\_100446/](https://experts.colorado.edu/display/fisid_100446/))  
Distinguished Professor; PhD, University of Cambridge (England)

Berta-Thompson, Zachory (<https://www.colorado.edu/aps/zachory-berta-thompson/>)  
Assistant Professor; PhD, Harvard University

Blum, Lauren W. ([https://experts.colorado.edu/display/fisid\\_167200/](https://experts.colorado.edu/display/fisid_167200/))  
Assistant Professor; PhD, University of Colorado Boulder

Brain, David A. ([https://experts.colorado.edu/display/fisid\\_149098/](https://experts.colorado.edu/display/fisid_149098/))  
Associate Professor; PhD, University of Colorado Boulder

Brown, Benjamin P. ([https://experts.colorado.edu/display/fisid\\_153758/](https://experts.colorado.edu/display/fisid_153758/))  
Associate Professor; PhD, University of Colorado Boulder

Burns, Jack O.  
Professor, Faculty Fellow; PhD, Indiana University Bloomington

Cash, Webster C. Jr. ([https://experts.colorado.edu/display/fisid\\_101759/](https://experts.colorado.edu/display/fisid_101759/))  
Professor; PhD, University of California, Berkeley

Comerford, Julia M. ([https://experts.colorado.edu/display/fisid\\_151471/](https://experts.colorado.edu/display/fisid_151471/))  
Associate Professor; PhD, University of California, Berkeley

Cranmer, Steven ([https://experts.colorado.edu/display/fisid\\_155051/](https://experts.colorado.edu/display/fisid_155051/))  
Associate Professor; PhD, University of Delaware

Darling, Jeremiah K. ([https://experts.colorado.edu/display/fisid\\_141767/](https://experts.colorado.edu/display/fisid_141767/))  
Professor; PhD, Cornell University

Dexter, Jason ([https://experts.colorado.edu/display/fisid\\_164095/](https://experts.colorado.edu/display/fisid_164095/))  
Assistant Professor; PhD, University of Washington Seattle

Ellingson, Erica ([https://experts.colorado.edu/display/fisid\\_100118/](https://experts.colorado.edu/display/fisid_100118/))  
Associate Professor; PhD, University of Arizona

Ergun, Robert E. ([https://experts.colorado.edu/display/fisid\\_115912/](https://experts.colorado.edu/display/fisid_115912/))  
Professor; PhD, University of California, Berkeley

Esposito, Larry Wayne ([https://experts.colorado.edu/display/fisid\\_100502/](https://experts.colorado.edu/display/fisid_100502/))  
Professor; PhD, University of Massachusetts at Amherst

Fleming, Brian ([https://experts.colorado.edu/display/fisid\\_154011/](https://experts.colorado.edu/display/fisid_154011/))  
Assistant Research Professor; PhD, Johns Hopkins University

France, Kevin Christopher ([https://experts.colorado.edu/display/fisid\\_145201/](https://experts.colorado.edu/display/fisid_145201/))  
Associate Professor, Associate Chair; PhD, Johns Hopkins University

Green, James C. ([https://experts.colorado.edu/display/fisid\\_102344/](https://experts.colorado.edu/display/fisid_102344/))  
Professor Emeritus; PhD, University of California, Berkeley

Halverson, Nils W. ([https://experts.colorado.edu/display/fisid\\_134252/](https://experts.colorado.edu/display/fisid_134252/))  
Professor, Chair; PhD, California Institute of Technology

Hamilton, Andrew J.S. ([https://experts.colorado.edu/display/fisid\\_101517/](https://experts.colorado.edu/display/fisid_101517/))  
Professor, Chair; PhD, University of Virginia

Hayne, Paul ([https://experts.colorado.edu/display/fisid\\_163352/](https://experts.colorado.edu/display/fisid_163352/))  
Assistant Professor; PhD, University of California, Los Angeles

Hindman, Bradley W. ([https://experts.colorado.edu/display/fisid\\_103726/](https://experts.colorado.edu/display/fisid_103726/))  
Assistant Research Professor, Lecturer; PhD, University of Colorado Boulder

Hornstein, Seth D. ([https://experts.colorado.edu/display/fisid\\_144237/](https://experts.colorado.edu/display/fisid_144237/))  
Senior Instructor; PhD, University of California, Los Angeles

Kazachenko, Maria ([https://experts.colorado.edu/display/fisid\\_160195/](https://experts.colorado.edu/display/fisid_160195/))  
Assistant Professor; PhD, Montana State University

