# Astrophysics

## Bachelor of Arts (BA)

The Department of Astronomy offers an undergraduate major and minor in Astrophysics. This program prepares students for astrophysics graduate work or other advanced degrees in related science and engineering fields. It also prepares students for careers in teaching or for working in data science, the tech industry, and other technical fields.

## Declaring the Major

Students can apply to declare the major after completing all lower division requirements (see major requirements tab). For applicants with prerequisites in progress, applications will be reviewed after the grades for all prerequisites are available. All the courses applied to the astrophysics major must be taken for a letter grade. A minimum grade point average of 2.0 is required for all prerequisites as well as for upper-division courses used for the major. If you are ready to declare or have additional questions about declaring the major, email Brianna Franklin (https://astro.berkeley.edu/people/brianna-franklin/).

## Minor Program

The Department of Astronomy offers a minor program in Astrophysics. All courses applied to the astrophysics minor must be taken for a letter grade. A minimum grade point average of 2.0 is required for the lower-division minor requirements as well as for the five upper-division courses used for the minor. Only one upper-division class may overlap between your major and the Astrophysics Minor. Students must complete the College of Letters and Science Completion of L&S Minor form (https://lsadvising.berkeley.edu/sites/default/files/minor_form_2023.pdf).

In addition to the University, campus, and college requirements, listed on the College Requirements tab, students must fulfill the below requirements specific to their major program.

## General Guidelines

- All courses taken to fulfill the major requirements below must be taken for a letter grade. Exception will be made for coursework taken from Spring 2020-Summer 2021 and Fall 2022.
- Only two upper-division courses can overlap between two majors.
- A minimum grade point average (GPA) of 2.0 must be maintained in both upper and lower division courses used to fulfill the major requirements.

For information regarding residency requirements and unit requirements, please see the College Requirements tab.

## Lower Division Major Requirements

**Required:**

| | | |
|---|---|---|
| MATH 51/1A | Calculus I (MATH 51 as of Fall 2025) | 4 |
| MATH 52/1B | Calculus II (MATH 52 as of Fall 2025) | 4 |
| MATH 53 | Multivariable Calculus | 4 |
| MATH 54 | Linear Algebra and Differential Equations [1] | 4 |
| or PHYSICS 89 | Introduction to Mathematical Physics | |
| PHYSICS 7A | Physics for Scientists and Engineers | 4 |
| or PHYSICS 5A | Introductory Mechanics and Relativity | |
| PHYSICS 7B | Physics for Scientists and Engineers | 4 |
| or PHYSICS 5B and PHYSICS 5BL | | |
| PHYSICS 7C | Physics for Scientists and Engineers | 4 |
| or PHYSICS 5C and PHYSICS 5CL | | |

**Highly Recommended:**

| | | |
|---|---|---|
| ASTRON 7A | Introduction to Astrophysics | 4 |
| ASTRON 7B | Introduction to Astrophysics | 4 |
| ASTRON 98 | Directed Group Study (Python) | 1-4 |
| or COMPSCI 61A, PHYSICS 77, PHYSICS 88 | | |

[1] If you are planning to double major with Physics, PHYSICS 89 is required

## Upper Division Major Requirements

**Required (choose one):**

| | |
|---|---|
| ASTRON 120 | Optical and Infrared Astronomy Laboratory [4] |
| ASTRON 121 | Radio Astronomy Laboratory [4] |
| ASTRON 128 | Astronomy Data Science Laboratory [4] |

**Required (choose two):**

| | |
|---|---|
| ASTRON 160 | Stellar Physics [4] |
| ASTRON C161 | Relativistic Astrophysics and Cosmology [4] |
| ASTRON C162 | Planetary Astrophysics [4] |

**Required Electives (choose at least 18 units for single majors; at least 12 units for double majors): [1]**

| | |
|---|---|
| ASTRON C180 | Order-Of-Magnitude Physics [4] |
| CHEM 104A | Advanced Inorganic Chemistry [3] |
| CHEM 104B | Advanced Inorganic Chemistry [3] |
| CHEM 105 | Instrumental Methods in Analytical Chemistry [4] |
| CHEM 108 | Inorganic Synthesis and Reactions [4] |
| CHEM 12A | Organic Chemistry [5] |
| CHEM 12B | Organic Chemistry [5] |
| CHEM 120A | Physical Chemistry [3] |
| CHEM 120B | Physical Chemistry [3] |
| CHEM 122 | Quantum Mechanics and Spectroscopy [3] |
| CHEM 125 | Physical Chemistry Laboratory [3] |
| CHEM 143 | Nuclear Chemistry [2] |
| COMPSCI 160 | User Interface Design and Development [4] |
| COMPSCI 164 | Programming Languages and Compilers [4] |
| COMPSCI 169 | Course Not Available [4] |
| COMPSCI 184 | Foundations of Computer Graphics [4] |
| COMPSCI 186 | Introduction to Database Systems [4] |
| COMPSCI 188 | Introduction to Artificial Intelligence [4] |
| COMPSCI 189 | Introduction to Machine Learning [4] |
| DATA C100 | Principles & Techniques of Data Science [4] |
| DATA C140 | Probability for Data Science [4] |
| EPS 102 | History and Evolution of Planet Earth [4] |
| EPS 108 | Geodynamics [4] |
| EPS 109 | Computer Simulations with Jupyter Notebooks [4] |
| EPS 113 | Biological Oceanography and Biogeochemistry [4] |
| EPS 117 | Geomorphology [4] |
| EPS 122 | Physics of the Earth and Planetary Interiors [3] |
| EPS 124 | Isotopic Geochemistry [4] |
| EPS C181 | Atmosphere, Ocean, and Climate Dynamics [3] |

