PHYSICS

Department of Physics

Physical Sciences Building, Room 119
(909) 537-5397 physics.csusb.edu

Bachelor of Arts

Physics

Bachelor of Science

Physics
Applied Physics

Minor

Physics
Applied Physics

FACULTY: Leo Connolly (Emeritus), Paul Dixon (Chair), Karen Kolehmainen, Paul Renteln, Javier Torner, Timothy Usher, Laura Woodney

Traditionally, physics majors have gone on to graduate work in physics, high school teaching, or employment in industrial or government laboratories. Other opportunities which have recently become interesting for physics graduates include atmospheric physics (including air pollution studies), geophysics, radiation safety, oceanography, astrophysics, technical administration, biophysics, computer science and medical instrumentation development.

The program for a bachelor of arts degree in physics provides basic knowledge in the main subject areas of physics as well as an opportunity for students to elect a considerable number of courses in other disciplines. This is a good choice for students planning careers in high school teaching. The bachelor of science program includes additional course work in physics and related fields which further prepares a student for employment or graduate work.

The Applied Physics option is designed to prepare students for direct employment in high-technology firms upon graduation. For traditional design tasks, high-technology firms typically hire applied physicists with a flexible and creative technical ability who can address a wide range of technical problems and develop an experimental system to attack problems. A solid understanding of theoretical physics across the curriculum is required and the ability to design, interface and control experimental apparatus. Because the tasks that applied physicists perform in the industrial environment are primarily experimental in nature, this option includes a number of laboratory courses in addition to the theory curriculum core: PHYS 150. Introductory Electronics; CSE 201. Computer Science I; PHYS 350. Data Acquisition and Control; PHYS 352. Advanced Electronics; and PHYS 430. Advanced Physics Laboratory. The courses in the applied physics option prepare students to function effectively in the computer-based experimental environment that they face in research and development, testing or process control.

Pre-engineering - The campus provides a pre-engineering program that enables students to complete the first two years of courses generic to engineering. Students may then transfer to an accredited engineering program of their choice. The following courses have been recommended as appropriate transfer courses: CHEM 215, 216, MATH 211, 212, 213, 251, 252, PHYS 221, 222, 223, and selected courses in computer science and general education.

Students considering a physics or pre-engineering major should call the department office for advising.

B.A. IN PHYSICS

Requirements (89 units)

Total units required for graduation: 180

Requirements for the B.A. in Physics:

Lower-division requirements (53 units)

1. CHEM 215. General Chemistry I: Atomic Structure and Chemical Bonding (6)
2. CHEM 216. General Chemistry II: Principles of Chemical Reactions (6)
3. MATH 211. Basic Concepts of Calculus (4)
4. MATH 212. Calculus II (4)
5. MATH 213. Calculus III (4)
6. MATH 251. Multivariable Calculus I (4)
7. MATH 252. Multivariable Calculus II (4)
8. PHYS 221. General Physics I (5)
9. PHYS 222. General Physics II (5)
10. PHYS 223. General Physics III (5)
11. PHYS 224. General Physics IV (3)
12. PHYS 225. General Physics V (3)

Upper-division requirements (28 units)

1. MATH 331. Linear Algebra (4)
2. PHYS 306. Classical Mechanics I (4)
3. PHYS 313. Electrodynamics I (4)
4. PHYS 324. Statistical and Thermal Physics (4)
5. PHYS 373. Mathematical Methods of Physics I (4)
4. PHYS 421. Quantum Mechanics I (4)
7. PHYS 430. Advanced Physics Laboratory (4)

Electives (8 units)

1. Eight units chosen from upper-division physics courses selected with the approval of the department:
   - PHYS 307. Classical Mechanics II (4)
   - PHYS 314. Electrodynamics II (4)
   - PHYS 315. Introduction to Modern Optics (4)
   - PHYS 318. Materials Science and Engineering (4)
   - PHYS 370. Introduction to Astrophysics (4)
   - PHYS 422. Quantum Mechanics II (4)
   - PHYS 450. Solid State Physics (4)
   - PHYS 461. Introduction to Nuclear Physics (4)
   - PHYS 463. Introduction to Elementary Particle Physics (4)
   - PHYS 473. Mathematical Methods of Physics II (4)
   - PHYS 480A. Topics in Classical Physics: Mechanics (4)
   - PHYS 480B. Topics in Classical Physics: Electrodynamics (4)
   - PHYS 485. Topics in Contemporary Physics (1-4)
   - PHYS 573. Mathematical Methods of Physics III (4)
   - PHYS 590. Physics Seminar (1)
   - PHYS 595. Independent Study (1-6)