Keller, John M. ([https://experts.colorado.edu/display/fisid\\_163223/](https://experts.colorado.edu/display/fisid_163223/))  
Senior Instructor; PhD, University of Arizona

Kowalski, Adam (<https://www.colorado.edu/aps/adam-kowalski/>)  
Assistant Professor; PhD, University of Washington

Linsky, Jeffrey  
Professor Emeritus

MacGregor, Meredith ([https://experts.colorado.edu/display/fisid\\_165825/](https://experts.colorado.edu/display/fisid_165825/))  
Assistant Professor; PhD, Harvard University

Madigan, Ann-Marie ([https://experts.colorado.edu/display/fisid\\_158298/](https://experts.colorado.edu/display/fisid_158298/))  
Assistant Professor; PhD, Leiden University (Netherlands)

Malaspina, David M. ([https://experts.colorado.edu/display/fisid\\_148393/](https://experts.colorado.edu/display/fisid_148393/))  
Assistant Professor; PhD, University of Colorado Boulder

Malville, J. McKim  
Professor Emeritus

Nelson, Erica Lynn ([https://experts.colorado.edu/display/fisid\\_166298/](https://experts.colorado.edu/display/fisid_166298/))  
Assistant Professor; PhD, Yale University

Pineda, John Sebastian ([https://experts.colorado.edu/display/fisid\\_158632/](https://experts.colorado.edu/display/fisid_158632/))  
Lecturer

Rast, Mark Peter ([https://experts.colorado.edu/display/fisid\\_142997/](https://experts.colorado.edu/display/fisid_142997/))  
Professor; PhD, University of Colorado Boulder

Reardon, Kevin Patrick ([https://experts.colorado.edu/display/fisid\\_154925/](https://experts.colorado.edu/display/fisid_154925/))  
Professor Adjunct

Schneider, Nicholas M. ([https://experts.colorado.edu/display/fisid\\_102620/](https://experts.colorado.edu/display/fisid_102620/))  
Professor; PhD, University of Arizona

Shull, J Michael  
Professor Emeritus; PhD, Princeton University

Snow, Theodore P. Jr  
Professor Emeritus

Stocke, John T.  
Professor Emeritus; PhD, University of Arizona

Thomas, Gary E.  
Professor Emeritus

Toomre, Juri ([https://experts.colorado.edu/display/fisid\\_100767/](https://experts.colorado.edu/display/fisid_100767/))  
Professor, Faculty Fellow; PhD, University of Cambridge (England)

## Courses

### ASTR 1000 (3) The Solar System

Introduction to the night sky, planets, moons and the life in our solar system. Highlights the latest discoveries from space. For non-science majors. Some lectures may be held at Fiske Planetarium. Offers opportunities for nighttime observations at Sommers-Bausch Observatory.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 1010, but without lab ASTR 1010 or ASTR 1030

**Requisites:** Restricted to non- Astronomy (ASTR) majors only.

**Additional Information:** Arts Sci Core Curr: Natural Science Sequence  
Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences  
MAPS Course: Natural Science

### ASTR 1010 (4) Introductory Astronomy: The Solar System w/Lab

Introduction to the night sky, planets, moons and the life in our solar system. Highlights the latest discoveries from space. For non-science majors. Some lectures may be held at Fiske Planetarium. Requires nighttime observations at Sommers-Bausch Observatory. Degree credit granted for only one of ASTR 1000 or ASTR 1010.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 1000, but with additional lab

**Requisites:** Restricted to non- Astronomy (ASTR) majors only.

**Additional Information:** Arts Sci Core Curr: Natural Science Sequence  
Arts Sci Core Curr: Natural Science Lab  
Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences  
MAPS Course: Natural Science Lab or Lab/Lec

### ASTR 1020 (4) Introductory Astronomy: Stars & Galaxies w/Recitation

Non-science majors learn the nature and workings of the Sun, stars, neutron stars, black holes, galaxies, quasars, structure and origins of the universe. Some lectures may be held at Fiske Planetarium. Offers opportunities for nighttime observations at Sommers-Bausch Observatory. Includes recitation.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 1040 or ASTR 1200

**Requisites:** Restricted to non-Astronomy (ASTR) majors only.

**Additional Information:** Arts Sci Core Curr: Natural Science Sequence  
Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

### ASTR 1030 (4) Accelerated Introductory Astronomy 1

Covers principles of modern astronomy summarizing our present knowledge about the Earth, Sun, moon, planets and origin of life. Requires nighttime observation sessions at Sommers-Bausch Observatory. Required in ASTR major/minor. Like ASTR 1000 and 1010, but taught at a higher intellectual level, including a significant amount of quantitative analysis.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 1000 or ASTR 1010

**Requisites:** Requires prerequisite or corequisite course of MATH 1300 or APPM 1350 or APPM 1340 and APPM 1345 (all minimum grade C-).

