PHYSICS

The curriculum offered by the Department of Physics provides knowledge of the physical concepts that are basic to the laws of nature, and the ability to use these fundamental concepts to answer questions and solve real problems. Students also gain an understanding of the relationship of physics to other fields such as astronomy, biology, engineering, chemistry and medicine.

Course code for this program is PHYS.

Areas of Study

Students can choose from one of three plans leading to the Bachelor of Arts (BA) degree. Plan 1 is designed primarily for students who plan to pursue graduate study in physics or go directly into professional employment. Plan 2 is intended for students who wish to combine a physics major with an interdisciplinary or applied physics focus. Interdisciplinary focuses include applied mathematics, biophysics, chemical physics, environmental science, history and philosophy of science, or premedicine. Plan 3 is a program designed specifically for those who wish to become secondary school teachers. It includes a teaching licensure in cooperation with the School of Education. A bachelor’s-accelerated master’s degree (BAM) is also available.

The Department of Physics also offers a Bachelor of Science degree in Engineering Physics (catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/engineering-physics/) through the College of Engineering and Applied Science.

Research Opportunities

Physics majors are strongly encouraged to work in a research laboratory. Such experience is especially useful in pursuing a career in science or engineering. Involvement in laboratory experimentation provides knowledge of modern electronic equipment and computerized instrumentation. As contributing members of a research group, students also get a real sense of the creative processes that are part of modern physics research.

Career Opportunities

Physics provides an excellent background for a wide variety of careers, as well as preparation for admission to graduate school in physics and related fields. Design and development work in industrial firms, government and academic laboratories, and nonprofit research centers present opportunities to apply theory to specific problems. In such settings, physics graduates often work closely with engineers, complementing specific disciplines with a broader physics perspective. Graduates can also go on to careers in business, law, finance or medicine after appropriate graduate work.

Bachelor's Degree

- Physics - Bachelor of Arts (BA) (catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/physics/physics-bachelor-arts-ba/)

Minor

- Physics - Minor (catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/physics/physics-minor/)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Ashby, Neil
Professor Emeritus

Baker, Daniel N. (https://experts.colorado.edu/display/fisd_103264/)
Distinguished Professor; PhD, University of Iowa

Bartlett, David
Professor Emeritus

Beale, Paul D. (https://experts.colorado.edu/display/fisd_101602/)
Professor; PhD, Cornell University

Becker, Andreas (https://experts.colorado.edu/display/fisd_146675/)
Associate Professor; Dr habil, Universite Laval (Canada)

Beterton, Meredith D. (https://experts.colorado.edu/display/fisd_125396/)
Associate Professor; PhD, Harvard University

Bolton, Daniel Ryan (https://experts.colorado.edu/display/fisd_155168/)
Instructor; PhD, University of Washington

Calkins, Michael Andrew (https://experts.colorado.edu/display/fisd_149720/)
Assistant Professor; PhD, University of California, Los Angeles

Cao, Gang (https://experts.colorado.edu/display/fisd_157991/)
Professor; PhD, Temple University

Cary, John R. (https://experts.colorado.edu/display/fisd_105901/)
Professor; PhD, University of California, Berkeley

Chasteen, Stephanie Viola (https://experts.colorado.edu/display/fisd_145183/)
Lecturer

Clark, Noel A. (https://experts.colorado.edu/display/fisd_101947/)
Professor; PhD, Massachusetts Institute of Technology

Cooper, John
Professor Emeritus

Cornell, Eric (https://experts.colorado.edu/display/fisd_100112/)
Professor Adjoint

Cumalat, John P. (https://experts.colorado.edu/display/fisd_105582/)
Professor, Chair; PhD, University of California, Santa Barbara

Cundiff, Steven (https://experts.colorado.edu/display/fisd_112280/)
Professor Adjoint, Lecturer

De Alwis, Senarath P. (https://experts.colorado.edu/display/fisd_103029/)
Professor; PhD, University of Cambridge (England)

Degrand, Thomas A. (https://experts.colorado.edu/display/fisd_102740/)
Professor; PhD, Massachusetts Institute of Technology

Dessau, Daniel S. (https://experts.colorado.edu/display/fisd_107532/)
Professor; PhD, Stanford University
DeWolfe, Oliver M. (https://experts.colorado.edu/display/fisid_1429992/)  
Associate Professor; PhD, Massachusetts Institute of Technology

