

Fall 2020 Course Descriptions as of 04/05/2020 08:10 PM

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Astronomy (ASTR)

ASTR 170A1: Planet Earth: Evolution of the Habitable World (3 units)

Description: This course develops a planetary perspective on the evolutionary processes that shaped Earth throughout history. We will examine why Earth is habitable, that is, why any kind of life can live on it, we will discuss the unique influences that biological processes and atmosphere/ocean systems have on each other, and we will review current notions of climate change, including evidence for the influence of human activities on it. This interdisciplinary treatment of Earth and its sister planets will encourage students to think about how science and engineering must be applied to today's challenges if humankind is to have a promising future on (and off) this planet.

Grading basis: Regular Grades

Career: Undergraduate

Course Components:	Discussion	May Be Offered
	Lecture	Required

Equivalent to: GEOS 170A1

Also offered as: PTYS 170A1

Course typically offered:

Main Campus: Fall, Spring

Home department: Planetary Sciences

Enrollment requirement: Enrollment not allowed if you have previously taken NATS 101 "A Geological Perspective" (Topic 1) or "Planet Earth: Evolution of the Habitable World " (Topic 9) or GEOS 170A1 or GEOG 150S1 or PTYS/ASTR 170S1.

General Education: NATS 101

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 170B1: The Physical Universe (3 units)

Description: This course presents an introduction to the science of Astronomy placed in the broader context of the physical sciences. Our survey of the Universe will include our current understanding of our Solar System, stars, the Milky Way Galaxy, other galaxies, and the large-scale structure and evolution of the Universe. We will also cover the basic principles of physics, chemistry, and geology needed to interpret astronomical observations. The application of the scientific method will be emphasized throughout the course.

Grading basis: Regular Grades

Career: Undergraduate

Course Components:	Discussion	May Be Offered
	Lecture	Required

Equivalent to: ASTR 170B2, PTYS 170B2

Course typically offered:

Main Campus: Fall, Spring

Online Campus: Fall

Enrollment requirement: Enrollment not allowed if you have previously taken PTYS/ASTR 170B2 or NATS 102 "The Physical Universe" (Topic 4) or NATS 102 "The Universe and Humanity: Origin and Destiny" (Topic 6).

General Education: NATS 102

ASTR 170B2: The Universe and Humanity: Origin and Destiny (3 units)

Description: This course explores the deep relationships that connect the largest structures in the universe to the world of atoms and subatomic particles. Topics covered begin with the scientific method and tools of science, proceed to fundamental physical concepts and processes that govern the natural world, and move on to a study of features of the natural world based upon fundamental laws of nature. This knowledge is used to create a broad perspective for understanding the origin and evolution of our Milky Way Galaxy, our Solar System, and their common cosmic heritage.

Grading basis: Regular Grades

Career: Undergraduate

Course Components:	Discussion	May Be Offered
	Lecture	Required

Equivalent to: ASTR 170B1

Also offered as: PTYS 170B2

Course typically offered:

Main Campus: Fall, Spring

Home department: Planetary Sciences

Enrollment requirement: Enrollment not allowed if you have previously taken ASTR 170B1 or NATS 102 "The Physical Universe" (Topic 4) or NATS 102 "The Universe and Humanity: Origin and Destiny" (Topic 6).

General Education: NATS 102

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 170S1: Evolution of a Sustainable World (3 units)

Description: This new hybrid course combines "Environment and Society" (GEOG 150C1) with "Evolution of a Habitable World" (PTYS/ASTR 170A1). We survey the natural sciences behind conditions that can support life on planets like Earth as well as the social science perspectives regarding how humans choose to interact with and influence the environment. This course also explores pathways to a sustainable future on Earth, including lessons for life and our possible relocation to other planets. Students can enroll through either PTYS/ASTR 170A1 (for Tier-1 NATS GenEd credit) or GEOG 150C1 (for Tier-1 INDV GenEd credit).

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Also offered as: PTYS 170S1

Co-convened with: GEOG 150S1

Course typically offered:

Main Campus: Fall, Spring

Recommendations and additional information: Students who complete this course not eligible for GEOG150C1 nor PTYS/ASTR170A1.

Home department: Planetary Sciences

Enrollment requirement: Must not have taken GEOG 150C1 or PTYS/ASTR 170A1.

Honors Course: Honors Contract

Honors Course: Honors Contract

ASTR 191: Preceptorship (1 - 5 units)

Description: Preceptors assist as part of a teaching team with the professor and graduate teaching assistant.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 5 units.

Course typically offered:

Main Campus: Fall, Spring

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 196: A Seminar in Astronomical Problem Solving (1 unit)

Description: ASTR 196 is a weekly seminar in problem-solving and critical thinking available to freshmen planning to major in astronomy. It is designed to introduce these students to astronomy and the types of thought processes they will need to succeed in future courses. Based on topics involving astronomical and natural phenomena, this course emphasizes basic reasoning and numerical skills, using pre-calculus mathematics. Students will learn techniques for analyzing questions, formulating logical solutions, physical intuition, the scientific method, and the use of numerical techniques, both mental and electronic.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Seminar Required

Course typically offered:

Main Campus: Fall

Field trip: Field trips may be offered to provide context, and different venue, for authentic problem-solving. Examples include the Mirror Laboratory, Flandrau planetarium, University Library collections.

