Physics

Bachelor of Arts (BA)

The Physics major is designed to give the student a broad and thorough understanding of the fundamentals of physics. Therefore, the emphasis is on this general understanding rather than on specialized skills, although some specialized courses are among the options open to the student. Those considering a physics major are urged to consult a departmental adviser early, in order to discuss the content of the major and also the opportunities after graduation. Recent graduates have entered graduate work in a number of scientific fields, and others have gone on to jobs in academic, industrial, and government laboratories.

Declaring the Major

Students may declare a physics major when all of the prerequisites for the major have been completed or their equivalent with a 2.0 grade point average (GPA) in the prerequisites and a 2.0 GPA in all University courses. For further information regarding the Prerequisites, please see the Major Requirements tab on this page.

The Department will consider applications to declare a physics major throughout the academic year. Students (continuing and transfer) declaring must furnish a copy of their grade record or past transcripts which include the prerequisite courses or their equivalents. Students must have their records reviewed and have a departmental file prepared by the Undergraduate Adviser in 368 LeConte Hall prior to seeing a faculty major adviser for departmental approval of the petition to declare a physics major. Students should be prepared to discuss a tentative schedule of their upper division courses.

Honors Program

Students with an overall grade point average (GPA) of 3.3 or higher in all courses in the major, upper-division courses in the major, and all University courses may be admitted to the honors program. A major adviser should be consulted before the student's last year of residence. This program requires completion of the major, at least one semester of PHYSICS H190, and a senior thesis, PHYSICS H195A and PHYSICS H195B.

Minor Program

The Department also offers a minor program in Physics. Students may petition for a minor in Physics from the time that the requirements are complete until the student graduates from the College of Letters and Science. Students who have completed the requirements for the minor will be required to furnish transcripts (official or unofficial) to the undergraduate adviser (in 368 LeConte Hall) to show their work and GPA in physics and math. After completing a confirmation of minor program petition (available in 368 LeConte Hall) the students will be directed to a faculty major adviser who will approve the completion of the minor program.

In addition to the University, campus, and college requirements, listed on the College Requirements tab, students must fulfill the below requirements specific to their major program.

General Guidelines

1. All courses taken to fulfill the major requirements below must be taken for graded credit, other than courses listed which are offered on a *Pass/No Pass* basis only. Other exceptions to this requirement are noted as applicable.
2. No more than one upper-division course may be used to simultaneously fulfill requirements for a student's major and minor programs with the exception of minors offered outside of the College of Letters and Science.
3. A minimum grade point average (GPA) of 2.0 must be maintained in both upper- and lower-division courses used to fulfill the major requirements.

For information regarding residence requirements and unit requirements, please see the College Requirements tab.

Lower-division Requirements

In addition to the requirements below, students who: (1) Have not taken a substantial chemistry course in high school are urged to take a one-year sequence or (2) Unfamiliar with a computer programming language are encouraged to include an introductory course in Computer Science.

PHYSICS 7A	Physics for Scientists and Engineers	4
or PHYSICS H7A	Physics for Scientists and Engineers	
PHYSICS 7B	Physics for Scientists and Engineers	4
or PHYSICS H7B	Physics for Scientists and Engineers	
PHYSICS 7C	Physics for Scientists and Engineers	4
or PHYSICS H7C	Physics for Scientists and Engineers	
MATH 1A	Calculus	4
MATH 1B	Calculus	4
MATH 53	Multivariable Calculus	4
MATH 54	Linear Algebra and Differential Equations	4

Upper-division

PHYSICS 105	Analytic Mechanics	4
PHYSICS 110A	Electromagnetism and Optics	4
PHYSICS 111	Course Not Available (Six units total required)	1-3
PHYSICS 112	Introduction to Statistical and Thermal Physics	4
PHYSICS 137A	Quantum Mechanics	4
PHYSICS 137B	Quantum Mechanics	4
Select one course from the following:		4
PHYSICS 110E	Electromagnetism and Optics	
PHYSICS 129	Particle Physics	
PHYSICS 130	Quantum and Nonlinear Optics	
PHYSICS 138	Modern Atomic Physics	
PHYSICS 139	Special Relativity and General Relativity	
PHYSICS 141A	Solid State Physics	
PHYSICS 141E	Solid State Physics	
PHYSICS 142	Introduction to Plasma Physics	
PHYSICS 151	Elective Physics: Special Topics	
PHYSICS C161	Relativistic Astrophysics and Cosmology	
PHYSICS 177	Principles of Molecular Biophysics	
PHYSICS C191	Quantum Information Science and Technology	

Recommended courses

For students planning to continue to graduate school, special programs may be worked out with the adviser. The following courses are also recommended for students interested in graduate school:

PHYSICS 110B	Electromagnetism and Optics	4
MATH 104	Introduction to Analysis	4
MATH 110	Linear Algebra	4
MATH 113	Introduction to Abstract Algebra	4
MATH 121A	Mathematical Tools for the Physical Sciences	4
MATH 121B	Mathematical Tools for the Physical Sciences	4
MATH 128A	Numerical Analysis	4
MATH 185	Introduction to Complex Analysis	4

Students who have a strong interest in an area of study outside their major often decide to complete a minor program. These programs have set requirements and are noted officially on the transcript in the memoranda section, but they are not noted on diplomas.