B.S. IN PHYSICS

Requirements (109 units)

Total units required for graduation: 182

Requirements for the B.S. in Physics:

Lower-division requirements (53 units)

1. CHEM 215. General Chemistry I: Atomic Structure and Chemical Bonding (6)
2. CHEM 216. General Chemistry II: Principles of Chemical Reactions (6)
3. MATH 211. Basic Concepts of Calculus (4)
4. MATH 212. Calculus II (4)
5. MATH 213. Calculus III (4)

6. MATH 251. Multivariable Calculus I (4)
7. MATH 252. Multivariable Calculus II (4)
8. PHYS 221. General Physics I (5)
9. PHYS 222. General Physics II (5)
10. PHYS 223. General Physics III (5)
11. PHYS 224. General Physics IV (3)
12. PHYS 225. General Physics V (3)

Upper-division requirements (44 units)

1. MATH 331. Linear Algebra (4)
2. PHYS 306. Classical Mechanics I (4)
3. PHYS 307. Classical Mechanics II (4)
4. PHYS 313. Electrodynamics I (4)
5. PHYS 314. Electrodynamics II (4)
6. PHYS 324. Statistical and Thermal Physics (4)
7. PHYS 373. Mathematical Methods of Physics I (4)
8. PHYS 421. Quantum Mechanics I (4)
9. PHYS 422. Quantum Mechanics II (4)
10. PHYS 430. Advanced Physics Laboratory (4)
11. PHYS 473. Mathematical Methods of Physics II (4)

Electives (12 units)

1. Eight units chosen from upper-division physics courses selected with the approval of the department:
   - PHYS 315. Introduction to Modern Optics (4)
   - PHYS 318. Materials Science and Engineering (4)
   - PHYS 370. Introduction to Astrophysics (4)
   - PHYS 450. Solid State Physics (4)
   - PHYS 461. Introduction to Nuclear Physics (4)
   - PHYS 463. Introduction to Elementary Particle Physics (4)
   - PHYS 480A. Topics in Classical Physics: Mechanics (4)
   - PHYS 480B. Topics in Classical Physics: Electrodynamics (4)
   - PHYS 485. Topics in Contemporary Physics (1-4)
   - PHYS 573. Mathematical Methods of Physics III (4)
   - PHYS 590. Physics Seminar (1)
   - PHYS 595. Independent Study (1-6)
2. Four units of computer science course work at the 200-level or above selected with the approval of the Physics Department.

B.S. IN PHYSICS - APPLIED PHYSICS OPTION

Requirements (110 units)

Total units required for graduation: 183

Requirements for the B.S. in Physics - Applied Physics Option:

Lower-division requirements (62 units)

1. CHEM 215. General Chemistry I: Atomic Structure and Chemical Bonding (6)
2. CHEM 216. General Chemistry II: Principles of Chemical Reactions (6)
3. CSE 201. Computer Science I (4)
4. MATH 211. Basic Concepts of Calculus (4)
5. MATH 212. Calculus II (4)
6. MATH 213. Calculus III (4)
7. MATH 251. Multivariable Calculus I (4)
8. MATH 252. Multivariable Calculus II (4)
9. PHYS 150. Introductory Electronics (5)
10. PHYS 221. General Physics I (5)
11. PHYS 222. General Physics II (5)
12. PHYS 223. General Physics III (5)
13. PHYS 224. General Physics IV (3)
14. PHYS 225. General Physics V (3)

Upper-division requirements (44 units)

1. MATH 331. Linear Algebra (4)
2. PHYS 306. Classical Mechanics I (4)
3. PHYS 313. Electrodynamics I (4)
4. PHYS 314. Electrodynamics II (4)
5. PHYS 318. Materials Science and Engineering (4)
6. PHYS 324. Statistical and Thermal Physics (4)
7. PHYS 350. Data Acquisition and Control (4)
8. PHYS 352. Advanced Electronics (4)
9. PHYS 373. Mathematical Methods of Physics I (4)
10. PHYS 421. Quantum Mechanics I (4)
11. PHYS 430. Advanced Physics Laboratory (4)

Electives (4 units)