| | |
|---|---|
| EL ENG 118 | Introduction to Optical Engineering [4] |
| EL ENG 120 | Signals and Systems [4] |
| EL ENG 126 | Probability and Random Processes [4] |
| MATH 104 | Introduction to Analysis [4] |
| MATH 110 | Abstract Linear Algebra [4] |
| MATH 113 | Introduction to Abstract Algebra [4] |
| MATH 121A | Mathematical Tools for the Physical Sciences [4] |
| MATH 121B | Mathematical Tools for the Physical Sciences [4] |
| MATH 128A | Numerical Analysis [4] |
| MATH 128B | Numerical Analysis [4] |
| MATH 160 | History of Mathematics [4] |
| MATH 185 | Introduction to Complex Analysis [4] |
| MEC ENG 106 | Fluid Mechanics [3] |
| MEC ENG C16 | Introduction to Flight Mechanics [3] |
| MEC ENG 163 | Engineering Aerodynamics [3] |
| NUC ENG 100 | Introduction to Nuclear Energy and Technology [3] |
| NUC ENG 101 | Nuclear Reactions and Radiation [4] |
| PHYSICS 105 | Analytic Mechanics [4] |
| PHYSICS 110A | Electromagnetism and Optics [4] |
| PHYSICS 110B | Electromagnetism and Optics [4] |
| PHYSICS 111A | Instrumentation Laboratory [4] |
| PHYSICS 111B | Advanced Experimentation Laboratory [1-3] |
| PHYSICS 112 | Introduction to Statistical and Thermal Physics [4] |
| PHYSICS 129 | Particle Physics [4] |
| PHYSICS 137A | Quantum Mechanics [4] |
| PHYSICS 137B | Quantum Mechanics [4] |
| PHYSICS 139 | Special Relativity and General Relativity [3] |
| PHYSICS 141A | Solid State Physics [4] |
| PHYSICS 141B | Solid State Physics [3] |
| PHYSICS 142 | Introduction to Plasma Physics [4] |
| PHYSICS 151 | Elective Physics: Special Topics [3] |
| PHYSICS 188 | Bayesian Data Analysis and Machine Learning for Physical Sciences [4] |
| STAT 134 | Concepts of Probability [4] |
| STAT 135 | Concepts of Statistics [4] |
| STAT C140 | Probability for Data Science [4] |
| STAT 153 | Introduction to Time Series [4] |
| STAT 154 | Modern Statistical Prediction and Machine Learning [4] |
| STAT 159 | Reproducible and Collaborative Statistical Data Science [4] |

[1] At least 18 units of electives for single majors to get to the 30 upper-division unit requirement. At least 12 units of electives for double majors to get to the 24 upper-division unit requirement.

Students who have a strong interest in an area of study outside their major often decide to complete a minor program. These programs have set requirements.

## General Guidelines

- All minors must be declared before the first day of classes in your Expected Graduation Term (EGT). For summer graduates, minors must be declared prior to the first day of Summer Session A.
- All upper-division courses must be taken for a letter grade.
- A minimum of three of the upper-division courses taken to fulfill the minor requirements must be completed at UC Berkeley.
- A minimum grade point average (GPA) of 2.0 is required in the upper-division courses to fulfill the minor requirements.
- No more than one upper division course may be used to simultaneously fulfill requirements for a student's major and minor programs.
- All minor requirements must be completed prior to the last day of finals during the semester in which the student plans to graduate. If students cannot finish all courses required for the minor by that time, they should see a College of Letters & Science adviser.
- All minor requirements must be completed within the unit ceiling. (For further information regarding the unit ceiling, please see the College Requirements tab.)