General Guidelines

1. All courses taken to fulfill the minor requirements below must be taken for graded credit.
2. A minimum of three of the upper-division courses taken to fulfill the minor requirements must be completed at UC Berkeley.
3. A minimum grade point average (GPA) of 2.0 is required for courses used to fulfill the minor requirements.
4. Courses used to fulfill the minor requirements may be applied toward the Seven-Course Breadth Requirement for Letters and Science students.
5. No more than one upper-division course may be used to simultaneously fulfill requirements for a student's major and minor programs.
6. All minor requirements must be completed prior to the last day of finals during the semester in which the student plans to graduate. Students who cannot finish all courses required for the minor by that time should see a College of Letters and Science adviser.
7. All minor requirements must be completed within the unit ceiling. (For further information regarding the unit ceiling, please see the College Requirements tab.)

Requirements

Lower-division Prerequisites		
PHYSICS 7A	Physics for Scientists and Engineers (or equivalent)	4
PHYSICS 7B	Physics for Scientists and Engineers (or equivalent)	4
PHYSICS 7C	Physics for Scientists and Engineers (or equivalent)	4
MATH 1A	Calculus (or equivalent)	4
MATH 1B	Calculus (or equivalent)	4
MATH 53	Multivariable Calculus (or equivalent)	4
MATH 54	Linear Algebra and Differential Equations (or equivalent)	4
Upper-division		
PHYSICS 137A	Quantum Mechanics	4
PHYSICS 110A	Electromagnetism and Optics	4
or PHYSICS 105	Analytic Mechanics	
Select three upper-division Physics courses (9 units minimum) [1]		

[1] The following upper-division courses will not fulfill minor requirements: PHYSICS H190, PHYSICS H195A, PHYSICS H195B, PHYSICS 198, and PHYSICS 199.

Undergraduate students in the College of Letters and Science must fulfill the following requirements in addition to those required by their major program.

For detailed lists of courses that fulfill college requirements, please see the College of Letters and Sciences (http://guide.berkeley.edu/archive/2014-15/undergraduate/colleges-schools/letters-science) page in this bulletin.

Entry Level Writing

All students who will enter the University of California as freshmen must demonstrate their command of the English language by fulfilling the Entry Level Writing Requirement. Fulfillment of this requirement is also a prerequisite to enrollment in all reading and composition courses at UC Berkeley.

American History and American Institutions

The American History and Institutions requirements are based on the principle that a U.S. resident graduated from an American university should have an understanding of the history and governmental institutions of the United States.

American Cultures

American Cultures is the one requirement that all undergraduate students at Cal need to take and pass in order to graduate. The requirement offers an exciting intellectual environment centered on the study of race, ethnicity and culture of the United States. AC courses offer students opportunities to be part of research-led, highly accomplished teaching environments, grappling with the complexity of American Culture.

Quantitative Reasoning

The Quantitative Reasoning requirement is designed to ensure that students graduate with basic understanding and competency in math, statistics, or computer science. The requirement may be satisfied by exam or by taking an approved course.

Foreign Language

The Foreign Language requirement may be satisfied by demonstrating proficiency in reading comprehension, writing, and conversation in a foreign language equivalent to the second semester college level, either by passing an exam or by completing approved course work.

Reading and Composition

In order to provide a solid foundation in reading, writing and critical thinking the College requires two semesters of lower division work in composition. Students must complete a first-level reading and composition course by the end of their second semester and a second-level course by the end of their fourth semester.

Breadth Requirements

The undergraduate breadth requirements provide Berkeley students with a rich and varied educational experience outside of their major program. As the foundation of a liberal arts education, breadth courses give students a view into the intellectual life of the University while introducing them to a multitude of perspectives and approaches to research and scholarship. Engaging students in new disciplines and with peers from other majors, the breadth experience strengthens interdisciplinary connections and context that prepares Berkeley graduates to understand and solve the complex issues of their day.

