Physics

INTRODUCTION

Physics is the natural science that deals with the properties and interactions of matter and radiation. As such, physics provides the fundamental basis for all other sciences, and for applied science fields such as engineering and the health sciences. Many physicists engage in research designed to expand the frontiers of physical knowledge; others engage in the application of physics concepts in industry and in private and government laboratories.

The physics major program can provide the education necessary for the student to continue studies at the graduate level that, in turn, lead to the master’s and doctoral degrees. Alternatively, the physics major program can provide the education necessary for the student to work immediately upon graduation with the bachelor’s degree, either in industry or government labs, in applied physics fields, or in teaching at the secondary school level. Our optional emphasis in business provides students with experience in starting or managing a technology-oriented business.

Students are encouraged to obtain research experience by working with faculty in their ongoing research efforts. Independent Study provides practical work experience that integrates classroom studies with the needs and methods of modern industrial science.

LEARNING GOALS AND STUDENT LEARNING OUTCOMES

The following goals and learning outcomes have been established for students pursuing a degree in Physics:

Content Knowledge

Students will demonstrate understanding of:

- Force, energy and momentum and apply this understanding to predict and describe motion
- Thermodynamics and the thermodynamic properties of materials
- Waves and wave propagation
- Electricity, magnetism, the relationship between electric and magnetic phenomena, and electromagnetic forces and waves
- Modern physics, including quantum theory, relativity and elementary particles

Investigation and Experimentation

Students will learn to:

- Ask scientific questions, formulate hypotheses, design and conduct experiments, and analyze data
- Collect, analyze and interpret data and information
- Use modern laboratory equipment including advanced computer hardware and software
- Use analytical, computational, graphical and advanced mathematical methods in problem-solving
- Apply mathematics to scientific investigation and experimentation for the purpose of quantifying results and drawing conclusions

**Communication**

Students will learn to:
- Communicate data, concepts, skills and processes to experts and non-experts in the field in logical and meaningful formats
- Communicate scientific observations, results and conclusions in clear, logical, and unbiased terms both verbally and in writing
- Use appropriate technology to communicate scientific results

**Nature of Science**

Students will learn to:
- Recognize that science is an active endeavor in which the acquisition of knowledge is based upon the collection and examination of data
- Recognize the synergistic nature of science and technology
- Experience and practice analyzing complex situations to make informed decisions and to participate in scientific problem solving
- Recognize their responsibility to increase scientific literacy so that the general population can understand current issues and appreciate their personal societal roles and responsibilities

**BACHELOR OF SCIENCE IN PHYSICS (120 UNITS)**

The Bachelor of Science in Physics requires 73 units in the major, including core courses, and upper-division physics, science and engineering electives. Each course in physics, mathematics, chemistry and English that is required for the major must be completed with a “C” (2.0) or better.

Formal academic advisement is required for all physics majors at least once every academic year.

**Lower Division (32-34 units)**

*General Chemistry (8 units)*
CHEM 120A, 125

*Mathematics (12 units)*
MATH 150A,B and 250A

*Fundamental Physics (12 units)*
PHYS 225, 226, 227 and 225L, 226L, 227L

*Note:* Students may take CHEM 120B in place of CHEM 125.

**Upper Division (21 units)**

PHYS 300 Survey of Mathematical Physics (3)
PHYS 310 Thermodynamics, Kinetic Theory and Statistical Physics (3)
PHYS 320 Classical Mechanics (3)
PHYS 330A Electromagnetic Theory I (3)
PHYS 330B Electromagnetic Theory II (3)
PHYS 340 Modern Physics (3)
PHYS 380 Methods of Experimental Physics (3)

**Upper-Division Physics Electives (14 units)**

Must include one laboratory course.
For students completing a minor or second major in mathematics, another science, engineering or computer science, the upper-division physics elective requirement is 12 units.

