Astrophysical & Planetary Sciences
UNIVERSITY OF COLORADO **BOULDER**

# Astrophysical and Planetary Sciences (APS) Undergraduate Program

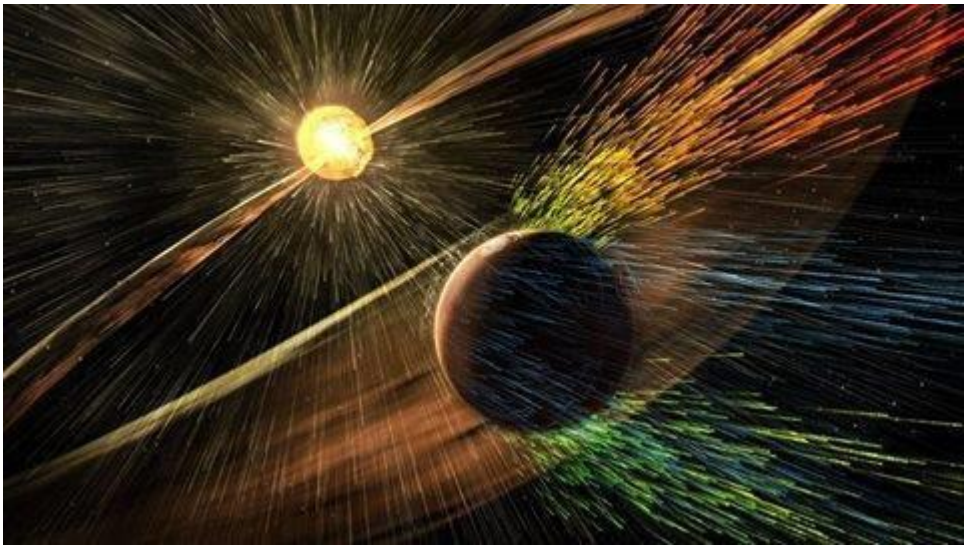

*Image courtesy of Prof. Dave Brain*

## Academic Year 2024-2025


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**Associate Chair for Undergraduate Education**
**Dr. Ann-Marie Madigan**
**JILA A-903**
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Check out our website: http://www.colorado.edu/aps/

# COLLEGE OF ARTS AND SCIENCES

Candidates for the Bachelor of Arts degree in the College of Arts and Sciences must satisfy the General Requirements of the College. These General Requirements are outlined in the University of Colorado Catalog (Boulder) and are given in detail in pamphlet's available from the College of Arts and Sciences
https://catalog.colorado.edu/undergraduate/collegesschools/arts-sciences/

Please note: Students may count a maximum of 45 credit hours in any one department (major) towards the 120 hours required; students in departmental honors may add up to 6 additional hours designated honors coursework to the 45-hour limit. For all major courses, as well as the ancillary courses, students must receive a "C-" or better. If a course is a pre-requisite for another course, the student may not register for the subsequent course until the grade in the pre-requisite is "C-" or better.

## Academic Advising

**APS First-Year Advisor:**
**Gretchen Lang**
Office: University Club #211 Phone:
303-735-7571
Gretchen.Lang@colorado.edu
http://www.colorado.edu/mycuhub/

**APS Undergraduate Advisors:**
**Kim Noice**
Office: U-Club 205
Phone: 303-4735-5626
Kim.Noice@colorado.edu http://www.colorado.edu/mycuhub/

**Erin Wood**
Office: Duane F211
Phone: 303-492-8806 erin.wood@colorado.edu
http://www.colorado.edu/mycuhub/

It is strongly recommended that students meet annually with their APS advisor.

We are all here to help you succeed! It is necessary to make sure that all requirements for the degree will be met in time for your graduation.

# Department of Astrophysical and Planetary Sciences
# Undergraduate Mentor Program

**Our department offers a mentoring program that is complementary to academic advising. Your mentor will help you make the most of your education in our department, with information about opportunities outside of your classes and advice on how to prepare for your future.**

**Group Mentoring:** In your first semester, you will attend one Group Mentoring session to learn about the department and receive direction on foundational coursework and other opportunities within our department. These sessions are co-led by an APS Faculty Member and Academic Advisor

**Faculty Mentoring:** Once you have 5 (or fewer) semesters left, you will be assigned to a faculty mentor according to your interests. Your mentor will meet with you at least once each semester to review astronomy-related activities (including research and educational opportunities), and help position you for your career after CU.

