

# ASTROPHYSICAL AND PLANETARY SCIENCES - BACHELOR OF ARTS (BA)

The APS Department is one of the few programs to combine both astrophysics and planetary science. As a result, we provide a unified view of solar and space sciences, planetary systems (our Solar System and others), stellar and galactic astronomy, and cosmology. We also offer hands-on experience with telescopes, optics, instrumentation, computer image processing and computer modeling. These skills are useful for students wishing to pursue graduate degrees or careers in aerospace, technical or computer industries.

The University of Colorado is recognized as a top university in the exploration and study of space. Our faculty members carry out forefront research in a wide range of disciplines, from theoretical cosmology to finding planets around other stars, from observing cosmic microwave background in Antarctica to building space probes to explore Mars' atmosphere. We offer many types of research opportunities for undergraduates including research-based courses, student positions that support research programs and individual research projects with faculty. Students can apply for funding from the Undergraduate Research Opportunities Program. The Honors Program (<https://www.colorado.edu/aps/undergraduate-students/honors-program/>) encourages students to write research theses to qualify for Latin Honors upon graduation.

We encourage all students to explore and share their enthusiasm for science and we support a wide range of extra-curricular activities. These include student groups, the Learning Assistant program, research activities and public outreach. The Sommers-Bausch Observatory (<http://www.colorado.edu/sbo/>) and Fiske Planetarium (<http://www.colorado.edu/fiske/>) offer opportunities for undergraduate students to become involved.

We offer students the ability to graduate with honors. Students must maintain a minimum GPA and write and defend an honors thesis. More information can be obtained from the APS department office and/or the Honors Council Representative (Ann-Marie Madigan (<https://www.colorado.edu/aps/ann-marie-madigan/>)). More general information about the honors thesis is on CU Boulder's Honors Program page (<http://www.colorado.edu/honors/>).

## Interdisciplinary Emphasis

The interdisciplinary emphasis highlights the science of astronomy, observation and technology. In this path of the major, students receive core training in astronomy, mathematics, physics and computational and instrumental technology. These skills prepare students for professions in space sciences and a range of other careers in education, science and technology. This path of the astrophysical and planetary sciences major is also designed to provide opportunities for students to explore a minor or second major in a complementary area of study. Students are mentored in groups during the first 2–3 semesters, but meet individually with an APS faculty member every semester thereafter to discuss their academic progress and post-graduation plans.

## Physics Emphasis

The physics emphasis shares the same foundational astronomy, math and physics course sequences as the interdisciplinary emphasis for the first two semesters, but then focuses on more advanced work in

these topics. Students may declare this option when beginning their coursework, or wait until completion of their foundational courses in astronomy, physics and mathematics (usually after the first two-three semesters). This option is jointly administered with the Department of Physics and requires substantial upper-division work in this field. Upon graduation, students should have solid theoretical and applied training for careers or graduate studies in the space sciences. For more detailed information, visit the department website (<https://www.colorado.edu/aps/undergraduate-students/degree-requirements/>).

## Requirements

The degree requirements are listed for the astrophysical and planetary sciences major for both the interdisciplinary emphasis and the physics emphasis. APS students will need to take the listed courses specific to their emphasis in order to complete their astrophysical and planetary sciences degree. In either emphasis, all required major courses and all required ancillary courses must be passed with a C- or better and cannot be taken pass/fail. No more than 45 credits in ASTR may be applied to overall graduation requirements. Students must have a GPA of at least 2.000 in the major in order to graduate.

## Interdisciplinary Emphasis

This is appropriate for someone aiming for a career in K–12 education, science journalism, science policy, information technology, science management or technical work who does not expect to pursue a graduate degree.

Students must complete a minimum of 32 credit hours in astrophysical and planetary sciences (this must include at least 18 upper-division credit hours) and a minimum of 9 credit hours in physics.

Through the required coursework for this path of the major, students will fulfill all 12 credits of the Natural Sciences area of the Gen. Ed. Distribution Requirement, including the lab component, and the QRMS component of the Gen. Ed. Skills Requirement. If ASTR 2000 is selected, a student could also complete the Global Perspective component of the Gen. Ed. Diversity Requirement.