**Upper-Division Science and Engineering Electives (3 units)**

Additional upper-division courses in mathematics, science, engineering and/or computer science approved by the department.

**Upper-Division Writing Requirement (3 units)**

One of the following:
ENGL 301, 360; BUAD 301 (for students pursuing the emphasis in business only); CHEM 340; MATH 380

**EMPHASIS IN BUSINESS**

Students who pursue the Emphasis in Business program do not take PHYS 227L and substitute ACCT 201A for CHEM 125 in lower-division major requirements, and complete the following 21 units in physics and business electives in place of the usual upper-division physics and science/engineering elective.

FIN 320 Business Finance (3)
MGMT 340 Organizational Behavior (3)
MGMT 465A New Venture Creation & Funding (3)
MGMT 465B New Venture Launch (3)
OR MGMT 461 Entrepreneurial Management (3)
MKTG 351 Principles of Marketing (3)
PHYS 481 Experimental Physics (3)
OR PHYS 482 Modern Optics Laboratory (3)
BUAD 301 Advanced Business Communication (3)

*Note:* BUAD 301 satisfies the upper-division writing requirement.

**MINOR IN PHYSICS**

**Lower Division (12 units)**

PHYS 225, 225L, 226, 226L, 227, 227L

**Upper Division (9 units)**

PHYS 380 Methods of Experimental Physics (3)

Six additional upper-division units in physics, selected in consultation with the academic adviser and approved by the department chair.

**TEACHING CREDENTIAL**

The Bachelor’s Degree in Physics may be effectively combined with subject matter studies necessary for the Single Subject Teaching Credential in science. Undergraduates are encouraged to contact the Center for Careers in Teaching (657-278-7130, fullerton.edu/cct) and the Science Education Programs Office.
MASTER OF SCIENCE IN PHYSICS (30 UNITS)

Admission Requirements

Students must meet the CSU requirements for admission to a master's degree program. Please consult the Graduate Admissions section in this catalog for complete information. In addition, applicants must have: (1) a degree from an accredited college or university with a major in physics or a closely related field (students with majors other than physics may be admitted with deficiencies); and (2) a grade-point average of 2.75 for upper-division courses in the physics major. For students with undergraduate degrees in engineering, mathematics or other physical sciences, a GPA of 3.0 in upper-division major courses is required. Applicants are also required to: (1) take the physics portion of the Graduate Record Exam (GRE) either previously or within a year of application (the GRE requirement can be waived for physics majors who enter with a GPA of 3.6 or higher); (2) submit a one-page, 500-word maximum, typed statement of purpose, explaining the student's interest in taking a higher degree in physics; and (3) submit three letters of recommendation.

International student applicants are required to pass the Test of English as a Foreign Language (TOEFL) with a score of 213 for the paper test.

Required Core Course (12 units)
PHYS 510 Mathematical Physics (3)
PHYS 520 Analytical Mechanics (3)
PHYS 530A Electromagnetic Theory I (3)
PHYS 555A Quantum Physics I (3)

Additional 500-Level Requirements (6 units)

Plan A (comprehensive exam)
Choose two of the following:
PHYS 530B Electromagnetic Theory II (3)
PHYS 555B Quantum Physics II (3)
PHYS 516 Statistical Mechanics and Thermodynamics (3)
PHYS 554 Solid State Physics (3)

Plan B (PHYS 598 Thesis)
Choose one of the following:
PHYS 530B, 555B, 516 or 554.

Plus
PHYS 599 Independent Graduate Research (3)

Plan C (PHYS 597 Project)
Choose one of the following:
PHYS 530B, 555B, 516 or 554

Plus
PHYS 599 Independent Graduate Research (3)

Electives (8-12 units)
Electives are chosen in consultation with the graduate adviser. Electives may be chosen from any 400- or 500-level physics course with the exception of any courses which were used to satisfy baccalaureate degree requirements. In cases where the research objectives or career goals are interdisciplinary in nature, courses may be chosen in other fields (e.g., mathematics, chemistry, engineering, biology, geological science, science/teacher education).