Unit Requirements

- 120 total units, including at least 60 L&S units
- Of the 120 units, 36 must be upper division units
- Of the 36 upper division units, 6 must be taken in courses offered outside your major department

Residence Requirements

For units to be considered in "residence," you must be registered in courses on the Berkeley campus as a student in the College of Letters and Science. Most students automatically fulfill the residence requirement by attending classes here for four years. In general, there is no need to be concerned about this requirement, unless you go abroad for a semester or year or want to take courses at another institution or through University Extension during your senior year. In these cases, you should make an appointment to see an adviser to determine how you can meet the Senior Residence Requirement.

Note: Courses taken through UC Extension do not count toward residence.

Senior Residence Requirement

After you become a senior (with 90 semester units earned toward your B.A. degree), you must complete at least 24 of the remaining 30 units in residence in at least two semesters. To count as residence, a semester must consist of at least 6 passed units. Intercampus Visitor, EAP, and UC Berkeley-Washington Program (UCDC) units are excluded.

You may use a Berkeley summer session to satisfy one semester of the Senior Residence Requirement, provided that you successfully complete 6 units of course work in the Summer Session and that you have been enrolled previously in the College.

Modified Senior Residence Requirement

Participants in the UC Education Abroad Program (EAP) or the UC Berkeley-Washington Program (UCDC) may meet a Modified Senior Residence Requirement by completing 24 (excluding EAP) of their final 60 semester units in residence. At least 12 of these 24 units must be completed after you have completed 90 units.

Upper Division Residence Requirement

You must complete in residence a minimum of 18 units of upper division courses (excluding EAP units), 12 of which must satisfy the requirements for your major.

Mission

The goal of the Physics major is to provide students with a broad understanding of the physical principles of the universe, to help them develop critical thinking and quantitative reasoning skills, to empower them to think creatively and critically about scientific problems and experiments, and to provide training for students planning careers in physics and in the physical sciences broadly defined including those whose interests lie in research, K-12 or college teaching, industrial jobs, or other sectors of society.

Physics majors complete a program which includes foundational lower division course work in math and physics and in-depth upper division course work. These topics are traditionally broadly divided into classical and modern physics. Some core topics, such as special relativity, classical optics, and classical thermodynamics, are covered only in lower division courses. Other topics, such as quantum mechanics, classical mechanics, statistical mechanics, thermodynamics, electricity and magnetism, and optics, are covered first at an introductory level in lower division and then at a more advanced level in the upper division courses. Advanced elective courses provide students the opportunity to further their knowledge in specific areas (such as atomic physics, condensed matter physics, optical properties, quantum computing, biophysics, astrophysics, particle physics). A two-semester upper division laboratory course provides additional training in electronic instrumentation, circuits, computer interfacing to experiments, independent project design, and advanced laboratory techniques experiments. This laboratory course also provides the capstone experience to the core courses, bringing the knowledge gained in different courses together and making the connection between theoretical knowledge taught in textbooks/homework problems and the experimental foundations of this knowledge. Activities outside the classroom, such as independent research or study, allow students to further develop their knowledge and understanding.

A student graduating from Berkeley with a major in physics will understand classical and modern physics (as outlined in the course requirements below) and will also acquire the skills to apply principles to new and unfamiliar problems. Their understanding should include the ability to analyze physical problems (often posed as “word problems”), be able to derive and prove equations that describe the physics of the universe, understand the meaning and limitations of these equations, and have both physical and numerical insight into physical problems (e.g. be able to make order-of-magnitude estimates, analyze physical situations by application of general principles as well as by textbook type calculations). They will also have developed basic laboratory, library, and computational skills, be familiar with important historical experiments and what physics they revealed, and be able to make both written and oral presentations on physics problems posed to them. At graduation, physics majors will have a set of fundamental competencies that are knowledge-based, performance/skills-based, and affective.

Learning Goals for the Major

Graduates will have the following:

1. Mastered a broad set of knowledge concerning the fundamentals in the basic areas of physics (quantum mechanics, classical mechanics, statistical mechanics, thermodynamics, electricity and magnetism, optics, and special relativity). This does not refer to knowledge about specific facts, but rather to a working knowledge of fundamental concepts that can then be applied in many different ways to understand or predict what nature does.

2. An understanding of the physical principles required to analyze a physical question or topic, including those not previously seen, and both quantitative and qualitative physical insight into these principles in order to understand or predict what happens. This includes understanding what equations and numerical physical constants are needed to describe and analyze fundamental physics problems.
3. A set of basic physical constants that enable their ability to make simple numerical estimates of physical properties of the universe and its constituents.
4. An understanding of how modern electronic instrumentation works, and how both classical and modern experiments are used to reveal the underlying physical principals of the universe and its constituents.
5. An understanding of how to use computers in data acquisition and processing and how to use available software as a tool in data analysis.
6. An understanding of modern library search tools used to locate and retrieve scientific information.