Diddams, Scott A. (https://experts.colorado.edu/display/fisid_148274/)  
Professor Adjunct

Dincao, Jose Paulo (https://experts.colorado.edu/display/fisid_143731/)  
Assistant Research Professor; PhD, Univ of Sao Paulo (Brazil)

Dreitlein, Joseph  
Professor Emeritus

Dubson, Michael A. (https://experts.colorado.edu/display/fisid_102266/)  
Senior Instructor, Associate Chair; PhD, Cornell University

Faller, James E. (https://experts.colorado.edu/display/fisid_102047/)  
Professor Adjunct

Finkelstein, Noah D. (https://experts.colorado.edu/display/fisid_129919/)  
Professor; PhD, Princeton University

Ford, William T.  
Professor Emeritus

Franklin, Allan D.  
Professor Emeritus

Glaser, Matthew A. (https://experts.colorado.edu/display/fisid_105271/)  
Professor Attendant Rank

Glenn, Jason (https://experts.colorado.edu/display/fisid_115556/)  
Professor; PhD, University of Arizona

Goldman, Martin V. (https://experts.colorado.edu/display/fisid_100567/)  
Professor; PhD, Harvard University

Gopinath, Juliet T. (https://experts.colorado.edu/display/fisid_147075/)  
Associate Professor; PhD, Massachusetts Institute of Technology

Gurarie, Victor Vladimir (https://experts.colorado.edu/display/fisid_129918/)  
Professor; PhD, Princeton University

Hall, John L. (https://experts.colorado.edu/display/fisid_103891/)  
Professor Adjunct

Halverson, Nils W. (https://experts.colorado.edu/display/fisid_134252/)  
Associate Professor; PhD, California Institute of Technology

Hamilton, Andrew J.S. (https://experts.colorado.edu/display/fisid_101517/)  
Professor; PhD, University of Virginia

Hasenfratz, Anna (https://experts.colorado.edu/display/fisid_102393/)  
Professor; PhD, Lorand Eotvos University, Budapest (Hungary)

Hermann, Allen M.  
Professor Emeritus

Hermele, Michael Aaron (https://experts.colorado.edu/display/fisid_143370/)  
Associate Professor; PhD, University of California, Santa Barbara

Holland, Murray John (https://experts.colorado.edu/display/fisid_105126/)  
Professor; PhD, Oxford University (England)

Horanyi, Mihaly (https://experts.colorado.edu/display/fisid_102420/)  
Professor; PhD, Eötvös Loránd University (Hungary)

Hough, Loren Evan (https://experts.colorado.edu/display/fisid_144904/)  
Assistant Professor; PhD, University of Colorado Boulder

Jaron-Becker, Agnieszka Anna (https://experts.colorado.edu/display/fisid_146689/)  
Associate Research Professor; PhD, University of Warsaw (Poland)

Kempf, Sascha (https://experts.colorado.edu/display/fisid_149628/)  
Assistant Professor; Dr habil, Technische Universität Braunschweig (Germany)

Kinney, Edward R. (https://experts.colorado.edu/display/fisid_101717/)  
Professor; PhD, Massachusetts Institute of Technology

Kunz, P. Dale  
Professor Emeritus

Lee, Minhyea (https://experts.colorado.edu/display/fisid_145209/)  
Assistant Professor; PhD, University of Chicago

Lehnert, Konrad W. (https://experts.colorado.edu/display/fisid_139785/)  
Professor Adjunct

Lewandowski, Heather Jean (https://experts.colorado.edu/display/fisid_111815/)  
Associate Professor, Associate Chair; PhD, University of Colorado Boulder

MacLennan, Joseph E. (https://experts.colorado.edu/display/fisid_104854/)  
Professor

Mahanthappa, K. T.  
Professor Emeritus; PhD, Harvard University; PhD, Harvard University

Marino, Alysia Diane (https://experts.colorado.edu/display/fisid_146427/)  
Associate Professor; PhD, University of California, Berkeley

Miller, Stanley  
Professor Emeritus

Munsat, Tobin Leo (https://experts.colorado.edu/display/fisid_134251/)  
Associate Professor; PhD, Princeton University