Project, Thesis or Comprehensive Exam (0-4 units)
PHYS 597 Project (1-3)
OR PHYS 598 Thesis (1-6)
OR Comprehensive Exam

ASTRONOMY COURSES
Courses are designated ASTR as in the class schedule.

101 Introduction to Astronomy (3)
Prerequisite: high school algebra recommended. Celestial motion, the solar system, galactic structure, theories of the origin of the universe and the solar system.

PHYSICS COURSES
Courses are designated as PHYS in the class schedule.
A "C" (2.0) or better is required in all prerequisite courses. Prerequisite requirements with exception of the grade requirement may be waived by the instructor of the course if the instructor is satisfied that the student is qualified to undertake the course.

101 Survey of Physics (3)
Basic concepts of physics for the non-science major. Physical concepts in real-world contexts such as global warming. How our ideas about motion, energy, heat and temperature, light and color, electricity, and atoms form a framework for understanding the natural world.

101L Survey of Physics Laboratory (1)
Corequisite: PHYS 101. Experiments that demonstrate important concepts in astronomy and physics. For non-science majors.

102 Physical Science for Future Elementary Teachers (3)
Designed especially for the prospective elementary teacher, this activity-based course examines physical science concepts in real-world contexts such as global warming, kitchen science and the automobile. Lecture and laboratory is combined into a single unified learning experience. (Same as CHEM 102)
115 Introductory Physics (4)
Prerequisites: high school algebra, geometry and intermediate algebra. Development of problem-solving skills in basic physics. For students with limited background in physics who plan to take additional physics courses. Does not fulfill physics requirements for majors or minors in the physical or biological sciences. (3 hours lecture, 1 hour recitation)

211 Elementary Physics (3)
Prerequisite: MATH 125 with a "C" (2.0) or better, or currently enrolled in MATH 130 or 150A. Corequisite: PHYS 211L. Introduction to mechanics and thermodynamics. Designed for life and health science majors.

211L Elementary Physics: Laboratory (1)
Corequisite: PHYS 211. Laboratory for PHYS 211. (3 hours laboratory). Instructional fee required.

212 Elementary Physics (3)
Prerequisite: PHYS 211 with a "C" (2.0) or better. Corequisite: PHYS 212L. Introduction to electricity and magnetism, wave motion and optics. Designed for life and health science majors.

212L Elementary Physics: Laboratory (1)
Corequisite: PHYS 212. (3 hours laboratory). Laboratory for PHYS 212. Instructional fee required.

225 Fundamental Physics: Mechanics (3)
Prerequisite: MATH 150A. Corequisite: PHYS 225L. Classical Newtonian mechanics; linear and circular motion; energy; linear/ angular momentum; systems of particles; rigid body motion; wave motion and sound.

225L Fundamental Physics: Laboratory (1)
Corequisite: PHYS 225 (3 hours laboratory). Laboratory for PHYS 225. Instructional fee required.

226 Fundamental Physics: Electricity and Magnetism (3)
Prerequisites: MATH 150B, PHYS 225 or equivalent. Corequisite: PHYS 226L. Electrostatics, electric potential, capacitance, dielectrics, electrical circuits, resistance, emf, electromagnetic induction, magnetism and magnetic materials, and introduction to Maxwell’s equations.

226L Fundamental Physics: Laboratory (1)
Corequisite: PHYS 226 (3 hours laboratory). Laboratory for PHYS 226. Instructional fee required.

227 Fundamental Physics: Waves, Optics, and Modern Physics (3 or 1)
Prerequisite: PHYS 226 with a "C" (2.0) or better, or equivalent. Corequisite: PHYS 227L. Laboratory except for Biochemistry, Chemistry and Mechanical Engineering majors who may enroll for one unit credit (optics component). All others must enroll for three units credit. Geometrical and physical optics, wave phenomena; quantum physics, including the photoelectric effect, line spectra and the Bohr atom; the wave nature of matter, Schroedinger’s equation and solutions; the Uncertainty Principle; special theory of relativity.

