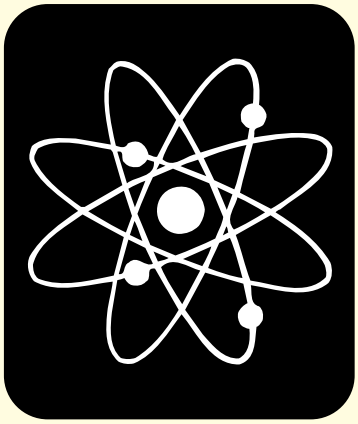

PHYSICS AND ASTRONOMY

BACHELOR OF ARTS
BACHELOR OF SCIENCE
SUBJECT MATTER PROGRAM
MINOR

PROGRAM DESCRIPTION

Physics is the most fundamental science and underlies our understanding of nearly all areas of science and technology. In a broad sense, physics is concerned with the study of energy, space, matter, the interactions between matter and the laws which govern these interactions. More specifically, physicists study mechanics, heat, light, electric and magnetic fields, gravitation, relativity, atomic and nuclear physics, and condensed matter physics.

The Department of Physics and Astronomy at CSUS offers three degree programs: The BA in Physics, the BS in Physics and the BA in Physical Science, and a program for a Physical Science Single Subject Teaching Credential. The Department also offers minor programs in Physics and Astronomy. The BS degree is recommended for students seeking a career in Physics or planning to pursue a graduate degree. The BA degree is recommended for students who are interested in teaching Physics in high school or who want a liberal arts education with an emphasis in Physics. Physics majors are encouraged to take additional mathematics and to develop skills in the use of computers.

Approximately 30 percent of the graduating physics majors from CSUS continue on to graduate school, earning advanced degrees in Physics, Mathematics, Engineering, Environmental Science, Medicine, or Business. Another 60 percent find job opportunities in industrial and government laboratories or agencies. The remaining 10 percent obtain their teaching credential.

FEATURES

In addition to providing a broad academic background and facility in analytic thinking, the study of physics fosters and emphasizes independent study experiences. Physics students at CSUS typically spend a year or two working on the design and building of scientific apparatus, assisting a faculty member in a research project, or doing independent study on a topic of special interest to them. These independent projects not only provide a vehicle for applying material learned in class and give students experience in electronics, measurement systems, computers, and machine shop work, but also teach students to work and think on their own. Faculty in the department are active in research in acoustics, atomic physics, astrophysics, energy, holography, nuclear physics, optics, quantum mechanics, relativity and solid state physics.

An advising system has been established by the Department of Physics and Astronomy to help students plan their schedules each semester, to discuss independent project possibilities, and to provide career and current job information. Because of the large number of sequential courses in the degree programs, the Department requires that each student contact his/her advisor before registering for classes each semester. If you do not have an advisor, contact Professor Charles Newcomb in the Science Building, Room 230, or call (916) 278-6518.

FACULTY

Charles Newcomb, *Department Chair*

Duane Aston; Edward Gibson; Donald Hall; James Klavetter; Sukhbir Mahajan; Zolili Ndlela; Michael Shea; Hossein Partovi; James Phelps; Gary Shoemaker; John Stevens; Lynn Tashiro; Paul Peter Urone

Rachel Brault, Department Secretary
Department Office, Science 230, 278-6518
Email: physics@csus.edu

CAREER POSSIBILITIES

Research Physicist or Applied Physicist in: Acoustics • Atmospheric Physics • Astrophysics • Astronomy • Atomic and Molecular Physics • Electricity and Magnetism • Electronic Instrumentation • Energy Conservation • Geophysics • Health Physics • Heat • Light • Mechanics • Medical Imaging • Nuclear Medicine • Nuclear Physics • Solar Energy and Solid State Physics • Scientific Computing • Engineer • Science Educator • Technical Writer

MAJOR REQUIREMENTS • BA PHYSICS

Total units required for BA: 124
Total units required for Major: 65
Courses in parentheses are prerequisites.