Murnane, Margaret (https://experts.colorado.edu/display/fisid_115333/)  
Distinguished Professor; PhD, University of California, Berkeley

Nagle, James L. (https://experts.colorado.edu/display/fisid_126784/)  
Professor; PhD, Yale University

Nandkishore, Rahul Mahajan (https://experts.colorado.edu/display/fisid_156417/)  
Assistant Professor; PhD, Massachusetts Institute of Technology

Nauenberg, Uriel  
Professor Emeritus

Nesbitt, David J. (https://experts.colorado.edu/display/fisid_100333/)  
Professor Adjunct; PhD, University of Colorado
O'Sullivan, William J.
Professor Emeritus
Parker, Scott E. (https://experts.colorado.edu/display/fisid_109685/)
Professor; PhD, University of California, Berkeley
Perkins, Katherine K. (https://experts.colorado.edu/display/fisid_124217/)
Associate Professor Attendant Rank
Perkins, Thomas T. (https://experts.colorado.edu/display/fisid_124578/)
Associate Professor Adjoint; PhD, Stanford University
Peterson, R. Jerome
Professor Emeritus; PhD, University of Washington; PhD, University of Washington
Phillipson, Paul E.
Professor Emeritus
Pollock, Steven J. (https://experts.colorado.edu/display/fisid_101392/)
Professor; PhD, Stanford University
Price, John C. (https://experts.colorado.edu/display/fisid_101129/)
Professor; PhD, Stanford University
Radzihovsky, Leo (https://experts.colorado.edu/display/fisid_107484/)
Professor; PhD, Harvard University
Rankin, Patricia (https://experts.colorado.edu/display/fisid_105939/)
Professor; PhD, University of London (England)
Raschke, Markus B. (https://experts.colorado.edu/display/fisid_148716/)
Professor; PhD, Tech Univ of Munich (Germany)
Regal, Cindy Anne (https://experts.colorado.edu/display/fisid_144184/)
Associate Professor; PhD, University of Colorado Boulder
Reznik, Dmitry (https://experts.colorado.edu/display/fisid_147659/)
Associate Professor; PhD, University of Illinois at Urbana–Champaign
Ristinen, Robert
Professor Emeritus
Ritzwoller, Michael H. (https://experts.colorado.edu/display/fisid_102264/)
Professor; PhD, University of California, San Diego
Robertson, Scott H.
Professor Emeritus
Rogers, Charles (https://experts.colorado.edu/display/fisid_101331/)
Professor; PhD, Cornell University
Romatschke, Paul (https://experts.colorado.edu/display/fisid_149870/)
Assistant Professor; PhD, Technical Univ of Vienna (Austria)
Schibli, Thomas Richard (https://experts.colorado.edu/display/fisid_143464/)
Associate Professor; PhD, Univ of Karlsruhe (Germany)
Shaheen, Sean Eric (https://experts.colorado.edu/display/fisid_153664/)
Associate Professor; PhD, University of Arizona
Shepard, James R.
Professor Emeritus
Smalyukh, Ivan (https://experts.colorado.edu/display/fisid_144757/)
Professor; PhD, Kent State University
Smythe, Rodman
Professor Emeritus
Stenson, Kevin M. (https://experts.colorado.edu/display/fisid_128676/)
Associate Professor, Associate Chair; PhD, University of Wisconsin–Madison
Taylor, John
Professor Emeritus
Uzdensky, Dmitri Anatoljevich (https://experts.colorado.edu/display/fisid_147430/)
Associate Professor; PhD, Princeton University
Wagner, Stephen R. (https://experts.colorado.edu/display/fisid_139773/)
Professor Attendant Rank, Lecturer
Wyss, Walter
Professor Emeritus
Ye, Jun (https://experts.colorado.edu/display/fisid_106154/)
Professor Adjoint
Yin, Xiaobo (https://experts.colorado.edu/display/fisid_153484/)
Associate Professor; PhD, Stanford University
Zhong, Shijie (https://experts.colorado.edu/display/fisid_118396/)
Professor; PhD, University of Michigan Ann Arbor
Zimmerman, Eric (https://experts.colorado.edu/display/fisid_122809/)
Professor; PhD, University of Chicago

Courses

PHYS 1000 (3) Preparatory Physics
Introduces basic physics, emphasizing an analytical approach to prepare for PHYS 1110 and PHYS 1120, the engineering majors sequence. Does not satisfy any MAPS deficiency in either the sciences or math. Department enforced prerequisite: 1 year high school algebra.

