

arts & sciences



Physics

Undergraduate Advising Guide

Academic Year 2019-2020



Physics

UNIVERSITY OF COLORADO **BOULDER**

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OVERVIEW

DEGREE PLANS

Students can choose from one of three plans leading to the Bachelor of Arts (BA) degree. It is possible to transfer among these options at any stage of their careers; however, transfers may require an additional period of study beyond the standard plan.

- **Plan 1:** Designed primarily for students who plan to pursue graduate study or go directly into professional employment.
- **Plan 2:** Gives students more flexibility in specializing in another area of interest through an interdisciplinary track or in applied physics.
- **Plan 3:** Designed specifically for students who wish to become elementary or secondary school teachers. It includes a teaching licensure in cooperation with the School of Education.
- **Bachelor of Science in Engineering Physics:** The Department of Physics also offers a Bachelor of Science in Engineering Physics through the College of Engineering and Applied Science. Students in the College of Arts and Sciences interested in pursuing Engineering Physics must submit an Intra-University Transfer (IUT) to transfer to the College of Engineering and Applied Science.
- **Concurrent Degree Program:** The Department of Physics offers five-year concurrent bachelor's/master's degree programs for both Physics and Engineering Physics majors. More information on the concurrent degree program can be found on the physics website: <http://www.colorado.edu/physics/academics/undergraduate-students/concurrent-bachelorsmasters-degree>

FACULTY MENTORS & ACADEMIC ADVISORS

Faculty Mentors

All physics students are assigned a physics faculty mentor in order to guide their academic progress while pursuing a major in physics. **You must meet with your assigned faculty mentor at least once a semester, prior to registering for classes.** Faculty Mentors provide guidance on physics major coursework, research opportunities, and career guidance. Faculty Mentors hold office hours every week during the fall and spring semesters. Contact information and office hours are available on the physics website: <http://www.colorado.edu/physics/phys-mentors>.

Academic Advisors

All physics students are assigned an academic advisor through the College of Arts and Sciences. During your first year, you will be assigned a First-year Advisor who can help you navigate campus living, explore academic fields, and discover your strengths. In your sophomore year and beyond, you will work with an academic advisor who specializes in advising physics students. Your academic advisor can provide guidance on your degree requirements, connect you to on-campus resources, and can help you overcome academic challenges. You may schedule an appointment with your academic advisor using MyCUHub (www.colorado.edu/mycuhub).

GRADUATION REQUIREMENTS

Arts and sciences students must fulfill the general graduation requirements of the College. These general requirements are listed below and outlined in the University of Colorado Boulder Catalog which is available at www.colorado.edu/catalog/.

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 of designated honors coursework to the 45-hour limit. Arts and Sciences Physics students must receive a "C-" or better in all major courses, as well as in ancillary courses. 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 a "C-" or better.

1. Pass a total of 120 hours.
2. Maintain a 2.00 (C) grade point average in all University of Colorado work and a 2.00 (C) in all major course work attempted. (Some majors may require a higher minimum grade point average.)
3. Pass 45 credit hours of upper-division work (courses numbered in the 3000s and 4000s).
4. Arts and Sciences students must complete a minimum of 45 credit hours in University of Colorado courses on the Boulder campus. Of these 45 credits, a minimum of 30 credits must be in arts and sciences upper-division credit hours completed as a matriculated student in the College of Arts and Sciences at the University of Colorado at Boulder and at least 12 of these upper-division hours must be in the major. A maximum of 6 credit hours taken at other University of Colorado campuses (CU-Denver and CU-Colorado Springs) can be counted toward the minimum 45 credits required on the Boulder campus. Courses taken while on CU-Boulder study abroad programs, through CU-Boulder continuing education, or CU-Boulder correspondence courses are considered to be in residence.
5. For the Bachelor of Arts degree, students must complete a minimum of 75 hours outside their major department. Students who complete designated departmental honors courses in their major department and/or in honors thesis credit can reduce the 75 hours required outside the major department by a corresponding number of credits, up to a maximum of 6.
6. For the bachelor of fine arts degree, students must complete a minimum of 53 credit hours outside of their major.
7. Complete a major. Students are subject to the major requirements in force when they declare the major. See the sections Majors and Other Areas of Interest and Minimum Major Requirements in this chapter.
8. Complete the general education (college core curriculum) and MAPS requirements with the following limitations:
 - Although a single course may be listed in more than one core area, a student may use it to meet only one area requirement.
 - Neither independent study nor pass/fail courses may be used to meet MAPS deficiencies, core requirements, minor requirements, or the minimum major requirements.
 - A single course may be used to meet both MAPS and core requirements as long as the course is applicable to both requirements. For example, a student admitted with a MAPS deficiency in English composition may take WRTG 1150, First-Year Writing and Rhetoric, to satisfy both the MAPS requirement and the core curriculum lower-division written communication requirement.

PHYSICS – PLAN 1

This program leads to a Bachelor of Arts degree in Physics in four years. Plan 1 is designed to give students a thorough grounding in physics, and is primarily for students who plan to pursue graduate study or go directly into professional employment. In addition to meeting the College of Arts and Sciences graduation requirements, students intending to graduate under this program must complete the following physics and ancillary coursework.

REQUIRED PHYSICS COURSES..... 36 CREDIT HRS

PHYSICS ELECTIVES & RESEARCH..... 9 CREDIT HRS

CHEMISTRY..... 10 CREDIT HRS

MATHEMATICS..... 16-21 CREDIT HRS

PHYSICS – PLAN 1

REQUIRED PHYSICS COURSES..... 36 CREDIT HRS

All prerequisites require a minimum grade of C-

- PHYS 1110¹ or PHYS 1115 (4)** General Physics 1
Coreq., MATH 1300 or APPM 1350
- PHYS 1120² or PHYS 1125 (4)** General Physics 2
Prereq., PHYS 1110 or PHYS 1115 and coreq., MATH 2300 or APPM 1360
- PHYS 1140 (1)** Experimental Physics 1
Coreq., PHYS 1120 or PHYS 1125
- PHYS 2170 (3)** Foundations of Modern Physics
Prereq., PHYS 1120 or PHYS 1125; coreq., MATH 2400 or APPM 2350
OR
PHYS 2130³ (3) General Physics 3 ****BY PETITION****
Prereq., PHYS 1120 or PHYS 1125; coreq., MATH 2400 or APPM 2350
- PHYS 2150 (1)** Experimental Physics 2
Prereq., PHYS 1120 or PHYS 1125 and PHYS 1140; coreq., PHYS 2170
- PHYS 2210 (3)** Classical Mechanics and Mathematical Methods 1
Prereq., PHYS 2130 or PHYS 2170; coreq., MATH 3430⁴ or APPM 2360
- PHYS 3210 (3)** Classical Mechanics and Mathematical Methods 2
Prereq., PHYS 2210
- PHYS 3220 (3)** Quantum Mechanics and Atomic Physics 1
Prereq., PHYS 3210
- PHYS 3310 (3)** Principles of Electricity and Magnetism 1
Prereq., PHYS 2210
- PHYS 3320 (3)** Principles of Electricity and Magnetism 2
Prereq., PHYS 3310
- PHYS 3330 (2)** Electronics for the Physical Sciences (Junior Lab)
Prereq., PHYS 2150 and PHYS 2130 or PHYS 2170
- PHYS 4230 (3)** Thermodynamics and Statistical Mechanics
Prereq., PHYS 2210; coreq., PHYS 3220
- PHYS 4410 (3)** Quantum Mechanics and Atomic Physics 2
Prereq., PHYS 3220 and PHYS 3310