ASTR 199: Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

ASTR 201: Cosmology (3 units)

Description: Extragalactic astronomy and cosmology are among the fastest developing fields in astronomy. This course presents cosmology as a modern, quantitative science. It describes what we know about galaxies, the large scale structure of the universe and the beginnings and evolution of the Universe. We know quite a bit, assume a lot and have a great deal to learn. The course critically examines our picture of the universe using lectures, a hands-on project, and discussion groups.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall, Spring

Online Campus: Fall

Recommendations and additional information: Two courses from Tier One, Natural Sciences (Catalog numbers 170A, 170B, 170C).

General Education: Tier 2 Natural Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 202: Life in the Universe (3 units)

Description: The main goal for students in this course is to have fun learning about the possibilities for life in the Universe and, in the process, gain an appreciation for the methods used in science. To achieve this goal, we will study such seemingly diverse topics as the origin of the Universe, heavy element production, the formation of stars and planets, the nature of planets and their atmospheres, basic chemistry, geological and atmospheric evolution, biological evolution, cultural and technological evolution, interstellar travel, and communication techniques.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: ASTR 214, ASTR 214, GEOS 214, GEOS 214, PTYS 214

Course typically offered:

Main Campus: Fall, Spring

Recommendations and additional information: Two courses from Tier One, Natural Sciences (Catalog numbers 170A, 170B, 170C).

Enrollment requirement: Enrollment not allowed if you have previously taken PTYS/ASTR 214.

General Education: Tier 2 Natural Sciences

ASTR 203: Stars (3 units)

Description: This course, intended for non-science majors, provides an in-depth and comprehensive study of the stars. Topics to be covered may include: the naming of stars and constellations, the classification and properties of stars, star formation and evolution, nuclear fusion, black holes, Einstein's theories of relativity, and the demographics of the stars in our Galaxy. The basic principles of physics which are needed to understand the stars (e.g. gravity, light, structure of the atom) will also be reviewed.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall, Spring

Recommendations and additional information: Two courses from Tier One, Natural Sciences (Catalog numbers 170A, 170B, 170C).

General Education: Tier 2 Natural Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 204: Great Debates in Astronomy (3 units)

Description: This course examines questions such as: How old is the Universe? Where did the Moon come from? Should astronauts or robots explore space? Students will study the methods and personalities behind key discoveries, participate in classroom debates, and argue their positions in detailed essays.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall

General Education: Tier 2 Natural Sciences

ASTR 206: Exploring Our Solar System (3 units)

Description: Our Solar System is filled with an incredible diversity of objects. These include the sun and planets, of course, but also many hundreds of moons -- some with exotic oceans, erupting volcanoes, or dynamic atmospheres. Billions of asteroids and comets inhabit the space between and beyond the planets. Each body is unique, and has followed its own evolutionary history. This class will explore our current understanding of the Solar System and emphasize similarities that unite the different bodies as well as the differences between them. We will develop an understanding of physical processes that occur on these bodies, including tectonics, impact cratering, volcanism, and processes operating in their interiors, oceans, and atmospheres. We will also discuss planets around nearby stars and the potential for life beyond Earth. Throughout the class, we will highlight the leading role that the University of Arizona has played in exploring our Solar System.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: ASTR 206

Also offered as: PTYS 206

Course typically offered:

Main Campus: Fall, Spring

Recommendations and additional information: two courses from Tier One, Natural Sciences (NATS 101, 102, 104).

Home department: Planetary Sciences

General Education: Tier 2 Natural Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 208: Energy, Society, and the Environment (3 units)

Description: This course will cover the methods, tools and perspectives to understand energy generation and use, focusing on traditional and alternative energy sources. The goal is to develop scientific and critical thinking in issues related to the technical and economic aspects, as well as policy decisions.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Spring

Field trip: Two

General Education: Tier 2 Natural Sciences

ASTR 214: Astrobiology: A Planetary Perspective (3 units)

Description: We will explore questions about the origin, evolution, and future of life on Earth and the possibility of life arising independently elsewhere in the Universe. We will examine what it means for a planet to be habitable, both in terms of basic necessities for living organisms to function and environmental limits to their ability to survive. Finally, we will review different approaches for searching for life within the Solar System and beyond using direct and remote sensing techniques.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: ASTR 202, ASTR 214, GEOS 214

Also offered as: GEOS 214, PTYS 214

Course typically offered:

Main Campus: Fall, Spring

Home department: Planetary Sciences

Enrollment requirement: Enrollment not allowed if you have previously taken ASTR 202.

General Education: Tier 2 Natural Sciences

Honors Course: Honors Contract

Honors Course: Honors Contract

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 250: Fundamentals of Astronomy (3 units)

Description: A calculus-based introductory course in astronomy and astrophysics, aimed mainly at sophomore astronomy majors and science majors from other departments. The class covers most aspects of astronomy, including stars, galaxies, cosmology and the solar system, but with a more mathematical treatment than in the 100-level Natural Science classes.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall, Spring

Enrollment requirement: (MATH 122B or 125) and (PHYS 141 or 161H) and MATH 129.

ASTR 296A: Topics in Astronomical Research (1 unit)

Description: The development and exchange of scholarly information, usually in a small group setting. The scope of work shall consist of research by course registrants, with the exchange of the results of such research through discussion, reports, and/or papers.