Skills

Graduates will have the following abilities:

1. Solve problems competently by identifying the essential parts of a problem and formulating a strategy for solving the problem. Estimate the numerical solution to a problem. Apply appropriate techniques to arrive at a solution, test the correctness of the solution, and interpret the results.
2. Explain the physics problem and its solution in both words and appropriately specific equations to both experts and non-experts.
3. Understand the objective of a physics laboratory experiment, properly carry out the experiments, and appropriately record and analyze the results.
4. Use standard laboratory equipment, modern instrumentation, and classical techniques to carry out experiments.
5. Know how to design, construct, and complete a science-based independent project (specifically in the area of electronics).
6. Know and follow the proper procedures and regulations for safely working in a lab.
7. Communicate the concepts and results of their laboratory experiments through effective writing and oral communication skills.

Affective

Graduates will be able to do the following:

1. Successfully pursue career objectives in graduate school or professional schools, in a scientific career in government or industry, in a teaching career, or in a related career.
2. Think creatively about scientific problems and their solutions, to design experiments, and to constructively question results they are presented with, whether these results are in a newspaper, in a classroom, or elsewhere.

All students interested in the Physics major should come in for major advising as soon as possible starting their first semester on campus for individualized assistance. Professional advisers can assist with a wide range of matters including academic course planning, research, career, and graduate school goals.

Advising Staff

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Berkeley Connect in Physics

Berkeley Connect in Physics is a mentoring program that pairs physics graduate mentors with undergraduate physics students. The goals of the program are to help students develop understanding, community, and career preparedness that go beyond what traditional courses provide. Interactions with graduate students and faculty will play a large role throughout the semester. The course is a small seminar class led by the physics graduate student mentor. Some of the meetings will include the following:

- Visits to research labs on campus and at the national labs to talk to faculty, scientists, and grad students
- Preparing students for a broad range of career trajectories including ones outside of academia
- Discussions of science in the news and science and society
- Resources for finding research opportunities on campus, REUs, internships
- Developing skills that will make you an attractive candidate for undergraduate research
- Exploration of the idea of scientific models
- Building a community of physics student scientists

Berkeley Connect is a 1-credit seminar course that meets once a week for one hour. It is designed to be very low workload but have large benefits for physics undergraduates. For more information please visit the Berkeley Connect website (http://www.berkeleyconnect.berkeley.edu) .

Physics

PHYSICS 7A Physics for Scientists and Engineers 4 Units
Mechanics and wave motion.
Rules & Requirements

Prerequisites: High school physics; MATH 1A; MATH 1B (which may be taken concurrently)

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 2 hours of discussion, and 2 hours of laboratory per week

Summer: 8 weeks - 6 hours of lecture, 4 hours of discussion, and 4 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 7B Physics for Scientists and Engineers 4 Units
Heat, electricity, and magnetism.
Rules & Requirements

Prerequisites: 7A, MATH 1A-1B, MATH 53 (may be taken concurrently)

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 2 hours of discussion, and 2 hours of laboratory per week

Summer: 8 weeks - 6 hours of lecture, 4 hours of discussion, and 4 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 7C Physics for Scientists and Engineers 4 Units
Electromagnetic waves, optics, relativity, and quantum physics.
Rules & Requirements

Prerequisites: 7A-7B, MATH 1A-1B, MATH 53, 54 (MATH 54 may be taken concurrently)

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Summer: 8 weeks - 6 hours of lecture, 2 hours of discussion, and 6 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS H7A Physics for Scientists and Engineers 4 Units
Honors sequence corresponding to 7A-7B-7C, but with a greater emphasis on theory as opposed to problem solving. Recommended for those students who have had advanced Physics on the high school level and who are intending to declare a major in physics. Entrance into H7A is decided on the basis of performance on an examination given during the first week of class or the consent of the instructor, and into H7B-H7C on performance in previous courses in a standard sequence.
Rules & Requirements

Prerequisites: High school physics; MATH 1A; MATH 1B (may be taken concurrently)

Credit Restrictions: Students will received no credit for H7A after taking 7A.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS H7B Physics for Scientists and Engineers 4 Units
Honors sequence corresponding to 7A-7B-7C, but with a greater emphasis on theory as opposed to problem solving. Recommended for those students who have had advanced Physics on the high school level and who are intending to declare a major in physics. Entrance into H7A is decided on the basis of performance on an examination given during the first week of class or the consent of the instructor, and into H7B-H7C on performance in previous courses in a standard sequence.
Rules & Requirements

Prerequisites: 7A, MATH 1A-1B, MATH 53 (may be taken concurrently)