¹ Students with equivalent advanced placement credit (see university catalog on advanced placement) may choose to skip PHYS 1110.

² It is acceptable for students who started with PHYS 2010 and then decide to become physics majors to go into PHYS 1120. Similarly, it is not essential for students who have completed PHYS 2020 to take PHYS 1120 and PHYS 1140.

³ PHYS 2170 is the recommended third semester modern physics course; however, students who have taken PHYS 2130 (a course designed for engineering students) can petition to substitute this course for PHYS 2170.

⁴ The combination MATH 2130-3 and MATH 3430-3 simultaneously may be substituted for APPM 2360-4; however, both should be completed before taking PHYS 3210-3. MATH 2130 can be taken concurrently with MATH 2400 (Calculus 3)

PHYSICS – PLAN 1

PHYSICS ELECTIVES & RESEARCH..... 9 CREDIT HRS

With a combination of research activity and physics electives, you can satisfy this requirement by completing one of the following options:

Option 1

- PHYS 4430: Advanced Laboratory (3)

AND

- Physics Electives (6) *see next page for selection of physics electives*

Option 2

- No credit research experience (0)

- Documentation of your accomplishments as an intern with a research group in the Physics Department or a suitable cognate department. Approval by a Physics faculty advisor is required and should be obtained in advance.

AND

- Physics Electives (9) *see next page for selection of physics electives*

Option 3

- Research credit (3-6):

- PHYS 4610/20/30: Physics Honors (2) (may be repeated, up to 6 credits)
 - PHYS 4840: Independent Study (1-3) (may be repeated, up to 6 credits)

AND

- Physics Electives (3-6) *see next page for selection of physics electives*

***Maximum of 6 credit hours from a combination of PHYS 4610/4620/4630 and PHYS 4840 can be counted for Physics Electives.**

PHYSICS – PLAN 1

SELECTION OF PHYSICS ELECTIVES

- PHYS 2600 (3)** Introduction to Programming and Scientific Computing
Prereq., PHYS 1120 and coreq., PHYS 2170 or PHYS 2130
- PHYS 3090 (3)** Introduction to Quantum Computing
Prereq., APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135
- PHYS 4150 (3)** Plasma Physics
Prereq., PHYS 3310 and coreq., PHYS 3320
- PHYS 4340 (3)** Introduction to Solid State Physics
Prereq., PHYS 3220
- PHYS 4420 (3)** Nuclear and Particle Physics
Prereq., PHYS 4410
- PHYS 4430 (3)** Advanced Laboratory
Prereq., PHYS 3330
- PHYS 4450 (3)** History and Philosophy of Physics
Prereq., PHYS 1020 or PHYS 1120 or PHYS 1125 or PHYS 2020
- PHYS 4460 (3)** Teaching and Learning Physics
Prereq., PHYS 3210 and PHYS 3310
- PHYS 4510 (3)** Optics
Prereq., PHYS 3320
- PHYS 4550 (3)** Cells, Molecules, and Tissues: A Biophysical Approach
Recommended prereqs., MCDB 3135 and 3145 and PHYS 2010 and 2020 and CHEM 1133 or 1371 and MATH 1300 and/or CHEM 3311 (minimum grade C-) or instructor consent required.
- PHYS 4560 (3)** Introduction to Biophysics
Recommended prereq., PHYS 4230
- PHYS 4610 (2)** Physics Honors
PHYS 4620 (2) Physics Honors
PHYS 4630 (2) Physics Honors
Prereq., 3.00 GPA and instructor consent
- PHYS 4810 (3)** Special Topics in Physics
Prereq., instructor consent; may take up to 7 credit hours of special topics
- PHYS 4840 (1-3)** Independent Study
Prereq., instructor consent; may take up to 7 total credit hours of independent study
- PHYS 5030 (3)** Intermediate Mathematical Physics 1
Prereq., instructor consent; same as MATH 5030
- PHYS 5040 (3)** Intermediate Mathematical Physics 2
Prereq., instructor consent; same as MATH 5040
- PHYS 5770 (3)** Gravitational Theory
Prereq., PHYS 3220 and PHYS 3320
- Other PHYS or ASTR upper-division courses as approved in advance by advisor**

PHYSICS – PLAN 1

CHEMISTRY..... 10 CREDIT HRS

- CHEM 1113 (4)** General Chemistry 1
Prereq., one year high school chemistry or CHEM 1021, and high school math through pre-calculus; coreq., CHEM 1114
- CHEM 1114 (1)** General Chemistry 1 Lab
Prereq., one year high school chemistry or CHEM 1021, and high school math through pre-calculus; coreq., CHEM 1113
- CHEM 1133 (4)** General Chemistry 2
Prereq., CHEM 1113/1114; coreq., CHEM 1134
- CHEM 1134 (1)** General Chemistry 2 Lab
Prereq., CHEM 1113/1114; coreq., CHEM 1133

MATHEMATICS..... 16-21 CREDIT HRS

Students may choose to complete the mathematics sequence in Math or Applied Math.

