ASTRONOMY (ASTR)

ASTR102 Science Information Literacy
Information literacy is the set of skills needed to find, retrieve, analyze, and use information. This course will focus on teaching these skills as especially applied to scientific information. Students will learn to determine the nature and extent of information needed, to acquire needed information effectively and efficiently, to evaluate information and its sources critically, and to use information effectively to accomplish a specific purpose. Students will also examine the economic, ethical, legal, and social issues surrounding the use of information and how information literacy is important to lifelong learning and keeping current to new developments in his/her field. Topics will include the structure of scientific information and scientific publishing, the research process, types of information retrieval systems, search strategies and syntax, use of bibliographic management software (e.g., EndNote), criteria for critical evaluation, open-access publication, plagiarism, and copyright.
Offering: Crosslisting
Grading: OPT
Credits: 0.50
Gen Ed Area: None
Identical With: MB&B102, CHEM102, BIOL102, PHYS103, NS&B102, PSYC102, E&ES102, MB&B102, CHEM102, BIOL102, PHYS103, NS&B102, PSYC102, E&ES102
Prereq: None

ASTR103 The Planets
More than 100 planets are now known in the universe, eight of which circle the sun. NASA missions and improved telescopes and techniques have greatly increased our knowledge of them and our understanding of their structure and evolution. In this course, we study those eight planets, beginning with the pivotal role that they played in the Copernican revolution, during which the true nature of the earth as a planet was first recognized. We will study the geology of the earth in some detail and apply this knowledge to our closest planetary neighbors--the moon, Venus, and Mars. This is followed by a discussion of the giant planets and their moons and rings. We finish the discussion of the solar system with an examination of planetary building blocks--the meteorites, comets, and asteroids. Additional topics covered in the course include spacecraft exploration, extrasolar planetary systems, the formation of planets, life in the universe, and the search for extraterrestrial intelligence.
Offering: Crosslisting
Grading: A-F
Credits: 1.25
Gen Ed Area: NSM-EES, NSM-EES
Identical With: E&ES151, E&ES151, E&ES151, E&ES151
Prereq: None

ASTR104 Solar Systems in the Milky Way
Our Earth is one of several planets in our solar system, and thanks to an exciting two decades of research, we now know our solar system is only one of many in the Milky Way galaxy. This course will focus on the Milky Way as a unit, discussing the galactic life cycle wherein the interstellar medium (ISM) of gas and dust is transformed into stars and planets and back again. The course will also cover the evolution and death of stars, the detection and characterization of planets around other stars, basic physics concepts that are important for astronomy such as light and gravity, and the scientific and observational methods and techniques used by astronomers.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR, NSM-ASTR
Prereq: None

ASTR105 Descriptive Astronomy
This course unveils the universe and how we have come to understand our place in it. We will touch on a full range of astronomical topics, including the mechanics of our solar system, the discovery of planets around other nearby stars, the stellar life cycle, the formation and evolution of galaxies, the big bang, and the ultimate fate of the universe. Special attention is paid to the universe’s dark side–dark matter, dark energy, and black holes. In addition, since developments in astronomy have so often accompanied the development of modern scientific thought, we examine astronomy from a historical perspective, gaining insight into how human factors affect progress in science.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR, NSM-ASTR, NSM-ASTR, NSM-ASTR
Prereq: None

ASTR107 The Universe
This course focuses on the modern scientific conception of the universe, including its composition, size, age, and evolution. We begin with the history of astronomy, tracing the development of thought that led ultimately to the big bang theory. This is followed by a closer look at the primary constituent of the universe–galaxies. We end with consideration of the origin and ultimate fate of the universe.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR, NSM-ASTR, NSM-ASTR
Prereq: None

ASTR108 Conceptual Astronomy: Science Fact vs. Science Fiction
Our conceptual understanding of the world around us is shaped by our experiences, often in subtle ways. In this media-dominated world, the public's predominant exposure to science comes from science fiction in popular culture, especially TV and movies. In this course, we will examine the ways in which popular culture has influenced our collective knowledge about astronomy: the good, the bad, and the really bad. Wide-ranging topics will include asteroids and comets threatening the earth, travel through space and time, and life in the universe. Through lecture, discussion, and laboratory exercises, we will examine these topics through the lens of science to expose the reality of the universe that is our home.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR
Prereq: None

