MATH113. Prerequisite: and get the chance to invent your own plausible planets! mistakes made in classic science fiction movies, novels and short stories why planets are the way they are. Along the way, you'll see examples of Planetary Systems will help you develop a deeper understanding of life in the Universe? These are difficult questions, but armed with the rich atmosphere? Have you ever suspected novelists and scriptwriters how lucky you are that you live on a water-rich planet with an oxygen-rich space? Has it ever crossed your mind we could live there without a spacesuit? Questions like these concern the characteristics and orbits of possible planets. Laboratory exercises include use of photographic material, computer simulations, and standard laboratory equipment.

Credit Only Granted for: ASTR100, ASTR101, or ASTR120.

ASTR120 Introductory Astrophysics - Solar System (3 Credits) For students majoring in astronomy or with a strong interest in science. Topics include development of astronomy, planetary orbits, electromagnetic radiation, telescopes as well as constituents and origin of the solar system (planets, satellites, comets, asteroids, meteoroids, etc.).

Prerequisite: Must have completed or be concurrently enrolled in MATH140.

Restriction: Must not have completed ASTR101 or ASTR100.

Credit Only Granted for: ASTR100, ASTR101, or ASTR120.

ASTR220 Collisions in Space - The Threat of Asteroid Impacts (3 Credits) Appropriate for non-science majors. Worried? Can't sleep? Collisions in Space will evaluate the threat of asteroid impacts with the Earth using knowledge of asteroid characteristics and orbits. The merits of possible defense plans will be discussed, as well as the budgetary and political concerns associated with implementing any such plan.

Restriction: Must not be in Astronomy program.

Additional Information: Course is open to Astronomy and Planetary Sciences minors.

ASTR305 Astronomy and the Media (3 Credits) Appropriate for non-science majors. This course will provide students with the tools and motivation to critically evaluate scientific news for themselves, enabling them to use the media to keep abreast of science throughout their lives.

Restriction: Must not be in Astronomy program.
ASTR330 Solar System Astronomy (3 Credits)
Designed primarily for non-science majors. The structure of planets and of their atmospheres, the nature of comets, asteroids, and satellites. Comparison of various theories for the origin of the solar system. Emphasis on a description of recent data and interpretation.
Prerequisite: ASTR100 or ASTR101; and completion of the CORE Distributive Studies requirement in Mathematics and Sciences or the General Education Fundamental Studies requirement in Mathematics. Or permission of CMNS-Astronomy department.
Credit Only Granted for: ASTR330 or GEOL212.

ASTR340 Origin of the Universe (3 Credits)
Designed primarily for non-science majors. A study of our progression of knowledge about the universe. Topics include: early cosmological models, geocentric vs. heliocentric theory, curvature of space, Hubble’s Law, Big Bang Theory, microwave background radiation, evolution of stars and galaxies, dark matter, active galaxies, quasars and the future of the universe.
Prerequisite: ASTR100 or ASTR101; and completion of the CORE Distributive Studies requirement in Mathematics and Sciences or General Education Fundamental Studies requirement in Mathematics. Or permission of CMNS-Astronomy department.

ASTR350 Black Holes (3 Credits)
Black holes are the most exotic prediction of Einstein’s Theory of General Relativity and, amazingly, the Universe seems to manufacture these bizarre objects in copious numbers. As well as being the ultimate laboratory for studying the nature of space and time, they drive some of the most energetic and extreme phenomena known to astronomers (with quasars and gamma-ray bursts being just a couple of examples). In this introduction to the physics and astrophysics of black holes, we start by examining the basic physics of black holes, which fundamentally means understanding gravity. We then look at the nature of stellar-mass black holes and supermassive black holes. We will discuss the fairly recent realization that black holes may be crucial agents for regulating the growth of galaxies. Finally, we dive into the realm of theoretical physics and probe how black holes may provide a route for uncovering new laws of physics governing the structure of space and time.
Prerequisite: ASTR100 or ASTR101; and completion of the CORE Distributive Studies requirement in Mathematics and Sciences or General Education Fundamental Studies requirement in Mathematics. Or permission of CMNS-Astronomy department.
Credit Only Granted for: ASTR 398B or ASTR 350. Formerly: ASTR 398B.

ASTR380 Life in the Universe - Astrobiology (3 Credits)
Designed primarily for non-science majors. Study of the astronomical perspective on the conditions for the origin and existence of life in the universe.