- | | |
|---|---|
| <input type="checkbox"/> MATH 1300 (5) Calculus 1 <i>Prereq., MATH 1150, or APPM 1235, or MATH 1011 and MATH 1021, or an ALEKS math score of 76% or greater</i> | <input type="checkbox"/> APPM 1350 (4) Calculus 1 for Engineers <i>Prereq., APPM 1235 or MATH 1021 or MATH 1150 or an ALEKS math score of 76% or greater</i> |
| <input type="checkbox"/> MATH 2300 (5) Calculus 2 <i>Prereq., MATH 1300</i> | <input type="checkbox"/> APPM 1360 (4) Calculus 2 for Engineers <i>Prereq., APPM 1350 or MATH 1300</i> |
| <input type="checkbox"/> MATH 2400 (5) Calculus 3 <i>Prereq., MATH 2300</i> | <input type="checkbox"/> APPM 2350 (4) Calculus 3 for Engineers <i>Prereq., APPM 1360 or MATH 2300</i> |
| <input type="checkbox"/> MATH 2130⁵ (3) Intro to Linear Algebra <i>Prereq., MATH 2300 or APPM 1360</i> | <input type="checkbox"/> APPM 2360 (4) Intro to Differential Equations with Linear Algebra <i>Prereq., APPM 1360 or MATH 2300. Credit not granted for this course and both MATH 2130 and MATH 3430.</i> |
| <input type="checkbox"/> MATH 3430 (3) Ordinary Differential Equations <i>Prereq., MATH 2400 and MATH 2130 or APPM 3310</i> | |

⁵ The combination MATH 2130 and MATH 3430 may be substituted for APPM 2360 however; both should be completed before taking PHYS 3210. Students who wish to stay in the MATH track should take MATH 2130 concurrently with MATH 2400 in order to stay on schedule.

PHYSICS – PLAN 1

SAMPLE FOUR-YEAR PLAN OF STUDY

Students should consult with their academic advisor concerning the appropriate sequence of courses to meet their academic goals and degree requirements.

| FRESHMAN YEAR | | CREDITS | CREDITS |
|--|---|--|------------------------|
| Fall Semester | | | Spring Semester |
| PHYS 1110 or PHYS 1115 General Physics 1 | 4 | PHYS 1120 or PHYS 1125 General Physics 2 | 4 |
| MATH 1300 Calculus 1 | 5 | PHYS 1140 Experimental Physics | 1 |
| | | MATH 2300 Calculus 2 | 5 |
| SOPHOMORE YEAR | | CREDITS | CREDITS |
| Fall Semester | | | Spring Semester |
| PHYS 2170 Foundations of Modern Phys | 3 | PHYS 2210 Classical Mech & Math Methods | 3 |
| PHYS 2150 Experimental Physics 2 | 1 | MATH 3430 Differential Equations | 3 |
| MATH 2400 Calculus 3 | 5 | CHEM 1113/1114 General Chemistry 1 | 5 |
| MATH 2130 Linear Algebra | 3 | | |
| JUNIOR YEAR | | CREDITS | CREDITS |
| Fall Semester | | | Spring Semester |
| PHYS 3210 Classical Mech & Math Meth 2 | 3 | PHYS 3220 Quantum Mechanics 1 | 3 |
| PHYS 3310 Principles of Elec & Mag 1 | 3 | PHYS 3320 Principles of Elec & Mag 2 | 3 |
| PHYS 3330 Junior Laboratory | 2 | Physics Elective | 3 |
| CHEM 1133/1134 General Chemistry 2 | 5 | | |
| SENIOR YEAR | | CREDITS | CREDITS |
| Fall Semester | | | Spring Semester |
| PHYS 4230 Thermodynamics | 3 | Physics Elective | 3 |
| PHYS 4410 Quantum Mechanics 2 | 3 | | |
| Physics Elective | 3 | | |

- The mathematics sequence may be completed in MATH or APPM (Applied Math)
- Students starting with Pre-Calculus should start the Chemistry sequence in the first semester
- The chemistry sequence may be completed in semesters other than suggested above, but completion prior to senior year is recommended

PHYSICS – PLAN 2

This program leads to a Bachelor of Arts degree in four years. Plan 2 gives an excellent background in the fundamentals of physics, and Plan 2 students specialize in a topical area closely related to Physics. Plan 2 provides an excellent preparation for graduate studies in Physics, the related topical area or for professional employment. The student's transcript will specify a major in physics with an (A) Interdisciplinary or (B) Applied Physics Program. Plan 2 is structured primarily for a person who wants to major in physics as an undergraduate and then study or work in a related or applied field after graduation. Students might also follow this plan if their eventual goals are in a professional career such as industrial laboratory work, technical writing, law or medicine.

Students pursuing Plan 2 are strongly urged to discuss their program with the physics advisor at the end of the sophomore year so that they can plan ahead to take courses in the interdisciplinary field as some of these courses are not given every semester or every year; otherwise they might have to spend an extra semester or two. **Also, the program has to be approved by the faculty mentor and be on record with the physics advisor at least one year prior to graduation.**

REQUIRED PHYSICS COURSES..... 33 CREDIT HRS

A. Interdisciplinary Program..... 12 CREDIT HRS

Physics Electives.....3 CREDIT HRS

OR

B. Applied Physics..... 15 CREDIT HRS

CHEMISTRY..... 10 CREDIT HRS

MATHEMATICS..... 16-21 CREDIT HRS

PHYSICS – PLAN 2

REQUIRED PHYSICS COURSES..... 33 CREDIT HRS

All prerequisites require a minimum grade of C-

- PHYS 1110⁶ or PHYS 1115 (4)** General Physics 1
Coreq., MATH 1300 or APPM 1350
- PHYS 1120⁷ or PHYS 1125 (4)** General Physics 2
Prereq., PHYS 1110 or PHYS 1115, and coreq., MATH 2300 or APPM 1360
- PHYS 1140 (1)** Experimental Physics 1
Coreq., PHYS 1120 or PHYS 1125
- PHYS 2170 (3)** Foundations of Modern Physics
Prereq., PHYS 1120 or PHYS 1125; coreq., MATH 2400 or APPM 2350
OR
PHYS 2130⁸ (3) General Physics 3 ****BY PETITION****
Prereq., PHYS 1120 or PHYS 1125; coreq., MATH 2400 or APPM 2350
- PHYS 2150 (1)** Experimental Physics 2
Prereq., PHYS 1120 or PHYS 1125, and PHYS 1140; coreq., PHYS 2170
- PHYS 2210 (3)** Classical Mechanics and Mathematical Methods 1
Prereq., PHYS 2130 or PHYS 2170; coreq., MATH 3430⁹ or APPM 2360
- PHYS 3210 (3)** Classical Mechanics and Mathematical Methods 2
Prereq., PHYS 2210
- PHYS 3220 (3)** Quantum Mechanics and Atomic Physics 1
Prereq., PHYS 3210
- PHYS 3310 (3)** Principles of Electricity and Magnetism 1
Prereq., PHYS 2210
- PHYS 3320 (3)** Principles of Electricity and Magnetism 2
Prereq., PHYS 3310
- PHYS 3330 (2)** Electronics for the Physical Sciences (Junior Lab)
Prereq., PHYS 2150 and PHYS 2130 or PHYS 2170
- PHYS 4230 (3)** Thermodynamics and Statistical Mechanics
Prereq., PHYS 2210; coreq., PHYS 3220

Note: For students majoring in Physics under Plan 2, the best sequence for the required physics courses is to follow the Plan 1 outline mentioned above through the junior year.