*You will have an "academic hold" on your ability to register for classes in the CU-SIS system (Student Registration System) each semester until you complete the mentoring.*

## For more information, please contact APS Lead Mentor:

**Dr. Zach Berta-Thompson**
**Office:** Duane D213
**Phone:** (303) 735-6821
zach.bertathompson@colorado.edu

# APS Undergraduate Major Program

**The APS department** offers an undergraduate Astrophysical and Planetary Sciences (APS) major program, culminating in a B.A. degree. 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. We also offer you the ability to graduate with honors. This requires you maintain a minimum 3.3 GPA, and that you write and defend an honors thesis. More information can be obtained from the APS website and CU-Boulder's Honors Program page (http://www.colorado.edu/honors), or the APS Honors Council Representative.

**APS Major:** Highlights the science of astronomy, observation, and technology. As an APS 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. The APS major is also designed to provide opportunities for students to explore a minor or second major in a complementary area of study.

After the first year, students who intend to continue to graduate school, research, or a career in a technical field, may choose to add the *Physics Emphasis*.

**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. The track 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.

# INTERDISCIPLINARY EMPHASIS

This is appropriate for someone aiming at a career in education, science journalism, science policy, information technology, science management or technical work that does not require a graduate degree.

**Part A: Lower division coursework (41 credit hour minimum)**

1. MATH 1300/2300 Calculus I, II
2. **Note:** MATH 2400 (Calculus III for Engineers) is not required for the APS major **(however we highly recommend it).**

   *OR*

   APPM 1350/1360 Calc. I for Engineers, Calc. II for Engineers (8)
   **Note:** APPM 2350 (Calculus III for Engineers) is not required for the APS major **(however we highly recommend it).**

3. PHYS 1115/1125/1140 preferred (or 1110/1120/1140 accepted) General Physics (9)
   ASTR 1030/1040 Accelerated Introductory Astronomy sequence (8)
4. One of the following courses:
   - PHYS 2130 General Physics 3 (3) [requires Calculus III]
   - PHYS 2170 Foundations of Modern Physics (3) [requires Calculus III] should be taken with PHYS 2150
   - ASTR 2100 Fundamental Concepts in Astrophysics (3)
5. Minimum of two (2) additional courses selected from:
   - ASTR 2000 Ancient Astronomies (3)
   - ASTR 2010 Modern Cosmology (3)
   - ASTR 2020 Intro to Space Astronomy (3)
   - ASTR 2030 Black Holes (3)
   - ASTR 2040 Life in the Universe (3)
   - ASTR 2050 The Sun and Society (3)
   - ASTR 2500 Gateway to Space (3)
   - ASTR 2600 Computational Techniques (3) **(highly recommended for research experience)**
6. One other Arts and Sciences lower division Natural Sciences sequence, including lab.
   - CHEM 1113/1114 and CHEM 1133/1134 (10)
   - EBIO 1210/1220/1230 (7)
   - GEOL 1010/1020/1030 (7)
   - ATOC 1050/1060/1070 (7)

**Part B: Upper Division Coursework**

One of the following upper-level course sequences:

**Planetary Sequence (6)**

- ASTR 3720 Planets & Their Atmospheres (3)
- ASTR 3750 Planets, Moons & Rings (3)

OR

**Stellar/Galactic Sequence (6)**

- ASTR 3730 Stellar & Interstellar (3)
- ASTR 3830 Galactic & Extragalactic (3)