227L Fundamental Physics: Laboratory (1)
Corequisite: PHYS 227 (3 hours laboratory). Laboratory for PHYS 227. Instructional fee required.

300 Survey of Mathematical Physics (3)
Prerequisite: MATH 250A. Mathematical techniques required for upper-division physics courses, including differential vector operators, complex variables, partial and ordinary differential equations, special functions, Fourier transforms and series, matrices and operators, probability and statistics.

301 Energy and Sustainability (3)
Prerequisites: completion of general education requirement in physical science or earth and astronomical science. Basic physical principles applied to the generation and use of energy. Conventional and alternative energy sources. Environmental consequences of energy use, greenhouse effect, global warming. Energy conservation principles. One or more sections offered online.

310 Thermodynamics, Kinetic Theory, and Statistical Physics (3)
Prerequisite: PHYS 227. Laws of thermodynamics with physical, chemical and engineering applications; kinetic theory of gases. Introduction to statistical physics with reexamination of laws of thermodynamics.

315 Computational Physics (3)
Prerequisite: PHYS 227. Previous computing experience recommended. Basic numerical methods in physics. Applications may include curve fitting and minimization, numerical simulation of classical particles, waves and Fourier analysis, quantum square well, Monte Carlo methods and diffusion. Hands-on computing with high-level languages, graphics and symbolic mathematics. (1 hour lecture, 4 hours activity)

320 Classical Mechanics (3)
Prerequisites: PHYS 227, 300. Classical mechanics and associated mathematical and numerical techniques: Newtonian dynamics; Lagrangian and Hamiltonian dynamics.
330A Electromagnetic Theory I (3)
Prerequisites: PHYS 227, 300. Application of vector calculus and special mathematics techniques to electric and magnetic phenomena in matter.

330B Electromagnetic Theory II (3)
Prerequisites: PHYS 300, 330A. Applications of Maxwell's equations to the propagation of EM waves in dielectrics, plasmas and conductors. Selected topics in radiation, diffraction and eigenfunction expansions of static and waveguide fields. Special relativity: Einstein's postulates, Lorentz transformations, relativistic motion of charged particles.

340 Modern Physics (3)
Prerequisites: PHYS 227, 300. Modern physical theories and associated mathematical techniques. Early quantum mechanics development; Schrodinger's equation; one-dimensional systems; the harmonic oscillator.

380 Methods of Experimental Physics (3)
Prerequisite: PHYS 226. Experiments using analog, digital, and integrated circuits, including filtering circuits, diodes, transistor amplifiers, operational amplifiers, triggers, and digital logic. Introduction to automated experimentation. (1 hour lecture, 6 hours laboratory). Instructional fee required.

411 Modern Optics (3)
Prerequisite: PHYS 300, 330 or 340. Wave propagation, Fourier optics, introduction to spatial filtering and image enhancement, lasers, analytical ray tracing, matrix methods in optics.

416 Thermal and Statistical Physics (3)
Prerequisites: PHYS 300, 310. Disciplines of thermodynamics statistical mechanics and kinetic theory (and their applications); their unifying microscopic foundation.

454 Introduction to the Solid State of Matter (3)
Prerequisites: PHYS 300, 340. Physical properties of matter in the solid state, as explained by atomic theory. Crystal structure, thermal, electric and magnetic properties of metals, semi-conductors, band theory and solid state devices.

455 Introduction to Quantum Physics (3)
Prerequisites: PHYS 300, 340. Concepts and theory of quantum physics. Early quantum theories, the Schroedinger equation, Eigenvalue equations, operators, commutation properties, applications to simple quantum systems, angular momentum.

