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 concurrent bachelor's/master's degree (BA/MS) 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.

Anderson, Dana Z. (https://experts.colorado.edu/display/fisid_102371)
Professor; PhD, University of Arizona

Ashby, Neil
Professor Emeritus

Baker, Daniel N. (https://experts.colorado.edu/display/fisid_103264)
Distinguished Professor; PhD, University of Iowa

Bartlett, David
Professor Emeritus

Beale, Paul D. (https://experts.colorado.edu/display/fisid_101602)
Professor; PhD, Cornell University

Becker, Andreas (https://experts.colorado.edu/display/fisid_146675)
Associate Professor; Dr habil, Universite Laval (Canada)

Betterton, Meredith D. (https://experts.colorado.edu/display/fisid_125396)
Associate Professor; PhD, Harvard University

Bolton, Daniel Ryan (https://experts.colorado.edu/display/fisid_155168)
Instructor; PhD, University of Washington

Calkins, Michael Andrew (https://experts.colorado.edu/display/fisid_149720)
Assistant Professor; PhD, University of California, Los Angeles

Cao, Gang (https://experts.colorado.edu/display/fisid_157991)
Professor; PhD, Temple University

Cary, John R. (https://experts.colorado.edu/display/fisid_105901)
Professor; PhD, University of California, Berkeley

Chasteen, Stephanie Viola (https://experts.colorado.edu/display/fisid_145183)
Lecturer

Clark, Noel A. (https://experts.colorado.edu/display/fisid_101947)
Professor; PhD, Massachusetts Institute of Technology

Cooper, John
Professor Emeritus

Cornell, Eric (https://experts.colorado.edu/display/fisid_100112)
Professor Adjoint

Cumalat, John P. (https://experts.colorado.edu/display/fisid_105582)
Professor, Chair; PhD, University of California, Santa Barbara

Cundiff, Steven (https://experts.colorado.edu/display/fisid_112280)
Professor Adjoint, Lecturer

De Alwis, Senarath P. (https://experts.colorado.edu/display/fisid_103029)
Professor; PhD, University of Cambridge (England)

Degrand, Thomas A. (https://experts.colorado.edu/display/fisid_102740)
Professor; PhD, Massachusetts Institute of Technology

Dessau, Daniel S. (https://experts.colorado.edu/display/fisid_107532)
Professor; PhD, Stanford University

DeWolfe, Oliver M. (https://experts.colorado.edu/display/fisid_142992)
Associate Professor; PhD, Massachusetts Institute of Technology

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

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 Adjoint

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)

Kapteyn, Henry C. (https://experts.colorado.edu/display/fisid_115334)
Professor; PhD, University of California, Berkeley

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 Adjoint

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

Neil, Ethan (https://experts.colorado.edu/display/fisid_153411)
Assistant Professor; PhD, Yale University

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

Wineland, David J. (https://experts.colorado.edu/display/fisid_119931)
Professor Adjoint

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 prereq., 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 Physicl 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

PHYS 1020 (4) Physics of Everyday Life 2
Intended primarily for nonscientists, this course is a continuation of PHYS 1010. Includes electrical power generation and distribution, electrical motors, radio, television, computers, copiers, lasers, fluorescent lights, cameras, and medical imaging. Department enforced prereq., high school algebra.
Requisites: Requires prerequisite course of PHYS 1010 (minimum grade C-).
Additional Information: GT Pathways: GT-SC1 - Natural Physcal Sci:Lec Crse w/ Req Lab
Arts Sci Core Curr: Quant Reasn Mathmat Skills
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

PHYS 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: PHYS 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 Physicl Sci:Lec Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 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: PHYS 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 (PHYS-BA) or Engineering Physics (EPEN-BS) or Astronomy (ASTR-BA) majors only.
Grading Basis: Letter Grade
Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 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 PHYS 1140.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 1125
Requisites: Requires prerequsite courses of PHYS 1110 or PHYS 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 Physicl Sci:Lec Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 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 PHYS 1140.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 1120
Requisites: Requires a prerequisite course of PHYS 1110 or PHYS 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.
Grading Basis: Letter Grade
Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 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 PHYS 1120 or PHYS 1125 (minimum grade C-).
Additional Information: GT Pathways: GT-SC1 - Natural Physcal Sci:Lec Crse w/ Req Lab
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 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 prereq., 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

PHYS 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 prereq., high school algebra or equivalent. Should not be taken by students with a math MAPS deficiency.
Additional Information: GT Pathways: GT-SC2 -Natural Physicl Sci:Lec Crse w/o Req Lab
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 1400 (1) Fundamentals of Scientific Inquiry
Explore and discuss the nature of science and what it means to work in science, technology, engineering or math. Focus on relevant open questions in these fields and the methods used to investigate them. For more information visit: www.colorado.edu/studentgroups/cuprime.

