PHYSICS

THE FACULTY

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THE MAJORS

Physics investigates and models nature in the most precise and fundamental ways possible. It is a driving force in the continual scientific and technological revolutions that define the modern world. This program prepares students for work or graduate studies in physics, astronomy, engineering, and other technical fields. Major courses address theoretical and experimental aspects of Classical Mechanics, Quantum Mechanics, Electricity and Magnetism, and Statistical Mechanics and Thermodynamics. Additionally, advanced topics courses are offered such as Astrophysics, Relativity, Physical Oceanography, and Condensed Matter. Students perform research in addition to coursework. There are opportunities to work with faculty in areas such as astronomy, planetary science, fluid dynamics, condensed matter, and optics.

The Physics department offers both Bachelor of Arts and Bachelor of Science degrees. Both majors offer training in the fundamentals of physics, from classical mechanics to quantum mechanics. We strongly recommend students begin either major with PHYS 231 General Physics I as early as possible (ideally, during the first year). Four years from the beginning of the General Physics sequence are required to complete the requirements for the Bachelor of Science degree, but the Bachelor of Arts degree can be completed in three years.

Students declaring a physics major are required to have a 2.5 cumulative GPA in the general physics and calculus sequences (PHYS 231, PHYS 233, and MATH 121, MATH 122, MATH 221).

Learning outcomes for these programs may be found at: www.redlands.edu/BA-PHYS/learning-outcomes.

BACHELOR OF ARTS

This program provides students with a basic understanding of the fundamentals of physics and allows them to choose which subjects to study at the advanced level. Students are encouraged to meet with physics faculty early in their program in order to choose courses that will prepare them for their future goals.

REQUIREMENTS

PHYSICS†: 31 credits
−− PHYS 231 General Physics I (4)
−− PHYS 232 General Physics II (4)
−− PHYS 233 General Physics III (4)
−− PHYS 391‡ Junior Seminar (2)
−− PHYS 491‡ Senior Seminar (2)
−− AND at least 15 additional credits at the 300 level

MATHEMATICS: 16 credits
−− MATH 121 Calculus I (4)
−− MATH 122 Calculus II (4)
−− MATH 221 Calculus III (4)
−− MATH 235 Differential Equations (4)

BACHELOR OF SCIENCE
This program offers advanced training in the fundamentals of physics. It is designed for well prepared and highly motivated students, particularly those interested in further study of physics at the graduate level. After completing this program, students will be well grounded in classical and modern physics and equipped to choose a specialized area for further study and research.

Requirements

PHYSICS†: 43–45 credits
−− PHYS 231 General Physics I (4)
−− PHYS 232 General Physics II (4)
−− PHYS 233 General Physics III (4)
−− PHYS 310 Electronics Applications (4)
−− PHYS 331 Classical Mechanics (4)
−− PHYS 332* Electricity and Magnetism (4)
−− PHYS 341* Quantum Mechanics (4)
−− PHYS 344* Thermal and Statistical Physics (4)
−− PHYS 349 Advanced Experimental Physics (4)
−− PHYS 391‡ Junior Seminar (2)
−− PHYS 491‡ Senior Seminar (2)
−− AND at least 2 credits of PHYS 378 or other department-approved research experience
−− AND at least 3 additional credits at the 300 level

RELATED FIELD REQUIREMENTS

CHEMISTRY: 4 credits
−− CHEM 131 General Chemistry (4)

MATHEMATICS/COMPUTER SCIENCE: 28 credits
−− MATH 121 Calculus I (4)
−− MATH 122 Calculus II (4)
−− MATH 221 Calculus III (4)
−− MATH 235 Differential Equations (4)

ALSO CHOOSE THREE OF THE FOLLOWING, WITH AT LEAST ONE FROM EACH CATEGORY:

CATEGORY A
−− MATH 222 Vector Calculus (4)
−− MATH 241 Linear Algebra (4)
−− MATH 311 Probability (4)
−− MATH 338 Partial Differential Equations (4)

OR
CATEGORY B
−− MATH 331 Numerical Analysis (4)
−− CS 110 Introduction to Programming (4)

EXPLANATION OF COURSE MARKINGS
† Math co- and pre-requisites for Physics courses are given in the individual course descriptions.
‡ Together satisfy WB requirement.
* These courses are offered every other year. Students should plan their schedules accordingly.