A. Required Lower Division Courses (37 units)

(4)	PHYS 11A	General Physics: Mechanics (MATH 30, 31; MATH 31 may be taken concurrently)
(4)	PHYS 11B	General Physics: Heat, Light, Sound (MATH 31, PHYS 11A)
(4)	PHYS 11C	General Physics: Electricity & Magnetism, Modern Physics (MATH 31, PHYS 11A)
(4)	MATH 30	Calculus I (MATH 29 or high school preparation)
(4)	MATH 31	Calculus II (MATH 30)
(4)	MATH 32	Calculus III (MATH 31)
(3)	MATH 45	Differential Equations for Science & Engineering (MATH 31)
(5)	CHEM 1A	General Chemistry
(5)	CHEM 1B	General Chemistry (CHEM 1A)

B. Required Upper Division Courses (28 units)

(3)	PHYS 105	Mathematical Methods in Physics (MATH 32, 45; PHYS 11A, 11B, 11C **or** PHYS 5A; 5B; **or** permission of instructor)
(3)	PHYS 106	Introduction to Modern Physics (MATH 31; PHYS 11A, 11B, 11C or PHYS 5A; 5B)
(3)	PHYS 110	Intermediate Mechanics (MATH 45, PHYS 105)
(4)	PHYS 115A	Introduction to Electric & Electronic Measurements (PHYS 11C)
(3)	PHYS 124	Thermodynamics & Statistical Mechanics (MATH 45, PHYS 11A, 11B, 11C)
(3)	PHYS 135	Electricity & Magnetism (MATH 45, PHYS 11C, 105)
(2)	PHYS 175	Advanced Physics Laboratory (6 units upper division Physics)
(1)	PHYS 190	Seminar
(6)	Elective units selected in consultation with an advisor	

MAJOR REQUIREMENTS • BS PHYSICS

Total units required for BS: 124
Total units required for Major: 74
Courses in parentheses are prerequisites.

A. Required Lower Division Courses (37 units)
Same as ***Section A*** for BA in Physics

B. Required Upper Division Courses (37 units)
Same as ***Section B*** for BA in Physics plus the following:

(3)	PHYS 150	Quantum Mechanics (MATH 45, PHYS 105, 106, 110)
(3)	PHYS 151	Advanced Modern Physics (PHYS 150)
(3)	Elective units in addition to the six units of electives required under the BA requirements	

Notes:

- For the BS degree PHYS 199 may be substituted for PHYS 175, if approved by the department.
- MATH 105A and 105B, Advanced Mathematics for Science and Engineering, are recommended.
- For students intending to pursue a graduate degree, the study of one foreign language is recommended. Development of computer skills and the acquisition of various machine shop skills are also recommended. Although a minor is not required for the Physics major, a minor in another science or mathematics is recommended.

MINOR REQUIREMENTS • PHYSICS

The minor requires 18-19 units, all of which must be taken in Physics. A minimum of 6 upper division units is required. Written approval from a Physics faculty advisor is required. Specific course requirements are:

(4)	PHYS 11A	General Physics: Mechanics (MATH 30, 31; MATH 31 may be taken concurrently)
(4)	PHYS 11B	General Physics: Heat Light, Sound (MATH 31, PHYS 11A)
(4)	PHYS 11C	General Physics: Electricity & Magnetism, Modern Physics (MATH 31, PHYS 11A)
(3)	PHYS 106	Introduction to Modern Physics (MATH 31; PHYS 11A, 11B, 11C **or** PHYS 5A; 5B)

(3-4) Select one of the following:

PHYS 110	Intermediate Mechanics (MATH 45, PHYS 11A, 11B, 11C)
PHYS 115A	Introduction to Electric & Electronic Measurements (PHYS 11C)
PHYS 124	Thermodynamics & Statistical Mechanics (MATH 45, PHYS 11A, 11B, 11C)
PHYS 130	Acoustics (MATH 45, PHYS 11A, 11B, 11C)
PHYS 135	Electricity & Magnetism (MATH 45, PHYS 11C, 105)
PHYS 145	Physical Optics (MATH 45, PHYS 11A, 11B, 11C)

Note: PHYS 5A; 5B, 106, 110 and an additional upper division physics course may be substituted for the program outlined above if approved by a Physics advisor.

