Astronomy is a quantitative physical science that applies physics, mathematics, and statistical analysis to observing, describing, and modeling the universe. The undergraduate courses and degree programs offered by the Department of Astronomy train students in research techniques and quantitative reasoning and develop creative problem solvers. Students who complete the major continue on to top-tier graduate programs in astrophysics or related science fields, and they are sought after by employers in a range of fields from health care management to the banking and investment industry. The department offers a B.A. in Astronomy and a B.S. in Astrophysics.

INTRODUCTORY COURSES

**Introductory courses with no prerequisites** The department offers a variety of courses without prerequisites that provide an introduction to astronomy with particular attention to recent discoveries and theories. Courses numbered below 150 are intended for students who desire a broad, nontechnical introduction to astronomy. These courses fulfill the science distributional requirement, and some also fulfill the quantitative reasoning distributional requirement.

Courses with numbers from 150 to 199 are topical rather than survey courses. Most of these offerings fulfill both the science and the quantitative reasoning requirements. ASTR 155 is a laboratory course that provides a hands-on introduction to astronomical observing. ASTR 160 and 170 provide an introduction to frontier topics in modern astrophysics and cosmology.

**Introductory courses with high school calculus and physics prerequisites** Students who have taken calculus and physics in high school may enroll in quantitative introductory courses. ASTR 210 and ASTR 220 focus on fundamental measurements and tools used in astronomy and include an in-depth study of stellar astrophysics (ASTR 210) or galaxies and cosmology (ASTR 220). These courses overlap in content, so students should take either ASTR 210 or 220 but not both. ASTR 255 provides training in data analysis and research techniques, including computer programming and numerical and statistical analysis.

PREREQUISITES

**B.A. degree program** The prerequisites for the B.A. degree are PHYS 170 and 171, or 180 and 181, or 200 and 201, and MATH 112 and 115.

**B.S. degree program** Prerequisites for the B.S. degree include an introductory physics sequence (PHYS 180 and 181, or 200 and 201, or 260 and 261); a physics laboratory sequence (PHYS 165L and 166L, or 205L and 206L); and the mathematics sequence MATH 112, 115, and either MATH 120 or ENAS 151. ASTR 155 may be substituted for one term of the physics laboratory sequence. All prerequisites should be completed by the end of the sophomore year.
Prerequisites for advanced electives  Courses numbered 300 and above are specialized and intensive. The prerequisites for these courses include ASTR 210 or 220, multivariable calculus, and two terms of introductory college physics.

Requirements of the Major

B.A. degree program  The B.A. degree program in Astronomy is designed for students who do not plan to continue in a graduate program in astronomy, but who are interested in the subject as a basis for a liberal arts education or as a physical science background to careers such as medicine, teaching, journalism, business, law, or government. It allows greater flexibility in course selection than the B.S. program because the emphasis is on breadth of knowledge rather than on specialization.

Ten courses are required beyond the prerequisites, including either ASTR 210 or 220, ASTR 255, 310, one additional Astronomy elective numbered 150 or above, and the senior requirement (ASTR 492). Two of the ten courses must be advanced courses in mathematics, such as MATH 120 or ENAS 151, or courses in mathematical methods, including statistics or computer science, such as CPSC 112, MATH 200 or above, or ASTR 356. Three electives can be drawn from any of the natural, applied, or mathematical sciences (including additional astronomy courses); at least two of these must be advanced enough to have college-level prerequisites.

B.S. degree program  The B.S. degree program in Astrophysics is designed to provide a strong foundation in astrophysics for students interested in graduate study or a career in astronomy, physics, or a related science.

Beyond the prerequisites, twelve courses are required in astronomy, physics, and mathematics. Students complete at least six courses in astronomy, including either ASTR 210 or 220, 255, 310, 320, and a two-term senior project (ASTR 490 and 491). Students also complete three physics courses numbered 400 or above, normally PHYS 401, 402, and 439. In addition, majors choose either one additional 400-level course in physics or an astronomy elective numbered 300 or higher. In mathematics, students complete a course in differential equations selected from MATH 246, PHYS 301, or ENAS 194, and either an additional mathematics course numbered 200 or above or a course in statistics or computing such as CPSC 112, 201, or ASTR 356.

