ASTRONOMY

Undergraduate Program Information

The department offers an undergraduate astronomy minor degree, which requires 18-20 credits. The department does not offer a BS degree but encourages interested students to enroll in the physics program as a first step toward a career in astronomy. Our 100- and 300-level courses meet various university general education requirements. All students are invited to share with us this exciting area of study, through our basic and advanced undergraduate courses

Prefix	Title	Credits
Course List [1]		
ASTR 1115G	Introduction to Astronomy Lecture & Laboratory	4
ASTR 1120G	The Planets Lecture & Laboratory	4
ASTR 301V	Revolutionary Ideas in Astronomy	3
ASTR 305V	The Search for Life in the Universe	3
ASTR 308V	Into the Final Frontier	3
ASTR 400	Undergraduate Research	1-3
ASTR 401	Topics in Modern Astrophysics	3
ASTR 402	Astronomical Observations and Techniques	3

1 Other courses at the 300 and 400-levels are offered on an occasional basis. Consult the "Course Descriptions" section in this catalog.

Graduate Program Information

The Department of Astronomy offers graduate work leading to the Doctor of Philosophy and Master of Science degrees. To be admitted as a regular student to the NMSU Graduate School as a major in astronomy, a student must present a suitable undergraduate background with emphasis (12-16 credits) on junior-senior level physics, and mathematics.

Information on assistantships and fellowships in teaching and research can be obtained from the department.

Each entering graduate student will be assigned a committee that will guide the student in choice of courses, suggest training if needed to remedy deficiencies and determine specific degree requirements in accord with the student's needs and objectives, and in agreement with departmental policies. The program requires 33 traditional course credit hours (11 classes), 4 seminar class credit hours, plus research in astronomy. Each student must demonstrate no later than during the third year sufficient academic and research ability to qualify for continuation in doctoral studies.

The MS degree in astronomy is closely connected with the astronomy Ph.D. program, and questions concerning requirements should be directed to the department.

Qualifying, Comprehensive and Final examinations are described elsewhere in this catalog. Questions concerning styles of the examinations should be directed to the department head.

The department has access to several different observing facilities. NMSU operates the Apache Point Observatory on behalf of the Astrophysical Research Corporation and the observatory is home to several telescopes:

- the ARC 3.5m telescope,
- a 1-meter telescope as part of the global SONG (http://astronomy.nmsu.edu/song-wiki/) project
- the ARCSAT 0.5m telescope, and
- the Sloan Digital Sky Survey (SDSS) 2.5m telescope.

The Department is a full partner in the SDSS project. The Department also operates the Dunn Solar Telescope and the Visitor Center at the Sunspot Solar Observatory. The Department also operates a 24-include telescope on Tortugas Mountain, near the NMSU campus.

The department is home to the NASA Planetary Data System Atmosphere Node, where solar system exploration data are archived.

Degrees for the Department

Master Degree(s)

- Astronomy - Master of Science (https://catalogs.nmsu.edu/nmsu/graduate-school/astronomy-master-science/)

Doctoral Degree(s)

- Astronomy - Doctor of Philosophy (https://catalogs.nmsu.edu/nmsu/graduate-school/astronomy-doctor-philosophy/)

Minors for the Department

- Astronomy - Undergraduate Minor (https://catalogs.nmsu.edu/nmsu/arts-sciences/astronomy/astronomy-undergraduate-minor/)

Professor, Jason Jackiewicz, Department Head

Professors: Chanover, Churchill, Jackiewicz***; Associate Professors***: Finlator, Lyra, Prescott; ***Assistant Professors:*** Burchett, Nielsen, Shetye; ***Observatory Specialist***: Edwards

J. Burchett, Ph.D. (University of Massachusetts) - galaxy clusters, inter-galactic medium, cosmic simulations;

N. Chanover, Ph.D. (New Mexico State) - planetary astronomy;

C. Churchill, Ph.D. (California-Santa Cruz) - galaxies and intergalactic medium;

K. Finlator, Ph.D. (University of Arizona) - galaxy evolution, the intergalactic medium, cosmological reionization;

J. Jackiewicz, Ph.D. (Boston College) - solar physics, helioseismology, stellar structure and evolution, planetary interiors;

W. Lyra (Uppsala University) - planet formation, habitability;

E. Nielsen, Ph.D. (University of Arizona) - extrasolar planets;

M. Prescott, Ph.D. (University of Arizona) - Lyman-alpha nebulae, kinematics of gas within cosmic web;

J. Shetye, Ph.D. (Armagh Observatory) - solar physics, Sun-Earth connection.

Professors Emeritus:

