

# Astrophysics

## Bachelor of Arts (BA)

The Department of Astronomy offers an undergraduate major and minor in Astrophysics. This major program prepares students for astrophysics graduate work or other advanced degrees in related fields, teaching, working in the field of computer applications, scientific and technical writing, a career as a field engineer, and other technical fields.

## Declaring the Major

Information, including lists of required courses and forms to complete before declaring, is available here (<http://astro.berkeley.edu/programs/undergraduate-program/astrophysics-declaration>) .

## Honors Program

For honors in Astrophysics a student must fulfill the following additional requirements:

1. Maintain a grade point average of at least 3.5 in all courses in astronomy and related fields, and an overall grade point average of at least 3.3 in the University.
2. Carry out an individual research or study project, involving at least 3 units of ASTRON H195.

The student's project is chosen in consultation with a departmental adviser, and the written report is judged by the student's research supervisor and by a departmental adviser.

## Minor Program

Students may petition for the minor in Astrophysics only after they have completed all required courses for the minor in Astrophysics. Graduating seniors must petition no later than two weeks after the end of the term. To petition students must fill out a "Completion of L&S Minor" form available from the College of Letters & Science Advising Office in 206 Evans Hall or from the L&S Advising website (<http://ls-advise.berkeley.edu/fp/00minor.pdf>) .

Turn in to the undergraduate adviser:

1. The completed petition for the minor.
2. A copy of transcripts (unofficial transcripts are OK) showing your completed astrophysics courses.

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

1. All courses taken to fulfill the major requirements below must be taken for graded credit, other than courses listed which are offered on a *Pass/No Pass* basis only. Other exceptions to this requirement are noted as applicable.
2. No more than one upper division course may be used to simultaneously fulfill requirements for a student's major and minor programs, with the exception of minors offered outside of the College of Letters & Science.

3. 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 residence requirements and unit requirements, please see the College Requirements tab.

## Lower Division Major Requirements

MATH 1A	Calculus	4
MATH 1B	Calculus	4
MATH 53	Multivariable Calculus	4
MATH 54	Linear Algebra and Differential Equations	4
PHYSICS 7A	Physics for Scientists and Engineers	4
PHYSICS 7B	Physics for Scientists and Engineers	4
PHYSICS 7C	Physics for Scientists and Engineers	4

## Upper Division Major Requirements

### Optional:

These courses are not required but strongly recommended for anyone considering the Astrophysics major. Please consult with the Undergraduate Adviser.

ASTRON 7A	Introduction to Astrophysics
ASTRON 7B	Introduction to Astrophysics
Python/IDL DeCal	Course Not Available

### Required (choose one of the following):

ASTRON 120	Optical and Infrared Astronomy Laboratory
ASTRON 121	Radio Astronomy Laboratory

### Required (choose two of the following):

ASTRON 160	Stellar Physics
ASTRON C161	Relativistic Astrophysics and Cosmology
ASTRON C162	Planetary Astrophysics

### Required (as needed):

Upper division electives so that the total is 30 units for a single major and 24 units for a double major.

CHEM 104A	Advanced Inorganic Chemistry
CHEM 104B	Advanced Inorganic Chemistry
CHEM 105	Instrumental Methods in Analytical Chemistry
CHEM 108	Inorganic Synthesis and Reactions
CHEM 112A	Organic Chemistry
CHEM 112B	Organic Chemistry
CHEM 120A	Physical Chemistry
CHEM 120B	Physical Chemistry
CHEM 122	Quantum Mechanics and Spectroscopy
CHEM 125	Physical Chemistry Laboratory
CHEM 142	Course Not Available
EPS 108	Geodynamics
EPS 121	Course Not Available
EPS 122	Physics of the Earth and Planetary Interiors
EL ENG 150	Course Not Available
EL ENG 160	Course Not Available
EL ENG 164	Course Not Available
EL ENG 169	Course Not Available
EL ENG 184	Course Not Available