MAJOR REQUIREMENTS • BA PHYSICAL SCIENCE

The Physical Science major offers a greater diversity than is possible with a major in a single science. Coursework is taken in each of the three physical sciences — Physics, Chemistry, and the Earth Sciences.

Total units required for BA: 124
Total units required for Major: 77
Courses in parentheses are prerequisites.

A. Required Lower Division Courses (47 units)

(4)	MATH 30	Calculus 1 (MATH 29 **or** high school preparation)
(4)	MATH 31	Calculus 11 (MATH 30)
(3)	MATH 45	Differential Equations for Science & Engineering (MATH 31)
(4)	PHYS 11A	General Physics: Mechanics (MATH 30, 31; MATH 31 may be taken concurrently)
(4)	PHYS 11B	General Physics: Heat, Light, Sound (MATH 31, PHYS 11A)
(4)	PHYS 11C	General Physics: Electricity & Magnetism, Modern Physics (MATH 31, PHYS 11A)
(5)	CHEM 1A	General Chemistry
(5)	CHEM 1B	General Chemistry (CHEM 1A)

(3) CHEM 20 Organic Chemistry
(3) ASTR 4 Introduction to Astronomy
(1) ASTR 6 Astronomical Observation Lab
(3) GEOL 10 Physical Geology
(1) GEOL 11 Field Laboratory for Physical Geology (GEOL 10; may be taken concurrent with instructor permission)
(3) BIO 10 Basic Biological Concepts

B. Required Upper Division Courses (30 units)

(3) GEOG 111 Elements of Meteorology (GEOG 1 or permission of instructor)
(1) GEOG 112 Elements of Meteorology Laboratory (GEOG 111; concurrent enrollment preferred)
(3) GEOL 130 Oceanography
(3) GEOL 121 Geology of California (GEOL 10) **OR**
GEOL 140 Geology & the Environment
(1) GEOL 184 Geology Field Trip (GEOL 10)
(3) PHSC 107 History of the Physical Sciences
(3) PHYS 106 Introduction to Modern Physics (MATH 31; PHYS 11A, 11B, 11C **or** PHYS 5A; 5B)
(4) PHYS 115A Introduction to Electric & Electronic Measurements (PHYS 11C)
(3) PHYS 145 Physical Optics (MATH 45, PHYS 11A, 11B, 11C) **OR**
PHYS 130 Acoustics (MATH 45, PHYS 11A, 11B, 11C)
(6) Select two of the following:
CHEM 124 Organic Chemistry Lecture 11 (CHEM 24 or permission of instructor)
CHEM 125 Organic Chemistry Laboratory 11 (CHEM 25, 124)
CHEM 140A Physical Chemistry Lecture (CHEM 31; MATH 32; PHYS 5A; 5B or PHYS 11A, 11B, 11C)
CHEM 140B Physical Chemistry Lecture (CHEM 140A)
CHEM 161 General Biochemistry (CHEM 20, BIO 10)

SUBJECT MATTER PROGRAM (Pre-Credential Preparation)

Physics majors who intend to pursue a teaching credential must complete a BA in Physics including courses in the Science Subject Matter Program which is described in this catalog. Upon successful completion, this program fulfills the subject matter competence requirement and qualifies students to enter the Teaching Credential Program in the School of Education. The science teaching credential with a concentration in Biology, Chemistry, Geoscience, and Physics allows candidates to teach all four of the natural sciences (Biology, Chemistry, Geoscience, and Physics) at the general science level and Physics at an advanced level in high school.

Currently there is a serious need in public school education for well-educated science teachers. Physics majors who have an interest in teaching should see the credential advisor in the Department (Dr. Michael Shea, SCI-139, 278-6540, sheamj@csus.edu) to plan an academic program and to explore ways to get involved in teaching-related activities such as tutoring, grading, and working in the schools.