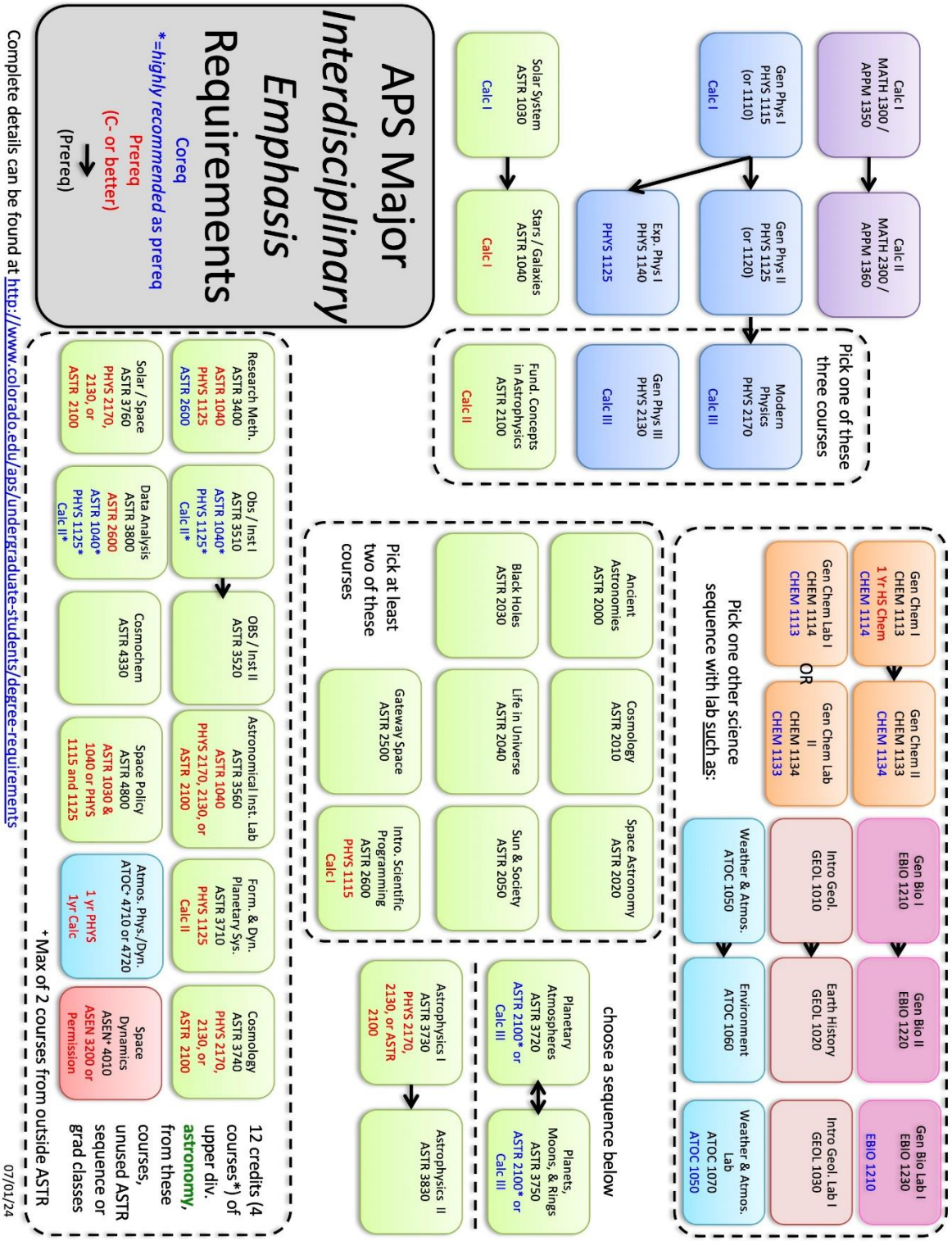
Plus four additional courses from the following or from those sequence courses not used above (12 hrs. minimum, no more than two courses from outside ASTR):

- ASTR 3400 Research Methods in Astronomy (3)
- ASTR 3510 Observations and Instrumentation 1 (4)
- ASTR 3520 Observations and Instrumentation 2 (4)
- ASTR 3560 Astronomical Instrumentation Lab (3)
- ASTR 3710 Formation & Dynamics of Planetary Systems (3)
- ASTR 3740 Cosmology & Relativity (3)
- ASTR 3760 Solar & Space Physics (3)
- ASTR 3800 Scientific Data Analysis & Computing (3) [Requires Calculus III]
- ASEN 4010 Introduction to Space Dynamics (3)
- ASTR 4330 Cosmochemistry (3)
- ATOC 4710 Introduction to Atmospheric Physics (3)
- ATOC 4720 Introduction to Atmospheric Dynamics (3)
- ASTR 4800 Space Practice and Policy (3)
- Any ASTR 5000 or 6000 level course with Instructor's permission