## Lower Division Minor Requirements

| | | |
|---|---|---|
| **Required:** | | |
| MATH 51/1A | Calculus I (MATH 51 as of Fall 2025) | 4 |
| MATH 52/1B | Calculus II (MATH 52 as of Fall 2025) | 4 |
| MATH 53 | Multivariable Calculus | 4 |
| MATH 54 | Linear Algebra and Differential Equations | 4 |
| or PHYSICS 89 | Introduction to Mathematical Physics | |
| PHYSICS 7A | Physics for Scientists and Engineers | 4 |
| or PHYSICS 5A | Introductory Mechanics and Relativity | |
| PHYSICS 7B | Physics for Scientists and Engineers | 4 |
| or PHYSICS 5B and 5BL | | |
| PHYSICS 7C | Physics for Scientists and Engineers | 4 |
| or PHYSICS 5C and 5CL | | |
| **Highly Recommended:** | | |
| ASTRON 7A | Introduction to Astrophysics | 4 |
| ASTRON 7B | Introduction to Astrophysics | 4 |
| ASTRON 98 | Directed Group Study (Python) | 1-4 |
| or COMPSCI 61A, PHYSICS 77, PHYSICS 88 | | |

## Upper Division Minor Requirements

| | |
|---|---|
| **Required (choose two):** | |
| ASTRON 120 | Optical and Infrared Astronomy Laboratory [4] |
| ASTRON 121 | Radio Astronomy Laboratory [4] |
| ASTRON 128 | Astronomy Data Science Laboratory [4] |
| ASTRON 160 | Stellar Physics [4] |
| ASTRON C161 | Relativistic Astrophysics and Cosmology [4] |
| ASTRON C162 | Planetary Astrophysics [4] |
| **Required Electives (choose three):** | |
| ASTRON C180 | Order-Of-Magnitude Physics [4] |
| CHEM 104A | Advanced Inorganic Chemistry [3] |

| | |
|---|---|
| CHEM 104B | Advanced Inorganic Chemistry [3] |
| CHEM 105 | Instrumental Methods in Analytical Chemistry [4] |
| CHEM 108 | Inorganic Synthesis and Reactions [4] |
| CHEM 12A | Organic Chemistry [5] |
| CHEM 12B | Organic Chemistry [5] |
| CHEM 120A | Physical Chemistry [3] |
| CHEM 120B | Physical Chemistry [3] |
| CHEM 122 | Quantum Mechanics and Spectroscopy [3] |
| CHEM 125 | Physical Chemistry Laboratory [3] |
| CHEM 143 | Nuclear Chemistry [2] |
| COMPSCI 160 | User Interface Design and Development [4] |
| COMPSCI 164 | Programming Languages and Compilers [4] |
| COMPSCI 169 | Course Not Available [4] |
| COMPSCI 184 | Foundations of Computer Graphics [4] |
| COMPSCI 186 | Introduction to Database Systems [4] |
| COMPSCI 188 | Introduction to Artificial Intelligence [4] |
| COMPSCI 189 | Introduction to Machine Learning [4] |
| DATA C100 | Principles & Techniques of Data Science [4] |
| DATA C140 | Probability for Data Science [4] |
| EPS 102 | History and Evolution of Planet Earth [4] |
| EPS 108 | Geodynamics [4] |
| EPS 109 | Computer Simulations with Jupyter Notebooks [4] |
| EPS 113 | Biological Oceanography and Biogeochemistry [4] |
| EPS 117 | Geomorphology [4] |
| EPS 122 | Physics of the Earth and Planetary Interiors [3] |
| EPS 124 | Isotopic Geochemistry [4] |
| EPS C181 | Atmosphere, Ocean, and Climate Dynamics [3] |
| EL ENG 118 | Introduction to Optical Engineering [4] |
| EL ENG 120 | Signals and Systems [4] |
| EL ENG 126 | Probability and Random Processes [4] |
| MATH 104 | Introduction to Analysis [4] |
| MATH 110 | Abstract Linear Algebra [4] |
| MATH 113 | Introduction to Abstract Algebra [4] |
| MATH 121A | Mathematical Tools for the Physical Sciences [4] |
| MATH 121B | Mathematical Tools for the Physical Sciences [4] |
| MATH 128A | Numerical Analysis [4] |
| MATH 128B | Numerical Analysis [4] |
| MATH 160 | History of Mathematics [4] |
| MATH 185 | Introduction to Complex Analysis [4] |
| MEC ENG 106 | Fluid Mechanics [3] |
| MEC ENG C162 | Introduction to Flight Mechanics [3] |
| MEC ENG 163 | Engineering Aerodynamics [3] |
| NUC ENG 100 | Introduction to Nuclear Energy and Technology [3] |
| NUC ENG 101 | Nuclear Reactions and Radiation [4] |
| PHYSICS 105 | Analytic Mechanics [4] |
| PHYSICS 110A | Electromagnetism and Optics [4] |
| PHYSICS 110B | Electromagnetism and Optics [4] |
| PHYSICS 111A | Instrumentation Laboratory [4] |
| PHYSICS 111B | Advanced Experimentation Laboratory [1-3] |
| PHYSICS 112 | Introduction to Statistical and Thermal Physics [4] |
| PHYSICS 129 | Particle Physics [4] |
| PHYSICS 137A | Quantum Mechanics [4] |
| PHYSICS 137B | Quantum Mechanics [4] |
| PHYSICS 139 | Special Relativity and General Relativity [3] |
| PHYSICS 141A | Solid State Physics [4] |
| PHYSICS 141B | Solid State Physics [3] |
| PHYSICS 142 | Introduction to Plasma Physics [4] |
| PHYSICS 151 | Elective Physics: Special Topics [3] |
| PHYSICS 188 | Bayesian Data Analysis and Machine Learning for Physical Sciences [4] |
| STAT 134 | Concepts of Probability [4] |
| STAT 135 | Concepts of Statistics [4] |
| STAT C140 | Probability for Data Science [4] |
| STAT 153 | Introduction to Time Series [4] |
| STAT 154 | Modern Statistical Prediction and Machine Learning [4] |
| STAT 159 | Reproducible and Collaborative Statistical Data Science [4] |

Undergraduate students must fulfill the following requirements in addition to those required by their major program.