**Additional Information:** GT Pathways: GT-SC1 - Natural Physcal Sci:Lec  
Crse w/ Req Lab

Arts Sci Core Curr: Natural Science Sequence

Arts Sci Core Curr: Natural Science Lab

Arts Sci Gen Ed: Distribution-Natural Sci Lab

Arts Sci Gen Ed: Distribution-Natural Sciences

### ASTR 1040 (4) Accelerated Introductory Astronomy 2

Covers principles of modern astronomy summarizing our present knowledge about the Sun, stars, birth and death of stars, neutron stars, black holes, galaxies, quasars, and the organization and origins of the universe. May require nighttime observing sessions at Sommers-Bausch Observatory. Required in ASTR major/minor. Includes a recitation. Taught at a higher intellectual level including a significant amount of quantitative analysis.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 1020 or ASTR 1200

**Requisites:** Requires prerequisite course of ASTR 1010 or ASTR 1030 and MATH 1300 or APPM 1350 or APPM 1340 and APPM 1345 (all minimum grade C-).

**Additional Information:** GT Pathways: GT-SC2 -Natural Physicl Sci:Lec  
Crse w/o Req Lab

Arts Sci Core Curr: Natural Science Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 1200 (3) Stars and Galaxies**

Non-science majors are introduced to the nature and workings of the Sun, stars, neutron stars, black holes, interstellar gas, galaxies, quasars, plus structure and origins of the universe. Some lectures may be held at Fiske Planetarium. Offers opportunities to attend nighttime observation sessions at Sommers-Bausch Observatory.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 1020 or ASTR 1040

**Requisites:** Restricted to non- Astronomy (ASTR) majors only.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences  
MAPS Course: Natural Science

**ASTR 2000 (3) Ancient Astronomies of the World**

Documents the numerous ways in which observational astronomy and cosmology have been features of ancient cultures. Includes naked eye astronomy, archaeoastronomy, ethnoastronomy, concepts of time, calendrics, cosmogony, and cosmology.

**Additional Information:** Arts Sci Core Curr: Human Diversity

Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Diversity-Global Perspective  
Arts Sci Gen Ed: Distribution-Natural Sciences  
MAPS Course: Natural Science

**ASTR 2010 (3) Modern Cosmology-Origin and Structure of the Universe**

Introduces modern cosmology to nonscience majors. Covers the Big Bang; the age, size, and structure of the universe; and the origin of the elements and of stars, galaxies, the solar system, and life.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences  
MAPS Course: Natural Science

**ASTR 2020 (3) Space Astronomy and Exploration**

Covers physical principles of performing astronomy from space for science and exploration. The basic design of launch vehicles and spacecraft, orbital dynamics, and instruments will be described in the context of specific space missions (e.g. Hubble Telescope, Mars rovers) as well as prospects for future space observatories in orbit and on the Moon.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences  
MAPS Course: Natural Science

**ASTR 2030 (3) Black Holes**

Black holes are one of the most bizarre phenomena of nature. Students are introduced to the predicted properties of black holes, astronomical evidence for their existence and formation, and modern ideas about space, time, and gravity.

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence

Arts Sci Gen Ed: Distribution-Natural Sciences  
MAPS Course: Natural Science

**ASTR 2040 (3) The Search for Life in the Universe**

Introduces the scientific basis for the possible existence of life elsewhere in the universe. Includes origin and evolution of life on Earth and the search for evidence of life in our solar system, including Mars and Jupiter's moon Europa. Discusses the conditions necessary for life and whether they might arise on planets around other stars. Credit only for this course or ASTR 3300.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 2040

**Additional Information:** Arts Sci Core Curr: Natural Science Non-Sequence  
Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 2050 (3) The Sun and Society: Living with an Active Star**

Introduces non-science majors to the many ways out Sun influences life and society. Covers how the Sun generates energy, how it evolves over billions of years, how it affects Earth's climate and biology, how it produces dangerous "space weather", how we can harness its power and how life in other solar systems would depend on the properties of their Suns.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences  
MAPS Course: Natural Science

**ASTR 2100 (3) Fundamental Concepts in Astrophysics**

Covers topics in modern physics required for upper-level astrophysics and planetary science courses, including quantum mechanics, electromagnetic spectra, atomic and nuclear physics, and thermodynamics, in the context of astrophysics, planetary and space sciences. Also introduces key topics in mathematics to support these topics.