J. Holtzman, J. Murphy, R. Walterbos

Affiliated Faculty:

R.T.J. McAteer, N. Vogt

Astronomy Courses

ASTR 1115G. Introduction to Astronomy Lecture & Laboratory
4 Credits (3+2P)
This course surveys observations, theories, and methods of modern astronomy. The course is predominantly for non-science majors, aiming to provide a conceptual understanding of the universe and the basic physics that governs it. Due to the broad coverage of this course, the specific topics and concepts treated may vary. Commonly presented subjects include the general movements of the sky and history of astronomy, followed by an introduction to basic physics concepts like Newton's and Kepler's laws of motion. The course may also provide modern details and facts about celestial bodies in our solar system, as well as differentiation between them – Terrestrial and Jovian planets, exoplanets, the practical meaning of "dwarf planets", asteroids, comets, and Kuiper Belt and Trans-Neptunian Objects. Beyond this we may study stars and galaxies, star clusters, nebulae, black holes, and clusters of galaxies. Finally, we may study cosmology--the structure and history of the universe.The lab component of this course includes hands-on exercises that work to reinforce concepts covered in the lecture, and may include additional components that introduce students to the night sky. May be repeated up to 4 credits.

Learning Outcomes

1. Students will discuss the night sky as seen from Earth, including coordinate systems, the apparent daily and yearly motions of the sun, Moon, and stars, and their resulting astronomical phenomena.
2. Students will list and apply the steps of the scientific method.
3. Students will describe the scale of the Solar System, Galaxy, and the Universe.
4. Students will explain telescope design and how telescopes and spectra are used to extract information about Astronomical objects.
5. Students will describe the formation scenarios and properties of solar system objects.
6. Students will describe gravity, electromagnetism, and other physical processes that determine the appearance of the universe and its constituents.
7. Students will describe methods by which planets are discovered around other stars and current results.
8. Students will describe the structure, energy generation, and activity of the sun.
9. Students will compare our sun to other stars and outline the evolution of stars of different masses and its end products, including black holes. 1
10. Students will describe the structure of the Milky Way and other galaxies and galaxy clusters. 1
11. Students will describe the origin, evolution, and expansion of the universe based on the Big Bang Theory and recent Astronomical observations. 1
12. Students will describe conditions for life, its origins, and possible locations in the universe.

ASTR 1116. Introduction to Astronomy Lab, Special
1 Credit (1)
This lab-only listing exists only for students who may have transferred to NMSU having taken a lecture-only introductory astronomy class, to allow them to complete the lab requirement to fulfill the general education requirement. Consent of Instructor required. , at some other institution). Restricted to Las Cruces campus only.

Prerequisite(s): Must have passed Introduction to Astronomy lecture-only.

Learning Outcomes

1. Course is used to complete lab portion only of ASTR 1115G or ASTR 112
2. Learning outcomes are the same as those for the lab portion of the respective course.

ASTR 1120G. The Planets Lecture & Laboratory
4 Credits (3+2P)
Comparative study of the planets, moons, comets, and asteroids which comprise the solar system. Emphasis on geological and physical processes which shape the surfaces and atmospheres of the planets. Laboratory exercises include analysis of images returned by spacecraft. Intended for non-science majors, but some basic math required. May be repeated up to 4 credits.

Learning Outcomes

1. Students will describe the sky as seen from Earth, the apparent daily and yearly motions of the Sun, Moon, planets and stars, and resulting astronomical phenomena.
2. Students will apply the process of the scientific method in an astrophysical setting.
3. Students will describe the structure of the solar system and explain the development of the currently accepted model of solar system formation.
4. Students will explain how telescopes and spectra are used to extract information about astronomical objects.
5. Students will describe properties of minor solar system objects, such as dwarf planets, moons, asteroids, meteoroids, and comets.
6. Students will compare and contrast bulk and unique properties of the Terrestrial and Jovian worlds.
7. Students will describe how gravity and other physical processes determine the appearance of the solar system and its constituents.

ASTR 301V. Revolutionary Ideas in Astronomy
3 Credits (3)
Examines recent fundamental scientific revolutions that have shaped our view of Earth and the universe. Topics in astronomy range from exoplanets to black holes to dark energy and raise questions about the very nature of how we use the scientific method to see the unseen, and how this shapes science research today.
Prerequisite(s): Any general education science course.