ASTR111 The Dark Side of the Universe
The physical world we experience is one of normal matter, energy, and--if one looks up at night--stars. But on larger scales, the universe has an exotic and much less-well-understood side dominated by things we call dark matter, dark energy, and black holes. What are these mysterious components, and what is the relationship between them and the world that is familiar to us? The answers lie at the frontier of modern astrophysics. In this course, we explore the evidence for the existence of these dark components and the current debates regarding their nature and origin. In different ways, each of them has a vital role in the evolution of the universe and its ultimate fate.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR, NSM-ASTR, NSM-ASTR, NSM-ASTR
Prereq: None
ASTR155 Introductory Astronomy
The fundamentals of astronomy will be covered. This course serves as an introduction to the subject for potential majors and as a survey for nonmajors who have a good high school preparation in math and science. We will cover selected topics within the solar system, galaxy, local universe, and cosmology, including the big bang theory of the origin of the universe and the discovery of planets around other stars.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR, NSM-ASTR, NSM-ASTR, NSM-ASTR, NSM-ASTR
Prereq: None

ASTR221 Observational Astronomy
This course introduces the techniques of observational astronomy. The students will acquire a basic knowledge of the sky and become familiar with the use of Van Vleck Observatory's telescopes and instruments. Acquisition and analysis of astronomical data via modern techniques are stressed. Topics include celestial coordinates, time, telescopes and optics, astronomical imaging, and photometry. Some basic computer and statistical analysis skills are developed as well. The concepts discussed in lecture are illustrated through observing projects and computer exercises.
Offering: Host
Grading: A-F
Credits: 1.50
Gen Ed Area: NSM-ASTR, NSM-ASTR, NSM-ASTR, NSM-ASTR
Prereq: ASTR108 OR ASTR111 OR ASTR105 OR ASTR107 OR [E&ES151 or ASTR103] OR ASTR155 OR ASTR105 OR ASTR107 OR [E&ES151 or ASTR103] OR ASTR155

ASTR221 Galactic Astronomy
The fundamentals of astrophysics are applied to the galaxy and objects therein. Topics include the interstellar medium, stellar populations, galactic structure, formation, and evolution.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR
Identical With: ASTR521
Prereq: [ASTR155 AND ASTR211]

ASTR222 Modern Observational Techniques
This course reviews the practices of modern observational astronomy, focusing primarily on techniques employed in the optical bands. Topics will include a description of the use of digital detectors for imaging, photometry, and spectroscopy in a wide variety of applications. Data acquisition, image processing, and data analysis methods will be discussed. In particular, students will gain hands-on experience with the analysis of data obtained from both ground- and satellite-based observatories. An introduction to the relevant error analysis methods is included.
Offering: Host
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-ASTR, NSM-ASTR
Identical With: ASTR522, ASTR522, ASTR522, ASTR522
Prereq: ASTR211

ASTR224 Exoplanets: Formation, Detection, and Characterization
Our ability to place the earth into a cosmic context dramatically improved in the last decades with the discovery of planets around other stars (exoplanets). The study of exoplanets has quickly become a dominant field in astronomy. This course will focus on the fundamentals of exoplanet formation, detection, and characterization (interiors and atmospheres) based on astronomical observables. We will also discuss the assessment of habitability for Earth-like exoplanets and the prospects for the detection of biosignatures.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR, NSM-ASTR, NSM-ASTR
Identical With: ASTR524, ASTR524, ASTR524, ASTR524, ASTR524, ASTR524, ASTR524
Prereq: (ASTR155 AND ASTR211) OR ASTR155 AND ASTR211

ASTR231 Stellar Structure and Evolution
As the principal source of light in galaxies today and as drivers of chemical evolution, stars play a critical role in the universe. It is important to understand their structure and evolution. Fortunately, we have a fairly well-developed and tested theory of stellar structure covering both their interiors and atmospheres. In this course, we will provide an introduction to that theory and examine its key results, including a basic description of how stars evolve.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR, NSM-ASTR
Identical With: ASTR331, ASTR331, ASTR331, ASTR331
Prereq: (PHYS213 AND PHYS214 AND ASTR155 AND ASTR211)

