PHYSICS

Department of Physics

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

Bachelor of Arts

Physics

Bachelor of Science

Physics
Applied Physics

Minor

Physics
Applied Physics

FACULTY: Steven Barnes, Leo Connolly, Paul Dixon, Karen Kolehmainen, Susan Lederer, Paul Renteln (Chair), 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; CSCI 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 - Although CSU San Bernardino does not offer an engineering degree, the campus does provide 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, 234, 235 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 228. 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 322. Quantum Mechanics I (4)
5. PHYS 324. Statistical and Thermal Physics (4)
6. PHYS 373. Mathematical Methods of Physics I (4)
7. PHYS 430. Advanced Physics Laboratory (4)

Elective course work (8 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 370. Introduction to Astrophysics (4)
   - PHYS 406. Classical Mechanics II (4)
   - PHYS 414. Electrodynamics II (4)
   - PHYS 422. Quantum Mechanics II (4)
   - PHYS 450. Introduction to 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. Seminar: Topics in Contemporary Physics (2)
   - 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 228. 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 322. Quantum Mechanics I (4)
5. PHYS 324. Statistical and Thermal Physics (4)
6. PHYS 373. Mathematical Methods of Physics I (4)
7. PHYS 406. Classical Mechanics II (4)
8. PHYS 414. Electrodynamics II (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 370. Introduction to Astrophysics (4)
   PHYS 450. Introduction to 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. Seminar: Topics in Contemporary Physics (2)
   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. CSCI 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 228. 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 322. Quantum Mechanics I (4)
5. PHYS 324. Statistical and Thermal Physics (4)
6. PHYS 350. Data Acquisition and Control (4)
7. PHYS 352. Advanced Electronics (4)
8. PHYS 373. Mathematical Methods of Physics I (4)
9. PHYS 414. Electrodynamics II (4)
10. PHYS 430. Advanced Physics Laboratory (4)
11. PHYS 450. Introduction to Solid State Physics (4)

Electives (4 units)

1. Four units chosen from upper-division physics course work selected with the approval of the department:
   PHYS 315. Introduction to Modern Optics (4)
   PHYS 370. Introduction to Astrophysics (4)
   PHYS 406. Classical Mechanics II (4)
   PHYS 422. Quantum Mechanics II (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. Seminar: Topics in Contemporary Physics (2)
   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 228. General Physics V (3)

Upper-division requirements (20 units)

1. PHYS 306. Classical Mechanics I (4)
2. PHYS 313. Electrodynamics I (4)
3. PHYS 322. Quantum Mechanics I (4)
4. PHYS 324. Statistical and Thermal Physics (4)
5. PHYS 373. Mathematical Methods of Physics I (4)

MINOR IN APPLIED PHYSICS

Requirements (54 units)

Requirements for a minor in Applied Physics:

Lower-division requirements (42 units)

1. CSCI 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 228. 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.

TEACHING CREDENTIAL PROGRAM

Teaching Credential Preparation Program Subject Matter Preparation Program in Science: Physics

Physics majors pursuing a single subject teaching credential in science with a Physics Specialization will need to take the CSET Examination to verify subject matter competence. To prepare for the CSET Exam, the following courses are recommended as part of, or in addition to, the physics degree:

1. BIOL 200. Biology of the Cell (5)
2. BIOL 201. Biology of Organisms (5)
3. BIOL 202. Biology of Populations (5)
4. CHEM 206. Fundamentals of Chemistry II: Organic Chemistry (5)
5. CHEM 215. General Chemistry I: Atomic Structure and Chemical Bonding (6)
6. CHEM 216. General Chemistry II: Principles of Chemical Reaction (6)
7. GEOL 101. Physical Geology (5)
8. GEOL 250. Historical Geology (5)
9. GEOL 306. Oceans and Atmospheres for the Science Teacher (3)
10. NSCI 300. Science and Technology (4)
11. PHYS 103. Descriptive Astronomy (5)
12. PHYS 590. Physics Seminar (1)

In addition, certain prerequisites and professional education courses are required. For information about admission to the teacher education program, education courses required or the specific requirements of the single subject teaching credential in science program, contact the Department of Science, Mathematics and Technology Education in the College of Education.

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. Write a thesis on a topic approved by the Department of Physics and the faculty member who will serve as project director;
3. One of the following: have the thesis approved by a committee consisting of three faculty members from the Department of Physics, one of whom is the project director, or have the thesis accepted for publication by a peer-reviewed scientific journal.

Application for honors and approval of the thesis topic must occur at least two full quarters before graduation (which will ordinarily be the Fall quarter of the senior year.) The thesis must be submitted and the thesis defense (or journal acceptance) successfully completed by the quarter of graduation according to the timeline on file in the department office

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: satisfactory score on the Entry Level Mathematics examination. (**GE**=B3) (5 units)

103. Descriptive Astronomy

A brief history of the development of astronomy followed by modern descriptions of our planetary system, stars, galaxies, models of the universe and the possibilities of life in the universe. Discussions of methods of extending knowledge of the universe. No previous background in natural sciences is required. Four hours lecture and three hours laboratory. Materials fee required. **(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) (PHYS 221=**CAN** PHYS 8) (PHYS 221+222+223+224+228=**CAN** PHYS SEQ C) (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 with a grade of "C" or better, MATH 212. Recommended: MATH 213. (PHYS 222=**CAN** PHYS 12) (PHYS 221+222+223+224+228=**CAN** PHYS SEQ C) (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 with a grade of "C" or better. (PHYS 221+222+223+224+228=**CAN** PHYS SEQ C) (5 units)