ENGINEERING
Through the Engineering 3-2 Combined Degree program, the Physics B.A. can be paired with an Engineering B.S. from Columbia University in New York City, or Manhattan College School of Engineering, or Washington University at St. Louis. This program combines three years at Redlands with two years at Columbia's or Washington's School of Engineering. For more information, see "ENGINEERING 3-2 COMBINED DEGREE" on page 308 in the Integrated Programs of Study section of this Catalog. Contact the program advisor listed for more information. Alternatively, a Physics bachelor's degree is good preparation for graduate study in various fields of Engineering.

THE MINORS

PHYSICS MINOR
A minor in physics can provide students with an understanding of the basic laws of the physical universe. When combined with a major in another science, students who minor in physics will be well prepared for graduate study in the sciences.

REQUIREMENTS: 32 credits

INTRODUCTORY PHYSICS†: 8 credits

CHOOSE ONE OF THE FOLLOWING SEQUENCES:
SEQUENCE A
−− PHYS 231 General Physics I (4)
−− PHYS 232 General Physics II (4)
OR
SEQUENCE B
−− PHYS 220 Fundamentals of Physics I (4)
−− PHYS 221 Fundamentals of Physics II (4)

ADDITIONAL PHYSICS COURSES: 12 credits
−− PHYS 233 General Physics III (4)
−− 8 credits in 300-level courses (except PHYS 391)

MATHEMATICS: 12 credits
−− MATH 121 Calculus I (4)
−− MATH 122 Calculus II (4)
−− MATH 221 Calculus III (4)

ASTRONOMY MINOR

Astronomy is the application of one or more of the physical sciences to the universe beyond the Earth. Astronomy has a vibrant amateur community whose interests and activities run the full range from simple stargazing to professional quality observation and research. The astronomy minor is intended for either non-science majors who wish to explore their astronomical interests, up to and including basic astronomical observation and research, or science majors who wish to augment their major through exposure to astronomy and the planetary sciences. Unless a student majors in one of the physical sciences, meeting the minimum requirements for the astronomy minor will not prepare one for graduate work in astronomy. However, it will allow one to develop a competence in the theories, tools, and techniques of astronomical discovery as used by professionals and amateurs alike.

Learning outcomes for the Astronomy Minor may be found at: www.redlands.edu/ASTR/learning-outcomes.

REQUIREMENTS†: 22–24 credits

A. A MINIMUM OF 6 CREDITS FROM THE FOLLOWING LIST OF INTRODUCTORY ASTRONOMY COURSES:
–– PHYS 102 Astronomy of Planets (4)
–– PHYS 103 General Astronomy (4)
–– PHYS 108 Astronomy Abroad, May Term (3)
–– PHYS 160 Topics in Physics and Astronomy (3–4) (must be an astronomy topic)

B. CHOOSE ONE OF THE FOLLOWING INTRODUCTORY PHYSICS SEQUENCES:
SEQUENCE A
–– PHYS 231 General Physics I (4)
–– PHYS 232 General Physics II (4)
(calculus-based)
OR
SEQUENCE B
–– PHYS 220 Fundamentals of Physics I (4)
–– PHYS 221 Fundamentals of Physics I (4)
(algebra-based)

C. Four credits from the following upper level physics and astronomy classes:
–– PHYS 360 Topics in Physics and Astrophysics (4) must be an astronomy topic)
–– PHYS 370 Independent Study or Research in Astronomy (may include a summer astronomy research program with a member of the Physics Department)

D. A minimum of four (4) additional credits from any course listed in Sections A or C

† Math co- and pre-requisites for Physics courses are given in the individual course descriptions.

DEPARTMENTAL HONORS

The Physics Department offers honors to recognize outstanding student achievement as reflected by a major GPA of at least 3.5 and an excellent research project culminating in a Senior Thesis (PHYS 491) and a presentation. Students should consult with the department chair for requirements.