ASTR 305V. The Search for Life in the Universe
3 Credits (3)
Use of information from several of the sciences to explore the likelihood that life exists elsewhere in the universe. Subjects include an overview of historical ideas about the possibility of life elsewhere in the universe, the chemistry and biology of life on Earth, recent explorations for life within our solar system, and current search strategies for life in the universe and their scientific basis.

ASTR 308V. Into the Final Frontier
3 Credits (3)
Exploration of space: a brief review of the history of space flight, the Apollo program, joint U.S.-Soviet space missions, and unstaffed exploration of the planets. Emphasis on knowledge gained through these efforts. Includes new space initiatives. Same as HNRS 308V.

ASTR 330V. Planetary Exploration
3 Credits (3)
A current planetary exploration mission is studied within the context of the solar system. The data acquired and principles involved in executing

the mission, as well as social, political, ethical and economic implications of planetary exploration, are examined. May be repeated up to 3 credits.

Learning Outcomes

1. Students will describe the various types of interplanetary missions used to explore solar system objects.
2. Students will explain the roles and responsibilities of the groups of scientists and engineers that comprise a mission team.
3. Students will describe the social, political, ethical, and financial challenges associated with planetary exploration.

ASTR 400. Undergraduate Research
1-3 Credits
Supervised individual study or research. May be repeated up to 9 credits.

Learning Outcomes

1. Students will learn basic astronomical research techniques in observation and theory.
2. Students will communicate their findings in venues such as department meetings.

ASTR 401. Topics in Modern Astrophysics
3 Credits (3)
This course is designed for students interested in astrophysics who have some background in math and physics and want to learn about basic astrophysics and interesting current topics. The course will cover basic astrophysical concepts such as orbital mechanics, light, and radiative processes and transfer. These concepts will be applied to the discussion of exciting modern topics involving planets, exoplanets, stars, galaxies, and/or cosmology, with topical emphasis determined by the instructor.
Prerequisite(s): MATH 1521G and (PHYS 2110 or PHYS 1310G).

ASTR 402. Astronomical Observations and Techniques
3 Credits (3)
Designed for students interested in astrophysics who have some background in math and astronomy and want to learn about techniques for obtaining and analyzing astronomical data. This course will review the properties of light and discuss the process of experimental design. The course will describe basic observational tools such as telescopes and detectors. It will discuss how data is obtained, and how features of the detector and the Earth's atmosphere can be corrected for. Some topics in basic astronomical data analysis will be discussed, with topical emphasis determined by the instructor. Some simple data analysis projects will be assigned. May be repeated up to 3 credits.
Prerequisite: MATH 1511G and (PHYS 2140 or PHYS 1320G) and (ASTR 1120G, ASTR 1115G, or ASTR 401).

Learning Outcomes

1. Review the properties of light and discuss the process of experimental design.
2. Describe basic observational tools such as telescopes and detectors.
3. Discuss how data is obtained, and how features of the detector and the Earth's atmosphere can be corrected for.
4. Discuss topics in basic astronomical data analysis.

ASTR 403. Fundamentals of Astronomy
3 Credits (3)
This course is designed to ensure a basic, quantitative knowledge of fundamental topics in astronomy and astrophysics. These topics include orbital mechanics, properties of radiation, principles of stellar radiation and spectra, structure and dynamics of the Milky Way, properties of galaxies, and basic cosmology. While this course is designed for first year graduate students, it is also cross-listed as a undergraduate course for students who have already had some exposure to astronomy and are prepared for a fast-paced review of fundamental topics and concepts in astronomy. Undergraduates will have a reduced homework load. Consent of Instructor required. Crosslisted with: ASTR 505.
Prerequisite(s): ASTR 401 or demonstrated background in astronomy and problem solving.

ASTR 499. Directed Study for Undergraduates
1-6 Credits
This course is for student who wish to minor in Astronomy but have already fulfilled all of the 6 credits of ASTR 400. This course will be administered by individual faculty who develop a meeting schedule with a student or students. It will count toward the minor requirements. May be repeated up to 6 credits.

Learning Outcomes

1. Students will learn basic astronomical research techniques in observation and theory.
2. Students will communicate their findings in venues such as department meetings.

ASTR 500. Seminar
1 Credit (1)
Organized group study treating selected topics.