1. Four units chosen from upper-division physics course work selected with the approval of the department:
   - PHYS 307. Classical Mechanics II (4)
   - PHYS 315. Introduction to Modern Optics (4)
   - PHYS 370. Introduction to Astrophysics (4)
   - PHYS 422. Quantum Mechanics II (4)
   - PHYS 450. Solid State Physics (4)
   - PHYS 461. Introduction to Nuclear Physics (4)
   - PHYS 463. Introduction to Elementary Particle Physics (4)
   - PHYS 473. Mathematical Methods of Physics II (4)
   - PHYS 480A. Topics in Classical Physics: Mechanics (4)
   - PHYS 480B. Topics in Classical Physics: Electrodynamics (4)
   - PHYS 485. Topics in Contemporary Physics (1-4)
   - PHYS 573. Mathematical Methods of Physics III (4)
   - PHYS 590. Physics Seminar (1)
   - PHYS 595. Independent Study (1-6)

MINOR IN PHYSICS

Requirements (61 units)

Requirements for a minor in Physics:

Lower-division requirements (41 units)

1. MATH 211. Basic Concepts of Calculus (4)
2. MATH 212. Calculus II (4)
3. MATH 213. Calculus III (4)
4. MATH 251. Multivariable Calculus I (4)
5. MATH 252. Multivariable Calculus II (4)
6. PHYS 221. General Physics I (5)
7. PHYS 222. General Physics II (5)
8. PHYS 223. General Physics III (5)
9. PHYS 224. General Physics IV (3)
10. PHYS 225. General Physics V (3)

Upper-division requirements (20 units)

1. PHYS 306. Classical Mechanics I (4)
2. PHYS 313. Electrodynamics I (4)
3. PHYS 324. Statistical and Thermal Physics (4)
4. PHYS 373. Mathematical Methods of Physics I (4)
5. PHYS 421. Quantum Mechanics I (4)

MINOR IN APPLIED PHYSICS

Requirements (54 units)

Requirements for a minor in Applied Physics:

Lower-division requirements (42 units)

1. CSE 201. Computer Science I (4)
2. MATH 211. Basic Concepts of Calculus (4)
3. MATH 212. Calculus II (4)
4. MATH 251. Multivariable Calculus I (4)
5. PHYS 150. Introductory Electronics (5)
6. PHYS 221. General Physics I (5)
7. PHYS 222. General Physics II (5)
8. PHYS 223. General Physics III (5)
9. PHYS 224. General Physics IV (3)
10. PHYS 225. General Physics V (3)

Upper-division requirements (12 units)

1. PHYS 350. Data Acquisition and Control (4)
2. PHYS 352. Advanced Electronics (4)
3. PHYS 373. Mathematical Methods of Physics I (4)

Note: The MATH 252 prerequisite for PHYS 373 will be waived for the applied physics minor.

DEPARTMENTAL HONORS

To be awarded departmental honors in physics a student must:

1. Achieve at least a 3.5 minimum grade point average in courses required for the major taken at California State University, San Bernardino and at least a 3.0 grade point average overall;
2. Conduct advanced research on a topic approved by a faculty member who will serve as project director;
3. Obtain written approval upon successful completion of the project from the project director and the chair, and present the results of the research to the department or at a research conference, and/or publish the results in a peer-reviewed scientific journal.

COURSE OFFERINGS IN PHYSICS (PHYS)

Lower Division

100. Physics in the Modern World

Examination of physics and its contemporary use, including topics of: mechanics, electricity, optics, sound, heat and radioactivity. This course is intended for students with little background in science. Four hours lecture and three hours laboratory. Materials fee required. Prerequisite: completion of the general education requirement in mathematics, category B1. (**GE**=B3) (5 units)

121. Basic Concepts of Physics I

First course of a three-course sequence surveying the basic concepts of physics, primarily for students entering fields relating to the biological sciences. This course will cover the basic principles of mechanics. Four hours lecture and three hours laboratory. Materials fee required. Prerequisite: MATH 192 or 211, with a grade of "C-" or better. (**GE**=B3) (5 units)

122. Basic Concepts of Physics II

Continuation of PHYS 121. Topics include electricity, electric circuits and magnetism. Three hours lecture and three hours laboratory. Materials fee required. Prerequisite: PHYS 121. (4 units)

123. Basic Concepts of Physics III

Continuation of PHYS 122. Topics include optics, waves and modern physics. Three hours lecture and three hours laboratory. Materials fee required. Prerequisite: PHYS 122. (4 units)