For more information, view the Interdisciplinary Emphasis Flowchart (<https://www.colorado.edu/aps/node/1295/>).

## Required Courses and Credits

Code	Title	Credit Hours
<b>Required Courses</b>		
ASTR 1030 & ASTR 1040	Accelerated Introductory Astronomy 1 and Accelerated Introductory Astronomy 2 <sup>1</sup>	8
PHYS 1115 & PHYS 1125 & PHYS 1140	General Physics 1 for Majors and General Physics 2 for Majors and Experimental Physics 1 <sup>2</sup>	9
<i>Select one of the following:</i>		3
ASTR 2100	Fundamental Concepts in Astrophysics	
PHYS 2130	Introduction to Quantum Mechanics and Its Applications	
PHYS 2170	Foundations of Modern Physics	
<i>Select a minimum of two of the following:</i>		6
ASTR 2000	Ancient Astronomies of the World	

ASTR 2010	Modern Cosmology-Origin and Structure of the Universe	
ASTR 2020	Space Astronomy and Exploration	
ASTR 2030	Black Holes	
ASTR 2040	The Search for Life in the Universe	
ASTR 2050	The Sun and Society: Living with an Active Star	
ASTR 2500	Gateway to Space	
ASTR 2600	Introduction to Scientific Programming	
Select one of the following upper-division course sequences:		6
ASTR 3720 & ASTR 3750	Planets and Their Atmospheres and Planets, Moons, and Rings	
ASTR 3730 & ASTR 3830	Astrophysics 1 - Stellar and Interstellar and Astrophysics 2 - Galactic and Extragalactic	
<b>Major Electives</b>		
Select four additional courses from the following or from those sequence courses not used for the upper-division sequence requirement above:		12-15
ASTR 3400	Research Methods in Astronomy	
ASTR 3510	Observations and Instrumentation 1	
ASTR 3520	Observations and Instrumentation 2	
ASTR 3560	Astronomical Instrumentation Laboratory	
ASTR 3710	Formation & Dynamics of Planetary Systems	
ASTR 3740	Cosmology and Relativity	
ASTR 3760	Solar and Space Physics	
ASTR 3800	Introduction to Scientific Data Analysis and Computing	
ASTR 4330	Cosmochemistry	
ASTR 4800	Space Science: Practice and Policy	
ASTR 5760	Astrophysical Instrumentation	
ATOC 4710	Introduction to Atmospheric Physics	
ATOC 4720	Atmospheric Dynamics	
<b>Total Credit Hours</b>		<b>44-47</b>

<sup>1</sup> Or ASTR 1010 and ASTR 1020 with permission from Lead APS Faculty Mentor.

<sup>2</sup> Or equivalent PHYS 1110, PHYS 1120 & PHYS 1140 sequence.

### Required Ancillary Coursework

Code	Title	Credit Hours
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#### Required Ancillary Calculus Coursework

Select one of the following sequences:		8-10
APPM 1350 & APPM 1360	Calculus 1 for Engineers and Calculus 2 for Engineers	
MATH 1300 & MATH 2300	Calculus 1 and Calculus 2	

#### Required Ancillary Science Sequence with Lab

Select one other science sequence with lab, such as: <sup>2</sup>		7-10
<i>CHEM Sequence</i>		
CHEM 1113 & CHEM 1114	General Chemistry 1 and Laboratory in General Chemistry 1	

CHEM 1133 & CHEM 1134	General Chemistry 2 and Laboratory in General Chemistry 2	
<i>EBIO Sequence</i>		
EBIO 1210 & EBIO 1230	General Biology 1 and General Biology Laboratory 1	
EBIO 1220 & EBIO 1240	General Biology 2 and General Biology Laboratory 2	
<i>GEOL Sequence</i>		
GEOL 1010 & GEOL 1030	Exploring Earth and Introduction to Geology Laboratory 1	
GEOL 1020	Dodos, Dinos, and Deinococcus: The History of a Habitable Planet	
<i>ATOC Sequence</i>		
ATOC 1050 & ATOC 1070	Weather and the Atmosphere and Weather and the Atmosphere Laboratory	
ATOC 1060	Our Changing Environment: El Nino, Ozone, and Climate	

**Total Credit Hours** **15-20**

## Physics Emphasis

The physics emphasis is jointly administered by the APS and Physics Departments. Students in this path are not eligible to pursue a Physics Plan 2 (with Astrophysics focus) major or a physics minor.