ASTR386 Experiential Learning (1-3 Credits)
Restriction: Junior standing or higher; and permission of CMNS-Astronomy department.

ASTR398 Special Topics in Astronomy (3 Credits)
This course is designed primarily for students not majoring in astronomy and is suitable for non-science students. It will concentrate study in some limited field in astronomy which will vary from semester to semester. Possible subjects for study are the solar system, extragalactic astronomy and cosmology, the inconstant universe.
Restriction: Junior standing or higher; or permission of CMNS-Astronomy department.
Repeatable to: 6 credits if content differs.

ASTR399 Honors Seminar (1-16 Credits)
Credit according to work done.
Restriction: Must be admitted to the departmental honors program in astronomy.

ASTR406 Stellar Structure and Evolution (3 Credits)
Study of stellar internal structure, nuclear reactions, and energy transport. Study of stellar evolution of both low-mass and high-mass stars, including the stellar end states of white dwarfs, neutron stars, and black holes.
Prerequisite: ASTR320; or permission of CMNS-Astronomy department.
Credit Only Granted for: ASTR 498N or ASTR 406. Formerly: ASTR 498N.

ASTR410 Radio Astronomy (3 Credits)
Introduction to current observational techniques in radio astronomy. The radio sky, radiophysics, coordinates and catalogs, antenna theory, Fourier transforms, interferometry and arrays, aperture synthesis, and radio detectors.
Prerequisite: ASTR121; and (PHYS271 and PHYS270; or PHYS273). Or permission of CMNS-Astronomy department.

ASTR415 Computational Astrophysics (3 Credits)
Introduction to the most important computational techniques being used in research in astrophysics. Topics include modern high performance computer architectures, scientific visualization and data analysis, and detailed descriptions of numerical algorithms for the solution to a wide range of mathematical systems important in astrophysics.
Prerequisite: ASTR121; and (PHYS271 and PHYS270; or PHYS273). Or permission of CMNS-Astronomy department. Jointly offered with ASTR615.
Credit Only Granted for: ASTR415 or ASTR615.

ASTR421 Galaxies (3 Credits)
Introduction to structure, kinematics, and dynamics of normal and peculiar galaxies. Quantitative descriptions of normal spiral galaxies (like our Milky Way) and elliptical galaxies will be followed by more exotic considerations such as interacting and merging galaxies, and active galactic nuclei.
Prerequisite: ASTR121; and (PHYS271 and PHYS270; or PHYS273). Or permission of CMNS-Astronomy department.

ASTR422 Cosmology (3 Credits)
Introduction to modern cosmology. Topics include large scale structure of universe, the intergalactic medium, the nature of dark matter cosmological models and galaxy formation.
Prerequisite: Must have completed or be concurrently enrolled in ASTR320; or permission of CMNS-Astronomy department.

ASTR430 The Solar System (3 Credits)
Prerequisite: ASTR121; and (PHYS271 and PHYS270; or PHYS273). Or permission of CMNS-Astronomy department.
**ASTR435 Astrophysics of Exoplanets (3 Credits)**
Introduction to exoplanets. Topics include historical development, advantages, and limitations of detection methods, the statistics of exoplanet characteristics, the bulk properties of known exoplanets, and remote sensing for characterization of exoplanets.

**Prerequisite:** ASTR121; and (PHYS273; or (PHYS270 and PHYS271)). Or permission of CMNS-Astronomy department.

**Credit Only Granted for:** ASTR 498X or ASTR 435.

**Formerly:** ASTR 498X.

**ASTR450 Orbital Dynamics (3 Credits)**
Vectorial mechanics, motion in a central force field, gravitational and non-gravitational forces, the two-body and three-body problems, orbital elements and orbital perturbation theory, resonances in the solar system, chaos. Intended for students majoring in any of the physical sciences.

**Prerequisite:** Must have completed or be concurrently enrolled in ASTR320; or permission of CMNS-Astronomy department.

**ASTR480 High Energy Astrophysics (3 Credits)**
The structure, formation, and astrophysics of compact objects, such as white dwarfs, neutron stars, and black holes, are examined. Phenomena such as supernovae and high-energy particles are also covered.

**Prerequisite:** Must have completed or be concurrently enrolled in ASTR320; or permission of CMNS-Astronomy department.

**ASTR498 Special Problems in Astronomy (1-6 Credits)**
Research or special study. Credit according to work done.

**Restriction:** Must be in one of the following programs (Physics; Astronomy); and permission of CMNS-Astronomy department.