**Total Credit Hours:**

44 minimum in ASTR and PHYS combined

*Substitutions can be requested by submitting a petition to the APS Lead Mentor*
https://www.colorado.edu/aps/undergraduate-students/degree-requirements


APS Major
Interdisciplinary
Emphasis
Requirements
Coreq
*=highly recommended as prereq
Prereq
(C- or better)
(Prereq)
Calc I
MATH 1300 /
APPM 1350
Calc II
MATH 2300 /
APPM 1360
Gen Phys I
PHYS 1115
(or 1110)
Calc I
Gen Phys II
PHYS 1125
(or 1120)
Exp. Phys I
PHYS 1140
PHYS 1125
Gen Phys III
PHYS 2130
Calc III
Solar System
ASTR 1030
Stars / Galaxies
ASTR 1040
Calc I
Fund. Concepts
in Astrophysics
ASTR 2100
Calc II
Pick one of these
three courses
Modern
Physics
PHYS 2170
Calc III
Gen Chem I
CHEM 1113
1 Yr HS Chem
CHEM 1114
Gen Chem II
CHEM 1133
CHEM 1134
Gen Chem Lab I
CHEM 1114
CHEM 1113
OR
Gen Chem Lab
II
CHEM 1134
CHEM 1133
Gen Bio I
EBIO 1210
Gen Bio II
EBIO 1220
Gen Bio Lab I
EBIO 1230
EBIO 1210
Intro Geol.
GEOL 1010
Earth History
GEOL 1020
Intro Geol. Lab I
GEOL 1030
Weather & Atmos.
ATOC 1050
Environment
ATOC 1060
Weather & Atmos.
Lab
ATOC 1070
ATOC 1050
Pick one other science
sequence with lab such as:
Ancient
Astronomies
ASTR 2000
Space Astronomy
ASTR 2020
Cosmology
ASTR 2010
Black Holes
ASTR 2030
Life in Universe
ASTR 2040
Sun & Society
ASTR 2050
Gateway Space
ASTR 2500
Intro. Scientific
Programming
ASTR 2600
PHYS 1115
Calc I
Pick at least
two of these
courses
choose a sequence below
Planetary
Atmospheres
ASTR 3720
ASTR 2100* or
Calc III
Planets,
Moons, & Rings
ASTR 3750
ASTR 2100* or
Calc III
Astrophysics I
ASTR 3730
PHYS 2170,
2130, or ASTR
2100
Astrophysics II
ASTR 3830
Research Meth.
ASTR 3400
ASTR 1040
PHYS 1125
ASTR 2600
Obs / Inst I
ASTR 3510
ASTR 1040*
PHYS 1125*
Calc II*
OBS / Inst II
ASTR 3520
Astronomical Inst. Lab
ASTR 3560
ASTR 1040
PHYS 2170, 2130, or
ASTR 2100
Form. & Dyn.
Planetary Sys.
ASTR 3710
PHYS 1125
Calc II
Cosmology
ASTR 3740
PHYS 2170,
2130, or
ASTR 2100
Solar / Space
ASTR 3760
PHYS 2170,
2130, or
ASTR 2100
Data Analysis
ASTR 3800
ASTR 2600
ASTR 1040*
PHYS 1125*
Calc II*
Cosmochem
ASTR 4330
Space Policy
ASTR 4800
ASTR 1030 &
1040 or PHYS
1115 and 1125
Atmos. Phys./Dyn.
ATOC* 4710 or 4720
1 yr PHYS
1yr Calc
Space
Dynamics
ASEN* 4010
ASEN 3200 or
Permission
12 credits (4
courses*) of
upper div.
astronomy,
from these
courses,
unused ASTR
sequence or
grad classes
*Max of 2 courses from outside ASTR
Complete details can be found at http://www.colorado.edu/aps/undergraduate-students/degree-requirements
07/01/24