Credit Restrictions: Students will receive no credit H7B after taking 7B.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS H7C Physics for Scientists and Engineers 4 Units
Honors sequence corresponding to 7A-7B-7C, but with a greater emphasis on theory as opposed to problem solving. Recommended for those students who have had advanced Physics on the high school level and who are intending to declare a major in physics. Entrance into H7A is decided on the basis of performance on an examination given during the first week of class or the consent of the instructor, and into H7B-H7C on performance in previous courses in a standard sequence.
Rules & Requirements

Prerequisites: 7A-7B, MATH 1A-1B, MATH 53, 54 (MATH 54 may be taken concurrently)

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 1 hour of discussion, and 3 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 8A Introductory Physics 4 Units
Introduction to forces, kinetics, equilibria, fluids, waves, and heat. This course presents concepts and methodologies for understanding physical phenomena, and is particularly useful preparation for upper division study in biology and architecture.
Rules & Requirements

Prerequisites: Mathematics 1A, 10A, 16A, or equivalent, or consent of instructor

Credit Restrictions: Students with credit for 7A will not receive credit for 8A.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 2 hours of discussion, and 2 hours of laboratory per week

Summer: 8 weeks - 6 hours of lecture, 4 hours of discussion, and 4 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 8B Introductory Physics 4 Units
Introduction to electricity, magnetism, electromagnetic waves, optics, and modern physics. The course presents concepts and methodologies for understanding physical phenomena, and is particularly useful preparation for upper division study in biology and architecture.
Rules & Requirements

Prerequisites: 8A or equivalent

Credit Restrictions: Students with credit for 7B or 7C will not receive credit for Physics 8B.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture, 2 hours of discussion, and 2 hours of laboratory per week

Summer: 8 weeks - 6 hours of lecture, 4 hours of discussion, and 4 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS C10 Descriptive Introduction to Physics 3 Units
The most interesting and important topics in physics, stressing conceptual understanding rather than math, with applications to current events. Topics covered may vary and may include energy and conservation, radioactivity, nuclear physics, the Theory of Relativity, lasers, explosions, earthquakes, superconductors, and quantum physics.
Rules & Requirements

Prerequisites: Open to students with or without high school physics

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Summer: 8 weeks - 6 hours of lecture and 2 hours of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Also listed as: L & S C70V

PHYSICS 21 Physics of Music 3 Units
Physical principles encountered in the study of music. The applicable laws of mechanics, fundamentals of sound, harmonic content, principles of sound production in musical instruments, musical scales. Numerous illustrative lecture demonstrations will be given. Only the basics of high school algebra and geometry will be used.
Rules & Requirements

Prerequisites: No previous courses in Physics are assumed, although Physics 10 is recommended

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS C21 Physics and Music 3 Units
What can we learn about the nature of reality and the ways that we humans have invented to discover how the world works? An exploration of these questions through the physical principles encountered in the study of music. The applicable laws of mechanics, fundamentals of sound, harmonic content, principles of sound production in musical instruments, musical scales. Numerous illustrative lecture demonstrations will be given. Only the basics of high school algebra and geometry will be used.
Rules & Requirements

Prerequisites: No previous courses in Physics are assumed, although Physics 10 is recommended

Credit Restrictions: Students will receive no credit for Physics C21/ Letters and Science C70W after completing Physics 21. A deficient grade in Physics 21 may be removed by taking Physics C21/Letters and Science C70W.

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Also listed as: L & S C70W

PHYSICS 24 Freshman Seminars 1 Unit
The Berkeley Seminar Program has been designed to provide new students with the opportunity to explore an intellectual topic with a faculty member in a small-seminar setting. Berkeley Seminars are offered in all campus departments, and topics vary from department to department and semester to semester.
Rules & Requirements

Repeat rules: Course may be repeated for credit as topic varies. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of seminar per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

PHYSICS 39 Lower Division Physics Seminar 1.5 - 4 Units
Enrollment limited to 20 students per section. Physics seminar course designed for both non major students and students considering a major in physics. Topics vary from semester to semester.
Rules & Requirements

Prerequisites: Enrollment by consent of instructor during the week of pre-enrollment. Consult bulletin boards outside 366 Le Conte for more information

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1.5-4 hours of seminar per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: The grading option will be decided by the instructor when the class is offered. Final exam required.

PHYSICS 49 Supplementary Work in Lower Division Physics 1 - 3 Units
Students with partial credit in lower division physics courses may, with consent of instructor, complete the credit under this heading.
Rules & Requirements

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Summer: 8 weeks - 1-3 hours of independent study per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam not required.