Additional Information: Arts Sci Core Curr: MAPS Course

PHYS 1010 (3) Physics of Everyday Life 1
Intended primarily for nonscientists, this course covers physics encountered in everyday life. Topics include balls, scales, balloons, stoves, insulation, light bulbs, clocks, nuclear weapons, basics of flashlights, and microwave ovens. Department enforced prerequisite: high school algebra or equivalent. This course should not be taken if the student has a MAPS deficiency in math.

Additional Information: GT Pathways: GT-SC2 -Natural Physical Sci:Lec Crse w/o Req Lab

Arts Sci Core Curr: Quant Reasn Mathmat Skills
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Quantitative Reasoning Math
MAPS Course: Chemistry
MAPS Course: Physics
PHY 1020 (4) Physics of Everyday Life 2
Intended primarily for nonscientists, this course is a continuation of PHY 1010. Includes electrical power generation and distribution, electrical motors, radio, television, computers, copiers, lasers, fluorescent lights, cameras, and medical imaging. Department enforced prerequisite, high school algebra.
Requisites: Requires prerequisite course of PHY 1010 (minimum grade C).
Additional Information: GT Pathways: GT-SC2 - Natural Physical Science; Crse w/ Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Quantitative Reasoning Math
Arts Sci Gen Ed: Distribution-Natural Sci Lab

PHY 1110 (4) General Physics 1
Three lect., one rec. per week, plus three evening exams in the fall and spring semesters. First semester of three-semester sequence for science and engineering students. Covers kinematics, dynamics, momentum of particles and rigid bodies, work and energy, gravitation, simple harmonic motion and introduction to thermodynamics.
Equivalent - Duplicate Degree Credit Not Granted: PHY 1115
Requisites: Requires prerequisite course of GEEN 3830 (minimum grade C) or prerequisite or corequisite course of APPM 1345 or APPM 1350 or MATH 1300 or MATH 1310 (minimum grade C).
Additional Information: GT Pathways: GT-SC2 - Natural Physical Science; Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

PHY 1115 (4) General Physics 1 for Majors
First semester of three semester sequence for physics, engineering physics and astronomy majors. Covers kinematics, dynamics momentum of particles and rigid bodies, work and energy, gravitation, simple harmonic motion and introduction to thermodynamics.
Equivalent - Duplicate Degree Credit Not Granted: PHY 1110
Requisites: Requires prerequisite course of GEEN 3830 or prerequisite or corequisite course of APPM 1345 or APPM 1350 or MATH 1300 or MATH 1310 (minimum grade C). Restricted to Physics (BS) or Engineering Physics (BS) or Astronomy (BA) majors only.
Grading Basis: Letter Grade
Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

PHY 1120 (4) General Physics 2
Three lect., one rec. per week, plus three evening exams in the fall and spring semesters. Second semester of three-semester introductory sequence for science and engineering students. Covers electricity and magnetism, wave motion and optics. Normally is taken concurrently with PHY 1140.
Equivalent - Duplicate Degree Credit Not Granted: PHY 1125
Requisites: Requires prerequisite courses of PHY 1110 or PHY 1115 and a prerequisite or corequisite course of APPM 1360 or MATH 2300 (all minimum grade of C).
Additional Information: GT Pathways: GT-SC2 - Natural Physical Science; Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

PHY 1125 (4) General Physics 2 for Majors
Three lect., one rec per week, plus three evening exams in the fall and spring semesters. Second semester of three semester introductory sequence for physics, engineering and astronomy majors. Covers electricity and magnetism, wave motion and optics. Normally is taken concurrently with PHY 1140.
Equivalent - Duplicate Degree Credit Not Granted: PHY 1120
Requisites: Requires a prerequisite course of PHY 1110 or PHY 1115.
Requires a prerequisite or corequisite course of APPM 1360 or MATH 2300 (all minimum grade C). Restricted to Physics (BA), Engineering Physics (BS) and Astronomy (BA) students only.
Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