Grading basis: Student Option ABCDE/PF

Career: Undergraduate

Course Components: Seminar Required

Course typically offered:

Main Campus: Spring (odd years only)

Special Exam: Special Exam Grade & Credit

ASTR 299: Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 299H: Honors Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

Enrollment requirement: Student must be active in the Honors College.

Honors Course: Honors Course

Honors Course: Honors Course

ASTR 300A: Astronomy and Astrophysics (3 units)

Description: Dynamics in Astrophysics.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall

Enrollment requirement: ASTR 250, MATH 254 or 355, PHYS 241 or 261H, and PHYS 263H.

Concurrent Enrollment: PHYS 321.

ASTR 300B: Astronomy and Astrophysics (3 units)

Description: Radiative Processes in Astrophysics.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Spring

Recommendations and additional information: Student must consult instructor prior to enrolling.

Enrollment requirement: Co-requisites: PHYS 331 and PHYS 371. Prerequisites: ASTR 300A.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 302: Introduction to Observational Astronomy (3 units)

Description: Optical and radio detectors; observing preparation, data acquisition and reduction, data analysis. Observing at optical and radio wavelengths. Astrophysical applications of radio data and optical imaging. Computer software and computer-code writing to reduce astronomical data and to solve astronomical problems. Out-of-class telescope sessions are required.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$25

Course Components:	Laboratory	May Be Offered
	Lecture	Required

Course typically offered:

Main Campus: Spring

Enrollment requirement: ASTR 250, (CSC 110 or ECE 175 or PHYS 105A or 305), (PHYS 142 or 162H), and (MATH 122B or 125).

ASTR 320: Philosophy and History of Astronomical Thought (3 units)

Description: Historical development of astronomical concepts and the scientific method; cosmological concepts from ancient times to the present; controversies in astronomy in the recent past and at present.

Grading basis: Regular Grades

Career: Undergraduate

Course Components:	Lecture	Required
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Course typically offered:

Main Campus: Fall, Spring

ASTR 325: Science and Science Fiction (3 units)

Description: As science and technology advance at an accelerating rate, the role they play in our lives becomes more central. The science fiction genre allows us to project future scenarios of scientific and technological development, and explore the way in which society might deal with these advances. This course will use a variety of science fiction texts to study the projected scenario, the change brought about by science and technology, and explore possible strategies we have for dealing with changes caused by science. We will explore the difficulties of trying to imagine the future, and study notable failures of the past in predicting future developments in science.

Grading basis: Regular Grades

Career: Undergraduate

Course Components:	Lecture	Required
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Course typically offered:

Main Campus: Fall, Spring

Recommendations and additional information: Completion of English composition requirement. Completion of Tier One Gen Ed Science requirement. ASTR 170B1 recommended.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 333: Astronomy and the Arts (3 units)

Description: Course examines astronomical ideas in works of literature, art, and music. It then contextualizes each work as a bridge between the history of astronomy and the history of the arts. A diverse assortment of cultural works from different periods will be examined, both for their astronomy and for their art. These include novels, philosophical tales, poetry, painting, music and operas. Classroom sessions will be a combination of lecture and discussion. There will be mid-term, a final exam, several short papers and a research project.

Grading basis: Student Option ABCDE/PF

Career: Undergraduate

Course Components:	Lecture	Required
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Repeatable: Course can be repeated a maximum of 2 times.

Course typically offered:

Main Campus: Fall, Spring

Honors Course: Honors Contract

Honors Course: Honors Contract

ASTR 337: Connecting with the Sky (3 units)

Description: Observation and measurement are essential parts of scientific exploration. Tucson's world-renown sky conditions allow the exploration of natural phenomena, both astronomical and atmospheric. Students will be engaged in hands-on construction, measurement, error analysis, interpretation, and presentation as a means of appreciating and understanding the sky, day and night. Starting with the construction of simple tools, each student will build a new measuring device and use it on a continuing basis to document, interpret, and react to natural phenomena. Instructional language emphasizes quantitative thinking, resourcefulness, creativity, the scientific method, and communication skills. Sessions on Monday and Wednesday allow time for outdoor nighttime observing, including sunsets. Friday's session allows daytime observing.

Grading basis: Regular Grades

Career: Undergraduate

Flat Fee: \$53

Course Components:	Laboratory	Required
	Lecture	Required

Course typically offered:

Main Campus: Spring (odd years only)

Recommendations and additional information: Liberal Arts Minor in astronomy. Instructor's approval required in advance. Successful completion of ASTR 170B1 and, ideally, also a Tier II ASTR course.

Field trip: Field trips to sites around Tucson will be encouraged, and supported, to record effects of light pollution, parallax, etc. and to experience the authentic nature of astronomical research.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 392: Directed Research (1 - 6 units)

Description: Individual or small group research under the guidance of faculty. This course will allow students to complete 3 units of independent research and receive a letter grade to be calculated in the GPA.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 12 units.

Course typically offered:

Main Campus: Fall, Spring, Summer

ASTR 399: Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

ASTR 399H: Honors Independent Study (1 - 3 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

Enrollment requirement: Student must be active in the Honors College.

Honors Course: Honors Course

Honors Course: Honors Course

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 400A: Theoretical Astrophysics (3 units)

Description: The theory of stellar structure and evolution, star formation, and planet formation.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall

Recommendations and additional information: MATH 254, 12 units of upper-division physics.