PHYS 1580 (3) Energy and Interactions
Engages non-physics majors in hands-on, minds-on activities and labs to investigate 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 Physcal 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.
Requisites: Requires a prerequisite course of PHYS 1110 or PHYS 2010 (minimum grade C-).
Additional Information: GT Pathways: GT-SC1 - Natural Physcal 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 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 nonscience 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, hydroelectric, 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 3310 or CSCI 2820 or MATH 2130 or MATH 2135 (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 (minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 3220 (3) Quantum Mechanics 1
Introduces quantum mechanics with wave, operator and matrix computational techniques. Investigates solutions for harmonic oscillator, potential well and systems with angular momentum. Develops a quantitative description of one-electron atoms in lowest order.
Requisites: Requires a prerequisite course of PHYS 3210 (minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 3221 (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 3310 (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 prerequisite courses of PHYS 2210 (minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 3311 (1) Tutorial Practicum for Electricity & Magnetism 1
Uses interactive group work to aid student learning in corequisite course PHYS 3310. 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 3310.
Grading Basis: Pass/Fail

PHYS 3320 (3) Principles of Electricity and Magnetism 2
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-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

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-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences Arts Sci Gen Ed: Distribution-Natural Sci Lab

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, Stm), 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 MCDB 1150 or MCDB 4550 or MCDB 5550 or PHYS 1120 or PHYS 2020 (minimum grade D-).

PHYS 4150 (3) Plasma Physics
Discusses 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 prerequsite 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
Statistical mechanics applied to macroscopic physical systems; statistical thermodynamics, classical thermodynamics systems; applications to simple systems. Examines relationship 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 prerequsite 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 a prerequsite course of PHYS 4410 (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.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 5430
Requisites: Requires a prerequsite course of PHYS 3330 (minimum grade of C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences Arts Sci Gen Ed: Distribution-Natural Sci Lab

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.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 5450 and PHIL 4450 and PHIL 5450
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 Arts Sci Gen Ed: Distribution-Natural Sciences

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.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 5460 and EDUC 4460 and EDUC 5460
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
Basic 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-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4550 (3) Cells, Molecules and Tissues: A Biophysical Approach
Focuses on the biophysics governing the structure/function of enzymes, cells, extra-cellar matrix and tissue. Synthesizes ideas from molecular biology, physics, and biochemistry, emphasizing how low Reynolds number physics, not Newtonian physics, is relevant to life inside a cell. Fulfills MCDB scientific reasoning requirement.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 5550 and MCDB 4550 and MCDB 5550
Recommended: Prerequisites MCDB 3135 and MCDB 3145 and PHYS 2010 and PHYS 2020 and CHEM 1133 or MATH 1300 and/or CHEM 3311 (minimum grade C-) or instructor consent required.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4560 (3) Introduction to Biophysics
Covers an introduction to the physics of living systems. Focuses on how living systems are able to generate order, with both physical principles and biological examples. Covers the development of quantitative models for biological systems, including estimates. Taught from a physics perspective, with biology background introduced as needed.
Equivalent - Duplicate Degree Credit Not Granted: PHYS 5560 and MCDB 4560 and MCDB 5560
Requisites: Requires a prerequisites course of PHYS 2210 (minimum grade C-).
Recommended: Prerequisite PHYS 4230.
Grading Basis: Letter Grade
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

PHYS 4610 (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 4620 and PHYS 4630. Department enforced prerequisite: mininimum 3.00 GPA. Registration by special arrangement with the Department of Physics.
Additional Information: Arts Sciences Honors Course

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: mininimum 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: mininimum 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 EBIO 1220 (all minimum grade D-).