150. Introductory Electronics

Introduces electronics for the sciences and engineering. Assumes no experience in electronics and can be taken prior to introductory physics. Focus is on analog electronics: practical circuits, passive and active circuit elements, signal conditioning, test and measurement skills, and a brief introduction to digital electronics. Four hours lecture and three hours laboratory. Materials fee required. Prerequisites: a knowledge of trigonometry and exponential functions. (5 units)

221. General Physics I

First course of a five-course sequence in introductory physics for scientists and engineers. This sequence is intended for students with a strong background in mathematics and the sciences. Mechanics. Four hours lecture and three hours laboratory. Materials fee required. Prerequisite: MATH 211. Prerequisite or corequisite: MATH 212. (**GE**=B3) (5 units)

222. General Physics II

Second course in a five-course sequence in introductory physics for scientists and engineers. Electromagnetism. Four hours lecture and three hours laboratory. Materials fee required. Prerequisites: PHYS 221, MATH 212. Recommended: MATH 213. (5 units)

223. General Physics III

Third course of a five-course sequence in introductory physics for scientists and engineers. Waves and optics. Four hours lecture and three hours laboratory. Materials fee required. Prerequisite: PHYS 222. (5 units)

224. General Physics IV

Fourth course of a five-course sequence in introductory physics for scientists and engineers. An introduction to thermodynamics, kinetic theory and quantum mechanics. Three hours lecture. Prerequisite or corequisite: PHYS 223 or consent of instructor. (3 units)

225. General Physics V

Fifth course of a five-course sequence in introductory physics for scientists and engineers. An introduction to special relativity, the photon theory of electromagnetic radiation, atomic physics, nuclear physics, and elementary particle physics. Three hours lecture. Formerly PHYS 228. Prerequisite: PHYS 224 or consent of instructor. (3 units)

295. Special Projects in Physics

Individual investigation, research, study or survey of selected problems. May be repeated for credit. Prerequisite: consent of instructor. (1-2 units)

Upper Division

303. Astronomy for Educators

An introductory course in the modern description of our planetary system, stars, galaxies, and models of the universe followed by basic principles and ideas in space science. Three hours lecture. (3 units)

304. Physics in the Classroom

Basic concepts of physics as related to the elementary and middle school classroom. Concepts include mechanics, electricity and magnetism, optics, thermodynamics, and modern physics. One hour lecture and three hours laboratory. Materials fee required. Prerequisite: one college level course in chemistry or earth science. (2 units)

305. Demonstration Laboratory in Physics

A demonstration laboratory exploring the basic principles of physics through individual student demonstration. Three hours laboratory. Materials fee required. Prerequisite or corequisite: PHYS 304. (1 unit)

306. Classical Mechanics I

A continuing study of dynamics with an introduction to advanced formulations. Four hours lecture. Prerequisites: PHYS 225 and 373 with a grade of "C" or better in each course. (4 units)

307. Classical Mechanics II

A continuation of PHYS 306 with emphasis on systems of particles, and rigid bodies. Four hours lecture. Formerly PHYS 406. Prerequisite: PHYS 306 with a grade of "C" or better. (4 units)

313. Electrodynamics I

Derivation and applications of Maxwell's equations. Four hours lecture. Prerequisites: PHYS 225 and 373 with a grade of "C" or better in each course. (4 units)

314. Electrodynamics II

A continuation of PHYS 313 with advanced applications of Maxwell's equations and electromagnetic waves. Four hours lecture. Formerly PHYS 414. Prerequisite: PHYS 313 with a grade of "C" or better. (4 units)

315. Introduction to Modern Optics
An introduction to geometrical optics, physical optics and lasers. Four hours lecture. Prerequisite: PHYS 313 with a grade of "C" or better. (4 units)

318. Materials Science and Engineering
Fundamental materials science concepts with applications. Topics include structural, electrical and thermal properties of materials, phase diagrams, interfaces, and electronic band structure. Four hours lecture. Prerequisites: CHEM 215, PHYS 224 and 373. (4 units)

324. Statistical and Thermal Physics
Basics of equilibrium thermodynamics including statistical description of physical systems, entropy and temperature, classical and quantum statistical ensembles, thermodynamics, and selected applications. Four hours lecture. Prerequisites: MATH 252 and PHYS 225 with a grade of "C" or better in each course. (4 units)