⁶ Students with equivalent advanced placement credit (see university catalog on advanced placement) may choose to skip PHYS 1110.

⁷ It is acceptable for students who started with PHYS 2010 and then decide to become physics majors to go into PHYS 1120. Similarly, it is not essential for students who have completed PHYS 2020 to take PHYS 1120 and PHYS 1140.

⁸ PHYS 2170 is the recommended third semester modern physics course; however, students who have taken PHYS 2130 (a course designed for engineering students) can petition to substitute this course for PHYS 2170.

⁹ The combination MATH 2130-3 and MATH 3430-3 simultaneously may be substituted for APPM 2360-4; however, both should be completed before taking PHYS 3210-3. MATH 2130 can be taken concurrently with MATH 2400 (Calculus 3)

PHYSICS – PLAN 2

A. Interdisciplinary Program..... 12 CREDIT HRS Physics Electives.....3 CREDIT HRS

In addition to the above requirements a student in Plan 2 is required to complete 12 hours in a field other than physics with a demonstrable relation to physics. Courses in this chosen program may include physics electives in addition to the basic 36 hours listed above. Please note that the 12 credit hours have to be in one disciplinary field as the purpose of the program is that a student becomes well versed in the chosen field. Up to three of these 12 hours may consist of research participation in the chosen field, under independent study or an honors project. Alternately or additionally, the student is encouraged to participate in research as an intern with a research activity within the Physics Department or a suitable cognate department, institute, or external entity such as NCAR, NIST, NOAA, etc. Internships do not confer academic credit.

Plan 2 students should construct their own curricula before the beginning of the junior year. **Plan 2** students must get prior approval from the Arts and Sciences Faculty Mentoring Committee in the Department of Physics for any curriculum other than the pre-approved plans/courses stated below. At least 24 semester hours of credit must be earned after a student has declared his/her proposed track.

Please note that the following lists are suggested options in the Interdisciplinary Program and are not restrictive or complete. Courses listed below may have additional pre-requisites or co-requisites.

➤ **Applications of Mathematics and Computer Science**

- MATH 4330-3 – Fourier Analysis
- MATH 4650-3 – Intermediate Numerical Analysis 1
- MATH 4450-3 – Introduction to Complex Variables
- MATH 4470-3 – Introduction to Partial Differential Equations 1
- MATH 4510-3 – Introduction to Probability Theory
- MATH 5030-3, 5040-3 (Same as PHYS 5030, 5040) – Intermediate Mathematical Physics 1, 2
- CSCI 3656-3 – Numerical Computation
- CSCI 5606-3 – Principles of Numerical Computation

➤ **Astrophysics and Atmospheric Sciences**

(ASTR or ATOC courses used for this option CAN NOT be used for the Astronomy Major. No ASTR or ATOC course lower than 3710 can be used for this option)

- ASTR 3710-3 – Formation & Dynamics of Planetary Systems
- ASTR/ATOC 3720-3 – Planets and Their Atmospheres
- ASTR 3730-3 – Astrophysics 1-Stellar and Interstellar
- ASTR 3740-3 – Cosmology and Relativity
- ASTR 3750-3 – Planets, Moons and Rings
- ASTR 3760-3 – Solar and Space Physics
- ASTR 3830-3 – Astrophysics 2-Galactic and Extragalactic
- ATOC 4720-3 – Introduction to Atmospheric Physics and Dynamics
- ASEN 5050-3 – Space Flight Dynamics
- ASTR 5110-3 – Atomic and Molecular Processes
- ASTR/PHYS 5150-3 – Intro Plasma Physics
- ASTR 5700-3 – Stellar Structure and Evolution
- PHYS 5770-3 – Gravitational Theory (Theory of General Relativity)

PHYSICS – PLAN 2

- **Biophysics**
 - MCDB 3135-3, MCDB 3145-3 – Molecular Cell Biology I, II
 - CHEM 3311-4 and 3331-4 – Organic Chemistry 1, 2
 - MCDB 4410-3 – Human Molecular Genetics
 - CHEM 4511-3, 4531-3 – Physical Chemistry 1, 2
 - MCDB 4314-3 – Algorithms for Molecular Biology
 - PHYS 4550-3 – Cells, Molecules, and Tissues: A Biophysical Approach
 - PHYS 4560-3 – Introduction to Biophysics
 - CHEM 4700-4, CHEM 4731-4 – Foundations of Biochemistry 1, 2
- **Chemical Physics**
 - CHEM 3311-4, CHEM 3331-4 – Organic Chemistry 1, 2
 - CHEM 4511-3, 4531-3 – Physical Chemistry 1, 2
 - CHEM 4581-1 – Physical Chemistry Lab 1
 - CHEM 4591-2 – Physical Chemistry Lab 2
- **Computer Science**
 - CSCI 3202-3 – Introduction to Artificial Intelligence
 - CSCI 3308-3 – Software Development Methods and Tools
 - CSCI 3434-3 – Theory of Computation
 - CSCI 3656-3 – Numerical Computation
 - CSCI 4448-3 – Object-Oriented Analysis and Design
- **Environmental Sciences**
 - GEOG 3412-3 – Conservation Practice and Resource Management
 - ATOC 3500-3 – Air Chemistry and Pollution
 - ENVS 3520-3 – Energy and Climate Change
 - ENVS 3600-3 – Principles of Climate
 - ATOC 4800-3 – Policy Implications of Climate Controversies
 - GEOG 4742-3 – Environments and Peoples
- **Geophysics**
 - GEOL 3010-3 – Introduction to Mineralogy
 - GEOL 3030-3 – Introduction to Hydrogeology
 - GEOL 3120-4 – Structural Geology 1
 - GEOL 4060-4 – Oceanography
 - GEOL 4093-4 – Remote Sensing of the Environment
 - GEOL 4130-3 – Principles of Geophysics
 - GEOL 4640-3 – Glacial Geology (not offered regularly)
 - GEOL 4714-2 – Field Geophysics
- **Philosophy and History of Science**
 - PHIL 3410-3 – History of Science: Ancients to Newton
 - PHIL 3430-3 – History of Science: Newton to Einstein
 - PHIL 4340-3 - Epistemology
 - PHIL 4360-3 – Metaphysics
 - PHIL 4400-3, PHIL-5400-3 – Philosophy of Science
 - PHIL 4440-3 – Topics in Logic
 - PHYS 4450-3 – History and Philosophy of Physics
- **Pre Medicine**
 - MCDB 2150-3, MCDB 2151-1 – Principles of Genetics and the Lab
 - CHEM 3311-4, CHEM 3331-4 – Organic Chemistry 1, 2
 - CHEM 4511-3 (or CHEM 4531-3) – Physical Chemistry
 - CHEM 4611-3 – Survey of Biochemistry