Credit/D/Fail  Courses taken Credit/D/Fail may not be counted toward the requirements of either degree program.

Senior Requirement

B.A. degree program  The senior requirement consists of a senior essay or independent research project carried out for one term in ASTR 492 under the supervision of a faculty member.

B.S. degree program  The senior requirement consists of an independent research project in astronomy carried out for two terms in ASTR 490 and 491 under the supervision of a faculty member.

Advising

Before entering the junior year, students must obtain approval of a course of study from the director of undergraduate studies (DUS).
Graduate work  Graduate courses in astronomy are open to qualified undergraduates who already have a strong preparation in mathematics, physics, and astronomy. Students wishing to take a graduate course must first obtain the permission of the instructor and of the director of graduate studies.

REQUIREMENTS OF THE MAJOR

ASTRONOMY, B.A.

Prerequisites  PHYS 170, 171, or 180, 181, or 200, 201; MATH 112, 115

Number of courses  10 courses beyond prereqs, incl senior req

Specific courses required  ASTR 210 or 220; ASTR 255, 310

Distribution of courses  1 astronomy elective numbered 150 or above; 2 advanced math courses; 3 science electives (may include addtl astronomy courses), at least 2 with college-level prereqs

Senior requirement  Senior essay or senior research project (ASTR 492)

ASTROPHYSICS, B.S.

Prerequisites  PHYS 180, 181, or 200, 201, or 260, 261; PHYS 165L, 166L, or 205L, 206L; MATH 112, 115; MATH 120 or ENAS 151

Number of courses  12 courses beyond prereqs, incl senior req

Specific courses required  ASTR 210 or 220; ASTR 255, 310, 320

Distribution of courses  3 courses in physics numbered 400 or above; 1 addtl upper-level course in astronomy or physics; 2 courses in math or mathematical methods, as specified

Substitution permitted  ASTR 155 for 1 term of physics lab prereq

Senior requirement  Senior independent research project (ASTR 490 and 491)

The Astronomy department offers courses that provide an understanding of the cosmos on a range of physical scales spanning our solar system, out to our galaxy, and well into the frontiers beyond. Course offerings are suitable for students at all levels of preparation.

For students interested in astronomy, the department offers a variety of courses without any prerequisites that focus on current knowledge and new discoveries that pertain to the structure, formation, and evolution of planets, stars, galaxies, and the universe as a whole. Courses with numbers below 150 offer a broad, nontechnical introduction to astronomy and include:

- ASTR 030, Search for Extraterrestrial Life
- ASTR 040, Expanding Ideas of Time and Space
- ASTR 110, Planets and Stars
- ASTR 120, Galaxies and the Universe
- ASTR 130, Origins and the Search for Life in the Universe
Courses numbered from 150 to 199 are topical and may assume some high school preparation in physics and/or mathematics. They include, for example, ASTR 160, Frontiers and Controversies in Astrophysics. Courses that offer an intensive introduction to modern astronomy for students who have a strong background in high school physics and mathematics include ASTR 210, Stars and Their Evolution, and ASTR 220, Galaxies and Cosmology.

FACULTY OF THE DEPARTMENT OF ASTRONOMY

Professors Hector Arce, Charles Bailyn, †Charles Baltay, Sarbani Basu (Chair), Paolo Coppi, Pierre Demarque (Emeritus), Debra Fischer, Marla Geha, Jeffrey Kenney, Richard Larson (Emeritus), Gregory Laughlin, Priyamvada Natarajan, †C. Megan Urry, William van Altena (Emeritus), Frank van den Bosch, Pieter van Dokkum, Robert Zinn

Associate Professors †Daisuke Nagai, †Nikhil Padmanabhan

Lecturer Michael Faison

†A joint appointment with primary affiliation in another department.