EL ENG 186	Course Not Available
EL ENG 188	Course Not Available
GEOG 146	Course Not Available
MATH 104	Introduction to Analysis
MATH 110	Linear Algebra
MATH 121A	Mathematical Tools for the Physical Sciences
MATH 121B	Mathematical Tools for the Physical Sciences
MATH 128A	Numerical Analysis
MATH 128B	Numerical Analysis
MATH 160	History of Mathematics
MATH 185	Introduction to Complex Analysis
PHYSICS 105	Analytic Mechanics
PHYSICS 110A	Electromagnetism and Optics
PHYSICS 110B	Electromagnetism and Optics
PHYSICS 111	Course Not Available
PHYSICS 112	Introduction to Statistical and Thermal Physics
PHYSICS 124	Course Not Available
PHYSICS 129A	Course Not Available
PHYSICS 129E	Course Not Available
PHYSICS 137A	Quantum Mechanics
PHYSICS 137E	Quantum Mechanics
PHYSICS 142	Introduction to Plasma Physics
PHYSICS 150	Course Not Available
STAT 101	Course Not Available
STAT 102	Course Not Available
STAT 135	Concepts of Statistics
STAT 153	Introduction to Time Series

- 1 ASTRON 7A and ASTRON 7B are recommended prerequisites for all upper division courses.
- 2 The 30 unit requirement (or 24 units for double majors with another major) is the sum of astronomy upper division courses and the electives.

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 and are noted officially on the transcript in the memoranda section, but are not noted on diplomas.

## General Guidelines

1. All courses taken to fulfill the minor requirements below must be taken for graded credit.
2. A minimum of three of the upper division courses taken to fulfill the minor requirements must be completed at UC Berkeley.
3. A minimum grade point average (GPA) of 2.0 is required for courses used to fulfill the minor requirements.
4. Courses used to fulfill the minor requirements may be applied toward the Seven-Course Breadth requirement, for Letters & Science students.
5. No more than one upper division course may be used to simultaneously fulfill requirements for a student's major and minor programs.
6. All minor requirements must be completed prior to the last day of finals during the semester in which you plan to graduate. If you

cannot finish all courses required for the minor by that time, please see a College of Letters & Science adviser.

7. 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 Major Requirements

MATH 1A	Calculus	4
MATH 1B	Calculus	4
MATH 53	Multivariable Calculus	4
MATH 54	Linear Algebra and Differential Equations	4
PHYSICS 7A	Physics for Scientists and Engineers	4
PHYSICS 7B	Physics for Scientists and Engineers	4
PHYSICS 7C	Physics for Scientists and Engineers	4

## Upper Division Major Requirements

### Optional:

The following are recommended for the minor, but are not required.

ASTRON 7A	Introduction to Astrophysics
ASTRON 7B	Introduction to Astrophysics

### Required (choose two of the following):

ASTRON 120	Optical and Infrared Astronomy Laboratory
ASTRON 121	Radio Astronomy Laboratory
ASTRON 160	Stellar Physics
ASTRON C161	Relativistic Astrophysics and Cosmology
ASTRON C162	Planetary Astrophysics

### Required (choose three of the following electives):

CHEM 104A	Advanced Inorganic Chemistry
CHEM 104B	Advanced Inorganic Chemistry
CHEM 105	Instrumental Methods in Analytical Chemistry
CHEM 108	Inorganic Synthesis and Reactions
CHEM 112A	Organic Chemistry
CHEM 112B	Organic Chemistry
CHEM 120A	Physical Chemistry
CHEM 120B	Physical Chemistry
CHEM 122	Quantum Mechanics and Spectroscopy
CHEM 125	Physical Chemistry Laboratory
CHEM 142	Course Not Available
EPS 108	Geodynamics
EPS 121	Course Not Available
EPS 122	Physics of the Earth and Planetary Interiors
EL ENG 150	Course Not Available
EL ENG 160	Course Not Available
EL ENG 164	Course Not Available
EL ENG 169	Course Not Available
EL ENG 184	Course Not Available
EL ENG 186	Course Not Available
EL ENG 188	Course Not Available
GEOG 146	Course Not Available
MATH 104	Introduction to Analysis
MATH 110	Linear Algebra
MATH 121A	Mathematical Tools for the Physical Sciences
MATH 121B	Mathematical Tools for the Physical Sciences