For students aiming for a graduate program in astrophysics or planetary sciences. Similar to Physics Plan 2 (Astrophysics focus), with additional astrophysics instrumentation labs and different electives.

Students must complete a minimum of 23 credits in astrophysical and planetary sciences and a minimum of 28 credits in physics (this must include at least 15 upper-division credits in astronomy and 12 in physics).

Through the required coursework for this path of the major, students will fulfill all 12 credits of the Natural Sciences area of the Gen. Ed. Distribution Requirement, including the lab component, and the QRMS component of the Gen. Ed. Skills Requirement.

For more information, view the Physics Emphasis Flowchart (<https://www.colorado.edu/aps/node/1293/>).

## Required Courses and Credits

Code	Title	Credit Hours
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### Lower-Division Coursework

The following courses are required:		
ASTR 1030 & ASTR 1040	Accelerated Introductory Astronomy 1 and Accelerated Introductory Astronomy 2	8
PHYS 1115 & PHYS 1125 & PHYS 1140	General Physics 1 for Majors and General Physics 2 for Majors and Experimental Physics 1 <sup>1</sup>	9
PHYS 2170 & PHYS 2150	Foundations of Modern Physics and Experimental Physics 2	4
PHYS 2210	Classical Mechanics and Mathematical Methods 1	3

### Upper-Division Coursework

The following physics courses are required:		
PHYS 3310	Principles of Electricity and Magnetism 1	3

PHYS 3320	Principles of Electricity and Magnetism 2	3
PHYS 3210	Classical Mechanics and Mathematical Methods 2	3
PHYS 3220	Quantum Mechanics 1	3

Select one of the following two astronomy sequences (6-hour minimum): 6

ASTR 3720 & ASTR 3750	Planets and Their Atmospheres and Planets, Moons, and Rings	
ASTR 3730 & ASTR 3830	Astrophysics 1 - Stellar and Interstellar and Astrophysics 2 - Galactic and Extragalactic	

#### Astronomy Electives

Select three additional courses from the following or from those sequence courses not used above (9-hour minimum): 9

ASTR 3400	Research Methods in Astronomy	
ASTR 3510	Observations and Instrumentation 1	
ASTR 3520	Observations and Instrumentation 2	
ASTR 3560	Astronomical Instrumentation Laboratory	
ASTR 3710	Formation & Dynamics of Planetary Systems	
ASTR 3740	Cosmology and Relativity	
ASTR 3760	Solar and Space Physics	
ASTR 3800	Introduction to Scientific Data Analysis and Computing	
ASTR 4330	Cosmochemistry	
ATOC 4710	Introduction to Atmospheric Physics	
ATOC 4720	Atmospheric Dynamics	
Any ASTR 5000- or 6000-level course with instructor's permission		

**Total Credit Hours** 51

<sup>1</sup> Or equivalent PHYS 1110, PHYS 1120 & PHYS 1140 sequence.