# INTERDISCIPLINARY EMPHASIS

## *Sample Course Selections*

### Freshman Year

| FALL | SPRING |
|---|---|
| ASTR I 030 (4) Accelerated Intro Astronomy I | ASTR 1040 (4) Accelerated Intro Astronomy II |
| MATH 1300 (5) Calculus I<br>*(Or APPM 1350 Calculus I for Engineers)* | MATH 2300 (5) Calculus II<br>*(Or APPM 1360 Calculus II for Engineers)* |
| *or* General Education Requirements/Maps (3) | General Education Requirements/Maps (3) |
| General Education Requirements/Maps (3) | Minor (3) |
| **Total: 15** | **Total: 15** |

### Sophomore Year

| | |
|---|---|
| ASTR 2000-Level Elective (3) | ASTR 2600 (3) Intro to Scientific Programming |
| MATH 2400 (4) Calculus III *(Or APPM 2350 Calculus III for Engineers)* † | PHYS 1125 (4) General Physics 2 |
| PHYS 1115 (4) General Physics I | PHYS 1140 (1) Experimental Physics I (Lab) |
| General Education Requirements/Maps (3) | ASTR 2000-Level Elective (3) |
| | General Education Requirements/Maps (3) |
| **Total: 14** | **Total: 14** |

### Junior Year

| | |
|---|---|
| ASTR 3730 (3) Astrophysics I *or* ASTR 3750 (3) Planets, Moons, and Rings | ASTR 3830 (3) Astrophysics II *or* ASTR 3720 (3) Planets and their Atmospheres |
| Natural Science Sequence with lab part one (4)* General | Natural Science Sequence with lab part two (4)* |
| PHYS 2130 (3) General Physics III† | General Education Requirements/Maps (3) |
| ASTR 3800 (3) Intro. Scientific Data Analysis & Computing or other Upper-Division Astronomy Elective | General Education Requirements/Maps (3) |
| General Education Requirements/Maps (3) | Minor (3) |
| **Total: 16** | **Total: 16** |

### Senior Year

| | |
|---|---|
| ASTR (3) Upper-Division Astronomy Elective | ASTR (3) Upper-Division Astronomy Elective |
| ASTR (3) Upper-Division Astronomy Elective | General Education Requirements/Maps (3) |
| Elective General Education Requirements/Maps (3) | Minor (3) |
| Minor (3) | Minor (3) |
| Minor (3) | Minor (3) |
| **Total: 15** | **Total: 15** |

* Any natural science sequence with lab, e.g. geology, biology, chemistry, atmospheric sciences.

† Recommended for major, not required.

TOTAL:

Lower Division: 17 Credit Hours in ASTR, 12 Credit Hours in PHYS Upper Division: 18 Credit Hours in ASTR
Required coursework in other Depts: 18 Credit Hours
Elective Credits: 24 Credit Hours
Arts and Sciences Core Courses: 27 Credit Hours; A&S Core curriculum satisfied University Total: 120 Credit Hours; General graduation requirements satisfied.

# PHYSICS EMPHASIS

## (Supervised by both APS and Physics Departments)

This is appropriate for someone intending to continue on to a graduate program or professional research in astrophysics or planetary sciences. It is similar to the Physics Plan 2 (Astrophysics) degree, but with additional labs in astrophysics instrumentation, and with different electives.

**Part A: Lower Division Coursework (40 credit hour minimum)**

1. Pre- or Co-Requisite Mathematics (16 hours minimum):
    - MATH 1300/2300/2400/2130/3430 Calculus I, II, III, Linear Algebra, Differential Equations (20)
      *OR*
    - APPM 1350/1360/2350/2360 Calc. I for Engineers, Calc. II for Engineers, Calc. III for Engineers, Linear Algebra/Differential Equations for Engineers (16)
2. Lower Division Physics (16 hours):
    - PHYS 1115/1125/1140 preferred (or 1110/1120/1140 accepted) General Physics (9)
    - PHYS 2170 Foundations of Modern Physics (3)
    - PHYS 2150 Experimental Physics (1) [Taken with PHYS 2170]
    - PHYS 2210 Classical Mechanics and Math Methods 1 (3)
3. Lower Division ASTR (8 hours):
    - ASTR 1030/1040 Accelerated Introductory Astronomy (4 + 4)