MATH 128A	Numerical Analysis
MATH 128B	Numerical Analysis
MATH 160	History of Mathematics
MATH 185	Introduction to Complex Analysis
PHYSICS 105	Analytic Mechanics
PHYSICS 110A	Electromagnetism and Optics
PHYSICS 110E	Electromagnetism and Optics
PHYSICS 111	Course Not Available
PHYSICS 112	Introduction to Statistical and Thermal Physics
PHYSICS 124	Course Not Available
PHYSICS 129A	Course Not Available
PHYSICS 129B	Course Not Available
PHYSICS 137A	Quantum Mechanics
PHYSICS 137B	Quantum Mechanics
PHYSICS 142	Introduction to Plasma Physics
PHYSICS 150	Course Not Available
STAT 101	Course Not Available
STAT 102	Course Not Available
STAT 135	Concepts of Statistics
STAT 153	Introduction to Time Series

Undergraduate students in the College of Letters & Science must fulfill the following requirements in addition to those required by their major program.

For detailed lists of courses that fulfill college requirements, please see the College of Letters & Sciences (<http://guide.berkeley.edu/archive/2015-16/undergraduate/colleges-schools/letters-science>) page in this Guide.

## 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.

## American History and American Institutions

The American History and Institutions requirements are based on the principle that a US resident graduated from an American university should have an understanding of the history and governmental institutions of the United States.

## American Cultures

American Cultures is the one requirement that all undergraduate students at Cal need to take and pass 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 offer students opportunities to be part of research-led, highly accomplished teaching environments, grappling with the complexity of American Culture.

## Quantitative Reasoning

The Quantitative Reasoning requirement is designed to ensure that students graduate with basic understanding and competency in math,

statistics, or computer science. The requirement may be satisfied by exam or by taking an approved course.

## 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.

## Reading and Composition

In order to provide a solid foundation in reading, writing and critical thinking the College requires two semesters of lower division work in composition. Students must complete a first-level reading and composition course by the end of their second semester and a second-level course by the end of their fourth semester.

## 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, including at least 60 L&S 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 here for four years. In general, there is no need to be concerned about this requirement, unless you go abroad for a semester or year or want to take courses at another institution or through University Extension during your senior year. In these cases, you should make an appointment to see an 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 BA 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) 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 EAP units), 12 of which must satisfy the requirements for your major.

## Undergraduate and Graduate Advising

Dexter Stewart, the Department of Astronomy's undergraduate and graduate adviser, is available to answer your questions relating to the Astrophysics major and minor, graduate degrees, and other related student matters.

Email: [dexters@berkeley.edu](mailto:dexters@berkeley.edu)

Phone: 510-642-8520

Fax: 510-642-3411

Hours:

- **Drop-in advising** is available from 1 to 4 p.m., Mondays through Fridays.
- **Appointments** are available 11 a.m. to 6 p.m., Mondays through Fridays.

## Undergraduate Faculty Adviser

Mariska Kriek (<http://astro.berkeley.edu/faculty-profile/mariska-kriek>) is the Department of Astronomy's undergraduate faculty adviser. She is available to assist with issues that arise during your time as an undergraduate student in the Astrophysics program; she is a great resource for explanations pertaining to the content of courses. Please email her to set up an appointment ([mkriek@berkeley.edu](mailto:mkriek@berkeley.edu)).

## Graduate Faculty Adviser

Eugene Chiang (<http://astro.berkeley.edu/faculty-profile/eugene-chiang>) is the Department of Astronomy's graduate faculty adviser. He is available to assist with a number of course and research matters that may arise during your graduate career; please email him to set up an appointment ([echiang@astro.berkeley.edu](mailto:echiang@astro.berkeley.edu)).

## 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 2017, Fall 2016, Fall 2015

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, 5C/5CL or PHYSICS 7A/B

**Credit Restrictions:** Students will receive 2 units of credit for Astronomy 7A after taking Astronomy 10; 6 units of credit for both Astronomy 7A-7B after taking Astronomy 10.