For a detailed lists of L&S requirements, please see Overview tab to the right in this guide or visit the L&S Degree Requirements (https://lsadvising.berkeley.edu/degree-requirements/) webpage. For College advising appointments, please visit the L&S Advising (https://lsadvising.berkeley.edu/home/) Pages.

## University of California Requirements

### Entry Level Writing

All students who will enter the University of California as freshmen must demonstrate their command of the English language by fulfilling the Entry Level Writing requirement. Fulfillment of this requirement is also a prerequisite to enrollment in all reading and composition courses at UC Berkeley and must be taken for a letter grade.

### American History and American Institutions

The American History and American Institutions requirements are based on the principle that all U.S. residents who have graduated from an American university should have an understanding of the history and governmental institutions of the United States.

## Berkeley Campus Requirement

### American Cultures

All undergraduate students at Cal need to take and pass this campus requirement course in order to graduate. The requirement offers an exciting intellectual environment centered on the study of race, ethnicity and culture of the United States. AC courses are plentiful and offer students opportunities to be part of research-led, highly accomplished teaching environments, grappling with the complexity of American Culture.

## College of Letters & Science Essential Skills Requirements

### Quantitative Reasoning

The Quantitative Reasoning requirement is designed to ensure that students graduate with basic understanding and competency in math, statistics, or computer/data science. The requirement may be satisfied by exam or by taking an approved course taken for a letter grade.

### Foreign Language

The Foreign Language requirement may be satisfied by demonstrating proficiency in reading comprehension, writing, and conversation in a foreign language equivalent to the second semester college level, either by passing an exam or by completing approved course work taken for a letter grade.

### Reading and Composition

In order to provide a solid foundation in reading, writing, and critical thinking the College of Letters and Science requires two semesters of lower division work in composition in sequence. Students must complete parts A & B reading and composition courses in sequential order by the end of their fourth semester for a letter grade.

## College of Letters & Science 7 Course Breadth Requirements

### Breadth Requirements

The undergraduate breadth requirements provide Berkeley students with a rich and varied educational experience outside of their major program. As the foundation of a liberal arts education, breadth courses give students a view into the intellectual life of the University while introducing them to a multitude of perspectives and approaches to research and scholarship. Engaging students in new disciplines and with peers from other majors, the breadth experience strengthens interdisciplinary connections and context that prepares Berkeley graduates to understand and solve the complex issues of their day.

## Unit Requirements

- 120 total units
- Of the 120 units, 36 must be upper division units
- Of the 36 upper division units, 6 must be taken in courses offered outside your major department

### Residence Requirements

For units to be considered in "residence," you must be registered in courses on the Berkeley campus as a student in the College of Letters & Science. Most students automatically fulfill the residence requirement by attending classes at Cal for four years, or two years for transfer students. In general, there is no need to be concerned about this requirement, unless you graduate early, go abroad for a semester or year, or want to take courses at another institution or through UC Extension during your senior year. In these cases, you should make an appointment to meet an L&S College adviser to determine how you can meet the Senior Residence Requirement.

Note: Courses taken through UC Extension do not count toward residence.

### Senior Residence Requirement

After you become a senior (with 90 semester units earned toward your B.A. degree), you must complete at least 24 of the remaining 30 units in residence in at least two semesters. To count as residence, a semester must consist of at least 6 passed units. Intercampus Visitor, EAP, and UC Berkeley-Washington Program (UCDC) units are excluded.

You may use a Berkeley Summer Session to satisfy one semester of the Senior Residence requirement, provided that you successfully complete 6 units of course work in the Summer Session and that you have been enrolled previously in the college.

### Modified Senior Residence Requirement

Participants in the UC Education Abroad Program (EAP), Berkeley Summer Abroad, or the UC Berkeley Washington Program (UCDC) may meet a Modified Senior Residence requirement by completing 24 (excluding EAP) of their final 60 semester units in residence. At least 12 of these 24 units must be completed after you have completed 90 units.

### Upper Division Residence Requirement

You must complete in residence a minimum of 18 units of upper division courses (excluding UCEAP units), 12 of which must satisfy the requirements for your major.

Major maps are experience maps that help undergraduates plan their Berkeley journey based on intended major or field of interest. Featuring student opportunities and resources from your college and department as well as across campus, each map includes curated suggestions for planning your studies, engaging outside the classroom, and pursuing your career goals in a timeline format.