PHYSICS 77 Introduction to Computational Techniques in Physics 2 Units
Introductory scientific programming in Python with examples from physics. Topics include: visualization, statistics and probability, regression, numerical integration, simulation, data modeling, function approximation, and algebraic systems. Recommended for freshman physics majors.
Rules & Requirements

Prerequisites: MATH 1A; Physics 5A or 7A (which may be taken concurrently) or permission of instructor

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture and 2 hours of workshop per week

Summer: 10 weeks - 3 hours of lecture and 3 hours of workshop per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

PHYSICS 89 Introduction to Mathematical Physics 4 Units
Complex numbers, linear algebra, ordinary differential equations, Fourier series and transform methods, introduction to partial differential equations, introduction to tensors. Applications to physics will be emphasized. This course or an equivalent course required for physics major.
Rules & Requirements

Prerequisites: MATH 53

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 2 hours of discussion per week

Summer: 10 weeks - 4 hours of lecture and 3 hours of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 98 Directed Group Study 1 - 4 Units
Rules & Requirements

Prerequisites: Restricted to freshman and sophomores only; consent of instructor

Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

Repeat rules: Course may be repeated for credit as topic varies. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1-4 hours of directed group study per week

Summer: 8 weeks - 1.5-7.5 hours of directed group study per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

PHYSICS 98BC Berkeley Connect 1 Unit
Berkeley Connect is a mentoring program, offered through various academic departments, that helps students build intellectual community. Over the course of a semester, enrolled students participate in regular small-group discussions facilitated by a graduate student mentor (following a faculty-directed curriculum), meet with their graduate student mentor for one-on-one academic advising, attend lectures and panel discussions featuring department faculty and alumni, and go on field trips to campus resources. Students are not required to be declared majors in order to participate.
Rules & Requirements

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of directed group study per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

PHYSICS 99 Supervised Independent Study 1 - 3 Units
Rules & Requirements

Prerequisites: Restricted to freshmen and sophomores only; consent of instructor

Credit Restrictions: Enrollment is restricted; see the Introduction to Courses and Curricula section of this catalog.

Repeat rules: Course may be repeated for credit as topic varies. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1-4 hours of independent study per week

Summer: 8 weeks - 1.5-7.5 hours of independent study per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

PHYSICS 100 Communicating Physics and Physical Science 2 Units
For undergraduate and graduate students interested in improving their ability to communicate scientific knowledge by teaching science in K-12 schools. The course will combine instruction in inquiry-based science teaching methods and learning pedagogy with 10 weeks of supervised teaching experience in a local school. Students will practice, with support and mentoring, communicating scientific knowledge through presentations and hands-on activities. Approximately three hours per week including time spent in school classrooms.
Hours & Format

Fall and/or spring: 15 weeks - 2 hours of lecture per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 105 Analytic Mechanics 4 Units
Newtonian mechanics, motion of a particle in one, two, and three dimensions, Larange's equations, Hamilton's equations, central force motion, moving coordinate systems, mechanics of continuous media, oscillations, normal modes, rigid body dynamics, tensor analysis techniques.
Rules & Requirements

Prerequisites: PHYSICS 7A, 7B, 7C

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 110A Electromagnetism and Optics 4 Units
Part I. A course emphasizing electromagnetic theory and applications; charges and currents; electric and magnetic fields; dielectric, conducting, and magnetic media; relativity, Maxwell equations. Wave propagation in media, radiation and scattering, Fourier optics, interference and diffraction, ray optics and applications.
Rules & Requirements

Prerequisites: PHYSICS 7A, 7B, 7C

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 110B Electromagnetism and Optics 4 Units
Part II. A course emphasizing electromagnetic theory and applications; charges and currents; electric and magnetic fields; dielectric, conducting, and magnetic media; relativity, Maxwell equations. Wave propagation in media, radiation and scattering, Fourier optics, interference and diffraction, ray optics and applications.
Rules & Requirements

Prerequisites: PHYSICS 7A, 7B, 7C and 110A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 111A Instrumentation Laboratory 3 Units
The instrumentation lab (formerly Basic Semiconductor Circuits) is an introductory course in basic design, analysis and modeling of circuits, and data analysis and control. Topics include but not limited to:
linear circuits, semiconductor diodes, JFETS, Op-Amps, Labview programming, ADC and DAC converters, signal processing, and feedback control.
Rules & Requirements

Prerequisites: Consent of Instructor

Hours & Format

Fall and/or spring: 15 weeks - 8 hours of laboratory and 3 hours of lecture per week

Summer: 10 weeks - 12 hours of laboratory and 4.5 hours of lecture per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Alternative to final exam.