Enrollment requirement: Prerequisites: MATH 254 or 355 and 9 units of upper division PHYS.

Writing Emphasis: Writing Emphasis Course

ASTR 400B: Theoretical Astrophysics (3 units)

Description: The structure and evolution of galaxies in a cosmological framework.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Spring

Recommendations and additional information: MATH 254, 12 units upper-division physics.

Enrollment requirement: Prerequisites: MATH 254 or 355 and 9 units of upper division PHYS.

ASTR 403: Physics of the Solar System (3 units)

Description: Survey of planetary physics, planetary motions, planetary interiors, geophysics, planetary atmospheres, asteroids, comets, origin of the solar system.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: ASTR 403, GEOS 403

Also offered as: GEOS 403, PHYS 403, PTYS 403

Course typically offered:

Main Campus: Spring (odd years only)

Home department: Planetary Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 416: Modern Astronomical Optics (3 units)

Description: This course provides an overview of astronomical optical systems and techniques for the observation of exoplanets. It introduces astronomical and optical concepts related to exoplanets observations. By focusing on a particularly challenging observational problem of modern astronomy, the course will teach design and analysis of ultra high precision optical systems and measurement techniques, including spectroscopy, photometry, optical metrology and interferometry.

Grading basis: Regular Grades

Career: Undergraduate

Course Components:	Lecture	Required
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Also offered as: OPTI 416

Co-convened with: ASTR 516

Course typically offered:

Main Campus: Spring

Home department: College of Optical Sciences

Enrollment requirement: Major: OSE. Adv Stdg: Engineering.

ASTR 418: Instrumentation and Statistic (3 units)

Description: Radiant energy; signals and noise; detectors and techniques for imaging, photometry, polarimetry and spectroscopy. Examples from stellar and planetary astronomy in the x-ray, optical, infrared and radio.

Grading basis: Student Option ABCDE/PF

Career: Undergraduate

Course Components:	Lecture	Required
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Equivalent to: PTYS 418

Co-convened with: ASTR 518

Course typically offered:

Main Campus: Fall (even years only)

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 428: Adaptive Optics and Imaging through Random Media (3 units)

Description: This course provides an overview of adaptive optics fundamentals. The course consists of lectures and team projects. For each of the three team projects during the semester, astronomy and optics students will work together to design an instrument, using material presented during the lectures. Each team projects will result in an oral presentation.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Also offered as: OPTI 428

Co-convened with: ASTR 528

Course typically offered:

Main Campus: Fall

Home department: College of Optical Sciences

Student Engagement Activity: Discovery

Student Engagement Competency: Innovation and Creativity

ASTR 442: Mars (3 units)

Description: In-depth class about the planet Mars, including origin and evolution, geophysics, geology, atmospheric science, climate change, the search for life, and the history and future of Mars exploration. There will be guest lectures from professors and research scientists with expertise about aspects of Mars. The course may include visits to Mars exploration centers at the University of Arizona and Arizona State University. There will be lots of discussion of recent results and scientific controversies about Mars. All students are expected to have a knowledge of basic calculus.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Equivalent to: ASTR 442, GEOS 442

Also offered as: GEOS 442, PTYS 442

Course typically offered:

Main Campus: Spring (odd years only)

Recommendations and additional information: PTYS 411 is strongly recommended but not required.

Home department: Planetary Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 450: Origin of the Solar System and Other Planetary Systems (3 units)

Description: This course will review the physical processes related to the formation and evolution of the protosolar nebula and of protoplanetary disks. In doing that, we will discuss the main stages of planet formation and how different disk conditions impact planetary architectures and planet properties. We will confront the theories of disk evolution and planet formation with observations of circumstellar disks, exoplanets, and the planets and minor bodies in our Solar System.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Also offered as: PTYS 450

Co-convened with: ASTR 550

Course typically offered:

Main Campus: Fall

Recommendations and additional information: Undergraduate students who have successfully completed two upper division science classes are eligible to take this class.

Home department: Planetary Sciences

ASTR 460: Seminar with a Focus on Stellar Evolution from an Observational Perspective (2 units)

Description: The current graduate astronomy curriculum includes a course called Astrophysics of Stars and Accretion (ASTR545), but this course has a focus mainly on the standard theory of stellar interiors and the physics of accretion disks. The undergraduate curriculum includes a basic introduction to astrophysics. This seminar is designed to be complementary to these core courses, and will connect the equations of stellar structure and evolution to the observed properties of a wide variety of stars, including spectral types, luminosity and temperature evolution on the Hertzsprung-Russell diagram, uncertainties in stellar evolution models, the inferred influence of composition, mass loss, binary star evolution, different types of stellar death, dependence on environment, and influence on the galactic environment (feedback). We will also explore some key observational diagnostics of stellar properties. The course will examine both the historical origin of several key ideas in the field, as well as current frontier topics in the literature. The course will benefit students who intend to specialize in research on stars, but will cover key topics relevant to interpreting observations of galaxies and the role of stars in galaxy evolution and cosmic evolution.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with:

Course typically offered:

Main Campus: Spring (even years only)

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 475: Planetary Astrobiology (3 units)

Description: The course will explore the processes related to planet formation and the emergence of life. We will study the formation of our Solar System and exoplanetary systems, the conditions that gave rise to life on the Earth, and the potential habitability of other planets/moons in our system or extrasolar systems.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Spring (odd years only)

Recommendations and additional information: At least 6 credits in upper division science courses.