Use the major map below to explore potential paths and design your own unique undergraduate experience:

**View the Astrophysics Major Map. (https://discovery.berkeley.edu/getting-started/major-maps/astrophysics/)**

## Undergraduate Advising

Brianna Franklin (https://astro.berkeley.edu/people/brianna-franklin/) is the Department of Astronomy's undergraduate advisor. Students are encouraged to see the undergraduate advisor for information on major and minor requirements, policies, procedures, department resources, events and activities as well as certifying degrees and majors. Advising appointments can be made using Calcentral. Drop-in advising is also available.

## Undergraduate Faculty Advisor

Eugene Chiang (https://astro.berkeley.edu/people/eugene-chiang/) is the Department of Astronomy's undergraduate faculty advisor. He is a great resource for content of courses, research, and career development in the field of astrophysics. Office hours are available here (https://astro.berkeley.edu/programs/undergraduate-program/undergraduate-resources/).

## Astrophysics

## ASTRON 3 Introduction to Modern Cosmology 2 Units

Terms offered: Fall 2015, Spring 2015, Spring 2014
Description of research and results in modern extragalactic astronomy and cosmology. We read the stories of discoveries of the principles of our Universe. Simple algebra is used.
**Hours & Format**

**Fall and/or spring:** 15 weeks - 2 hours of lecture per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Bloom, Ma

## ASTRON 7A Introduction to Astrophysics 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
This is the first part of an overview of astrophysics, with an emphasis on the way in which physics is applied to astronomy. This course deals with the solar system and stars, while 7B covers galaxies and cosmology. Solar system topics include orbital mechanics, geology of terrestrial planets, planetary atmospheres, and the formation of the solar system. The study of stars will treat determination of observations, properties and stellar structure, and evolution. The physics in this course includes mechanics and gravitation; kinetic theory of gases; properties of radiation and radiative energy transport; quantum mechanics of photons, atoms, and electrons; and magnetic fields.

**Rules & Requirements**

**Prerequisites:** Math 1A -1B. Physics 5A, 5B/5BL or Physics 7A/B (5B or 7B can be taken concurrently)

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of laboratory per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Chiang, Kriek, Weisz, Dressing

## ASTRON 7AB Introduction to Astrophysics: From Planets to Cosmology 4 Units

Terms offered: Summer 2025 Second 6 Week Session, Summer 2024 Second 6 Week Session, Summer 2023 Second 6 Week Session
This course provides a broad introduction to astrophysics, with an emphasis on the way in which physics is applied to astronomy. The course will cover astrophysics at small and large scales from stars and planets to galaxies and cosmology. Topics include observational astronomy, orbital mechanics, planets, stars, the interstellar medium, degenerate objects, the Milky Way galaxy, galaxies, black holes, quasars, dark matter, the expansion of the universe, the large-scale structure of the universe, cosmology, and the Big Bang. The physics in this course includes mechanics, gravitation, kinetic theory of gases, radiation, energy transport, quantum mechanics, magnetic fields, special relativity, and general relativity.

**Rules & Requirements**

**Prerequisites:** Knowledge of introductory calculus at the level of Math 1A/1B or Math 16A/16B is strongly recommended. Knowledge of introductory mechanics and gravitation at the level of Physics 7A/5A is strongly recommended. Knowledge of introductory electricity & magnetism at the level of Physics 7B/5B is recommended

**Credit Restrictions:** Students will receive no credit for ASTRON 7AB after completing ASTRON 7A, or ASTRON 7B.

**Hours & Format**

**Summer:** 6 weeks - 8 hours of lecture and 2 hours of discussion per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Dressing

## ASTRON 7B Introduction to Astrophysics 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
This is the second part of an overview of astrophysics, which begins with 7A. This course covers the Milky Way galaxy, star formation and the interstellar medium, galaxies, black holes, quasars, dark matter, the expansion of the universe and its large-scale structure, and cosmology and the Big Bang. The physics in this course includes that used in 7A (mechanics and gravitation; kinetic theory of gases; properties of radiation and radiative energy transport; quantum mechanics of photons, atoms, and electrons; and magnetic fields) and adds the special and general theories of relativity.

**Rules & Requirements**

**Prerequisites:** Math 1A -1B. Physics 5A, 5B/5BL, 5C/5CL, or Physics 7A/B/C (5C or 7C can be taken concurrently)

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of laboratory per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Bloom, Chiang

## ASTRON 9 Selected Topics in Astronomy 3 Units

Terms offered: Summer 2025 Second 6 Week Session, Summer 2024 First 6 Week Session, Summer 2024 Second 6 Week Session
This seminar will explore one of a variety of subjects in greater depth than in introductory courses. Possible topics include stars, galaxies, the solar system, the interstellar medium, relativity and cosmology, history of astronomy, observational astronomy, and life in the universe.