**Part B: Upper Division Coursework (27 credit hour minimum)**

1. Advanced Physics (12 hours):
    - PHYS 3310 Electricity & Magnetism 1 (3)
    - PHYS 3320 Electricity & Magnetism 2 (3)
    - PHYS 3210 Classical Mechanics and Math Methods 2 (3)
    - PHYS 3220 Quantum Mechanics & Atomic Physics 1 (3)

   We suggest (optional) electives from the following:
    - PHYS 4150 Plasma Physics (3)
    - PHYS 4230 Thermodynamics & Statistical Mechanics (3)
    - PHYS 4410 Quantum Mechanics & Atomic Physics 2 (3)
    - PHYS 4420 Nuclear & Particle Physics (3)
    - PHYS 4510 Optics (3)

2. Advanced ASTR, one of the following two sequences (6 hours):
    - ASTR 3720/3750 Planetary sequence (3+3)
    - ASTR 3730/3830 Stellar and Galactic Astronomy (3+3)

Plus three additional courses from the following or from those sequence courses not used above (9 hours minimum, no more than two courses outside of ASTR):

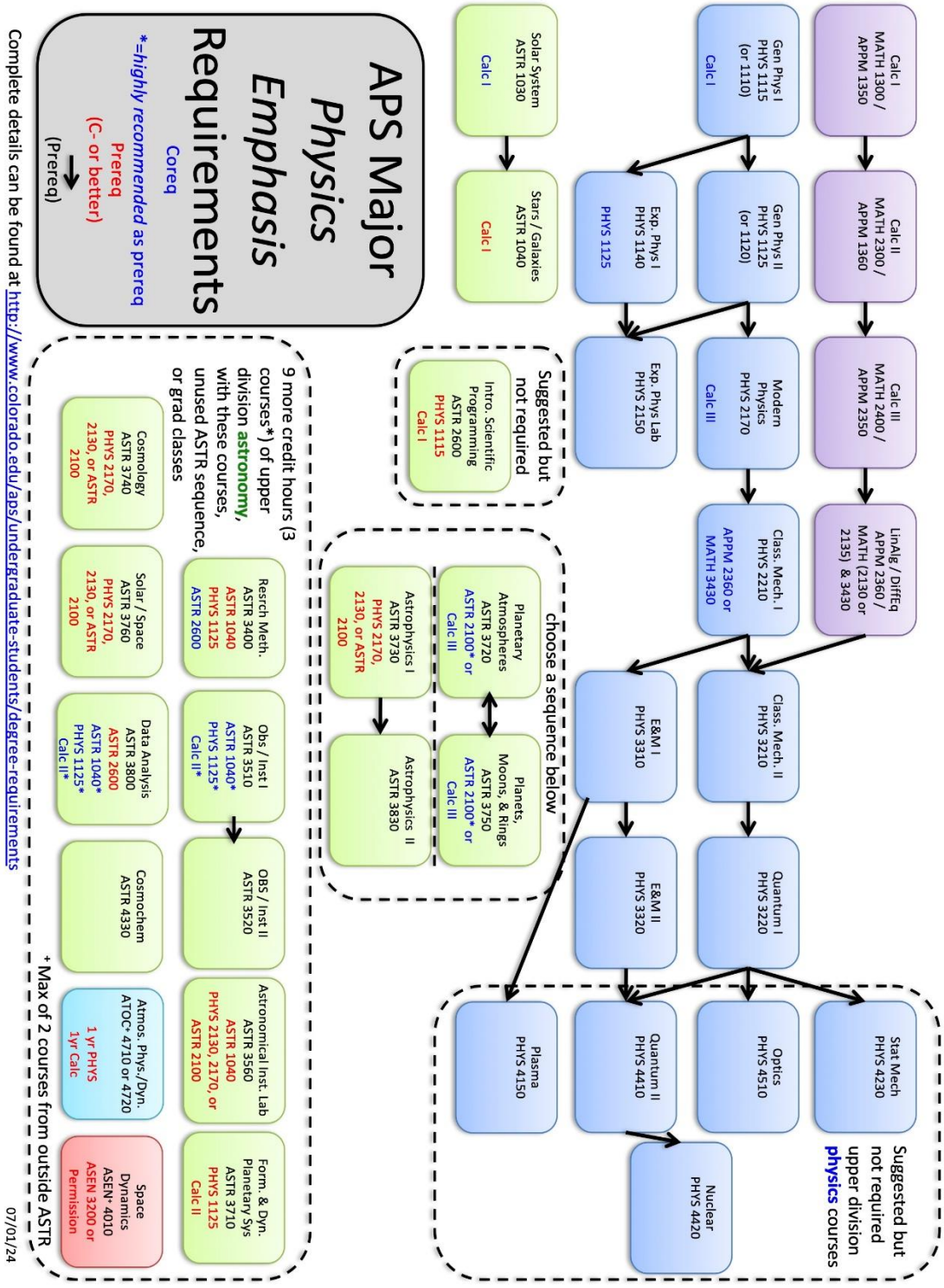
- ASTR 3400 Research Methods in Astronomy (3)
- ASTR 3510 Observations and Instrumentation 1 (4)
- ASTR 3520 Observations and Instrumentation 2 (4)
- ASTR 3560 Astronomical Instrumentation Laboratory (3)
- ASTR 3710 Formation & Dynamics of Planetary Systems (3)
- ASTR 3740 Cosmology & Relativity (3)
- ASTR 3760 Solar & Space Physics (3)
- ASTR 3800 Scientific Data Analysis & Computing (3) [Requires Calculus III]
- ASTR 4330 Cosmochemistry (3)
- ATOC 4710 Introduction to Atmospheric Physics (3)
- ATOC 4720 Introduction to Atmospheric Dynamics (3)
- ASEN 4010 Introduction to Space Dynamics (3)
- Any ASTR 5000 or 6000 level course with Instructor's permission