#### Required Ancillary Calculus Coursework

Code	Title	Credit Hours
Select one of the following sequence of courses:		16-19
APPM 1350 & APPM 1360 & APPM 2350 & APPM 2360	Calculus 1 for Engineers and Calculus 2 for Engineers and Calculus 3 for Engineers and Introduction to Differential Equations with Linear Algebra	
MATH 1300 & MATH 2300 & MATH 2400 & APPM 2360	Calculus 1 and Calculus 2 and Calculus 3 and Introduction to Differential Equations with Linear Algebra	
<b>Total Credit Hours</b>		<b>16-19</b>

#### Recommended Physics Electives

Code	Title	Credit Hours
PHYS 4150	Plasma Physics	
PHYS 4230	Thermodynamics and Statistical Mechanics	
PHYS 4410	Quantum Mechanics 2	

PHYS 4420	Nuclear and Particle Physics	
PHYS 4510	Optics	

## Four-Year Plans of Study

Through the required coursework for either track in the major, students will fulfill all 12 credits of the Natural Sciences area of the Gen Ed Distribution Requirement, including the Lab requirement, and the QRMS component of the Gen Ed Skills Requirement. For more information, view the Astronomy Degree Requirements Flowchart ([https://www.colorado.edu/aps/sites/default/files/block/astronomy\\_flowchart\\_0.jpg](https://www.colorado.edu/aps/sites/default/files/block/astronomy_flowchart_0.jpg)).

## Interdisciplinary Emphasis

### Year One

Fall Semester		Credit Hours
ASTR 1030	Accelerated Introductory Astronomy 1	4
APPM 1350 or MATH 1300	Calculus 1 for Engineers or Calculus 1	4-5
PHYS 1115 or PHYS 1110	General Physics 1 for Majors or General Physics 1	4
Gen Ed Skills course/Elective/FYSM		3
<b>Credit Hours</b>		<b>15-16</b>

### Spring Semester

ASTR 1040	Accelerated Introductory Astronomy 2	4
APPM 1360 or MATH 2300	Calculus 2 for Engineers or Calculus 2	4-5
PHYS 1125 or PHYS 1120	General Physics 2 for Majors or General Physics 2	4
PHYS 1140	Experimental Physics 1	1
Gen Ed Distribution course /Elective		3
<b>Credit Hours</b>		<b>16-17</b>

### Year Two

Fall Semester		Credit Hours
ASTR 2600	Introduction to Scientific Programming	3
PHYS 2170	Foundations of Modern Physics (or an Elective)	3
PHYS 2150	Experimental Physics 2	1
APPM 2350	Calculus 3 for Engineers (or an Elective)	4
Ancillary Science Sequence + LAB (CHEM 1113 & CHEM 1114 or EBIO 1210 & EBIO 1230 or GEOL 1010 & GEOL 1030, or ATOC 1050 & ATOC 1070)		4-5
<b>Credit Hours</b>		<b>15-16</b>

### Spring Semester

ASTR 2100 or ASTR 3400	Fundamental Concepts in Astrophysics (If Phys 2170 or 2130 not taken) or Research Methods in Astronomy	3
ASTR 3800	Introduction to Scientific Data Analysis and Computing (Or Upper Division ASTR-Elective)	3
ASTR 2000-level course		3
Ancillary Science Sequence Continued (Chem 1133, EBIO 1220, GEOL 1020, or ATOC 1060)		3-4
Gen Ed Distribution/Diversity course/Elective/Minor		3
<b>Credit Hours</b>		<b>15-16</b>

**Year Three****Fall Semester**

ASTR 3720 or ASTR 3730	Planets and Their Atmospheres (part one of required sequence) or Astrophysics 1 - Stellar and Interstellar	3
ASTR Upper division or Elective/Minor		3
Gen Ed Skills course/Elective/Minor		3
Gen Ed Distribution Course		3
Elective		3
<b>Credit Hours</b>		<b>15</b>

**Spring Semester**

ASTR 3750 or ASTR 3830	Planets, Moons, and Rings (part two of required sequence) or Astrophysics 2 - Galactic and Extragalactic	3
ASTR Upper-Division Elective		3
Upper Division Elective/Minor		3
Gen Ed Distribution course		3
Gen Ed Distribution course		3
<b>Credit Hours</b>		<b>15</b>

**Year Four****Fall Semester**

ASTR Upper-division Elective		3
ASTR Upper-Division Elective		3
Gen Ed Distribution course - Upper Division		3
Upper-Division Elective / Minor/ Research/ Independent Study (Independent Study does not count for Upper Division ASTR credit)		3
Upper-Division Elective / Minor		3
<b>Credit Hours</b>		<b>15</b>