**Rules & Requirements**

**Repeat rules:** Course may be repeated for credit without restriction.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3-3 hours of lecture per week

**Summer:** 6 weeks - 7.5 hours of lecture per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

## ASTRON 10 Introduction to General Astronomy 4 Units

Terms offered: Summer 2025 Second 6 Week Session, Summer 2024 Second 6 Week Session, Summer 2023 Second 6 Week Session
A description of modern astronomy with emphasis on the structure and evolution of stars, galaxies, and the Universe. Additional topics optionally discussed include quasars, pulsars, black holes, and extraterrestrial communication, etc. Individual instructor's synopses available from the department.

**Rules & Requirements**

**Credit Restrictions:** Students will receive no credit for ASTRON 10 after completing ASTRON C10, ASTRON N10, ASTRON S10, or ASTRON 10S. A deficient grade in ASTRON 10 may be removed by taking XASTRON 10, or ASTRON C10.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Summer:**
6 weeks - 8 hours of lecture and 2 hours of discussion per week
8 weeks - 6 hours of lecture and 2 hours of discussion per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Bloom

## ASTRON C10 Introduction to General Astronomy 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023, Fall 2022
A description of modern astronomy with emphasis on the structure and evolution of stars, galaxies, and the Universe. Additional topics optionally discussed include quasars, pulsars, black holes, and extraterrestrial communication, etc. Individual instructor's synopses available from the department.

**Rules & Requirements**

**Credit Restrictions:** Students will receive no credit for ASTRON C10 after completing ASTRON N10, ASTRON 10S, ASTRON 7S, or ASTRON 10.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Summer:**
6 weeks - 8 hours of lecture and 2.5 hours of discussion per week
8 weeks - 6 hours of lecture and 2 hours of discussion per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Filippenko

**Also listed as:** L & S C70U

## ASTRON N10 Introduction to General Astronomy 3 Units

Terms offered: Prior to 2007
The nature and evolution of the universe: history of astronomical knowledge; overall structure of the universe; galaxies, radio galaxies, peculiar galaxies, and quasars; structure and evolution of stars; exploding stars, pulsars, and black holes; exploration of the solar system; the search for extraterrestrial life.
**Rules & Requirements**

**Prerequisites:** High school algebra will be presumed but used sparingly

**Credit Restrictions:** Students will receive no credit for 10 after taking 7.

**Hours & Format**

**Summer:** 8 weeks - 6 hours of lecture per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

## ASTRON C12 The Planets 3 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
A tour of the mysteries and inner workings of our solar system. What are planets made of? Why do they orbit the sun the way they do? How do planets form, and what are they made of? Why do some bizarre moons have oceans, volcanoes, and ice floes? What makes the Earth hospitable for life? Is the Earth a common type of planet or some cosmic quirk? This course will introduce basic physics, chemistry, and math to understand planets, moons, rings, comets, asteroids, atmospheres, and oceans. Understanding other worlds will help us save our own planet and help us understand our place in the universe.
**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Summer:** 6 weeks - 7.5 hours of lecture and 2.5 hours of discussion per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Jeanloz, Dressing

**Also listed as:** EPS C12/L & S C70T

## ASTRON W12 The Planets 3 Units

Terms offered: Summer 2025 8 Week Session, Summer 2024 8 Week Session, Summer 2023 8 Week Session
A tour of the mysteries and inner workings of our solar system. What are planets made of? Why do they orbit the sun the way they do? How do planets form, and what are they made of? Why do some bizarre moons have oceans, volcanoes, and ice floes? What makes the Earth hospitable for life? Is the Earth a common type of planet or some cosmic quirk? This course will introduce basic physics, chemistry, and math to understand planets, moons, rings, comets, asteroids, atmospheres, and oceans. Understanding other worlds will help us save our own planet and help us understand our place in the universe. This course is web-based.
**Hours & Format**

**Summer:** 8 weeks - 6 hours of web-based lecture per week

**Online:** This is an online course.

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Militzer

**Formerly known as:** Astronomy W12/Earth and Planetary Science W12

**Also listed as:** EPS W12

## ASTRON C13 Origins: from the Big Bang to the Emergence of Humans 4 Units

Terms offered: Fall 2018, Fall 2016, Fall 2014
This course will cover our modern scientific understanding of origins, from the Big Bang to the formation of planets like Earth, evolution by natural selection, the genetic basis of evolution, and the emergence of humans. These ideas are of great intrinsic scientific importance and also have far reaching implications for other aspects of people's lives (e.g., philosophical, religious, and political). A major theme will be the scientific method and how we know what we know.
**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 2 hours of discussion per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Marshall, Quataert

**Also listed as:** INTEGBI C13

## ASTRON 24 Freshman Seminars 1 Unit

Terms offered: Fall 2015, Fall 2011, Spring 2011
The Berkeley Seminar Program has been designed to provide new students with the opportunity to explore an intellectual topic with a faculty member in a small-seminar setting. Berkeley Seminars are offered in all campus departments, and topics vary from department to department and semester to semester.

**Rules & Requirements**

**Repeat rules:** Course may be repeated for credit when topic changes.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 1 hour of seminar per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** The grading option will be decided by the instructor when the class is offered. Final exam required.