ASTR 485: Radio Astronomy (3 units)

Description: While the origin of optical astronomy is lost in the mists of time, we know exactly when radio astronomy was born, January 1932. This was when Karl Jansky began his first experiments at Bell Telephone Laboratory in Holmdel, NJ. Since then radio astronomy has grown from a serendipitous science to a cornerstone of modern astronomy. In radio astronomy we use photons with characteristic dimensions from 100's of meters to 100's of microns, to probe a huge variety of objects and phenomenon, everything from comets and the origin of the solar system to the origin and structure of the Universe. In this course, you will be introduced to the fundamentals of radio astronomy. Topics will include instrumentation and techniques, emission and absorption mechanisms, present and future telescopes, as well as data analysis techniques. Course material will be introduced through a mixture of classroom discussion, hands-on laboratory experiments, and observational projects.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with: ASTR 585

Course typically offered:

Main Campus: Spring (even years only)

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 488A: Astrochemistry (3 units)

Description: This astrochemistry course is the study of gas phase and solid state chemical processes that occur in the universe, including those leading to pre-biotic compounds. Topics include chemical processes in dying stars, circumstellar gas, planetary nebulae, diffuse clouds, star-forming regions and proto-planetary discs, as well as planets, satellites, comets and asteroids. Observational methods and theoretical concepts will be discussed.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Lecture Required

Co-convened with: ASTR 588A

Course typically offered:

Main Campus: Fall (odd years only)

Recommendations and additional information: Consent of instructor.

ASTR 492: Directed Research (1 - 6 units)

Description: Individual or small group research under the guidance of faculty. This course will allow students to complete 3 units of independent research and receive a letter grade to be calculated in the GPA.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 12 units.

Course typically offered:

Main Campus: Fall, Spring, Summer

Student Engagement Activity: Discovery

Student Engagement Competency: Innovation and Creativity

ASTR 498: Senior Capstone (1 - 3 units)

Description: A culminating experience for majors involving a substantive project that demonstrates a synthesis of learning accumulated in the major, including broadly comprehensive knowledge of the discipline and its methodologies. Senior standing required.

Grading basis: Student Option ABCDE/PF

Career: Undergraduate

Course Components: Independent Study Required

Course typically offered:

Main Campus: Fall, Spring

Student Engagement Activity: Discovery

Student Engagement Competency: Innovation and Creativity

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 498H: Honors Thesis (3 units)

Description: An honors thesis is required of all the students graduating with honors. Students ordinarily sign up for this course as a two-semester sequence. The first semester the student performs research under the supervision of a faculty member; the second semester the student writes an honors thesis.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated for a maximum of 9 units.

Course typically offered:

Main Campus: Fall, Spring

Enrollment requirement: Student must be active in the Honors College.

Honors Course: Honors Course

Honors Course: Honors Course

Student Engagement Activity: Discovery

Student Engagement Competency: Innovation and Creativity

Writing Emphasis: Writing Emphasis Course

ASTR 499: Independent Study (1 - 5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Alternative Grading: S, P, F

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

Student Engagement Activity: Discovery

Student Engagement Competency: Innovation and Creativity

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 499H: Honors Independent Study (1 - 5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work.

Grading basis: Regular Grades

Career: Undergraduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

Enrollment requirement: Student must be active in the Honors College.

Honors Course: Honors Course

Honors Course: Honors Course

Student Engagement Activity: Discovery

Student Engagement Competency: Innovation and Creativity

ASTR 502: Data Mining and Machine Learning in Astronomy (2 units)

Description: This is a graduate level elective course aiming at providing the interface between astronomical data analysis problems and modern statistics methods. Modern astronomy and astrophysics is undergoing a revolution with dramatic increases in both the volume and complexity of astronomical data. The last decade saw the emergence of many terabyte-level sky surveys across the electromagnetic spectrum; the next decade, data volumes will enter the petabyte regime, with an ever strong time domain component. These new data sets represent quantum leaps in our abilities for new astronomical discoveries, but also present significant challenges to standard analysis tools normally employed in astronomy. The goal of this course is to bridge the gap between modern large data surveys and the data analysis tools that have been provided in normal graduate courses. The course will start with a brief review of the modern statistics framework relevant to large scale data analysis, including probabilities and statistical distribution, classical and Bayesian statistical inferences. Then it will cover the main topics of the course: data mining and machine learning, including density estimation, clustering analysis, dimensionality reduction, regression and model fitting, classification and time series analysis. Another key component of the course is to introduce commonly used data mining and machine learning tools, in the context of Python-based packages, which will be used in solving data problems throughout the course.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 503: Physics of the Solar System (3 units)

Description: Survey of planetary physics, planetary motions, planetary interiors, geophysics, planetary atmospheres, asteroids, comets, origin of the solar system. Graduate-level requirements include an in-depth research paper on a selected topic and an oral class presentation.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: ASTR 503, GEOS 503

Also offered as: GEOS 503, PHYS 503, PTYS 503

Course typically offered:

Main Campus: Spring (odd years only)