**Total Credit Hours:**

23 minimum in ASTR, including 15 hrs upper division PLUS

28 minimum in PHYS, including 12 hrs upper division

*Substitutions can be requested by submitting a petition to the APS Lead Mentor*
*http://www.colorado.edu/aps/course-substitution-petition*


APS Major
Physics
Emphasis
Requirements
Coreq
*=highly recommended as prereq
Prereq
(C- or better)
(Prereq)
Calc I
MATH 1300 /
APPM 1350
Calc II
MATH 2300 /
APPM 1360
Calc III
MATH 2400 /
APPM 2350
LinAlg / DiffEq
APPM 2360 /
MATH (2130 or
2135) & 3430
Gen Phys I
PHYS 1115
(or 1110)
Calc I
Gen Phys II
PHYS 1125
(or 1120)
Modern
Physics
PHYS 2170
Calc III
Class. Mech. I
PHYS 2210
APPM 2360 or
MATH 3430
Exp. Phys I
PHYS 1140
PHYS 1125
Exp. Phys Lab
PHYS 2150
E&M I
PHYS 3310
Class. Mech. II
PHYS 3210
Quantum I
PHYS 3220
E&M II
PHYS 3320
Solar System
ASTR 1030
Calc I
Stars / Galaxies
ASTR 1040
Calc I
Suggested but
not required
Intro. Scientific
Programming
ASTR 2600
PHYS 1115
Calc I
choose a sequence below
Planetary
Atmospheres
ASTR 3720
ASTR 2100* or
Calc III
Planets,
Moons, & Rings
ASTR 3750
ASTR 2100* or
Calc III
Astrophysics I
ASTR 3730
PHYS 2170,
2130, or ASTR
2100
Astrophysics II
ASTR 3830
Suggested but
not required
upper division
physics courses
Stat Mech
PHYS 4230
Optics
PHYS 4510
Quantum II
PHYS 4410
Nuclear
PHYS 4420
Plasma
PHYS 4150
9 more credit hours (3
courses*) of upper
division astronomy,
with these courses,
unused ASTR sequence,
or grad classes
Resrch Meth.
ASTR 3400
ASTR 1040
PHYS 1125
ASTR 2600
Obs / Inst I
ASTR 3510
ASTR 1040*
PHYS 1125*
Calc II*
OBS / Inst II
ASTR 3520
Astronomical Inst. Lab
ASTR 3560
ASTR 1040
PHYS 2130, 2170, or
ASTR 2100
Form. & Dyn.
Planetary Sys
ASTR 3710
PHYS 1125
Calc II
Cosmology
ASTR 3740
PHYS 2170,
2130, or ASTR
2100
Solar / Space
ASTR 3760
PHYS 2170,
2130, or ASTR
2100
Data Analysis
ASTR 3800
ASTR 2600
ASTR 1040*
PHYS 1125*
Calc II*
Cosmochem
ASTR 4330
Atmos. Phys./Dyn.
ATOC* 4710 or 4720
1 yr PHYS
1yr Calc
Space
Dynamics
ASEN* 4010
ASEN 3200 or
Permission
+ Max of 2 courses from outside ASTR
Complete details can be found at http://www.colorado.edu/aps/undergraduate-students/degree-requirements
07/01/24