PHYSICS – PLAN 2

Students under **Plan 2** Interdisciplinary program must also take a minimum of 3 hours of courses chosen from the following list of physics courses. Students choosing Applied Physics Program (see Section B) are required to take one more course in applied physics instead of one the following electives:

SELECTION OF PHYSICS ELECTIVES

- PHYS 2600 (3)** Introduction to Programming and Scientific Computing
Prereq., PHYS 1120 and coreq., PHYS 2170 or PHYS 2130
- PHYS 3090 (3)** Introduction to Quantum Computing
Prereq., APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135
- PHYS 4150 (3)** Plasma Physics
Prereq., PHYS 3310 and coreq., PHYS 3320
- PHYS 4340 (3)** Introduction to Solid State Physics
Prereq., PHYS 3220
- PHYS 4410 (3)** Quantum Mechanics and Atomic Physics 2
Prereq., PHYS 3220 and PHYS 3310
- PHYS 4420 (3)** Nuclear and Particle Physics
Prereq., PHYS 4410
- PHYS 4430 (3)** Advanced Laboratory
Prereq., PHYS 3330
- PHYS 4450 (3)** History and Philosophy of Physics
Prereq., PHYS 1020 or PHYS 1120 or PHYS 1125 or PHYS 2020
- PHYS 4460 (3)** Teaching and Learning Physics
Prereq., PHYS 3210 and PHYS 3310
- PHYS 4510 (3)** Optics
Prereq., PHYS 3320
- PHYS 4550 (3)** Cells, Molecules, and Tissues: A Biophysical Approach
Recommended prereqs., MCDB 3135 and 3145 and PHYS 2010 and 2020 and CHEM 1133 or 1371 and MATH 1300 and/or CHEM 3311 (minimum grade C-) or instructor consent required.
- PHYS 4560 (3)** Introduction to Biophysics
Recommended prereq., PHYS 4230
- PHYS 4610 (2)** Physics Honors, **PHYS 4620 (2)** Physics Honors, **PHYS 4630 (2)** Physics Honors
Prereq., 3.00 GPA and instructor consent
- PHYS 4810 (3)** Special Topics in Physics
Prereq., instructor consent; may take up to 7 credit hours of special topics
- PHYS 4840 (1-3)** Independent Study
Prereq., instructor consent; may take up to 7 total credit hours of independent study
- PHYS 5030 (3)** Intermediate Mathematical Physics 1
Prereq., instructor consent; same as MATH 5030
- PHYS 5040 (3)** Intermediate Mathematical Physics 2
Prereq., instructor consent; same as MATH 5040
- PHYS 5770 (3)** Gravitational Theory
Prereq., PHYS 3220 and PHYS 3320
- Other PHYS or ASTR upper-division courses as approved in advance by advisor**

PHYSICS – PLAN 2

B. Applied Physics..... 15 CREDIT HRS

Plan 2 Applied Physics Program is more intensely related to physics.

A student in this program is required to complete **15 hours** in any one of the following categories, in addition to the above 33 hours of required courses. **Plan 2** Applied Physics students must get prior approval from the Arts and Sciences Faculty Mentoring Committee in the Department of Physics for any curriculum other than the pre-approved plans/courses stated below. At least 24 hours of credit must be earned after a student has declared their proposed track. Please note that courses offered through the College of Engineering and Applied Science are subject to restrictions based on major or prerequisites.

➤ **Biotechnology**

- PHYS 4430-3 – Advanced Laboratory
- PHYS 4510-3 – Optics
- ECEN 4120-3 – Neural Network Design
- ECEN 4341-3 – Bio-electromagnetics
- ECEN 4811-3 – Neural Signals and Functional Brain Imaging
- ECEN 4821-3 – Neural Systems and Physiological Control

➤ **Optics**

- PHYS 4430-3 – Advanced Laboratory
- PHYS 4510-3 – Optics
- PHYS 5160-3 – Laser Fundamentals
- PHYS 7550-3 – Atomic and Molecular Spectra
- ECEN 4116-3 – Introduction to Optical Communications
- ECEN 4242-3 – Communications Theory
- ECEN 4606-3 – Undergraduate Optics Laboratory
- ECEN 4616-3 – Optoelectronic System Design

➤ **Electronic Devices**

- ECEN 3250-3 – Microelectronics
- ECEN 3320-3 – Semiconductor Devices
- PHYS 4340-3 – Solid State Physics
- ECEN 4555-3 – Principles of Energy Systems & Devices
- ECEN 5355-3 – Principles of Electronic Devices 1

PHYSICS – PLAN 2

CHEMISTRY..... 10 CREDIT HRS

- CHEM 1113 (4) General Chemistry 1**
Prereq., one year high school chemistry or CHEM 1021, and high school math through pre-calculus; coreq., CHEM 1114
- CHEM 1114 (1) General Chemistry 1 Lab**
Prereq., one year high school chemistry or CHEM 1021, and high school math through pre-calculus; coreq., CHEM 1113
- CHEM 1133 (4) General Chemistry 2**
Prereq., CHEM 1113/1114; coreq., CHEM 1134
- CHEM 1134 (1) General Chemistry 2 Lab**
Prereq., CHEM 1113/1114; coreq., CHEM 1133

MATHEMATICS..... 16-21 CREDIT HRS

Students may choose to complete the mathematics sequence in Math or Applied Math.

- | | |
|---|---|
| <input type="checkbox"/> MATH 1300 (5) Calculus 1 <i>Prereq., MATH 1150, or APPM 1235, or MATH 1011 and MATH 1021, or an ALEKS math score of 76% or greater</i> | <input type="checkbox"/> APPM 1350 (4) Calculus 1 for Engineers <i>Prereq., APPM 1235 or MATH 1021 or MATH 1150 or an ALEKS math score of 76% or greater</i> |
| <input type="checkbox"/> MATH 2300 (5) Calculus 2 <i>Prereq., MATH 1300</i> | <input type="checkbox"/> APPM 1360 (4) Calculus 2 for Engineers <i>Prereq., APPM 1350 or MATH 1300</i> |
| <input type="checkbox"/> MATH 2400 (5) Calculus 3 <i>Prereq., MATH 2300</i> | <input type="checkbox"/> APPM 2350 (4) Calculus 3 for Engineers <i>Prereq., APPM 1360 or MATH 2300</i> |
| <input type="checkbox"/> MATH 2130¹⁰ (3) Intro to Linear Algebra <i>Prereq., MATH 2300 or APPM 1360</i> | <input type="checkbox"/> APPM 2360 (4) Intro to Differential Equations with Linear Algebra <i>Prereq., APPM 1360 or MATH 2300. Credit not granted for this course and both MATH 2130 and MATH 3430.</i> |
| <input type="checkbox"/> MATH 3430 (3) Ordinary Differential Equations <i>Prereq., MATH 2400 and MATH 2130 or APPM 3310</i> | |

¹⁰ The combination MATH 2130 and MATH 3430 may be substituted for APPM 2360 however; both should be completed before taking PHYS 3210. Students who wish to stay in the MATH track should take MATH 2130 concurrently with MATH 2400 in order to stay on schedule.