PHYSICS 111B Advanced Experimentation Laboratory 1 - 3 Units
In the advanced experimentation lab students complete four of 20+ advanced experiments. These include many experiments in atomic, nuclear, particle physics, biophysics, and solid-state physics, among others.
Rules & Requirements

Prerequisites: PHYSICS 111A and 137A or consent of instructor

Credit Restrictions: Three units of the Advanced Experimentation lab required for physics major; After the first three units, lab may be repeated for additional credit. No more than three units may be completed in one semester.

Repeat rules: Course may be repeated for a maximum of REPEAT_REQUIRES_INSTRUCTOR_CONSENT units. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 3-9 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam not required.

Formerly known as: Physics 111

PHYSICS 112 Introduction to Statistical and Thermal Physics 4 Units
Basic concepts of statistical mechanics, microscopic basis of thermodynamics and applications to macroscopic systems, condensed states, phase transformations, quantum distributions, elementary kinetic theory of transport processes, fluctuation phenomena.
Rules & Requirements

Prerequisites: PHYSICS 7A, 7B, 7C

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 129 Particle Physics 4 Units
Tools of particle and nuclear physics. Properties, classification, and interaction of particles including the quark-gluon constituents of hadrons. High energy phenomena analyzed by quantum mechanical methods. Course will survey the field including some related topics in nuclear physics.
Rules & Requirements

Prerequisites: 137A, 137B (may be taken concurrently), or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Formerly known as: 129A

PHYSICS 130 Quantum and Nonlinear Optics 3 Units
Detailed theory and experimental basis of quantum and nonlinear optics, exhibiting concepts of quantum measurement, noise, stochastic processes and dissipative quantum systems. Topics include second-quantization of electromagnetic fields, photodetection, coherence properties, light-atom interactions, cavity quantum electrodynamics, nonlinear optical systems, squeezed light, aspects of quantum information science, and contemporary research.
Rules & Requirements

Prerequisites: 110A and 137A-137B, or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 137A Quantum Mechanics 4 Units
Part I. Introduction to the methods of quantum mechanics with applications to atomic, molecular, solid state, nuclear and elementary particle physics.
Rules & Requirements

Prerequisites: PHYSICS 7A, 7B, 7C

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Summer: 8 weeks - 6 hours of lecture and 2 hours of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 137B Quantum Mechanics 4 Units
Part II. Introduction to the methods of quantum mechanics with applications to atomic, molecular, solid state, nuclear and elementary particle physics.
Rules & Requirements

Prerequisites: PHYSICS 7A, 7B, 7C and 137A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Summer: 8 weeks - 6 hours of lecture and 2 hours of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 138 Modern Atomic Physics 3 Units
This course covers atomic, molecular, and optical physics as a quantitative description of atoms and fields, a generalized toolbox for controlling quantum systems, and a vibrant research area. Topics covered include atomic structure and spectra, atom-field interactions, topics in quantum electrodynamics, methods of resonant manipulation of quantum systems, resonance optics, and experimental techniques.
Rules & Requirements

Prerequisites: 137A-137B

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 139 Special Relativity and General Relativity 3 Units
Historical and experimental foundations of Einstein's special theory of relativity; spatial and temporal measurements, particle dynamics, electrodynamics, Lorentz invariants. Introduction to general relativity. Selected applications. Designed for advanced undergraduates in physics and astronomy.
Rules & Requirements

Prerequisites: 105, 110A or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 141A Solid State Physics 4 Units
Part I. A thorough introductory course in modern solid state physics. Crystal symmetries; classification of solids and their bonding; electromagnetic, elastic, and particle waves in periodic lattices; thermal magnetic and dielectric properties of solids; energy bands of metals and semi-conductors; superconductivity; magnetism; ferroelectricity; magnetic resonances.
Rules & Requirements

Prerequisites: 137A-137B; 137B may be taken concurrently

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 141B Solid State Physics 3 Units
Part II. A thorough introductory course in modern solid state physics. Crystal symmetries; classification of solids and their bonding; electromagnetic, elastic, and particle waves in periodic lattices; thermal magnetic and dielectric properties of solids; energy bands of metals and semi-conductors; superconductivity; magnetism; ferroelectricity; magnetic resonances.
Rules & Requirements

Prerequisites: 137A-137B and 141A

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 142 Introduction to Plasma Physics 4 Units
Motion of charged particles in electric and magnetic fields, dynamics of fully ionized plasma from both microscopic and macroscopic point of view, magnetohydrodynamics, small amplitude waves; examples from astrophysics, space sciences and controlled-fusion research.
Rules & Requirements

Prerequisites: 105, 110A-110B (110B may be taken concurrently)

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS 151 Elective Physics: Special Topics 3 Units
Topics vary from semester to semester. The subject matter level and scope of the course are such that it is acceptable as the required elective course in the Physics major. See Department of Physics course announcements.
Rules & Requirements