### 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, Quataert, Kriek

**ASTRON 7B Introduction to Astrophysics 4 Units**

Terms offered: Spring 2017, Spring 2016, Spring 2015

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 or their equivalent. PHYSICS 5A, 5B/5BL, 5C/5CL or Physics 7ABC

**Credit Restrictions:** Students will receive 2 units of credit for Astronomy 7B after taking Astronomy 10; 6 units of credit for both Astronomy 7A-7B after taking Astronomy 10.

**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, Quataert

**ASTRON 9 Selected Topics in Astronomy 3 Units**

Terms offered: Summer 2017 Second 6 Week Session, Summer 2016 10 Week Session, Summer 2016 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 when topic changes.

**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 2017 First 6 Week Session, Summer 2017 Second 6 Week Session, Spring 2017

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 Astronomy 10 after taking Astronomy 7A or 7B, XAstronomy 10. Students can remove a deficient grade in XAstronomy 10 by taking Astronomy 10, Letter and Science C70U or Astronomy 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 2.5 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:** Bloom

**ASTRON C10 Introduction to General Astronomy 4 Units**

Terms offered: Fall 2017, Fall 2016, Fall 2015

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 10 after taking 7A or 7B.

**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 2017, Spring 2016, Summer 2015 First 6 Week Session, Fall 2014

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.

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

**ASTRON W12 The Planets 3 Units**

Terms offered: Summer 2017 8 Week Session, Summer 2016 10 Week Session, Summer 2016 8 Week Session, Summer 2015 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.

**Instructors:** Marcy, Militzer

**Also listed as:** EPS W12

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

Terms offered: Fall 2017, Fall 2016, Fall 2014, Fall 2013

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 2012, Fall 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 as topic varies. 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: Fall 2017, Spring 2017, Fall 2016

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 as topic varies. 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: Fall 2017, Spring 2017, Fall 2016

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 as topic varies. 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: Summer 2017 Second 6 Week Session, Spring 2017, Summer 2016 Second 6 Week Session  
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. Course may be repeated for credit when topic changes.

**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 2017, Fall 2016, Fall 2015

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; PHYSICS 7A-7B-7C (7C may be taken concurrently)

**Hours & Format**

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

**Additional Details**

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

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

**Instructor:** Graham

**ASTRON 121 Radio Astronomy Laboratory 4 Units**

Terms offered: Spring 2017, Spring 2016, Spring 2015

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 IDL language, and high-quality written reports.

**Rules & Requirements**

**Prerequisites:** 7A-7B; Mathematics 53, 54; PHYSICS 7A-7B-7C; PHYSICS 110B recommended

**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.

**Instructors:** Heiles, Parsons

**ASTRON 160 Stellar Physics 4 Units**

Terms offered: Fall 2017, Fall 2016, Fall 2015

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:** Senior standing in astronomy/physics or consent of instructor. PHYSICS 112 (may be taken concurrently) and either PHYSICS 110A-110B or PHYSICS 137A-137B

**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, Stahler

**Formerly known as:** C160A and Physics C160A

**ASTRON C161 Relativistic Astrophysics and Cosmology 4 Units**

Terms offered: Spring 2017, Spring 2016, Spring 2015

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:** 110A-110B; 112 (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:** Boggs, Holzapfel, A. Lee, Ma, Quataert

**Also listed as:** PHYSICS C161

**ASTRON C162 Planetary Astrophysics 4 Units**

Terms offered: Fall 2017, Fall 2016, Fall 2015

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 per week

**Additional Details**

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

**Grading/Final exam status:** Letter grade. Alternative to final exam.

**Instructors:** Chiang, de Pater, Marcy

**Also listed as:** EPS C162

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

Terms offered: Fall 2017, Spring 2017, Fall 2016

Individual project of research or study.

**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: Fall 2017, Spring 2017, Fall 2016

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. 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 199 Supervised Independent Study and Research 1 - 4 Units**

Terms offered: Fall 2017, Summer 2017 8 Week Session, Summer 2017 First 6 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. Course may be repeated for credit when topic changes.

**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.