**Spring Semester**

ASTR Upper-Division Elective		3
Gen Ed Distribution course- Upper-division		3
Upper-Division Elective / Minor/ Research/ Independent Study (Independent Study does not count for Upper Division ASTR credit)		3
Upper-Division Elective / Minor		3
Upper-Division Elective / Minor		3
<b>Credit Hours</b>		<b>15</b>
<b>Total Credit Hours</b>		<b>121-125</b>

**Physics Emphasis****Year One****Fall Semester**

ASTR 1030	Accelerated Introductory Astronomy 1	4
PHYS 1115	General Physics 1 for Majors	4
APPM 1350 or MATH 1300	Calculus 1 for Engineers or Calculus 1	4-5
Gen Ed Skills course / FYSM		3
<b>Credit Hours</b>		<b>15-16</b>

**Spring Semester**

ASTR 1040	Accelerated Introductory Astronomy 2	4
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APPM 1360 or MATH 2300	Calculus 2 for Engineers or Calculus 2	4-5
PHYS 1125	General Physics 2 for Majors	4
PHYS 1140	Experimental Physics 1	1
Gen Ed Distribution/Diversity course		3
<b>Credit Hours</b>		<b>16-17</b>

**Year Two****Fall Semester**

APPM 2350	Calculus 3 for Engineers	4
PHYS 2170	Foundations of Modern Physics	3
PHYS 2150	Experimental Physics 2	1
Gen Ed Distribution course (example: Social Sciences)		3
Elective		3
<b>Credit Hours</b>		<b>14</b>

**Spring Semester**

PHYS 2210	Classical Mechanics and Mathematical Methods 1	3
ASTR 2600	Introduction to Scientific Programming (recommended, not required)	3
APPM 2360	Introduction to Differential Equations with Linear Algebra	4
Gen Ed Distribution/Diversity course (example: Social Sciences/US Perspective)		3
Elective		3
<b>Credit Hours</b>		<b>16</b>

**Year Three****Fall Semester**

ASTR 3730 or ASTR 3710	Astrophysics 1 - Stellar and Interstellar (part one of required sequence) or Formation & Dynamics of Planetary Systems	3
ASTR 3400	Research Methods in Astronomy (Or Upper Division ASTR-Elective)	3
PHYS 3210	Classical Mechanics and Mathematical Methods 2	3
PHYS 3310	Principles of Electricity and Magnetism 1	3
Gen Ed Distribution course		3
<b>Credit Hours</b>		<b>15</b>

**Spring Semester**

ASTR 3830 or ASTR 3720	Astrophysics 2 - Galactic and Extragalactic (part two of required sequence) or Planets and Their Atmospheres	3
PHYS 3220	Quantum Mechanics 1	3
PHYS 3320	Principles of Electricity and Magnetism 2	3
Gen Ed Skills Course (Upper Division Writing)		3
Gen Ed Upper Division course / Elective		3
<b>Credit Hours</b>		<b>15</b>

**Year Four****Fall Semester**

ASTR Upper-division Elective		3
PHYS 4230	Thermodynamics and Statistical Mechanics (recommended, not required)	3
Gen Ed Course or Upper Division Elective		3

Upper-Division Elective or ASTR Independent Study or Research (would not count for ASTR Upper Division Credit)	3
Upper-Division Elective or ASTR Upper-Division Elective	3
<b>Credit Hours</b>	<b>15</b>
<b>Spring Semester</b>	
PHYS 4410 Quantum Mechanics 2 (recommended, not required)	3
ASTR Upper-division Elective or ASTR Independent Study or Research (would not count for ASTR Upper Division Credit)	3
ASTR Upper-division Elective	3
Upper-Division Elective	3
Gen Ed Distribution course	3
<b>Credit Hours</b>	<b>15</b>
<b>Total Credit Hours</b>	<b>121-123</b>