PHYSICS – PLAN 3

This program leads to a Bachelor of Arts degree and recommendation for a teacher's certificate in four years.¹¹ For students intending to become Secondary school teachers, this plan involves a minimum of 30 credit hours of Physics, and a minimum of 35 hours in Education courses. Students must also apply for admission directly through the School of Education (<http://www.colorado.edu/education>).

Both Arts and Sciences Physics and School of Education requirements must be satisfied in order to graduate under this plan.

PHYSICS PLAN 3 REQUIREMENTS

| | |
|-------------------------------|------------------|
| REQUIRED PHYSICS COURSES..... | 30 CREDIT HRS |
| CHEMISTRY..... | 7-10 CREDIT HRS |
| ASTRONOMY..... | 4 CREDIT HRS |
| MATHEMATICS..... | 16-21 CREDIT HRS |

SCHOOL OF EDUCATION REQUIREMENTS

¹¹ Teacher's Certificates are not granted automatically at graduation. Application forms for a Colorado Teacher's Certificate are available in the office in the School of Education. Application forms for other states can be obtained by writing the State Department of Education in the capital city of that state.

PHYSICS – PLAN 3

REQUIRED PHYSICS COURSES..... 30 CREDIT HRS

All prerequisites require a minimum grade of C-

- PHYS 1110¹² or PHYS 1115 (4)** General Physics 1
Coreq., MATH 1300 or APPM 1350
- PHYS 1120¹³ or PHYS 1125 (4)** General Physics 2
Prereq., PHYS 1110 or PHYS 1115 and coreq., MATH 2300 or APPM 1360
- PHYS 1140 (1)** Experimental Physics 1
Coreq., PHYS 1120 or PHYS 1125
- PHYS 2170 (3)** Foundations of Modern Physics
Prereq., PHYS 1120 or PHYS 1125; coreq., MATH 2400 or APPM 2350
- OR**
- PHYS 2130 (3)** General Physics 3
Prereq., PHYS 1120 or PHYS 1125; coreq., MATH 2400 or APPM 2350
- PHYS 2150 (1)** Experimental Physics 2
Prereq., PHYS 1120 or PHYS 1125, and PHYS 1140; coreq., PHYS 2170
- PHYS 2210 (3)** Classical Mechanics and Mathematical Methods 1
Prereq., PHYS 2130 or PHYS 2170; coreq., MATH 3430¹⁴ or APPM 2360
- PHYS 3210 (3)** Classical Mechanics and Mathematical Methods 2
Prereq., PHYS 2210
- PHYS 3220 (3)** Quantum Mechanics and Atomic Physics 1
Prereq., PHYS 3210
- PHYS 3310 (3)** Principles of Electricity and Magnetism 1
Prereq., PHYS 2210
- PHYS 3330 (2)** Electronics for the Physical Sciences (Junior Lab)
Prereq., PHYS 2150 and PHYS 2130 or PHYS 2170
- PHYS 4460 (3)** Teaching and Learning Physics
Prereq., PHYS 3210 and PHYS 3310
- OR**
- PHYS 4450 (3)** History and Philosophy of Physics
Prereq., PHYS 1020 or PHYS 1120 or PHYS 1125 or PHYS 2020

¹² Students with equivalent advanced placement credit (see university catalog on advanced placement) may choose to skip PHYS 1110.

¹³ It is acceptable for students who started with PHYS 2010 and then decide to become physics majors to go into PHYS 1120. Similarly, it is not essential for students who have completed PHYS 2020 to take PHYS 1120 and PHYS 1140.

¹⁴ The combination MATH 2130-3 and MATH 3430-3 simultaneously may be substituted for APPM 2360-4; however, both should be completed before taking PHYS 3210-3. MATH 2130 can be taken concurrently with MATH 2400 (Calculus 3)

PHYSICS – PLAN 3

CHEMISTRY..... 7-10 CREDIT HRS

- CHEM 1011 (3)** Environmental Chemistry 1
AND
- CHEM 1031 (4)** Environmental Chemistry 2
Prereq., CHEM 1011
- OR**
- CHEM 1113 (4)** General Chemistry 1
Prereq., one year high school chemistry or CHEM 1021, and high school math through pre-calculus; coreq., CHEM 1114
- CHEM 1114 (1)** General Chemistry 1 Lab
Prereq., one year high school chemistry or CHEM 1021, and high school math through pre-calculus; coreq., CHEM 1113
- CHEM 1133 (4)** General Chemistry 2
Prereq., CHEM 1113/1114; coreq., CHEM 1134
- CHEM 1134 (1)** General Chemistry 2 Lab
Prereq., CHEM 1113/1114; coreq., CHEM 1133

ASTRONOMY..... 4 CREDIT HRS

- ASTR 1030 (4)** Accelerated Introductory Astronomy 1
Prereq., or coreq., MATH 1300 or APPM 1350 or APPM 1340 and APPM 1345 (all min. grade C-)

MATHEMATICS..... 16-21 CREDIT HRS

Students may choose to complete the mathematics sequence in Math or Applied Math.

- | | |
|---|---|
| <input type="checkbox"/> MATH 1300 (5) Calculus 1 <i>Prereq., MATH 1150, or APPM 1235, or MATH 1011 and MATH 1021, or an ALEKS math score of 76% or greater</i> | <input type="checkbox"/> APPM 1350 (4) Calculus 1 for Engineers <i>Prereq., APPM 1235 or MATH 1021 or MATH 1150 or an ALEKS math score of 76% or greater</i> |
| <input type="checkbox"/> MATH 2300 (5) Calculus 2 <i>Prereq., MATH 1300</i> | <input type="checkbox"/> APPM 1360 (4) Calculus 2 for Engineers <i>Prereq., APPM 1350 or MATH 1300</i> |
| <input type="checkbox"/> MATH 2400 (5) Calculus 3 <i>Prereq., MATH 2300</i> | <input type="checkbox"/> APPM 2350 (4) Calculus 3 for Engineers <i>Prereq., APPM 1360 or MATH 2300</i> |
| <input type="checkbox"/> MATH 2130¹⁵ (3) Intro to Linear Algebra <i>Prereq., MATH 2300 or APPM 1360</i> | <input type="checkbox"/> APPM 2360 (4) Intro to Differential Equations with Linear Algebra <i>Prereq., APPM 1360 or MATH 2300. Credit not granted for this course and both MATH 2130 and MATH 3430.</i> |
| <input type="checkbox"/> MATH 3430 (3) Ordinary Differential Equations <i>Prereq., MATH 2400 and MATH 2130 or APPM 3310</i> | |

¹⁵ The combination MATH 2130 and MATH 3430 may be substituted for APPM 2360 however; both should be completed before taking PHYS 3210. Students who wish to stay in the MATH track should take MATH 2130 concurrently with MATH 2400 in order to stay on schedule.