LOWER DIVISION COURSES

Physics

1. Physical Reasoning and Calculation. An introduction to the analytical skills needed for the study of Physics. The focus is to prepare students to take PHYS 11A, however, PHYS 1 is also suitable as preparation for PHYS 5A. Emphasis is on reasoning and problem-solving, including conceptualization, visualization, and interpretation of written descriptions of physical situations, and on the connection of physical laws to the mathematical techniques used in their solution. 2 units.

2. Topics in Elementary Physics. A one semester introductory physics course including a laboratory. Covers the fundamental concepts of physics with an emphasis on everyday life situations and applications. The range of material includes mechanics, waves, electricity and optics. One hour lecture, two hour discussion, and a three hour laboratory session. **Prerequisites:** a recent one year course in high school algebra and one year of plane geometry or a college course in algebra (MATH 9). 4 units.

5A. General Physics: Mechanics, Heat, Sound. The Physics 5A-B sequence is a two-semester course in introductory physics in which fundamental concepts are emphasized including some physiological applications. These courses satisfy the requirement for pre-medical and pre-dental students and biology majors. Lecture one hour, quiz two hours, laboratory three hours. **Prerequisites:** recently completed three years of high school algebra and geometry; and a college course in algebra and trigonometry (MATH 9 recommended) for those having an inadequate mathematics background. 4 units. (CAN PHYS 2)

5B. General Physics; Light, Electricity and Magnetism, Modern Physics. Lecture one hour, quiz two hours, laboratory three hours. **Prerequisite:** PHYS 5A or permission of instructor. 4 units. (CAN PHYS 4)

7. Basic Concepts in Physics. A quantitative introduction to the concepts of motion, force, matter and energy. Two activity sessions a week. Those who have had substantial chemistry and physics courses in high school, or who transfer to CSUS with a college-level physical science course should take a placement test, given by the Physics Department, in order to determine whether they can have this course waived. **Prerequisite:** MATH 17 or a passing score on the Intermediate Algebra Diagnostic Exam. 2 units.

10. Physics in Our World. This introductory Physics course is designed for non-science students completing general education requirements. Students will be introduced to basic concepts in Physics through the study of astronomy, atomic nature of matter, electromagnetic waves, energy, sound and earthquake waves, current electricity, magnetism, and nuclear processes. Development of reasoning and quantitative skills and applying them to scientific and technological topics of current importance will be emphasized. 3 units.

10L. Physics in Our World Laboratory. This laboratory course complements PHYS 10 and satisfies the general education science lab requirement. Emphasis is placed on the nature of scientific observation and measurement and their relationship to general physical concepts. Students will be given a concrete, *hands-on* sense of observing and interpreting data from a variety of experimental environments. **Prerequisite:** PHYS 10; may be taken concurrently. 1 unit.

11A. General Physics: Mechanics. The PHYS 11A, 11B, 11C sequence is a three semester course in introductory physics requiring elementary calculus. This sequence satisfies the lower division physics requirement for a major in physics, physical science, chemistry, geology, or engineering. Lecture two hours, quiz two hours, laboratory three hours. **Prerequisites:** MATH 30, 31; or equivalent certificated high school courses. MATH 31 may be taken concurrently. 4 units. (CAN PHYS 8)

11B. General Physics: Heat, Light, Sound. Lecture one hour, quiz two hours, laboratory three hours. **Prerequisite:** MATH 31, PHYS 11A. 4 units. (PHYS 11A + 11B + 11C = CAN PHYS SEQ. B)

11C. General Physics: Electricity and Magnetism, Modern Physics. Lecture one hour, quiz two hours, laboratory three hours. **Prerequisites:** MATH 31, PHYS 11A. 4 units. (PHYS 11A + 11B + 11C = CAN PHYS SEQ. B)

99. Special Problems. Individual projects or directed reading. **Note:** open only to students who appear competent to assume individual work on the approval of the instructor. For students with lower division standing. Up to four units may be taken for grade. 1-3 units.