350. Data Acquisition and Control
An introduction to computer-based data acquisition, control and analysis. Topics include instrument control, graphical programming, algorithm development, feedback control algorithms, and computer-based data analysis. Three hours lecture and three hours laboratory. Materials fee required. Prerequisites: CSE 201, PHYS 150 and 222. (4 units)

352. Advanced Electronics
Advanced analog electronics techniques for science and engineering. Topics include computer-aided circuit design, high frequency techniques, modular circuit design, and computer-experiment interfacing. Three hours lecture and three hours laboratory. Materials fee required. Prerequisites: PHYS 350 and 373 with a grade of "C" or better in each course. (4 units)

370. Introduction to Astrophysics
Basic principles of stellar structure and evolution, galactic structure, extragalactic astronomy and cosmology. Four hours lecture. Prerequisites: PHYS 225 and 373 with a grade of "C" in each course. (4 units)

373. Mathematical Methods of Physics I
Vector calculus, Fourier analysis, and ordinary differential equations. Emphasis on techniques applicable to the problems of physics. Prerequisites: PHYS 222 and MATH 252. MATH 331 is recommended. (4 units)

421. Quantum Mechanics I
Introduction to quantum mechanics. Topics include the origins of quantum theory, angular momentum, the Dirac formalism, 2-level systems and the harmonic oscillator. Four hours lecture. Formerly PHYS 322. Prerequisites: MATH 331, PHYS 225, and 306 with a grade of "C" or better in each course. (4 units)

422. Quantum Mechanics II
Continued study of the principles of quantum mechanics introduced in PHYS 421. Topics include the axiomatic formulation of quantum mechanics, spin and orbital angular momentum, the Schroedinger equation in three dimensions, approximation methods, and scattering. Prerequisites: PHYS 306, 314, and 421 with a grade of "C" or better in each course. (4 units)

430. Advanced Physics Laboratory
Selected advanced experiments appropriate to a student's previous preparation. May be repeated for credit. Two hours lecture and six hours laboratory. Materials fee required. Prerequisite: PHYS 313 with a grade of "C" or better. Recommended: PHYS 421. (4 units)

450. Solid State Physics
A lecture course exploring selected topics in condensed matter physics. May be repeated for credit as topics change. Four hours lecture. Prerequisites: PHYS 318, 421, and 473 with grades of "C" or better. (4 units)

461. Introduction to Nuclear Physics
Basic concepts of nuclear structure and reactions, including accelerators and detectors, the nucleon-nucleon force, basic nuclear properties, the shell model, radioactivity, heavy ion reactions and quarks. Four hours lecture. Prerequisites: PHYS 306 and 422 with a grade of "C" or better in each course. (4 units)

463. Introduction to Elementary Particle Physics
A survey of elementary particle physics, including accelerators, relativistic kinematics, conservation laws, quarks, the standard model, and quantum field theories. Four hours lecture. Prerequisites: PHYS 306 and 422 with a grade of "C" or better in each course. (4 units)

473. Mathematical Methods of Physics II
A continuation of PHYS 373. Topics covered include functions of a complex variable and partial differential equations. Prerequisite: PHYS 373. MATH 331 and PHYS 225 are strongly recommended. (4 units)

480. Topics in Classical Physics
Further treatment of topics in physics introduced in previous courses.

A. Mechanics. Prerequisite: PHYS 307 with a grade of "C" or better. (4 units)
B. Electrodynamics. Prerequisite: PHYS 314 with a grade of "C" or better. (4 units)

485. Topics in Contemporary Physics
A lecture course on a current topic or on new developments in physics. May be repeated for credit as topics change. (1-4 units)

573. Mathematical Methods of Physics III
A continuation of PHYS 473 with emphasis on advanced topics relevant to physics. Prerequisites: MATH 331 and PHYS 473. (4 units)

585. Internship in Physics
Supervised work and study in physics in private or public setting. May be repeated for up to six units of credit. Graded credit/no credit. Prerequisites: consent of instructor and department. (2-4 units)

590. Physics Seminar
Provides a vehicle for assessing the subject matter competency of physics graduates. May be repeated for credit. A total of two units may be applied towards the major requirements for graduation. Lecture only. Prerequisites: senior standing and consent of department. (1 unit)

595. Independent Study
Research in physics conducted under the direction of a faculty member. A total of six units in PHYS 595 may be applied toward graduation. Prerequisites: a minimum overall grade point average of 3.0, consent of instructor and departmental approval of a written proposal of a project submitted on a standard application filed in advance of the quarter in which the course is to be taken. (1-6 units)