SCHOOL OF EDUCATION REQUIREMENTS

Application for Admission

Admission information for the Teacher Education Program can be found on the School of Education website <https://www.colorado.edu/education/academics/teacher-licensure/secondary/science>. In order to be considered for admission to the Teacher Education Program, **Plan 3** students must submit an application for admission, which includes the following:

- Application to the Undergraduate Teacher Education Program, available online through the School of Education.
- One (1) Letter of Recommendation from a College-Level Instructor
- Personal Statement
- Youth Experience Verification Form

To be considered for admission, applicants must meet the following:

1. **Minimum of 2.75 GPA (on 4.0 scale) cumulatively among all institutions attended.** Applicants to a Secondary (7-12) program must also have a 2.75 GPA in all content area coursework.
2. **A minimum of 26 semester hours of college level course work completed or in progress.** Transfer students must have at least one semester of grades at CU-Boulder before applying.
3. **A completed program application with all required documents, including documentation of 25 hours of youth experience**

Education course requirements

Students should review the Undergraduate Program of Studies Checklist for Secondary Science for Arts & Sciences majors on the School of Education website for current teacher licensure requirements. <http://www.colorado.edu/education/teacher-licensure>

The Teacher Education Program encourages students to check in EARLY in their academic career. There are many academic courses required for licensure which students can complete during the first two years they are at CU Boulder.

All Teacher Licensure program candidates must pass one of the state-approved licensure exams in order to be eligible for student teaching and Colorado Initial Teacher Licensure. Visit the School of Education website for more details on this requirement.

In addition, the student under **Plan 3** must satisfy the requirements of the College of Arts and Sciences as outlined before. Many school systems require a master's degree or require that the teacher work toward the master's degree in summers.

PHYSICS – PLAN 3

Current Education Course Requirements for Secondary Science can be viewed on the University Catalog (<https://catalog.colorado.edu>)

Content Coursework Requirements

- **Mathematics**
 - MATH 1300 (or MATH 1310 or APPM 1350)
- **Science**
 - Choose two of each: biology courses, chemistry courses, earth/space science courses, and physics courses
 - Complete three out of four of the following content area lab courses separately or as part of a course:
 - Biology lab, chemistry lab, earth/space science lab, physics lab

Education Course Requirements

- **Take Any Time**
 - **EDUC 3013 School & Society**
 - **EDUC 4050 Knowing & Learning.** Includes up to 2 hours per week of school-based practicum.
 - **EDUC 4232 Language and Literacy across the Curriculum.** *Spring only.*
- **Complete two courses from the following:**
 - **EDUC 1580/PHYS 1580** Energy and Interactions
 - **MCDB 4811** Teaching & Learning Biology
 - **EDUC 4822** Teaching & Learning Chemistry
 - **PHYS 4460/EDUC 4460** Teaching & Learning Physics
 - **EDUC 4833** Teaching & Learning Earth Systems
 - **GEEN 4400** Teaching Design
- **Semester One**
 - **EDUC 2020 Step 1: Inquiry Approaches to Teaching** or **EDUC 4610 Math and Science Education** (EDUC 4610 is restricted to students admitted to the Learning Assistant program and is a variable credit course.
- **Semester Two**
 - **EDUC 2030 Step 2: Inquiry Based Lesson Design.** EDUC 2020 or EDUC 4610 is a prerequisite for enrolling in EDUC 2030.
 - **EDUC 4060 Classroom Interactions** (includes up to 5 hours per week of school-based practicum)
- **Semester Three**
 - **EDUC 5385 Project-Based Science Instruction.** Includes up to 6 hours per week of school-based practicum.
 - **EDUC 4023 Differentiating Instruction in Diverse Secondary Classrooms.** Includes up to 4 hours per week of school-based practicum.

Student Teaching & Required Tests and Assessments

- **EDUC 4513 Education and Practice.** Must be taken with EDUC 4712.
- **EDUC 4712 Student Teaching: Secondary School.** Must be taken with EDUC 4513
- **Licensure Exam: Prior to Student Teaching (PRAXIS)**
- **edTPA: During Student Teaching**

ADDITIONAL EDUCATIONAL OPPORTUNITIES

PHYSICS DEPARTMENT HONORS PROGRAM

An honors designation with the College of Arts & Sciences is only achievable by the completion of an original piece of research. A senior thesis must be submitted, with typical lengths from 20 to 100 pages. An oral defense of the thesis also must be given to a committee of three faculty members. Typically the presentations last for 40 minutes. The level of Honors that a student receives depends on two factors, GPA and the quality of the senior Honors thesis. The following GPA cut-off acts as a guideline:

GPA > 3.8 Summa Cum Laude

GPA > 3.5 Magna Cum Laude

GPA > 3.3 Cum Laude

However, a GPA of 4.0 with no Honors thesis will not earn an Honors designation, nor will a 4.0 GPA with a poor quality thesis earn the designation of Summa or any designation at all if the quality is low enough. In addition, an especially high quality thesis may bump a student up from one designation to another. For instance, a student with a 3.4 and a very strong thesis may earn a Magna designation. Even a Summa designation is not impossible, but such jumps are very rare.

Honors Thesis Advisor and Committee

Students are encouraged to find a faculty member from Physics or any of our associated departments (including APS, CASA and JILA or even NIST or NREL) to serve as a thesis advisor. These advisors serve to support students through their research and thesis process. Please contact the Honors Chair for important direction in finding a thesis advisor. The departmental Honors Chair must approve any thesis advisor that originates outside of physics. Each student's Honors thesis committee is composed of three faculty members: two members from the Physics Department, one of whom must be a member of the Honors Council, and an external member from outside the Physics Department. If the student's thesis advisor does not fall into these categories, he/she can be added as a fourth member to the Honors thesis committee.