PHY 1140 (1) Experimental Physics 1
Introduces experimental physics through laboratory observation of a wide range of phenomena. Covers experiments on physical measurements, including mechanics, electricity & magnetism, and optics, with the mathematical analysis of physical errors associated with the experimental process.
Requisites: Requires a prerequisite or corequisite course of PHY 1120 or PHY 1125 (minimum grade C).
Additional Information: GT Pathways: GT-SC1 - Natural Physical Science; Crse w/ Req Lab
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

PHY 1230 (3) Light and Color for Nonscientists
Discusses light, color, vision, and perception. Covers reflection, refraction, lenses, and applications to photography and other methods of light sensing. Other topics include lasers and holography. Course is geared toward nonscience majors. Department enforced prerequisite, high school algebra or equivalent. Should not be taken by students with a math MAPS deficiency.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
MAPS Course: Natural Science
MAPS Course: Chemistry
MAPS Course: Physics

PHY 1240 (3) Sound and Music
Explores the physical processes that underlie the diversity of sound and musical phenomena. Topics covered include the physical nature of sound, the perception of sound, the perception of pitch and harmony, musical instruments, synthesizers and samplers, and room acoustics. Geared toward nonscience majors. Department enforced prerequisite, high school algebra or equivalent. Should not be taken by students with a math MAPS deficiency.
Additional Information: GT Pathways: GT-SC2 - Natural Physical Science; Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
MAPS Course: Natural Science
MAPS Course: Chemistry
MAPS Course: Physics
PHYS 1400 (1) Fundamentals of Scientific Inquiry
Engages students in discussions and experimentation centered around what it means to be a scientist and a member of the greater scientific community. Topics include model-building, metacognition, and the process of science. The second half of the course consists of student-led group research projects culminating in a poster presentation session. Does not count toward the PHYS-BA major requirements. To apply online or for more information, please visit: http://www.cuprime.org/class

PHYS 1580 (3) Energy and Interactions
Engages non-physics majors in hands-on, minds-on activities and labs to explore the physical world, the nature of science, and how science knowledge is constructed. This introductory course is especially relevant for future elementary and middle school teachers although it will meet the needs of most non-physics and non-science majors. Physical content focuses on interactions and energy.
Equivalent - Duplicate Degree Credit Not Granted: EDUC 1580
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
MAPS Course: Chemistry
MAPS Course: Physics
MAPS Course: Natural Science

PHYS 2010 (5) General Physics 1
Includes three lectures, one two-hour laboratory/recitation per week, plus three evening exams in the fall and spring semesters. Covers mechanics, heat and sound. Thorough presentation of fundamental facts and principles of physics using algebra and trigonometry. Designed for life science majors, including premed students. Natural science majors with a knowledge of calculus and others taking calculus are urged to take the calculus-based courses PHYS 1110, PHYS 1120, PHYS 1140 and PHYS 2130, rather than PHYS 2010 and PHYS 2020. Department enforced prerequisites: ability to use high school algebra and trigonometry.
Additional Information: GT Pathways: GT-SC1 - Natural Physical Sci:Lec Crse w/ Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab
MAPS Course: Natural Science

PHYS 2020 (5) General Physics 2
Includes three lectures, one two-hour laboratory/recitation per week, plus three evening exams in the fall and spring semesters. Covers electricity and magnetism, light and modern physics. Designed for life science majors, including premed students. Natural science majors with a knowledge of calculus and others taking calculus are urged to take the calculus-based courses PHYS 1110, PHYS 1120, PHYS 1140 and PHYS 2130, rather than PHYS 2010 and PHYS 2020. Department enforced prerequisites: ability to use high school algebra and trigonometry.
Additional Information: GT Pathways: GT-SC1 - Natural Physical Sci:Lec Crse w/ Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

PHYS 2130 (3) General Physics 3
Covers special relativity, quantum theory, atomic physics, solid state and nuclear physics. Third semester of introductory sequence for science and engineering students. Physics majors should take PHYS 2170 instead of this course. Normally taken with PHYS 2150.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 2170
Requisites: Requires a prerequisite course of PHYS 1120 or PHYS 1125, and a prerequisite or corequisite course of MATH 2400 or APPM 2350 (all minimum grade C).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 2150 (1) Experimental Physics 2
One lect., one 2-hour lab per week. Includes many experiments of modern physics, including atomic physics, solid state physics, electron diffraction, radioactivity and quantum effects. Normally taken concurrently with PHYS 2130 or PHYS 2170, this course may be taken after PHYS 2130 or PHYS 2170.
Requisites: Requires a prerequisite course of PHYS 1140 and a prerequisite or corequisite course of PHYS 2130 or PHYS 2170 (all minimum grade C).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences
Arts Sci Gen Ed: Distribution-Natural Sci Lab