SINGLE-SUBJECT TEACHING CREDENTIAL

Students who wish to be certified to teach science should meet with an advisor in the School of Education for information concerning certification and the teacher education preparation program process. Most students complete the teacher preparation program, including student teaching, during a fifth year after graduation. Please refer to the School of Education section of this Catalog for a more detailed list of requirements.

ADVANCED PLACEMENT IN PHYSICS

Students who scored well on the Physics AP exams may receive credit and place out of introductory courses based on an interview with department faculty. There are two different exams in physics:

Physics 1: Students who earned a score of three receive 0 to 4 credits, depending on the results of an interview with department faculty. Scores of four or five earn 4 credits.

Physics 2: Students who earned a score of three receive 0 to 4 credits, depending on the results of an interview with department faculty. Scores of four or five earn 4 credits.

Physics C: Students who earn a score of three may receive 0 to 7 credits, depending on the results of a faculty interview. Scores of four or five earn 3 to 8 credits, depending on the results of the faculty interview.

RESEARCH

Research is an important component of a science student's experience at Redlands. Physics students can work with faculty during the school year for credit (PHYS 378) and during the summer when a number of research fellowship positions are available for students within the Stauffer Center for Science and Mathematics. They can also take advantage of summer programs offered by other institutions (such as Research Experiences for Undergraduates). Most students begin work in their sophomore or junior years that evolves into a senior thesis.

Students join faculty on research in areas such as Astronomy, Turbulence, Optics, and Surface Science. They have controlled telescopes remotely (such as the NASA IRTF in Mauna Kea, Hawaii and the VLA in Soccoro, New Mexico), analyzed data from ground-based telescopes and satellites, and modeled volcanoes on other planets, the pulsation of variable stars, and star formation in other galaxies. The fluid dynamics lab is a student designed facility for geophysical dynamics experiments as well as analysis of oceanic and atmospheric flow observations. Students have worked on a variety of laser and optical experiments, including light scattering, optical tweezers, and quantum optics. Recent surface science work has featured the development and construction of a Scanning Tunneling Microscope to investigate atomic-scale surface features and phenomena.

COURSE DESCRIPTIONS (PHYS)

102 Astronomy of Planets.
Fall (4), Spring (4).
Introductory study of selected topics in planetary science. Basic information about the planets, moons, and other objects in our solar system will be covered. Additional possible topics include space exploration, planetary geology, search for life in the solar system, and planetary impact hazards. Includes lecture and laboratory components. Expects competency in high school algebra, geometry, and trigonometry.
Offered as needed.

103 General Astronomy.
Fall (4), Spring (4).
Introductory study of astronomy designed to acquaint the student with stars, black holes, galaxies, and the origin and present state of the universe. Students will learn about these concepts in the context of the scientific method. Laboratory is one day a week with occasional evening observing sessions. Includes lecture and laboratory components.
Prerequisite: Expects competency in high school algebra, geometry, and trigonometry.
Offered as needed.

106 Physics Comes to Light.
Fall (4), Spring (4).
Introductory study of the physics of light. Students will learn about the production of light, the nature of color, everyday optical phenomena, vision, quantum mechanics, and relativity. Includes lecture and laboratory components. Expects competency in high school algebra.
Offered as needed.

107 Sound Physics.
Fall (4), Spring (4).
This is an introductory-level lab science course. Students will develop an understanding of the physical principles underlying the phenomena of musical acoustics: sound production, propagation, and perception. Includes lecture and laboratory components. Expects competency in high school algebra.
Offered as needed.

108 Astronomy Abroad.
May Term (3).
Astronomy is a scientific endeavor that has been pursued all over the Earth for thousands of years. Astronomy Abroad classes take a group of students to a specific location on Earth to learn about the historical and modern astronomy that takes place there. Included are locations such as Hawaii, Italy, and Salzburg.

160 Topics in Physics and Astronomy.
Fall (4), Spring (4), May Term (3).
Topics in physics and astronomy of interest to non-majors that are not regularly offered. May be repeated for degree credit for a maximum of 12 credits, given different topics.
Offered as needed.