Prerequisites: Consent of instructor

Repeat rules: Course may be repeated for credit as topic varies. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS C161 Relativistic Astrophysics and Cosmology 4 Units
Elements of general relativity. Physics of pulsars, cosmic rays, black holes. The cosmological distance scale, elementary cosmological models, properties of galaxies and quasars. The mass density and age of the universe. Evidence for dark matter and dark energy and concepts of the early universe and of galaxy formation. Reflections on astrophysics as a probe of the extrema of physics.
Rules & Requirements

Prerequisites: 110A-110B; 112 (may be taken concurrently)

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructors: Boggs, Davis, Holzapfel, A. Lee, Ma, Quataert

Formerly known as: C160B and Physics C160B

Also listed as: ASTRON C161

PHYSICS 177 Principles of Molecular Biophysics 3 Units
We will review the structure of proteins, nucleic acids, carbohydrates, lipids, and the forces and interactions maintaining their structure in solution. We will describe the thermodynamics and kinetics of protein folding. The principles of polymer chain statistics and of helix-coil transitions in biopolymers will be reviewed next, together with biopolymer dynamics. We will then cover the main structural methods in biology: X-ray crystallography, MNR and fluorescence spectroscopy, electron and probe microscopy, and single molecular methods.
Rules & Requirements

Prerequisites: 112 or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture and 1 hour of discussion per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

PHYSICS H190 Physics Honors Course 2 Units
A seminar which includes study and reports on current theoretical and experimental problems. Open only to students officially in the physics honors program or with consent of instructor.
Rules & Requirements

Prerequisites: Consent of instructor

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 2 hours of seminar per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

PHYSICS C191 Quantum Information Science and Technology 3 Units
This multidisciplinary course provides an introduction to fundamental conceptual aspects of quantum mechanics from a computational and informational theoretic perspective, as well as physical implementations and technological applications of quantum information science. Basic sections of quantum algorithms, complexity, and cryptography, will be touched upon, as well as pertinent physical realizations from nanoscale science and engineering.
Hours & Format

Fall and/or spring: 15 weeks - 3 hours of lecture per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. Final exam required.

Instructors: Crommie, Vazirani, Whaley

Also listed as: CHEM C191/COMPSCI C191

PHYSICS H195A Senior Honors Thesis Research 2 Units
Thesis work under the supervision of a faculty member. To obtain credit the student must, at the end of two semesters, submit a satisfactory thesis. A total of four units must be taken. The units may be distributed between one or two semesters in any way.
Rules & Requirements

Prerequisites: Open only to students in the honors program

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. This is part one of a year long series course. A provisional grade of IP (in progress) will be applied and later replaced with the final grade after completing part two of the series. Final exam not required.

PHYSICS H195B Senior Honors Thesis Research 2 Units
Thesis work under the supervision of a faculty member. To obtain credit the student must, at the end of two semesters, submit a satisfactory thesis. A total of four units must be taken. The units may be distributed between one or two semesters in any way.
Rules & Requirements

Prerequisites: Open only to students in the honors program

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Letter grade. This is part two of a year long series course. Upon completion, the final grade will be applied to both parts of the series. Final exam not required.

PHYSICS 198 Directed Group Study 1 - 4 Units
Enrollment restrictions apply; see the Introduction to Courses and Curricula section in this catalog.
Rules & Requirements

Repeat rules: Course may be repeated for credit. Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1-4 hours of directed group study per week

Summer:
6 weeks - 2.5-10 hours of directed group study per week
8 weeks - 1.5-7.5 hours of directed group study per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

PHYSICS 198BC Berkeley Connect 1 Unit
Berkeley Connect is a mentoring program, offered through various academic departments, that helps students build intellectual community. Over the course of a semester, enrolled students participate in regular small-group discussions facilitated by a graduate student mentor (following a faculty-directed curriculum), meet with their graduate student mentor for one-on-one academic advising, attend lectures and panel discussions featuring department faculty and alumni, and go on field trips to campus resources. Students are not required to be declared majors in order to participate.
Rules & Requirements

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of directed group study per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.

PHYSICS 199 Supervised Independent Study 1 - 3 Units
Enrollment restrictions apply; see the Introduction to Courses and Curricula section in this catalog.
Rules & Requirements

Repeat rules: Course may be repeated for credit when topic changes.

Hours & Format

Fall and/or spring: 15 weeks - 0 hours of independent study per week

Summer:
6 weeks - 2.5-7.5 hours of independent study per week
8 weeks - 1.5-5.5 hours of independent study per week
10 weeks - 1.5-4.5 hours of independent study per week

Additional Details

Subject/Course Level: Physics/Undergraduate

Grading/Final exam status: Offered for pass/not pass grade only. Final exam not required.