UPPER DIVISION COURSES

Physics

100. Concepts in Physics. Stresses direct involvement with the physical world through activities and labs. Topics selected from electricity, magnetism, wave motion and sound, light, and nuclear physics. Two activity sessions per week. **Prerequisite:** PHYS 7. 2 units.

105. Mathematical Methods in Physics. Vector algebra and calculus and their application to physical systems; coordinate systems and transformations; abstract vector spaces and operators and their use in physics; eigenfunction expansions and their applications. **Prerequisites:** MATH 32; PHYS 11A, 11B, 11C or PHYS 5A, 5B. Fall only. 3 units.

106. Introduction to Modern Physics. Basic concepts of special relativity and quantum theory of matter. Phenomenological study of atomic and molecular energy states and spectra. Elements of solid-state and nuclear physics. **Prerequisites:** MATH 31; PHYS 11A, 11B, 11C or PHYS 5A, 5B. 3 units.

110. Intermediate Mechanics. Fundamental principles of statics and dynamics, including Newton's equations and conservation laws, damped and forced oscillations, central field motion, accelerated coordinate systems, coupled oscillations, continuum mechanics, and Lagrangian methods. **Prerequisites:** MATH 45, PHYS 105. Spring only. 3 units.

115A. Introduction to Electric and Electronic Measurements. Linear and non-linear circuits, measurement fundamentals and instruments, operational amplifiers, electronic devices and transducers, introduction to digital circuits. Lecture two hours, laboratory six hours. **Prerequisite:** PHYS 11C. Fall only. 4 units.

115B. Electronic Systems and Instrumentation A/D and D/A conversion, noise reduction techniques, microprocessor interfacing, radio frequency and microwave measurements, and similar topics. Lecture one hour, laboratory six hours. **Prerequisite:** PHYS 115A. Spring only. 3 units.

124. Thermodynamics and Statistical Mechanics. Basic concepts and laws of thermodynamics and thermal properties of matter; kinetic theory of gases; use of distribution functions and ensembles in statistical mechanics; connection of probability and entropy; quantum statistics; applications to various systems. **Prerequisites:** MATH 45, PHYS 11A, 11B, 11C. Fall only. 3 units.

130. Acoustics. Theoretical and experimental study of sound sources, sound waves and sound measurement. Basic properties of waves in continuous media; spectral analysis of vibrations; use of acoustic impedance and circuit analogies; applications to environmental noise analysis, room acoustics, and loudspeaker and microphone design and use; experience with acoustic instrumentation. Lecture two hours, laboratory three hours. **Prerequisites:** MATH 45, PHYS 11A, 11B, 11C. 3 units.

135. Electricity and Magnetism. Development of electromagnetic theory from basic experimental laws; electrostatics, electric currents, magnetostatics, electric and magnetic properties of matter, induction, Maxwell's equations, conservation laws, electromagnetic waves, and simple radiating systems. **Prerequisites:** MATH 45, PHYS 11C, 105. Spring only. 3 units.

142. Applied Solid State Physics. Elementary treatment of crystal structure and lattice and electron dynamics. Physics of semiconductor junctions, diodes, transistors and MOSFETS, solar cells, lasers, electro-optic and acousto-optic devices. Introduction to basic physical properties such as electrical conduction of selected amorphous solids and their applications. Laboratory experience. **Prerequisites:** MATH 45, PHYS 106. 3 units.

145. Physical Optics. Theoretical and experimental treatment of wave optics; interference, diffraction, absorption, scattering, dispersion, polarization. Selected topics from contemporary optics: Fourier optics, coherence theory, lasers, holography. Lecture two hours, laboratory three hours. **Prerequisites:** MATH 45, PHYS 11A, 11B, 11C. Fall only. 3 units.

150. Quantum Mechanics. Foundations of wave mechanics, including wave packets, superposition, and the uncertainty principle. The Schroedinger equation and its relation to operators and eigenstates. Symmetric systems and conserved quantities. Introduction to matrix mechanics, spin, scattering, and perturbation theory. **Prerequisites:** MATH 45, PHYS 106, 110. Fall only. 3 units.