220 Fundamentals of Physics I.
Fall (4).
Introduction to Newtonian mechanics, fluids, and thermodynamics. Includes lecture and laboratory components. Expects competency in high school algebra, geometry, and trigonometry.

221 Fundamentals of Physics II.
Spring (4).
Introduction to oscillations, waves, electricity, magnetism, optics, and modern physics. Includes lecture and laboratory components.
Prerequisite: PHYS 220.

231 General Physics I.
Fall (4).
Quantitative study of classical Newtonian mechanics. Includes lecture and laboratory components.
Prerequisite: MATH 119, MATH 121, MATH 122 or MATH 221.

232 General Physics II.
Spring (4).
Introduction to classical electricity and magnetism. Includes lecture and laboratory components.
Prerequisite: PHYS 231;
Pre- or corequisite: MATH 122 or MATH 221.

233 General Physics III.
Fall (4).
Introduction to geometric optics, wave optics, quantum mechanics, thermodynamics, and statistical mechanics. Includes lecture and laboratory components.
Prerequisite: PHYS 231–232 or instructor's permission.
Pre- or corequisite: MATH 221.

291 Physics Instructional Techniques.
292 Physics Instructional Techniques.
Fall (2–4), Spring (2–4).
Experience in classroom lecturing, experimental demonstration, construction and design of student laboratory experiments, tutoring, and individual instruction. This course may be associated with any 100- or 200-level physics course.
Prerequisite: instructor's permission. Available concurrently with associated Physics courses.

310 Electronics Applications.
Spring (4).
Instrumentation, transistor theory, integrated circuits, and fundamental analog and digital circuit design. Lecture and lab components.
Prerequisite: PHYS 221 or PHYS 232 or by permission.

331 Classical Mechanics.
Spring (4).
Applications of Newtonian mechanics to various systems, and introduction of calculus of variations and Lagrangian mechanics. This course acquaints students with mathematical techniques used to solve more realistic and complex problems.
Prerequisite: PHYS 231.
Pre- or corequisite: MATH 235.

332 Electricity and Magnetism.
Fall (4).
Development and application of Maxwell's equations describing electromagnetic fields. Topics include boundary value problems, and dielectric and magnetic materials.
Prerequisites: PHYS 232 and MATH 235.
Offered in alternate years.

341 Quantum Mechanics.
Fall (4).
Fundamentals of quantum theory. Includes development of mathematical formalism, application to two- and three-dimensional models, and a detailed treatment of the one-electron atom.
Prerequisites: PHYS 233 and MATH 235.
Offered in alternate years.

344 Thermal and Statistical Physics.
Fall (4).
Fundamental principles of classical thermodynamics and kinetic theory. Classical and quantum statistical properties of matter and radiation.
Prerequisites: PHYS 233 and MATH 221.
Offered in alternate years.

349 Advanced Experimental Physics.
Fall (4).
Laboratory course in solid state, molecular, atomic, optical, nuclear, and particle physics.
Prerequisite: PHYS 233 and PHYS 310.

360 Topics in Physics and Astronomy.
Fall (2–4), Spring (2–4), May Term (3).
Special topics in physics and astronomy not otherwise covered in the curriculum. Topics vary with semester and may include astrophysics, optics, computational physics, planetary science, relativity, and solid state physics.
May be repeated for degree credit given a different topic.
Prerequisite: PHYS 231 and PHYS 233 or instructor's permission.
Offered as needed.

378 Physics Research.
Fall (1–4), Spring (1–4).
Students can earn credits while gaining valuable research experience with faculty in the department. Contact individual faculty to discuss opportunities. May be repeated for degree credit.
Prerequisite: instructor's permission.
Credit/no credit and Evaluation grade only.

391 Junior Seminar.
Spring (2).
Students develop the skills for communicating scientific articles, writing papers, and giving presentations.
Prerequisites: PHYS 233 and junior standing, or by permission.
Numeric and Evaluation grade only.

491 Senior Seminar.
Spring (2).
Development of written and oral communication skills. Preparation and presentation of a senior thesis.
Prerequisite: PHYS 391 Junior Seminar.
Numeric and Evaluation grade only.