PHYS 2170 (3) Foundations of Modern Physics
Covers special relativity, quantum mechanics and atomic structure. Completes the three-semester sequence of general physics for physics and engineering physics majors. Normally taken with the laboratory PHYS 2150.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 2130
Requisites: Requires a prerequisite course of PHYS 1120 or PHYS 1125, and a prerequisite or corequisite course of MATH 2400 or APPM 2350 (all minimum grade C).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 2210 (3) Classical Mechanics and Mathematical Methods 1
Theoretical Newtonian mechanics, including position and velocity dependent forces, oscillation, stability, non-inertial frames and gravitation from extended bodies. Ordinary differential equations, vector algebra, curvilinear coordinates, complex numbers, and Fourier series will be introduced in the context of the mechanics.
Requisites: Requires a prerequisite course of PHYS 2130 or PHYS 2170 and a prerequisite or corequisite course of APPM 2350 or MATH 2400 and a prerequisite or corequisite course of APPM 2360 or MATH 3430 (all minimum grade C).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 2600 (3) Introduction to Programming and Scientific Computing
Covers basic concepts in programming and scientific computing, including numerical integration and simulation of physical systems. Students will learn the programming language Python and associated graphics libraries. Programming examples will be drawn from classical physical systems that can only be solved numerically, such as projectile motion with drag and N-body problems.
Requisites: Requires prerequisite course of PHYS 1120 (minimum grade C). Requires prerequisite or corequisite course of PHYS 2170 or PHYS 2130 (minimum grade C).

PHYS 2840 (1-3) Independent Study
Selected topics for undergraduate independent study. Subject matter to be arranged.
Repeatable: Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.
PHYS 3000 (3) Science and Public Policy
For non-science majors. Reading, discussions, debates and lectures are
used to study how science affects society economically, intellectually,
and in terms of health and national security. Another focus is how
government fosters and funds scientific activities. Department enforced
prerequisite: completion of core science requirement.

PHYS 3050 (3) Writing in Physics: Problem-Solving and Rhetoric
Teaches strategies used in scientific writing with an emphasis on
argument, reviews and reinforces essential writing skills, provides
experience in writing both academic and professional communications
in a style appropriate to the literature of physics. Department enforced
prerequisite: lower-division core writing requirement. Does not count
toward the PHYS-BA major requirements or major GPA.
Requisites: Requires a prerequisite course of PHYS 2130 or PHYS 2170
(minimum grade C-). Restricted to students with 57-180 credits (Juniors
or Seniors).
Additional Information: GT Pathways: GT-CO3 - Communication:
Advanced Writing Course
Arts Sci Core Curr: Written Communication
Arts Sci Gen Ed: Written Communication-Upper

PHYS 3070 (3) Energy and the Environment
Contemporary issues in energy consumption and its environmental
impact, including fossil fuel use and depletion; nuclear energy and
waste disposal; solar, wind, hydropower, and other renewable sources;
home heating; energy storage; fuel cells; and alternative transportation
vehicles. Included are some basic physical concepts and principles that
often constrain choices. No background in physics is required.
Equivalent - Duplicate Degree Credit Not Granted: ENVS 3070
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 3090 (3) Introduction to Quantum Computing
Covers the basics of quantum computation, including the basics of
quantum information; axioms of quantum mechanics; quantum circuits
and universality; the relationship between quantum and classical
complexity classes; simple quantum algorithms such as the quantum
Fourier transform; Shor factoring algorithm; Grover search algorithm;
physical implementation of quantum computation; error correction and
fault tolerance.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 3090
Requisites: Requires prerequisite course of APPM 2360 or APPM 3130 or
CSCI 2820 or MATH 2130 or MATH 2135 or MATH 3130 or MATH 3135
(minimum grade C-).