## ASTRON 39 Seminar 1.5 Unit

Terms offered: Spring 2011, Spring 2008, Spring 2007
A small-size undergraduate seminar exploring one astronomical topic in depth. Students are responsible for much of the presentation.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 2 hours of seminar per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** The grading option will be decided by the instructor when the class is offered. Final exam required.

**Instructors:** Basri, Filippenko, Davis

## ASTRON 84 Sophomore Seminar 1 or 2 Units

Terms offered: Spring 2023, Spring 2021, Spring 2020
Sophomore seminars are small interactive courses offered by faculty members in departments all across the campus. Sophomore seminars offer opportunity for close, regular intellectual contact between faculty members and students in the crucial second year. The topics vary from department to department and semester to semester. Enrollment limited to 15 sophomores.

**Rules & Requirements**

**Prerequisites:** At discretion of instructor

**Repeat rules:** Course may be repeated for credit when topic changes.

**Hours & Format**

**Fall and/or spring:**
5 weeks - 3-6 hours of seminar per week
10 weeks - 1.5-3 hours of seminar per week
15 weeks - 1-2 hours of seminar per week

**Summer:**
6 weeks - 2.5-5 hours of seminar per week
8 weeks - 1.5-3.5 hours of seminar and 2-4 hours of seminar per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** The grading option will be decided by the instructor when the class is offered. Final exam required.

## ASTRON 98 Directed Group Study 1 - 4 Units

Terms offered: Spring 2025, Fall 2024, Spring 2024
Topics will vary with instructor.

**Rules & Requirements**

**Prerequisites:** Restricted to freshmen and sophomores; consent of instructor

**Credit Restrictions:** Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

**Repeat rules:** Course may be repeated for credit when topic changes.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 1-4 hours of directed group study per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

## ASTRON 99 Directed Study in Astronomy 1 - 3 Units

Terms offered: Fall 2022, Spring 2022, Fall 2021
Supervised observational studies or directed reading for lower division students.

**Rules & Requirements**

**Prerequisites:** 7A-B, 10 and consent of instructor

**Repeat rules:** Course may be repeated for credit without restriction.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 1-3 hours of independent study per week

**Summer:** 6 weeks - 2.5-7.5 hours of independent study per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

## ASTRON 120 Optical and Infrared Astronomy Laboratory 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
This course requires four to six experiments such as the following: accurate position and brightness measurements of stars; laboratory exploration of the characteristics of two-dimensional charge-coupled devices (CCDs) and infrared detectors; measurement of the distance, reddening, and age of a star cluster; measurement of the Stokes parameters and linear polarization of diffuse synchrotron and reflection nebulae; measurement of the period and pulse shape of the Crab pulsar using Fourier techniques. Professional telescopes will be used such as those at Leuschner Observatory and Lick Observatory. There is a emphasis on error analysis, software development in the IDL language, and high-quality written reports.

**Rules & Requirements**

**Prerequisites:** Astronomy 7A-7B recommended; Mathematics 54 or Physics 89 (may be taken concurrently); Physics 7A-7B-7C (7C may be taken concurrently) or Physics 5A-5B-5C (5C may be taken concurrently)

**Hours & Format**

**Fall and/or spring:** 15 weeks - 4 hours of laboratory per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Graham, Duchene

## ASTRON 121 Radio Astronomy Laboratory 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
Several basic laboratory experiments that concentrate on microwave electronics and techniques; construction of receiving, observing, and data analysis systems for two radioastronomical telescopes, a single-dish 21-cm line system and a 12-GHz interferometer; use of these telescopes for astronomical observing projects including structure of the Milky Way galaxy, precise position measurement of several radio sources, and measurement of the radio brightness distributions of the sun and moon with high angular resolution. There is a heavy emphasis on digital data acquisition, software development in the Python language, and high-quality written reports.

**Rules & Requirements**

**Prerequisites:** Astro 7A-7B recommended; Mathematics 53; Mathematics 54 or Physics 89; Physics 7A-7B-7C or Physics 5A-5B-5C

**Hours & Format**

**Fall and/or spring:** 15 weeks - 4 hours of discussion and 1 hour of lecture per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructor:** Parsons

## ASTRON 128 Astronomy Data Science Laboratory 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
This course features 3 data-centric laboratory experiments that draw on a variety of tools used by professional astronomers. Students will learn to procure and clean data (drawn from a variety of world-class astronomical facilities), assess the fidelity/quality of data, build and apply models to describe data, learn statistical and computational techniques to analyze data (e.g., Bayesian inference, machine learning, parallel computing), and effectively communicate data and scientific results. There is a heavy emphasis on software development in the Python language, statistical techniques, and high-quality communication (e.g., written reports, oral presentations, and data visualization).

**Rules & Requirements**

**Prerequisites:** Astro 7A-7B; Mathematics 53; Mathematics 54 or Physics 89; Astro 160; Astro C161 (may be taken concurrently) and Data C8 or C100 (or equivalent level of fluency of the Python programming language)

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of laboratory per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Alternate method of final assessment during regularly scheduled final exam group (e.g., presentation, final project, etc.).