ASTR 503. Fundamentals of Astrophysics
3 Credits (3)
This course is designed to ensure a basic, quantitative knowledge of fundamental topics in astronomy and astrophysics. These topics include orbital mechanics, properties of radiation, principles of stellar radiation and spectra, structure and dynamics of the Milky Way, properties of galaxies, and basic cosmology.

Learning Outcomes

1. Ensure a basic, quantitative knowledge of fundamental topics in astronomy and astrophysics.
2. Discuss orbital mechanics, properties of radiation, principles of stellar radiation and spectra, structure and dynamics of the Milky Way, properties of galaxies, and basic cosmology.

ASTR 506. Dynamics and Hydrodynamics
3 Credits (3)
Graduate level course on basic stellar dynamics and fundamentals of hydrodynamics. May be repeated up to 3 credits.

Learning Outcomes

1. Learn and be able to apply basics of stellar dynamics and hydrodynamics.

ASTR 530. Gas and Radiative Processes
3 Credits (3)
This course will introduce the basic physics of the the primary gaseous environments in the universe and their observational signatures. Astrophysical environment to be addressed will include the atmospheres of stars, the interstellar medium, the circumgalactic medium, and the intergalactic medium. Physical processes covered will include gas hydrodynamics, radiative and collisional excitation and ionization balance in astrophysics, atomic processes and detailed balancing, heating and cooling balance, and evolution. From the observational point of view, the course will discuss the spectral signatures of these processes, including stellar spectra, 21-cm spectra, emission line spectra from HII regions and planetary nebulae, and absorption lines from the interstellar medium, circumgalactic medium, and intergalactic medium.

Learning Outcomes

1. Introduce the basic physics of the the primary gaseous environments in the universe and their observational signatures.
2. Describe the atmospheres of stars, the interstellar medium, the circumgalactic medium, and the intergalactic medium.

3. Understand principles of gas hydrodynamics, radiative and collisional excitation and ionization balance in astrophysics, atomic processes and detailed balancing, heating and cooling balance, and evolution.
4. Discuss spectral signatures of these processes, including stellar spectra, 21-cm spectra, emission line spectra from HII regions and planetary nebulae, and absorption lines from the interstellar medium, circumgalactic medium, and intergalactic medium.

ASTR 535. Observational Techniques
3 Credits (3)
Up-to-date introduction to modern observational astronomy in a two-semester sequence. Topics include: introduction to computers, error analysis in data, the different types of optical telescopes, and optical and infrared photometry, image processing, and detectors. May be repeated up to 3 credits.

Learning Outcomes

1. Discuss an introduction to computers, error analysis in data, the different types of optical telescopes, and optical and infrared photometry, image processing, and detectors.

ASTR 545. Stellar Spectroscopy
3 Credits (3)
This course covers the physics of stellar atmospheres with emphasis on using spectra as a diagnostic tool for understanding the properties of stars. Topics include spectral classification, radiative transfer, gas equilibrium physics, line and continuum opacities, adiabatic and superadiabatic convection, and extraction of observed quantities from spectra for deducing physical conditions of the source.

ASTR 555. Galaxies I
3 Credits (3)
Fundamentals of the properties of galaxies and galaxy components, including stars and stellar populations, gas and dust, central black holes, and dark matter. Includes a detailed description of the properties of the Milky Way Galaxy.

ASTR 565. Stellar Interiors
3 Credits (3)
Internal constitutions of stars, computation of stellar models, and stellar evolution.

ASTR 598. Special Research Programs
1-6 Credits
Individual investigations, either analytical or experimental.

ASTR 599. Master's Thesis
1-15 Credits (1-15)
Master's level research in astrophysics or observational astronomy. May be repeated up to 88 credits.

Learning Outcomes

1. Varies

ASTR 600. Pre-dissertation Research
1-15 Credits
Research.

ASTR 601. Thesis Proposal Preparation
1 Credit (1)
This is a one-credit course that introduces students to Departmental expectations regarding the Thesis Proposal and provides rigorous training in proposal-writing. Drawing heavily from the presentation in the course textbook, Writing Science by Joshua Schimel, students will practice devising, developing, and proposing three new ideas for astronomical research over the course of the academic term. Classroom activity will consist of a mixture of short lecture-discussions and focused peer-editing sessions; homework will consist of readings and writing assignments. While the course will assist students in developing their thesis proposals, its topics are general enough to be useful for any proposal. Students taking Pre-Dissertation Research in their fifth semester are required to register for this course, while students in their fourth and fifth years who have not yet defended their thesis proposals are strongly encouraged to join them. This course should not change the total number of credits for which students are expected to register in a semester

Learning Outcomes

1. Provide continuing programmatic/structural support to students as they transition from structured coursework/cumes to unstructured thesis work.
2. Suppress the temptation for students to distance physically starting in the third year.
3. Optimize balance between programmatic progress and ongoing research/outreach commitments.
4. Clarify thesis proposal expectations and improve consistency between experiences of different students.
5. Suppress thesis proposal inflation.
6. Train students in ideation and proposal writing.