PHYS 3210 (3) Classical Mechanics and Mathematical Methods 2
Lagrangian and Hamiltonian treatment of theoretical mechanics,
including coupled oscillations, waves in continuous media, central force
motion, rigid body motion and fluid dynamics. The calculus of variations,
linear algebra, tensor algebra, vector calculus, and partial differential
equations will be introduced in the context of the mechanics.
Requisites: Requires a prerequisite course of PHYS 2210 and a
prerequisite course of APPM 2350 or MATH 2400 and a prerequisite
course of MATH 3430 or APPM 2360 (all minimum grade C-).

PHYS 3211 (1) Tutorial Practicum for Quantum Mechanics 1
Uses interactive group work to aid student learning in corequisite course
PHYS 3220. In this tutorial, students will work in small groups to practice
how to solve challenging problems and their underlying conceptual
basis, as well as using hands-on activities, demonstrations, and other
techniques to help learn content.
Requisites: Requires a corequisite course of PHYS 3220.
Grading Basis: Pass/Fail

PHYS 3210 (3) Principles of Electricity and Magnetism 1
Covers mathematical theory of electricity and magnetism, including
electrostatics, magnetostatics, and polarized media, and provides an
introduction to electromagnetic fields, waves, and special relativity.
Requisites: Requires a prerequisite course of PHYS 2210 and a
prerequisite course of APPM 2350 or MATH 2400 and a prerequisite
course of MATH 3430 or APPM 2360 (all minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 3310 (3) Principles of Electricity and Magnetism 1
Continuation of PHYS 3310. Electromagnetic induction; magnetic
energy; microscopic theory of magnetic properties; AC circuits; Maxwell's
Equations; planewaves; waveguides and transmission lines; radiation
from electric and magnetic dipoles and from an accelerated charge.
Requisites: Requires a prerequisite course of PHYS 3310 (minimum grade
C-).

PHYS 3330 (2) Electronics for the Physical Sciences
Introduces laboratory electronics for physical science students. Includes
basic electronic instruments, dc bridge circuits, operational amplifiers,
bipolar transistors, field-effect transistors, photodiodes, noise in
electronic circuits, digital logic and microcontrollers. Students gain
hands-on experience in designing, building and debugging circuits. Two
lectures and one three hour laboratory per week. Concludes with a three-
week project in which students design and build an experiment of their
choice and present a seminar on the results.
Requisites: Requires prerequisite courses of PHYS 2150 and PHYS 2130
or PHYS 2170 (all minimum grade C-).

PHYS 4130 (3) Biological Electron Microscopy: Principles and Recent
Advances
Covers basic mechanisms for imaging and recent advances used
in current biological research, elements of electron optics, image
optimization, resolution, radiation damage, various imaging modes (TEM,
HVEM, Sem, Stem, Smt), specimen quantitation and reconstruction
(stereo and 3-D), microanalysis and electron diffraction. Specimen
preparation treated only incidentally.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 5130
Requisites: Requires a prerequisite course of EBIO 1220 or MCB 1150 or
MCDB 4550 or MCDB 5550 or PHYS 1120 or PHYS 2020 (minimum grade
D-).
PHYS 4150 (3) Plasma Physics
Focuses on the fundamentals of plasma physics, including particle motion in electromagnetic fields, wave propagation, collisions, diffusion, and resistivity. Presents examples from space plasmas, astrophysical plasmas, laboratory fusion plasmas, and plasmas in accelerators.

Requisites: Requires a prerequisite course of PHYS 3310 and a prerequisite or corequisite course of PHYS 3320 (all minimum grade of C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4230 (3) Thermodynamics and Statistical Mechanics
Introduces thermodynamics, statistical thermodynamics, classical thermodynamics systems; applications to simple systems. Examines relationships of statistical to thermodynamic points of view.

Requisites: Requires a prerequisite course of PHYS 2210 and a prerequisite or corequisite course of PHYS 3220 (all minimum grade of C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4340 (3) Introduction to Solid State Physics
Discusses crystal structure, lattice dynamics, band theory, semiconductors and ferromagnetism.

Requisites: Requires a prerequisite course of PHYS 3220 (minimum grade of C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4410 (3) Quantum Mechanics 2
Extends quantum mechanics to include perturbation theory and its applications to atomic fine structure, multi-particle systems, interactions with external forces, the periodic table, and dynamical processes including electromagnetic transition rates.