Home department: Planetary Sciences

ASTR 513: Statistical and Computational Methods in Astrophysics (3 units)

Description: This course introduces basic computational methods for solving problems numerically in astrophysics and the foundations of modern statistical methods that are used in current research problems, with emphasis on big-data science. The topics will include basic scientific algorithms to solve integrals and simple differential equations frequently encountered in astrophysics, frequentist and Bayesian inference methods, non-linear regressions methods, modeling of data, Monte Carlo techniques, error estimation, and model selection.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Spring

Field trip: None

ASTR 515: The Interstellar Medium and Star Formation (4 units)

Description: Radiative processes and the derivation of physical conditions in the interstellar medium. Topics include: Ionized, atomic, and molecular clouds. The formation of stars. Astrochemistry and the physics of interstellar dust. Spectral line diagnostics. Non-LTE excitation, ionization equilibrium, heating and cooling, and shocks.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall (odd years only)

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 516: Modern Astronomical Optics (3 units)

Description: This course provides an overview of astronomical optical systems and techniques for the observation of exoplanets. It introduces astronomical and optical concepts related to exoplanets observations. By focusing on a particularly challenging observational problem of modern astronomy, the course will teach design and analysis of ultra high precision optical systems and measurement techniques, including spectroscopy, photometry, optical metrology and interferometry. Graduate-level requirements include a 45 minute final oral examination.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Also offered as: OPTI 516

Co-convened with: ASTR 416

Course typically offered:

Main Campus: Spring

Home department: College of Optical Sciences

ASTR 518: Instrumentation and Statistic (3 units)

Description: Radiant energy; signals and noise; detectors and techniques for imaging, photometry, polarimetry and spectroscopy. Examples from stellar and planetary astronomy in the x-ray, optical, infrared and radio. Graduate-level requirements include an in-depth research paper.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: ATMO 518, PTYS 518

Also offered as: PTYS 518

Co-convened with: ASTR 418

Course typically offered:

Main Campus: Fall (even years only)

ASTR 520: Advanced Extragalactic Astronomy (2 units)

Description: This advanced graduate elective course will cover topics in observational and theoretical extragalactic astronomy, focusing on areas of current research interest. Topics will be selected from broad areas including cosmology, galaxy formation and evolution, reionization, the intergalactic medium, and the early universe.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Spring (odd years only)

Recommendations and additional information: ASTR 540 and ASTR 541.

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 528: Adaptive Optics and Imaging through Random Media (3 units)

Description: This course provides an overview of adaptive optics fundamentals. The course consists of lectures and team projects. For each of the three team projects during the semester, astronomy and optics students will work together to design an instrument, using material presented during the lectures. Each team projects will result in an oral presentation. Graduate students will be asked to solve problems using course material during the oral final exam.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Also offered as: OPTI 528

Co-convened with: ASTR 428

Course typically offered:

Main Campus: Fall

Home department: College of Optical Sciences

ASTR 537: The Physics of the Sun (3 units)

Description: The purpose of this course is to present an introduction to the physics of the Sun. The course begins with a discussion of the standard solar model, the solar-neutrino problem, and observational techniques. Long-term variability in the total irradiance, sunspot number, and diameter, and its effect on Earth's climate will be addressed in some detail. Other topics include the physics of the solar interior, solar oscillations, and solar composition. This course will also introduce the equations of magnetohydrodynamics and apply them to important solar-physics problems, such as: the solar magnetic dynamo, stability of prominences, physics of sunspots and flares, and heating of the solar atmosphere. The emphasis throughout will be on basic physical processes and the various approximations used in their application to concrete problems.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Equivalent to: ASTR 537, ATMO 537, PHYS 537

Also offered as: ATMO 537, PHYS 537, PTYS 537

Home department: Planetary Sciences

ASTR 540: Structure and Dynamics of Galaxies (2 units)

Description: Observational properties of galaxies; structure, kinematics, star and gas content. Structure of our own galaxy. Dynamics of stellar systems: equilibria, instabilities, internally and externally driven evolution.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Course typically offered:

Main Campus: Fall (even years only)

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 541: Extragalactic Astronomy and Cosmology (3 units)

Description: The structure, origin and evolution of the physical universe from theory and observations of systems outside our own galaxy. Relativistic cosmology; galaxy evolution and clustering; active galaxies and quasars; the microwave background; galaxy formation; the hot big bang; and physics of the early universe.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Discussion	May Be Offered
	Lecture	Required

Course typically offered:

Main Campus: Fall (even years only)

Recommendations and additional information: ASTR 540.

ASTR 542: Mars (3 units)

Description: In-depth class about the planet Mars, including origin and evolution, geophysics, geology, atmospheric science, climate change, the search for life, and the history and future of Mars exploration. There will be guest lectures from professors and research scientists with expertise about aspects of Mars. The course may include visits to Mars exploration centers at the University of Arizona and Arizona State University. There will be lots of discussion of recent results and scientific controversies about Mars. All students are expected to have a knowledge of basic calculus. Graduate-level requirements include the completion of a research project that will be presented in class as well as a report. The research project could be analysis of Mars datasets, a laboratory experiment, or new theoretical modeling.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Equivalent to: ASTR 542, GEOS 542

Also offered as: GEOS 542, PTYS 542

Co-convened with:

Course typically offered:

Main Campus: Spring (odd years only)

Recommendations and additional information: PTYS 511, Geology of the Solar System is strongly recommended but not required.