ASTR232 Galaxies, Quasars, and Cosmology
This course introduces modern extragalactic astronomy, blending established practices in the field and important recent discoveries. Three major themes will be developed. First, the basics of Newtonian and relativistic cosmologies will be discussed, including modern determinations of the Hubble Law and the observations that have led to the currently favored cosmological model. Next, the universe of galaxies will be investigated: their constituents, structure and kinematics, and multiwavelength properties. Finally, the nature of galactic nuclei will be explored, including the observational consequences of black-hole accretion and the coordinated growth of galaxies and their central black holes. Outstanding research questions related to the topics covered will be highlighted throughout the course.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR
Identical With: ASTR532
Prereq: (ASTR155 AND ASTR211)

ASTR240 Radio Astronomy
This course will introduce students to the origins, theory, and practice of radio astronomy. It will cover theory of antennas and interferometers, as well as signal detection and measurement techniques. Particular emphasis will be placed on the theory and applications of Fourier transforms. A practical laboratory component will provide experience working with single-dish and interferometric data.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR
Identical With: ASTR532
Prereq: ASTR155

ASTR401 Individual Tutorial, Undergraduate
A tutorial for individual undergraduate students who require instruction in subjects not covered in other courses.
Offering: Host
Grading: OPT

ASTR402 Individual Tutorial, Undergraduate
A tutorial for individual undergraduate students who require instruction in subjects not covered in other courses.
Astronomy (ASTR)

**ASTR407 Senior Tutorial**
Downgraded Senior Thesis Tutorial - Project to be arranged in consultation with the tutor.
Offering: Host
Grading: A-F

**ASTR408 Senior Tutorial**
Downgraded Senior Thesis Tutorial - Project to be arranged in consultation with the tutor.
Offering: Host
Grading: A-F

**ASTR409 Senior Thesis Tutorial**
Topic to be arranged in consultation with tutor.
Offering: Host
Grading: OPT

**ASTR410 Senior Thesis Tutorial**
Offering: Host
Grading: OPT

**ASTR411 Group Tutorial, Undergraduate**
Offering: Host
Grading: OPT

**ASTR412 Group Tutorial, Undergraduate**
Offering: Host
Grading: OPT

**ASTR421 Undergraduate Research, Science**
Individual research projects for undergraduate students supervised by faculty members.
Offering: Host
Grading: OPT

**ASTR422 Undergraduate Research, Science**
Individual research projects for undergraduate students supervised by faculty members.
Offering: Host
Grading: OPT

**ASTR423 Advanced Research Seminar, Undergraduate**
Offering: Host
Grading: OPT

**ASTR424 Advanced Research Seminar, Undergraduate**
Offering: Host
Grading: OPT

**ASTR430 Seminar on Astronomical Pedagogy**
Methods for effectively teaching astronomy at all levels from general public outreach to college level will be discussed.
Offering: Host
Grading: Cr/U
Credits: 0.25
Gen Ed Area: NSM-ASTR
Prereq: ASTR155 OR ASTR211

**ASTR431 Research Discussion in Astronomy**
Current research topics in astronomy will be presented and discussed by astronomy staff and students.
Offering: Host
Grading: Cr/U
Credits: 0.25
Gen Ed Area: NSM-ASTR
Prereq: ASTR155 OR ASTR211

**ASTR491 Teaching Apprentice Tutorial**
Apprenticeships are available in both the introductory and advanced courses.
Offering: Host
Grading: OPT

**ASTR492 Teaching Apprentice Tutorial**
Apprenticeships are available in both the introductory and advanced courses.
Offering: Host
Grading: OPT

**ASTR500 Graduate Pedagogy**
The elements of good teaching will be discussed and demonstrated through lectures, practice teaching sessions, and discussions of problems encountered in the actual teaching environment. The staff consists of faculty and experienced graduate students. An integral part of the course is a required one-day workshop BEFORE the first day of formal classes.
Offering: Crosslisting
Grading: Cr/U
Credits: 0.50
Gen Ed Area: None
Identical With: E&ES500, CHEM500, BIOL500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500, BIOL500, CHEM500, E&ES500, MB&B500, MUSC500, PHYS500, PSYC500, MATH500
Prereq: None

**ASTR501 Individual Tutorial for Graduates**
A tutorial for individual graduate students who require instruction in subjects not covered in other courses.
Offering: Host
Grading: OPT

**ASTR502 Individual Tutorial for Graduates**
A tutorial for individual graduate students who require instruction in subjects not covered in other courses.
Offering: Host
Grading: OPT

