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 advisor, and the written report is judged by the student's research supervisor and by a departmental adviser.

Minor Program

The Department of Astronomy offers a minor program in Astrophysics. Students can work out the details by seeing the undergraduate major adviser in 501 Campbell Hall.

All the 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.

Once enrolled in the final course/courses to complete the Astrophysics Minor, students must complete the College of Letters and Science Completion of L&S Minor form (https://ls.berkeley.edu/sites/default/files/minor.2019.pdf).

Turn in to the Undergraduate Adviser in 501 Campbell Hall: 1) the completed petition for the minor, and 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 residency requirements and unit requirements, please see the College Requirements tab.

Lower Division Major Requirements

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>MATH 1A</td>
<td>Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 1B</td>
<td>Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 53</td>
<td>Multivariable Calculus</td>
<td>4</td>
</tr>
<tr>
<td>MATH 54</td>
<td>Linear Algebra and Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 7A</td>
<td>Physics for Scientists and Engineers</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 7B</td>
<td>Physics for Scientists and Engineers</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 7C</td>
<td>Physics for Scientists and Engineers</td>
<td>4</td>
</tr>
<tr>
<td>MATH 53</td>
<td>Linear Algebra and Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 5A</td>
<td>Introduction to Mathematical Physics</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 5B</td>
<td>Introduction to Mathematical Physics</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 5C</td>
<td>Introduction to Mathematical Physics</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 5CL</td>
<td>Introduction to Mathematical Physics</td>
<td>4</td>
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</tbody>
</table>

Optional:

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

<table>
<thead>
<tr>
<th>Course</th>
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<th>Units</th>
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</thead>
<tbody>
<tr>
<td>ASTRON 7A</td>
<td>Introduction to Astrophysics</td>
<td>4</td>
</tr>
<tr>
<td>ASTRON 7B</td>
<td>Introduction to Astrophysics</td>
<td>4</td>
</tr>
<tr>
<td>PHYSICS 88</td>
<td>Data Science Applications in Physics</td>
<td>4</td>
</tr>
<tr>
<td>COMPSCI 61A</td>
<td>Data Science Applications in Physics</td>
<td>2</td>
</tr>
<tr>
<td>PHYSICS 77</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Required (choose one of the following):

<table>
<thead>
<tr>
<th>Course</th>
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<th>Units</th>
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<tbody>
<tr>
<td>ASTRON 120</td>
<td>Optical and Infrared Astronomy Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>ASTRON 121</td>
<td>Radio Astronomy Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>ASTRON 128</td>
<td>Astronomy Data Science Laboratory</td>
<td>4</td>
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</tbody>
</table>

Required (choose two of the following):

<table>
<thead>
<tr>
<th>Course</th>
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</thead>
<tbody>
<tr>
<td>ASTRON 160</td>
<td>Stellar Physics</td>
<td>4</td>
</tr>
<tr>
<td>ASTRON 161</td>
<td>Relativistic Astrophysics and Cosmology</td>
<td>4</td>
</tr>
<tr>
<td>ASTRON 162</td>
<td>Planetary Astrophysics</td>
<td>4</td>
</tr>
</tbody>
</table>

Required (as needed):

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

<table>
<thead>
<tr>
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<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 104A</td>
<td>Advanced Inorganic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 104B</td>
<td>Advanced Inorganic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 105</td>
<td>Instrumental Methods in Analytical Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 108</td>
<td>Inorganic Synthesis and Reactions</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 12A</td>
<td>Organic Chemistry</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 12B</td>
<td>Organic Chemistry</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 120A</td>
<td>Physical Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 120B</td>
<td>Physical Chemistry</td>
<td>3</td>
</tr>
</tbody>
</table>
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 Minor Requirements

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</tr>
<tr>
<td>PHYSICS 7C</td>
<td>Physics for Scientists and Engineers</td>
<td>4</td>
</tr>
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</table>

### Upper Division Minor Requirements

#### Optional:

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

- ASTRON 7A Introduction to Astrophysics [4]
- ASTRON 7B Introduction to Astrophysics [4]

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

- 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 (choose three of the following electives):

- CHEM 104A Advanced Inorganic Chemistry [3]
- CHEM 104B Advanced Inorganic Chemistry [3]
- 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]
- EPS 122 Physics of the Earth and Planetary Interiors [3]
- EPS C181 Atmospheric Physics and Dynamics [3]
- COMPSCI 160 User Interface Design and Development [4]
American History and American Institutions (http://guide.berkeley.edu/undergraduate/colleges-schools/letters-science/american-history-institutions-requirement)

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.

Berkeley Campus Requirement

American Cultures (http://americancultures.berkeley.edu/students/courses)

All undergraduate students at Cal need to take and pass this 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 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 (http://guide.berkeley.edu/undergraduate/colleges-schools/letters-science/quantitative-reasoning-requirement)

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 (http://guide.berkeley.edu/undergraduate/colleges-schools/letters-science/foreign-language-requirement)

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 (http://guide.berkeley.edu/undergraduate/colleges-schools/letters-science/reading-composition-requirement)

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

College of Letters & Science 7 Course Breadth Requirements

Breadth Requirements (http://guide.berkeley.edu/undergraduate/colleges-schools/letters-science/breadthrequirementstext)

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 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 UC Extension during your senior year. In these cases, you should make an appointment to meet 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), 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.