460T Advanced Topics in Contemporary Physics (3)
Prerequisites: junior or senior standing in physics and consent of instructor and department chair. Advanced lecture course covering a field of physics of current interest not covered in other courses, such as plasma physics, superconductivity, solid state devices, fiber optics and photonics, astrophysics, subatomic physics. May be repeated for credit with a different topic.

476 Atomic/Molecular Physics (3)
Prerequisite: PHYS 300, 340. Theory of atoms and small molecules including perturbation methods. Topics include the interaction of atoms and molecules with electric and magnetic fields and electromagnetic radiation, angular momentum coupling, antisymmetrization, and the spectroscopy of atoms and simple diatomic methods.

481 Experimental Physics (3)
Prerequisite: PHYS 300, 380. Techniques and methods of experimental physics including: use of sensors, transducers, time series, power spectra, phase sensitive detection, computer interfacing and signal conditioning. Experiments cover several areas of physics. (1 hour lecture, 6 hours laboratory). Instructional fee required.

482 Modern Optics Laboratory (3)
Prerequisites: PHYS 340, 380, 411 recommended. Experiments in optics, including Fourier optics, holography, fiber optics, diffraction, interferometry, laser physics, light scattering and optical detection, including photon counting and photographic techniques. (1 hour lecture, 6 hours laboratory). Instructional fee required.

495 Internship (1-3)
Prerequisites: junior or senior standing in physics and consent of the chair. Professional physics work in industry or government to provide an in-depth experience. Written report required. May be repeated once for credit.

496 Student-to-Student Tutorials (1-3)
Prerequisites: junior or senior standing and consent of chair. Learn through teaching, increase mastery of subject matter, develop awareness of teaching problems and competence in teaching techniques. Consult "Student-to-Student Tutorials" in this catalog for more complete course description.

499 Independent Study (1-3)
Prerequisite: approval of study plan by department chair and instructor. Topic in physics, selected in consultation with and completed under the supervision of the instructor. May be repeated for credit to a maximum of six units.

510 Mathematical Physics (3)
Prerequisite: PHYS 300. Advanced techniques in mathematical physics: calculus of variation, coordinate transformations, tensor analysis, special functions, series solutions of differential equations, orthogonal functions, partial differential equations, numerical techniques for the solution of differential equations, complex variables, integral transforms, probability, Monte Carlo methods.
516 Statistical Mechanics and Thermodynamics (3)

520 Analytical Mechanics (3)
Prerequisites: PHYS 330, 510. Advanced techniques for solution of problems in classical mechanics: Lagrangian and Hamiltonian formulations of the equations of motion, variation techniques, conservation theorems, canonical transformations, Hamilton-Jacobi theory, numerical techniques, selected applications.

530A Electromagnetic Theory I (3)

530B Electromagnetic Theory II (3)
Prerequisites: PHYS 510, 530A. Advanced electromagnetic theory: wave guides and cavities, radiating systems, scattering, diffraction, relativistic effects, collisions between charged particles, radiation from moving charges, multipole fields, radiation damping, absorption and radiation by sound systems.

554 Solid State Physics (3)
Prerequisites: PHYS 510, 555A. Fundamental physics of matter in solid state systems. Crystal structure, metals (Drude theory, Sommerfeld theory, band structure, semiclassical model of electron dynamics, magnetic properties, phonons in metals); semiconductors and superconductors; experimental techniques.

555A Quantum Physics I (3)
Prerequisites: PHYS 340, 455 recommended. Corequisite: PHYS 510. Principles and techniques of modern quantum mechanics, applications to simple three-dimensional systems, properties of angular momentum.

555B Quantum Physics II (3)

560T Advanced Topics in Contemporary Physics (3)
Prerequisites: PHYS 510 and consent of instructor. Current advances and research topics in physics, including atomic physics, quantum electrodynamics, fiber optics/photons. May be repeated once for credit with a different topic.