ASTR 605. Interstellar Medium
3 Credits (3)
Basics of radiative transfer and processes in the interstellar medium. Properties of dust and infrared emission from grains. Applications to neutral atomic and molecular gas and ionized plasmas in galaxies. May be repeated up to 3 credits.

ASTR 616. Galaxies II
3 Credits (3)
Galaxy formation within a cosmological context. Topics include an introduction to cosmology, the growth of linear and nonlinear structures, the formation of dark matter halos, galaxy growth and feedback processes, and their observational signatures in the intergalactic and circumgalactic media.

ASTR 620. Planetary Processes
3 Credits (3)
Evaluation and analysis of observational data on solar system objects to determine their nature and physical conditions, with emphasis upon atmospheres (composition, structure, thermodynamics, evolution, etc.). Restricted to Astronomy Majors. May be repeated up to 3 credits.

Learning Outcomes

1. Evaluation and analysis of observational data on solar system objects to determine their nature and physical conditions, with emphasis upon atmospheres (composition, structure, thermodynamics, evolution, etc.)

ASTR 621. Planetary System Formation
3 Credits (3)
The physical processes involved in planetary system formation are addressed. Specific foci include molecular cloud collapse, disk processes, and competing theories of planet formation within disks. Additional topics to be discussed may include: the solar wind, planetary magnetic fields, planetary ring processes, and mineralogy. May be repeated up to 3 credits. Restricted to: ASTR majors.

ASTR 630. Advanced Methods in Astrophysics
3 Credits (3)
Provides basic background in numerical and statistical methods relevant to astrophysical research. Topics include a review of probability and probability distribution functions, Bayesian and frequentist approaches,

data simulation, parameter estimation, Markov Chain Monte Carlo, image processing, feature detection, inversions or other topics. May be repeated up to 3 credits.

Learning Outcomes

1. Perform basic background in numerical and statistical methods relevant to astrophysical research.
2. Review of probability and probability distribution functions, Bayesian and frequentist approaches, data simulation, parameter estimation, Markov Chain Monte Carlo, image processing, feature detection, inversions or other topics.

ASTR 670. Heliophysics, Space Plasmas, and Space Weather
3 Credits (3)

Explore the Sun and its processes. the heliopshere, and its interactions with the planets. Topics include: A introductory description of space weather and its physics; energy interaction with the space environment; the quiet Sun and its interactions with planetary atmospheres (with an emphasis on Earth); Magnetohydrodynamics; frozen-in flux; the solar wind; magnetized fluid dynamics; the active Sun(flares and coronal mass ejections); the effects of Space Weather. May be repeated up to 3 credits.

Learning Outcomes

1. Manipulate the equations of electromagnetism for any astrophysical plasma, and thereby predict the behavior of any plasma under specific conditions.
2. Use the equations of electromagnetism to explain temporal and spatial size scales throughout the heliosphere.
3. Interpret the role magnetism plays in both the storage and release of energy in plasmas.
4. Analyze the effect and impact of solar particles and radiation on Earth, and at other planets.

ASTR 671. Solar Astrophysics
3 Credits (3)

Solar astrophysics, including observational and theoretical aspects of the Sun's atmosphere. Although focused on the Sun, the course will be conducted so be of general interest to all astronomy graduate students

Learning Outcomes

1. Develop critical thinking skills in study the solar atmosphere.
2. Asses the validity of solar MHD and other approximations in uncovering the physics of the Sun.
3. Investigate the evolution of solar features at multiple size scales.
4. Determine the connections of the solar plasma oscillations and particle acceleration to energy release processes.

ASTR 698. Special Topics.
1-9 Credits

Special topics.

ASTR 700. Doctoral Dissertation
1-15 Credits (1-15)

Dissertation. May be repeated up to 88 credits.

Learning Outcomes

1. Varies

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