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: abanayat@berkeley.edu
Phone: 510-463-1839
Fax: 510-642-3411
Hours:
• Drop-in advising is available from 2 to 3 p.m., Mondays and Tuesdays.
• Appointments are available:
  • 11 PM to 1:00 PM, Mondays and Tuesdays
  • 11 AM to 12:00 PM and 3 to 4:00 PM, Thursdays

Astrophysics

Graduate Faculty Adviser
Aaron Parsons (http://astro.berkeley.edu/faculty-profile/aaron-parsons) 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 (aparsons@astro.berkeley.edu).

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.

Undergraduate Faculty Adviser
Mariska Kriek (http://astro.berkeley.edu/faculty-profile/james-graham) 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, getting involved in research, and a career in astrophysics in general. Please email her to set up an appointment (mkriek@berkeley.edu).
ASTRON 7A Introduction to Astrophysics 4 Units
Terms offered: Fall 2019, Fall 2018, Fall 2017
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.

ASTRON 7B Introduction to Astrophysics 4 Units
Terms offered: Spring 2020, Spring 2019, Spring 2018
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: Physics 7A-7B (7B can be concurrent) or consent of the instructor

ASTRON 9 Selected Topics in Astronomy 3 Units
Terms offered: Summer 2020 First 6 Week Session, Summer 2020 Second 6 Week Session, Summer 2019 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.

Selected Topics in Astronomy: Read Less [-]
ASTRON 10 Introduction to General Astronomy 4 Units
Terms offered: Summer 2020 First 6 Week Session, Summer 2020 Second 6 Week Session, Summer 2019 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.
Introduction to General Astronomy: Read More [+]
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
Additional Details
Subject/Course Level: Astronomy/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Bloom
Introduction to General Astronomy: Read Less [-]

ASTRON C10 Introduction to General Astronomy 4 Units
Terms offered: Fall 2019, Fall 2018, Fall 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.
Introduction to General Astronomy: Read More [+]
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
Introduction to General Astronomy: Read Less [-]

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.
Introduction to General Astronomy: Read More [+]
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.
Introduction to General Astronomy: Read Less [-]
ASTRON C12 The Planets 3 Units
Terms offered: Spring 2020, Spring 2019, Spring 2018
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.
The Planets: Read More [+]

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

The Planets: Read Less [-]

ASTRON W12 The Planets 3 Units
Terms offered: Summer 2020 8 Week Session, Summer 2019 8 Week Session, Summer 2018 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.
The Planets: Read More [+]

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

The Planets: Read Less [-]

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.
Origins: from the Big Bang to the Emergence of Humans: Read More [+]

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

Origins: from the Big Bang to the Emergence of Humans: Read Less [-]

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.
Freshman Seminars: Read More [+]

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.

Freshman Seminars: Read Less [-]
ASTRON 39 Seminar 1.5 Unit
A small-size undergraduate seminar exploring one astronomical topic in depth. Students are responsible for much of the presentation.
Seminar: Read More [+]

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
Seminar: Read Less [-]

ASTRON 84 Sophomore Seminar 1 or 2 Units
Terms offered: Spring 2020, Spring 2019, Spring 2017
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.
Sophomore Seminar: Read More [+]

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.
Sophomore Seminar: Read Less [-]

ASTRON 98 Directed Group Study 1 - 4 Units
Terms offered: Spring 2020, Fall 2019, Spring 2019
Topics will vary with instructor.
Directed Group Study: Read More [+]

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.
Directed Group Study: Read Less [-]

ASTRON 99 Directed Study in Astronomy 1 - 3 Units
Terms offered: Spring 2016, Spring 2015, Fall 2014
Supervised observational studies or directed reading for lower division students.
Directed Study in Astronomy: Read More [+]

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.
Directed Study in Astronomy: Read Less [-]
ASTRON 120 Optical and Infrared Astronomy Laboratory 4 Units
Terms offered: Fall 2019, Fall 2018, Fall 2017
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.
Optical and Infrared Astronomy Laboratory: Read More [+]
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 per week
Additional Details
Subject/Course Level: Astronomy/Undergraduate
Grading/Final exam status: Letter grade. Final exam required.
Instructor: Graham
Optical and Infrared Astronomy Laboratory: Read Less [-]

ASTRON 121 Radio Astronomy Laboratory 4 Units
Terms offered: Spring 2020, Spring 2019, Spring 2018
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.
Radio Astronomy Laboratory: Read More [+]
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
Radio Astronomy Laboratory: Read Less [-]
ASTRON 128 Astronomy Data Science Laboratory 4 Units
Terms offered: Spring 2020, Spring 2019
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).

ASTRON C161 Relativistic Astrophysics and Cosmology 4 Units
Terms offered: Spring 2020, Spring 2019, Spring 2018
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.

ASTRON 160 Stellar Physics 4 Units
Terms offered: Fall 2019, Spring 2019, Spring 2018

ASTRON C162 Planetary Astrophysics 4 Units
Terms offered: Fall 2019, Fall 2018, Fall 2017
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.
ASTRON H195 Special Study for Honors Candidates 2 - 4 Units
Terms offered: Spring 2019, Spring 2018, Spring 2017
Individual project of research or study.
Special Study for Honors Candidates: Read More [+]

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 2020, Fall 2019, Spring 2019
Topics will vary with instructor.
Directed Group Study: Read More [+]

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
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.

ASTRON 199 Supervised Independent Study and Research 1 - 4 Units
Terms offered: Spring 2020, Fall 2019, Spring 2019
Supervised Independent Study and Research: Read More [+]

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.