Home department: Planetary Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 545: Stars and Planets (4 units)

Description: This course will explore the physical principles that govern the structure and evolution of stars and planets. Topics covered will include hydrostatic equilibrium, energy generation and transport, dimensional analysis, equations of state, and fluid dynamics. Applying physical models and computational methods, fundamental properties of stars and planets will be derived, and compared with observational constraints.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Also offered as: PTYS 545

Course typically offered:

Main Campus: Fall (odd years only)

ASTR 550: Origin of the Solar System and Other Planetary Systems (3 units)

Description: This course will review the physical processes related to the formation and evolution of the protosolar nebula and of protoplanetary disks. In doing that, we will discuss the main stages of planet formation and how different disk conditions impact planetary architectures and planet properties. We will confront the theories of disk evolution and planet formation with observations of circumstellar disks, exoplanets, and the planets and minor bodies in our Solar System. Graduate-level requirements include advanced quantitative problems in homeworks and tests.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Also offered as: PTYS 550

Co-convened with: ASTR 450

Course typically offered:

Main Campus: Fall

Recommendations and additional information: All students enrolled in the astronomy, physics, planetary science, and optical science Ph.D. programs may enroll.

Home department: Planetary Sciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

Description: Dynamical processes affecting the orbital evolution of planets, asteroids, and satellites, and the rotational evolution of solid bodies. Emphasizes modern nonlinear dynamics and chaos.

Career: Graduate

Also offered as: PTYS 553

Course typically offered:

Main Campus: Spring (even years only)

Recommendations and additional information: MATH 254, PHYS 422 or consult department before enrolling.

Home department: Planetary Sciences

Description: The goal of this course is to present an introduction to fundamental plasma physics and magnetohydrodynamics, beginning with kinetic theory. The various important limits including the vlasov equation and magnetohydrodynamics will be derived. Applications will be mostly from astrophysics and the solar system. These will include the main dynamical processes in the solar atmosphere, interplanetary medium, magnetospheres, interstellar medium, blast waves, accretion disks, etc. The emphasis throughout will be on basic physical processes and the various approximations used in their application to concrete problems.

Career: Graduate

Equivalent to: ASTR 558, PHYS 558

Also offered as: PHYS 558, PTYS 558

Course typically offered:

Main Campus: Spring

Home department: Planetary Sciences

-**CC** represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 560: Seminar with a Focus on Stellar Evolution from an Observational Perspective
(2 units)

Description: The current graduate astronomy curriculum includes a course called Astrophysics of Stars and Accretion (ASTR 545), but this course has a focus mainly on the standard theory of stellar interiors and the physics of accretion disks. The undergraduate curriculum includes a basic introduction to astrophysics. This seminar is designed to be complementary to these core courses, and will connect the equations of stellar structure and evolution to the observed properties of a wide variety of stars, including spectral types, luminosity and temperature evolution on the Hertzsprung-Russell diagram, uncertainties in stellar evolution models, the inferred influence of composition, mass loss, binary star evolution, different types of stellar death, dependence on environment, and influence on the galactic environment (feedback). We will also explore some key observational diagnostics of stellar properties. The course will examine both the historical origin of several key ideas in the field, as well as current frontier topics in the literature. The course will benefit students who intend to specialize in research on stars, but will cover key topics relevant to interpreting observations of galaxies and the role of stars in galaxy evolution and cosmic evolution. Graduate-level requirements include in depth presentations in class, including reviews of important papers from the literature and presentation of associated material. Final exam will involve more advanced questions.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Co-convened with:

Course typically offered:

Main Campus: Spring (even years only)

ASTR 575: Planetary Astrobiology (3 units)

Description: The course will explore the processes related to planet formation and the emergence of life. We will study the formation of our Solar System and exoplanetary systems, the conditions that gave rise to life on the Earth, and the potential habitability of other planets/moons in our system or extrasolar systems. Graduate-level requirements include advanced homework assignments and written examination.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Also offered as: PTYS 575

Co-convened with: ASTR 475

Course typically offered:

Main Campus: Spring (odd years only)

Interdisciplinary Interest Area: GEOS - Geosciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 578: Writing Across the Space Sciences (3 units)

Description: The purpose of this class is to strengthen the writing skills of the student along the entire range of writing, from technical scientific writing in the space sciences to popular articles about science. It has the secondary purpose of preparing the student for the wide variety of occasions when communication skills, written and verbal, will be required in the professional practice of the space sciences.

Grading basis: Regular Grades

Career: Graduate

Course Components: Discussion May Be Offered
 Lecture Required

Also offered as: PTYS 578

Recommendations and additional information: Graduate standing.

ASTR 582: High-Energy Astrophysics (2 units)

Description: A study of pulsars, black holes, accretion disks, X-ray binaries, gamma-ray sources, radio galaxies, active galactic nuclei, and the acceleration of charged particles near these objects, together with the radiation mechanisms they employ to produce the high-energy emission we detect at Earth.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Repeatable: Course can be repeated a maximum of 2 times.