# PHYSICS EMPHASIS

## *Sample Course Selections*

### Freshman Year

| FALL | SPRING |
|---|---|
| ASTR 1030 (4) Accelerated Intro Astronomy I | ASTR 1040 (4) Accelerated Intro Astronomy II |
| PHYS 1115 (4) General Physics I | PHYS 1125 (4) General Physics II |
| MATH 1300 (5) Calculus I<br>*(Or APPM 1350 (4) Calculus I for Engineers)* | MATH 2300 (5) Calculus II<br>*(Or APPM 1360 (4) Calculus II for Engineers)* |
| General Education Requirements/Maps (3) | PHYS 1140 (1) Experimental Physics I (lab) |
| **Total: 16** | **Total: 14** |

### Sophomore Year

| | |
|---|---|
| PHYS 2170 (3) Foundations of Modem Physics | PHYS 2210 (3) Classical Mechanics and Math Methods I |
| PHYS 2150 (1) Experimental Physics (lab) | ASTR 2600 (3) Intro to Scientific Programming † |
| MATH 2400 (4) Calculus III *(Or APPM 2350 (4) Calculus III for Engineers and MATH 2130 (3) Intro to Linear Algebra* | APPM 2360 (4) Introduction to Differential Equations with Linear Algebra *(or MATH 3430 Ordinary Differential Equations and 2130 Linear Algebra)* |
| General Education Requirements/Maps (3) | General Education Requirements/Maps (3) |
| General Education Requirements/Maps (3) | General Education Requirements/Maps (3) |
| **Total: 14** | **Total: 16** |

### Junior Year

| | |
|---|---|
| ASTR 3730 (3) Astrophysics I **or** ASTR 3750 (3) Planets, Moons, and Rings | ASTR 3830 (3) Astrophysics II **or** ASTR 3720 (3) Planets and their Atmospheres |
| PHYS 3210 (3) Classical Mechanics and Math Methods II | PHYS 3220 (3) Quantum Mechanics and Atomic Physics I |
| PHYS 331 0 (3) Principles of Electricity and Magnetism I | PHYS 3320 (3) Principles of Electricity and Magnetism II |
| ASTR Upper Division Elective (3) | General Education Requirements/Maps (3) |
| General Education Requirements/Maps (3) | General Education Requirements/Maps (3) |
| **Total: 15** | **Total: 15** |

### Senior Year

| | |
|---|---|
| ASTR Upper Division Elective (3) | ASTR Upper Division Elective (3) |
| PHYS 4230 (3) Thermodynamics and Statistical Mechanics † | PHYS 4410 (3) Quantum Mechanics and Atomic Physics II † |
| General Education Requirement/Maps (3) | General Education Requirement/Maps (3) |
| General Education Requirement/Maps (3) | General Education Requirement/Maps (3) |
| General Education Requirement/Maps (3) | General Education Requirement/Maps (3) |
| **Total: 15** | **Total: 15** |

† Recommended, not required

**TOTAL:**

Lower Division: 11 Credit Hours in ASTR, 16 Credit Hours in PHYS
Upper Division: 15 Credit Hours in ASTR, 12 Credit Hours in PHYS
Required Coursework in other Departments: 18 Credit Hours
Arts and Sciences Core Courses: 27 Credit Hours; Arts and Sciences core curriculum satisfied.
University Total: 120 Credit Hours; General graduation requirements satisfied.