224. General Physics IV

Fourth course of a five-course sequence in introductory physics for scientists and engineers. Special relativity, kinetic theory and thermodynamics. Three hours lecture. Prerequisite or corequisite: PHYS 223 or consent of instructor. (PHYS 221+222+223+224+228=**CAN** PHYS SEQ C) (3 units)

228. General Physics V
Fifth course of a five-course sequence in introductory physics for scientists and engineers. Modern physics. Three hours lecture. Prerequisite: PHYS 224 with a grade of "C" or better or consent of instructor. (PHYS 221+222+223+224+228=**CAN** PHYS SEQ C) (3 units)

234. Vector Statics
Two and three dimensional equilibria of frames, machines, and trusses using vector algebra; friction; principles of moments, moments of inertia for areas and masses, centroids and centers of gravity. Prerequisite: PHYS 221. Prerequisite or corequisite: MATH 213. (4 units)

235. Vector Dynamics
Vector treatment of absolute and relative motion of particles and rigid bodies in translating and rotating reference frames. Newton's law of motion, work-energy, impulse-momentum. Prerequisite: PHYS 234 with a grade of "C" or better. Prerequisite or corequisite: MATH 251. (4 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 or 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 228 and one of the following: MATH 373, PHYS 373. (4 units)

311. A Cosmic Perspective of Earth
Formation and evolution of the Earth, including its atmospheres, oceans and internal structure, placed in the context of our solar system. A comparative planetology course focusing on Earth and providing students with an understanding of where Earth fits into our solar system by introducing other solar system objects: planets, asteroids, comets, and moons alike. Fulfills the Earth and Space Science requirement for liberal studies. Four hours lecture and three hours laboratory. Materials fee required. May not count for credit towards the major or minor in Physics. Prerequisites: CHEM 100 and PHYS 100. (5 units)

313. Electrodynamics I
Derivation and applications of Maxwell's equations. Four hours lecture. Prerequisites: PHYS 228 and one of the following: MATH 373 or PHYS 373. (4 units)

315. Introduction to Modern Optics
An introduction to geometrical optics, physical optics and lasers. Four hours lecture. Prerequisite: PHYS 313. (4 units)

322. Quantum Mechanics I
Introduction to quantum mechanics. Topics include the origins of quantum theory, wave functions, the Schroedinger equation, and one dimensional potentials. Four hours lecture. Formerly PHYS 321/421. Prerequisites: PHYS 228 and one of the following: MATH 373 or PHYS 373. Recommended: MATH 331. (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. Formerly PHYS 424. Prerequisites: MATH 252 and PHYS 228. (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: CSCI 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 one of the following: MATH 373 or PHYS 373. (4 units)

370. Introduction to Astrophysics
Basic principles of stellar structure and evolution, galactic structure, extragalactic astronomy and cosmology. Four hours lecture. Prerequisites: PHYS 228 and one of the following: MATH 373 or PHYS 373. (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. (Also offered as MATH 373. Students may not receive credit for both.) Prerequisites: PHYS 222 and MATH 252. MATH 331 is recommended. (4 units)

406. Classical Mechanics II
A continuation of PHYS 306 with emphasis in Lagrangian and Hamiltonian formulation in classical mechanics. Four hours lecture. Prerequisites: PHYS 306 and one of the following: PHYS 373 or MATH 373. (4 units)

414. Electrodynamics II
A continuation of PHYS 313 with advanced applications of Maxwell's equations and electromagnetic waves. Four hours lecture. Prerequisite: PHYS 313. (4 units)

422. Quantum Mechanics II
Continued study of the principles of quantum mechanics introduced in PHYS 322. 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, 322 and 414. (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. Recommended: PHYS 322. (4 units)

450. Introduction to Solid State Physics
Basic concepts of solid state physics, including crystal structure; free electron gas model; electronic structure of solids; phonons; properties of metals, insulators and semiconductors; magnetism; superconductivity. Four hours lecture. Prerequisite: PHYS 322. (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, 422 and one of the following: MATH 373, PHYS 373. (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, 422 and one of the following: MATH 373, PHYS 373. (4 units)

473. Mathematical Methods of Physics II
A continuation of MATH/PHYS 373. Topics covered include functions of a complex variable and partial differential equations. (Also offered as MATH 473. Students may not receive credit for both.) Prerequisite: MATH 373, or PHYS 373. MATH 331 and PHYS 228 are strongly recommended. (4 units)

480. Topics in Classical Physics
Further treatment of topics in physics introduced in previous courses.
A. Mechanics. Prerequisite: PHYS 406. (4 units)
B. Electrodynamics. Prerequisite: PHYS 414. (4 units)

485. Seminar: 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. (2 units)

573. Mathematical Methods of Physics III
A continuation of MATH/PHYS 473 with emphasis on advanced topics relevant to physics. (Also offered as MATH 573. Students may not receive credit for both.) Prerequisites: MATH 331, and MATH 473 or 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 to 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 to 6 units)