Also offered as: PTYS 582

Course typically offered:

Main Campus: Spring (even years only)

Interdisciplinary Interest Area: PHYS - Physics

ASTR 584: The Coevolution of Earth and the Biosphere (3 units)

Description: This course examines the interplay of changes in earth environments and biological evolution from the earliest life to the present. The focus is geochemical and topics include the early earth and life, evolutionary jumps, mass extinctions, and the rise of hominids. Graduate level requirements include multiple in-class presentations/reviews on journal articles.

Grading basis: Regular Grades

Career: Graduate

Flat Fee: \$31

Course Components: Lecture Required

Also offered as: GEOS 584, PTYS 584

Recommendations and additional information: Calculus II (MATH 129) or consent of the instructor.

Field trip: 2-3 field trips to geologic localities near Tucson, Arizona.

Home department: Geosciences

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 585: Radio Astronomy (3 units)

Description: While the origin of optical astronomy is lost in the mists of time, we know exactly when radio astronomy was born, January 1932. This was when Karl Jansky began his first experiments at Bell Telephone Laboratory in Holmdel, NJ. Since then radio astronomy has grown from a serendipitous science to a cornerstone of modern astronomy. In radio astronomy we use photons with characteristic dimensions from 100's of meters to 100's of microns, to probe a huge variety of objects and phenomenon, everything from comets and the origin of the solar system to the origin and structure of the Universe. In this course, you will be introduced to the fundamentals of radio astronomy. Topics will include instrumentation and techniques, emission and absorption mechanisms, present and future telescopes, as well as data analysis techniques. Course material will be introduced through a mixture of classroom discussion, hands-on laboratory experiments, and observational projects. Graduate students requirements include more extensive homework, laboratory, and observing assignments than the undergraduate participants.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Co-convened with: ASTR 485

Course typically offered:

Main Campus: Spring (even years only)

ASTR 588A: Astrochemistry (3 units)

Description: This astrochemistry course is the study of gas phase and solid state chemical processes that occur in the universe, including those leading to pre-biotic compounds. Topics include chemical processes in dying stars, circumstellar gas, planetary nebulae, diffuse clouds, star-forming regions and proto-planetary discs, as well as planets, satellites, comets and asteroids. Observational methods and theoretical concepts will be discussed. Graduate-level requirements include a project and an oral exam.

Grading basis: Regular Grades

Career: Graduate

Course Components: Lecture Required

Also offered as: PTYS 588A

Co-convened with: ASTR 488A

Course typically offered:

Main Campus: Fall (odd years only)

Recommendations and additional information: Consent of instructor.

Interdisciplinary Interest Area: CHEM - Chemistry

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 589: Physics of Astrophysics (3 units)

Description: This is a foundational course in Theoretical Astrophysics that will provide an introduction to the basic elements of astrophysics. The topics will include radiative transfer, radiative processes, fluid mechanics, gas physics, and dynamics. The course will serve as a basis for numerous core classes in the graduate program and for research in astronomy and astrophysics. It will aim to develop a basic understanding and formulation of these topics and also apply it to a number of problems in the forefront of current research.

Grading basis: Regular Grades

Career: Graduate

Course Components:	Lecture	Required
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Course typically offered:

Main Campus: Fall

Recommendations and additional information: Required of first year graduate students

Field trip: None

ASTR 596B: Methods in Computational Astrophysics (3 units)

Description: The course is a "hands-on" introduction to computer use for research by scientists in astrophysics and related areas. The course begins with a survey of and introduction to tools available on Linux systems, web-based tools, and open-source software widely used in astrophysics. Standard methods for integration, iteration, differential and difference equations, and Monte Carlo simulations, are discussed, in one to four dimensions. Historically important methods of radiative transfer, reaction networks, and hydrodynamics are presented, and contrasted with presently-used methods. Parallel programming is introduced, and discussed in terms of new and future computer systems. Special topics are added to reflect new developments. The course is task-oriented, with individual and team work projects, and class participation determining grades. Most of the work is done on the student's own personal computer (Linux or Mac operating systems are preferred).

Grading basis: Student Option ABCDE/PF

Career: Graduate

Course Components: Seminar Required

Equivalent to: PHYS 596B, PTYS 596B

Also offered as: PTYS 596B

Course typically offered:

Main Campus: Spring (odd years only)

Interdisciplinary Interest Area: PHYS - Physics

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 599: Independent Study (1 - 5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work. Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699, or 799.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

ASTR 699: Independent Study (1 - 5 units)

Description: Qualified students working on an individual basis with professors who have agreed to supervise such work. Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699, or 799.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

ASTR 900: Research (1 - 8 units)

Description: Individual research, not related to thesis or dissertation preparation, by graduate students.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

ASTR 910: Thesis (2 - 4 units)

Description: Research for the master's thesis (whether library research, laboratory or field observation or research, artistic creation, or thesis writing). Maximum total credit permitted varies with the major department.

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.

ASTR 920: Dissertation (1 - 9 units)

Description: Research for the doctoral dissertation (whether library research, laboratory or field observation or research, artistic creation, or dissertation writing).

Grading basis: Alternative Grading: S, P, F

Career: Graduate

Course Components: Independent Study Required

Repeatable: Course can be repeated a maximum of 99 times.

Course typically offered:

Main Campus: Fall, Spring, Summer

-SA represents a Student Abroad & Student Exchange offering

-CC represents a Correspondence Course offering

May Be Offered Departments may offer this component in some semesters. See the Schedule of Classes for term-specific offerings.