**Requisites:** Requires prerequisite course of PHYS 1120 or PHYS 1125 and APPM 1360 or MATH 2300 (minimum grade C-).

**Grading Basis:** Letter Grade

**ASTR 2500 (3) Gateway to Space**

Introduces the basics of atmosphere and space sciences, space exploration, spacecraft design, rocketry and orbits. Students design, build, and launch a miniature satellite on a high altitude balloon. Explores the current research in space through lectures from industry.

**Equivalent - Duplicate Degree Credit Not Granted:** ASEN 1400, ASEN 1403, ECEN 1400 and GEEN 1400

**Requisites:** Restricted to Astronomy (ASTR) majors only.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 2600 (3) Introduction to Scientific Programming**

Introduces principles, methods and tools of scientific programming commonly used in research. Topics include an introduction to programming in Python, data structures, numerical methods for calculus and data manipulation/visualization. Techniques covered are relevant to many technical fields but emphasis is placed on application to problems in astronomy and planetary science. Class time is split between lectures and in-lab tutorials.

**Equivalent - Duplicate Degree Credit Not Granted:** PHYS 2600

**Requisites:** Requires prerequisite course of MATH 1300 or APPM 1350 and PHYS 1110 or PHYS 1115 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 2840 (1-3) Independent Study**

Instructor consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**ASTR 3300 (3) Extraterrestrial Life**

Discusses the scientific basis for the possible existence of extraterrestrial life. Includes origin and evolution of life on Earth; possibility of life elsewhere in the solar system, including Mars; and the possibility of life on planets around other stars. Department enforced prerequisite: one-year sequence in a natural science. Credit only for this course or ASTR 2040.

**Equivalent - Duplicate Degree Credit Not Granted:** GEOL 3300

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3400 (3) Research Methods in Astronomy**

Introduces research methods in astronomy and engages students in an active research project. The research projects will vary and may include astronomical observations, data analysis, scientific programming, theoretical models and statistical inference. As part of their research, students will read scientific papers, attend local seminars and prepare oral and written research proposals and reports. Elective for ASTR majors.

**Requisites:** Requires prerequisite courses of ASTR 1040 and PHYS 1125 or 1120 (all minimum grade C-). Requires co-requisite or prerequisite of ASTR 2600 or PHYS 2600 (minimum grade C-). Restricted to ASTR majors.

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3510 (4) Observations and Instrumentation 1**

Lab course in astronomical observation and instrumentation. Hands-on exercises include obtaining and analyzing multi-wavelength data, basic optical design and instrumentation and statistical analysis of data, with emphasis on imaging applications. A significant number of night time observation sessions are required. Elective for APS majors. Elective for APS minors on space available basis.

**Requisites:** Requires a prerequisite or corequisite core of APPM 1360 or MATH 2300 and ASTR 1020 or ASTR 1040 and PHYS 1120 (all minimum grade C-). Restricted to Astrophysics (ASTR) majors only.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3520 (4) Observations and Instrumentation 2**

Lab course in observation and instrumentation. Hands-on exercises include obtaining and analyzing multi-wavelength data, optical design and instrumentation, and statistical analysis, with emphasis on spectroscopy. A significant number of night time observation sessions are required. Elective for APS majors. Elective for APS minors on space available basis.

**Requisites:** Requires a prerequisite course of ASTR 3510 (minimum grade C-). Restricted to Astrophysics (ASTR) majors only.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3560 (3) Astronomical Instrumentation Laboratory**

Teaches students aspects of astronomical instrument design in a hands-on setting. Students will learn elementary principles of geometrical optics, diffraction, light detection, signal conditioning, data acquisition and motion control, and mechanical design. Students will apply these principles working in groups to design and build optical spectrometers.

**Requisites:** Requires prerequisite courses of ASTR 1040 and (PHYS 2130 or PHYS 2170 or ASTR 2100) (minimum grade C-).

**Grading Basis:** Letter Grade

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sci Lab  
Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3710 (3) Formation & Dynamics of Planetary Systems**

Covers the origin of planetary systems and their dynamical evolution. Topics include the physics and chemistry of planetary formation, orbital mechanics and extrasolar planets. This course and ASTR 3720 and ASTR 3750 may be taken in any order. Elective for APS major and minor.