151. Advanced Modern Physics. Structure of matter and its interaction with radiation, including x-ray and optical spectra, selection rules, and lasers. Electric and magnetic properties of solids and band theory of conduction. Nuclear systematics and reactions. Fundamental forces and elementary particle physics. **Prerequisite:** PHYS 150. Spring only. 3 units.

156. Advanced Classical Physics. Topics from classical field theory, including wave propagation in material media, reflection and refraction, polarization, cavities, waveguides, optical fibers, simple radiating systems, dipole radiation, radiation from an accelerated charge, and special relativity. Advanced formulations of mechanics, including Lagrange's equations and applications, rigid body motion, introduction to Hamiltonian methods, small vibrations and normal modes, and introduction to nonlinear dynamics and chaos. **Prerequisites:** PHYS 110, 135. Fall only. 3 units.

162. Computational Physics. Study of methods and development of skills for application of computers in solution of physical problems. Calculation techniques, modeling and simulation, data acquisition and manipulation, and use of programming resources. Practical experience in methods. **Prerequisites:** MATH 31, PHYS 11A, 11B, 11C, one course in computer programming; or permission of instructor. Fall only. 3 units.

175. Advanced Physics Laboratory. Advanced experiments chosen from several of the major areas of physics, performed usually on an individual basis. Laboratory six hours. May be repeated once with permission of advisor. **Prerequisite:** six units of upper division physics. Spring only. 2 units.

185. Energy: Critical Choices. A study of energy, its sources and its uses, and the human ecological implications of energy and energy policy. Through lectures, discussions, and informal experiments the students develop an intuitive understanding of energy. Ecological and public policy issues are then discussed. No technical background required. 3 units.

186. Musical Acoustics: Science and Sound. Physical principles of vibration and wave motion, with illustrations involving musical instruments and concert hall acoustics; principles of electronic synthesis, recording, and reproduction of sound; operation of the human ear and brain in receiving and analyzing sound; relation of the harmonic series to sound quality, harmony and scales; proper roles for science in explaining music as an artistic activity. **Note:** no technical background required; course cannot be used to meet Physics BS program requirements. This course is cross-listed with MUSC 186.3 units.

190. Physics Seminar. Special lecture series on announced topics by local and visiting speakers, emphasizing current research developments, with related reading assignments. May be taken twice for credit. 1-2 units.

194. Physics Related Work Experience. Supervised employment in a physics or astronomy related company or agency. Placement is arranged through the Department and the Cooperative Education Program office. Requires completion of a three-to-six month work assignment and a written report. **Note:** PHYS 194 may not be used to meet major requirements in Physics. **Prerequisite:** Upper-division standings and permission of Department Chair. Graded Credit/No Credit. 6-12 units.

196. Experimental Offerings in Physics. To be offered in the various fields of physics in response to student demand. **Prerequisites:** appropriate upper division coursework and permission of instructor. 1-3 units.

198. Co-Curricular Activities. The student may provide special tutoring to students taking physics courses, participate in community oriented projects, assist in activity sessions for teacher training courses, or engage in activities related to the subject matter and concerns of the Physics and Astronomy Department. Up to four units may be taken for grade. 1-3 units.

199. Special Problems. Individual projects or directed reading. Open only to students who appear competent to assume individual work on the approval of the instructor. Up to 4 units may be taken for grade. 1-3 units.

Physical Science

107. History of the Physical Sciences. A study of the development of the major physical laws presently used in describing our physical world. Some considerations of the influences of these developments on other areas of knowledge and on society in general. This course is cross-listed with HIST 107. Only one of these courses may be counted for credit. 3 units.

196. Experimental Offerings in Physical Science. When a sufficient number of qualified students apply, one of the staff will conduct a seminar in some topic in one of the physical sciences. 1-3 units.

199. Special Problems. Individual projects or directed reading. **Note:** open only to students who appear competent to assume individual work on the approval of the instructor. Up to four units may be taken for grade. 1-3 units.