Requisites: Requires prerequisite courses of PHYS 3220 and PHYS 3310 (all minimum grade of C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4420 (3) Nuclear and Particle Physics
Introduces structure of the atomic nucleus, spectroscopy of subnuclear particles, scattering, reactions, radioactive decay, fundamental interactions of quarks and leptons.

Requisites: Requires prerequisite courses of PHYS 3320 and PHYS 4410 (all minimum grade of C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4430 (3) Advanced Laboratory
Two lectures, one lab per week. Experiments introduce students to realities of the experimental physics so they gain a better understanding of theory and an appreciation of the vast amount of experimental work done in the physical sciences today.

Requisites: Requires a prerequisite course of PHYS 3330 (minimum grade of C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4450 (3) History and Philosophy of Physics
Investigates the role of experiment in physics, case studies in the history and philosophy of physics and in scientific methodology.

Requisites: Requires a prerequisite course of PHYS 1020 or PHYS 1120 or PHYS 1125 or PHYS 2020 (minimum grade of C).

Additional Information: Arts Sci Gen Ed: Distribution-Arts Humanities

PHYS 4460 (3) Teaching and Learning Physics
Learn how people understand key concepts in physics. Through examination of physics content, pedagogy and problems, through teaching, and through research in physics education, students will explore the meaning and means of teaching physics. Students will gain a deeper understanding of how education research is done and how people learn. Useful for all students, especially for those in interested in physics, teaching and education research.

Requisites: Requires prerequisite courses of PHYS 3210 and PHYS 3310 (all minimum grade of C).

Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4510 (3) Optics
Focuses on the basics of electromagnetic theory of light, using Maxwell's equations. Examples in geometrical optics; extensive applications in physical optics including diffraction and polarization. Spectra, including Zeeman effect and fluorescence. Recent advances in experimental techniques: microwaves, lasers, image converters.

Requisites: Requires a prerequisite course of PHYS 3320 (minimum grade of C).
**PHYS 4620 (2) Physics Honors**  
Students are matched with a faculty member and work independently on a research topic. Typically, the honors program lasts three semesters. A senior thesis and an oral presentation of the work are required. See also PHYS 4610 and PHYS 4630. Department enforced prerequisite: minimum 3.00 GPA. Registration by special arrangement with the Department of Physics.  
**Additional Information:** Arts Sciences Honors Course

**PHYS 4630 (2) Physics Honors**  
Students are matched with a faculty member and work independently on a research topic. Typically, the honors program lasts three semesters. A senior thesis and an oral presentation of the work are required. See also PHYS 4610 and PHYS 4620. Department enforced prerequisite: minimum 3.00 GPA. Registration by special arrangement with the Department of Physics.  
**Additional Information:** Arts Sciences Honors Course

**PHYS 4810 (1-3) Special Topics in Physics**  
Various topics not normally covered in the curriculum. Offered intermittently depending on student demand and availability of instructors.  
**Repeatable:** Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.  
**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences

**PHYS 4840 (1-3) Independent Study**  
Selected topics for undergraduate independent study. Subject matter to be arranged. See also PHYS 4850.  
**Repeatable:** Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.

**PHYS 4850 (1-3) Independent Study**  
Selected topics for undergraduate independent study. Subject matter to be arranged. See also PHYS 4840.  
**Repeatable:** Repeatable for up to 7.00 total credit hours. Allows multiple enrollment in term.

**PHYS 4970 (3) Seminar on Physical Methods in Biology**  
Covers basic mechanisms and applications of physical methods used in current biological research, microprobe analysis, Eels, elementary electron and x-ray crystallography, biomedical imaging (NMR, MRI, Pet, Cat), Fourier analysis, synchrotron radiation, Exafs, neutron scattering and novel ultramicroscopy techniques. Includes lectures, student presentations, occasional demonstrations. Emphasis depends on student interest.  
**Equivalent - Duplicate Degree Credit Not Granted:** PHYS 5970  
**Requisites:** Requires a prerequisite course of PHYS 1120 or PHYS 2020 and MCDB 1150 or EBIOP 1220 (all minimum grade D-).