Honors Courses: PHYS 4610/4620/4630

To graduate with an Honors designation, students should enroll in at least one semester of Physics honors (PHYS 4610/4620/4630), although two or three are more usual. Due to the dependence of the Honors designation on GPA, PHYS 4610/4620/4630 are controlled enrollment courses. Students need to contact the Honors Chair (the teacher of these classes) to be admitted to the class. Typically, students will be enrolled only if their GPA lies within striking range of the 3.3 minimum. This is considered on a case-by-case basis.

All students are required to attend a once a week, hour-long Honors class. These classes are designed to help shepherd students through the Honors process. As part of these class sessions, students rotate through giving 20-minute oral presentations of their research to their peers.

Honors Research

To be eligible for Departmental Honors in Physics, a student either must (if in A&S) or may (if in Engineering) complete an original piece of research and write and defend an honors thesis. It is expected that Honors students will spend between 6-10 hours per week working on their Honors research. Information on how to

ADDITIONAL EDUCATIONAL OPPORTUNITIES

obtain a research opportunity can be found on our Research Opportunity page:

<http://www.colorado.edu/physics/academics/undergraduate-students/undergraduate-research-opportunities>.

Thesis advisors and the Honors Chair can also provide guidance to find a research opportunity.

STUDENT SOCIETIES

CU Prime is a student-driven effort led by grad students in the Physics Department, aimed at building an inclusive and diverse community of scientists at all levels. They run biweekly talks on cutting-edge research that are understandable to intro physics students, a one-credit course on model building and what it is to be a physicist, and a mentorship program. For more information on CU Prime, please visit their website:

<http://www.colorado.edu/studentgroups/cuprime/>

The Society of Physics Students is a student organization open to all Physics, Engineering Physics, and Astronomy majors and minors. Society of Physics Students meets once per week to discuss physics and life, relax, and enjoy some pizza. For more information, please visit: <http://www.colorado.edu/physics/academics/undergraduate-students/student-organizations>

Sigma Pi Sigma is the only nationally recognized Physics Honor Society. Students who enter junior or senior year with a 3.80 or higher cumulative grade point average may be invited to join the University of Colorado at Boulder Chapter of Sigma Pi Sigma.

Beyond Boulder is a resource for undergrads in fields related to physics and astronomy at CU-Boulder. It is a program designed to help guide you through the process of thinking about and planning for your future career. During the academic year, Beyond Boulder meets once per week for useful workshops, seminars, questions and frank answers. For more information on Beyond Boulder, please visit: <http://beyondboulder.pbworks.com>

JOB OPPORTUNITIES FOR PHYSICS MAJORS

Students interested in job opportunities, including summer jobs in physics, are urged to see Career Services in Center for Community, N352, or phone (303) 492-6541. <http://www.colorado.edu/career>

Summer and part time research jobs are also available within the Department of Physics. Interested students may discuss these possibilities and employment related issues with the faculty advisors in the physics department. Students are encouraged to contact faculty members directly about the possibility of working in research labs.

DISTRIBUTED STUDIES PROGRAM

Admission to the distributed studies track requires completion of 60 credits or more and permission from the dean's office. The distributed studies track is intended for students who have accumulated a significant number of credit hours toward the completion of one or more majors and are not eligible to continue in those majors.

An individually structured track also is available in the distributed studies program. Students pursuing the individually structured track must write and defend a thesis based on original scholarly or creative work. For more information, contact the College of Arts and Sciences Academic Advising Center in Woodbury 109.

PHYSICS – MINOR

The requirements for a physics minor are listed below. Interested students may declare a physics minor by meeting with the physics advisor.

REQUIRED PHYSICS COURSES..... 16 CREDIT HRS

- | | |
|--|---|
| <input type="checkbox"/> PHYS 1110¹⁶ (4) General Physics 1 <i>Coreq., MATH 1300 or APPM 1350</i> | <input type="checkbox"/> PHYS 2150 (1) Experimental Physics 2 <i>Prereq., PHYS 1120 and PHYS 1140; coreq., PHYS 2170</i> |
| <input type="checkbox"/> PHYS 1120¹⁷ (4) General Physics 2 <i>Prereq., PHYS 1110 and coreq., MATH 2300 or APPM 1360</i> | <input type="checkbox"/> PHYS 2210 (3) Classical Mechanics and Mathematical Methods 1 <i>Prereq., PHYS 2130 or PHYS 2170; coreq., MATH 3430¹⁹ or APPM 2360</i> |
| <input type="checkbox"/> PHYS 1140 (1) Experimental Physics 1 <i>Coreq., PHYS 1120</i> | |
| <input type="checkbox"/> PHYS 2170 (3) Foundations of Modern Physics <i>Prereq., PHYS 1120; coreq., MATH 2400 or APPM 2350</i> | |
| OR | |
| <input type="checkbox"/> PHYS 2130¹⁸ (3) General Physics 3 **BY PETITION** <i>Prereq., PHYS 1120; coreq., MATH 2400 or APPM 2350</i> | |

UPPER-DIVISION PHYSICS ELECTIVES..... 9 CREDIT HRS

Note: If the student's major requires any of these courses, the student should take other courses from this list or other 4000-level physics courses so that the total number of credit hours (not already required by the student's major) is 9.

- PHYS 3210 (3)** Classical Mechanics and Mathematical Methods 2
Prereq., PHYS 2210
- PHYS 3220 (3)** Quantum Mechanics and Atomic Physics 1
Prereq., PHYS 3210
- PHYS 3310 (3)** Principles of Electricity and Magnetism 1
Prereq., PHYS 2210
- PHYS 3320 (3)** Principles of Electricity and Magnetism 2
Prereq., PHYS 3310
- PHYS 4230 (3)** Thermodynamics and Statistical Mechanics
Prereq., PHYS 2210; coreq., PHYS 3220

TOTAL (16 LOWER-DIVISION + 9 UPPER-DIVISION)..... 25 CREDIT HRS

¹⁶ Students with equivalent advanced placement credit (see university catalog on advanced placement) may choose to skip PHYS 1110.

¹⁷ It is acceptable for students who started with PHYS 2010 and then decide to become physics majors to go into PHYS 1120. Similarly, it is not essential for students who have completed PHYS 2020 to take PHYS 1120 and PHYS 1140.

¹⁸ PHYS 2170 is the recommended third semester modern physics course; however, students who have taken PHYS 2130 (a course designed for engineering students) can petition to substitute this course for PHYS 2170.

¹⁹ The combination MATH 2130-3 and MATH 3430-3 simultaneously may be substituted for APPM 2360-4; however, both should be completed before taking PHYS 3210-3. MATH 2130 can be taken concurrently with MATH 2400 (Calculus 3)