**Instructors:** Weisz, Bloom

## ASTRON 160 Stellar Physics 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
Topics covered include some, but not necessarily all, of the following. Observational constraints on the properties and evolution of stars. Theory of stellar structure and evolution. Stellar atmospheres and stellar spectroscopy. Stellar nucleosynthesis. Supernovae. Degeneracy of matter and structure of collapsed stars. Elements of gas dynamics, accretion onto compact objects, and x-ray sources. Dynamics and evolution of close binary systems. Stellar pulsation.

**Rules & Requirements**

**Prerequisites:** Astro 7A recommended; Physics 7A-7B-7C (7C may be taken concurrently) or Physics 5A-5B-5C (5C may be taken concurrently)

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Filippenko, Quataert, Lu

## ASTRON C161 Relativistic Astrophysics and Cosmology 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
Elements of general relativity. Physics of pulsars, cosmic rays, black holes. The cosmological distance scale, elementary cosmological models, properties of galaxies and quasars. The mass density and age of the universe. Evidence for dark matter and dark energy and concepts of the early universe and of galaxy formation. Reflections on astrophysics as a probe of the extrema of physics.

**Rules & Requirements**

**Prerequisites:** Astro 7B recommended; Physics 7A-7B-7C (7C may be taken concurrently) or Physics 5A-5B-5C (5C may be taken concurrently)

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Lee, Ma, Kasen

**Also listed as:** PHYSICS C161

## ASTRON C162 Planetary Astrophysics 4 Units

Terms offered: Fall 2025, Spring 2025, Spring 2024
Physics of planetary systems, both solar and extra-solar. Star and planet formation, radioactive dating, small-body dynamics and interaction of radiation with matter, tides, planetary interiors, atmospheres, and magnetospheres. High-quality oral presentations may be required in addition to problem sets and a final exam.

**Rules & Requirements**

**Prerequisites:** Mathematics 53, 54; Physics 7A-7B-7C

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

**Instructors:** Chiang, Dressing, Militzer

**Also listed as:** EPS C162

## ASTRON C180 Order-Of-Magnitude Physics 4 Units

Terms offered: Fall 2025, Fall 2024
Learn how to understand the world around you to within a factor of 10, how to solve real-life problems from physical first principles, how to make ill-posed questions well-posed, and how to sketch solutions quickly and avoid long and formal derivations. These skills build physical intuition and are crucial for all lines of work, especially research. You will learn how to guess intelligently, how to follow your hunches while guided by the laws of physics, and how to maximize understanding from just a modicum of information --- how to reason inductively and quantitatively. All of undergraduate physics --- mechanics, E&M, quantum mechanics, statistical mechanics --- will be covered in useful, memorable, and entertaining ways.

**Rules & Requirements**

**Prerequisites:** Physics 7A, 7B, 7C (or 5 equivalent) + preferably at least 1 upper-division course in the physical sciences. Suitable also for graduate students

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture and 1 hour of discussion per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required, with common exam group.

**Formerly known as:** Physics C101/Astronomy C101

**Also listed as:** PHYSICS C180

## ASTRON 190 Undergraduate Special Topics 3 Units

Terms offered: Prior to 2007
Rotating astronomy topics for undergraduate students. This course meets for three hours per week. The focus will be not only on the formal subject matter, but also on the nature of scientific inquiry itself.
**Rules & Requirements**

**Prerequisites:** Upper division standing

**Repeat rules:** Course may be repeated for credit without restriction. Students may enroll in multiple sections of this course within the same semester.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 3 hours of lecture per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam required.

## ASTRON H195 Special Study for Honors Candidates 2 - 4 Units

Terms offered: Spring 2025, Fall 2024, Spring 2024
Individual project of research or study.
**Rules & Requirements**

**Repeat rules:** Course may be repeated for credit without restriction.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 2-4 hours of independent study per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Letter grade. Final exam not required.

## ASTRON 198 Directed Group Study 1 - 4 Units

Terms offered: Spring 2022, Fall 2021, Fall 2020
Topics will vary with instructor.
**Rules & Requirements**

**Credit Restrictions:** Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

**Repeat rules:** Course may be repeated for credit without restriction.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 1-4 hours of directed group study per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.

## ASTRON 199 Supervised Independent Study and Research 1 - 4 Units

Terms offered: Spring 2025, Fall 2024, Summer 2024 8 Week Session
**Rules & Requirements**

**Credit Restrictions:** Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

**Repeat rules:** Course may be repeated for credit without restriction.

**Hours & Format**

**Fall and/or spring:** 15 weeks - 1-4 hours of independent study per week

**Summer:**
6 weeks - 1-5 hours of independent study per week
8 weeks - 1-4 hours of independent study per week

**Additional Details**

**Subject/Course Level:** Astronomy/Undergraduate

**Grading/Final exam status:** Offered for pass/not pass grade only. Final exam not required.