**Requisites:** Requires prerequisite course of PHYS 1120 and MATH 2300 or APPM 1360 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3720 (3) Planets and Their Atmospheres**

Explores the physics and chemistry of the atmospheres of Mars, Venus, Jupiter, Saturn, and Titan. Examines evolution of the atmospheres of Earth, Venus, and Mars; and the escape of gases from the Galilean satellites, Titan and Mars; the orbital characteristics of moons, planets, and comets. Uses recent results of space exploration. Elective for APS major and minor.

**Equivalent - Duplicate Degree Credit Not Granted:** ATOC 3720

**Requisites:** Requires prerequisite courses of PHYS 1120 and (APPM 1360 or MATH 2300) and prerequisite or corequisite course of ASTR 2100 or MATH 2400 or APPM 2350 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3730 (3) Astrophysics 1 - Stellar and Interstellar**

Provides a quantitative introduction to the radiative and gravitational physics relevant to stellar and galactic astrophysics, as applied to understanding observations of stars, stellar evolution, stellar remnants and the structure of the Milky Way. Elective for APS major and minor.

**Requisites:** Requires prerequisite courses of PHYS 2130 or PHYS 2170 or ASTR 2100 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3740 (3) Cosmology and Relativity**

Special and general relativity as applied to astrophysics, cosmological models, observational cosmology, experimental relativity and the early universe. Elective for APS major and minor.

**Requisites:** Requires prerequisite courses of PHYS 2130 or PHYS 2170 or ASTR 2100 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3750 (3) Planets, Moons, and Rings**

Approaches the physics of planets, emphasizing their surfaces, satellites, and rings. Topics include formation and evolution of planetary surfaces, history of the terrestrial planets, and dynamics of planetary rings. This course and ASTR 3720 may be taken for credit in any order. Elective for APS major and minor.

**Requisites:** Requires prerequisite courses of PHYS 1120 and (APPM 1360 or MATH 2300) and prerequisite or corequisite course of ASTR 2100 or MATH 2400 or APPM 2350 (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3760 (3) Solar and Space Physics**

Explores the physical processes linking the Sun and planets, emphasizing solar radiative and particulate variability and the response of planetary atmospheres and magnetospheres. Topics include the solar dynamo, solar wind, coronal mass ejections, cosmic ray modulation, magnetospheres, aurora, the space environment, and climate variability. Elective for APS major and minor.

**Requisites:** Requires prerequisite courses of PHYS 2130 or PHYS 2170 or ASTR 2100 (all minimum grade C-).

**Recommended:** Prerequisite PHYS 3310.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3800 (3) Introduction to Scientific Data Analysis and Computing**

Introduces scientific data analysis from a practical perspective. Covers statistical analysis, model fitting, error analysis, theoretical compliance and image analysis with examples from space-based and ground-based astronomy. Elective for APS major. Opened to qualified non-majors with instructor consent.

**Requisites:** Requires prerequisite course of (ASTR 2600 or PHYS 2600) and prerequisite or corequisite courses of (ASTR 1020 or ASTR 1040) and PHYS 1120 and (APPM 1360 or MATH 2300) (all minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 3830 (3) Astrophysics 2 - Galactic and Extragalactic**

The second semester of a year-long introduction to astrophysical processes. The physical processes developed in ASTR 3730 are applied to topics in extragalactic astronomy, including galaxies, supermassive black holes, galaxy clusters and cosmology. Elective for APS major and minor.

**Requisites:** Requires prerequisite course of ASTR 3730 (minimum grade C-).

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 4330 (3) Cosmochemistry**

Investigates chemical and isotopic data to understand the composition of the solar system: emphasis on the physical conditions in various objects, time scales for change, chemical and nuclear processes leading to change, observational constraints, and various models that attempt to describe the chemical state and history of cosmological objects in general and the early solar system in particular. Department enforced prerequisite: upper-division undergraduate standing in physical science and upper-division undergraduate chemistry or physics or math courses.

**Equivalent - Duplicate Degree Credit Not Granted:** ASTR 5330 and GEOL 4330 and GEOL 5330

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 4500 (1-3) Special Topics in Astrophysical and Planetary Sciences**

Topics vary each semester.

**Repeatable:** Repeatable for up to 9.00 total credit hours.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 4800 (3) Space Science: Practice and Policy**

Exposes students to current controversies in science that illustrate the scientific method and the interplay of observation, theory, and science policy. Students research and debate both sides of the issues, which include strategies and spin-offs of space exploration, funding of science, big vs. small science, and scientific heresy and fraud.

**Recommended:** Prerequisite one year of college level astronomy or physics.

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**ASTR 4840 (1-3) Independent Study**

Instructor consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**ASTR 4841 (1-3) Independent Study**

**Repeatable:** Repeatable for up to 7.00 total credit hours.