**ASTR503 Selected Topics, Graduate Sciences**
Offering: Host
Grading: OPT

**ASTR504 Selected Topics, Graduate Sciences**
Offering: Host
Grading: OPT

**ASTR521 Galactic Astronomy**
The fundamentals of astrophysics are applied to the galaxy and objects therein. Topics include the interstellar medium, stellar populations, galactic structure, formation, and evolution.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR
Identical With: ASTR221
Prereq: (ASTR155 AND ASTR211)
ASTR522 Modern Observational Techniques
This course reviews the practices of modern observational astronomy, focusing primarily on techniques employed in the optical bands. Topics will include a description of the use of digital detectors for imaging, photometry, and spectroscopy in a wide variety of applications. Data acquisition, image processing, and data analysis methods will be discussed. In particular, students will gain hands-on experience with the analysis of data obtained from both ground- and satellite-based observatories. An introduction to the relevant error analysis methods is included.
Offering: Crosslisting
Grading: A-F
Credits: 0.50
Gen Ed Area: NSM-ASTR, NSM-ASTR
Identical With: ASTR222, ASTR222, ASTR222, ASTR222
Prereq: ASTR211

ASTR524 Exoplanets: Formation, Detection, and Characterization
Our ability to place the earth into a cosmic context dramatically improved in the last decades with the discovery of planets around other stars (exoplanets). The study of exoplanets has quickly become a dominant field in astronomy. This course will focus on the fundamentals of exoplanet formation, detection, and characterization (interiors and atmospheres) based on astronomical observables. We will also discuss the assessment of habitability for Earth-like exoplanets and the prospects for the detection of biosignatures.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR, NSM-ASTR, NSM-ASTR
Identical With: ASTR224, ASTR224, ASTR224, ASTR224, ASTR224, ASTR224, ASTR224
Prereq: (ASTR155 AND ASTR211) OR ASTR155 AND ASTR211

ASTR531 Stellar Structure and Evolution
As the principal source of light in galaxies today and as drivers of chemical evolution, stars play a critical role in the universe. It is important to understand their structure and evolution. Fortunately, we have a fairly well-developed and tested theory of stellar structure covering both their interiors and atmospheres. In this course, we will provide an introduction to that theory and examine its key results, including a basic description of how stars evolve.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR, NSM-ASTR
Identical With: ASTR231, ASTR231, ASTR231, ASTR231
Prereq: (PHYS213 AND PHYS214 AND ASTR155 AND ASTR211)

ASTR532 Galaxies, Quasars, and Cosmology
This course introduces modern extragalactic astronomy, blending established practices in the field and important recent discoveries. Three major themes will be developed. First, the basics of Newtonian and relativistic cosmologies will be discussed, including modern determinations of the Hubble Law and the observations that have led to the currently favored cosmological model. Next, the universe of galaxies will be investigated: their constituents, structure and kinematics, and multwavavelength properties. Finally, the nature of galactic nuclei will be explored, including the observational consequences of black-hole accretion and the coordinated growth of galaxies and their central black holes.
Outstanding research questions related to the topics covered will be highlighted throughout the course.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-ASTR
Identical With: ASTR232

Prereq: (ASTR155 AND ASTR211)

ASTR549 Advanced Research Seminar, Graduate
Offering: Host
Grading: OPT

ASTR550 Advanced Research Seminar, Graduate
Offering: Host
Grading: OPT

ASTR555 Planetary Science Seminar
This course will examine topics and methods in the interdisciplinary field of Planetary Science. Students will join several faculty members in the Planetary Science Group to discuss the origin, evolution and habitability of planets in this and other solar systems. This class is intended for graduate students who are pursuing or mean to pursue the Planetary Science Concentration. Other graduate and undergraduate students may request admission to the course.
Offering: Crosslisting
Grading: Cr/U
Credits: 0.25
Gen Ed Area: NSM-EES, NSM-EES, NSM-EES
Prereq: None

ASTR589 Advanced Research, BA/MA
Intensive investigation of special research problems leading to a BA/MA thesis.
Offering: Host
Grading: A-F

ASTR590 Advanced Research, BA/MA
Intensive investigation of special research problems leading to a BA/MA thesis.
Offering: Host
Grading: OPT

ASTR591 Advanced Research, Graduate
Individual thesis research projects for graduate students supervised by faculty members.
Offering: Host
Grading: OPT

ASTR592 Advanced Research, Graduate
Individual thesis research projects for graduate students supervised by faculty members.
Offering: Host
Grading: OPT