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 advisors in 368 or 374 Physics North 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 advisor 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 & Science. Students who have completed the requirements for the minor will be required to furnish transcripts (official or unofficial) to the undergraduate advisors (in 368 or 374 Physics North) to show their work and GPA in physics and math. After completing a confirmation of minor program petition (available in 368 or 374 Physics North), 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 two upper division courses may be used to simultaneously fulfill requirements for a student's double major and no more one course may be used to fulfill minor program requirements with the exception of minors offered outside of the College of Letters & 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 are unfamiliar with a computer programming language are encouraged to include an introductory course in computer science. Physics 77 is strongly recommended for Physics Majors.

PHYSICS 7A	Physics for Scientists and Engineers	4
or PHYSICS 5A	Introductory Mechanics and Relativity	
PHYSICS 7B	Physics for Scientists and Engineers	4
or PHYSICS 5B and PHYSICS 5BL (effective Spring 2017)		
PHYSICS 7C	Physics for Scientists and Engineers	4
or PHYSICS 5C and PHYSICS 5CL (effective Fall 2017)		
MATH 51/1A	Calculus I (MATH 51 as of Fall 2025)	4
MATH 52/1B	Calculus II (MATH 52 as of Fall 2025)	4
MATH 53	Multivariable Calculus	4
PHYSICS 89	Introduction to Mathematical Physics	4

Upper Division

PHYSICS 105	Analytic Mechanics	4
PHYSICS 110A	Electromagnetism and Optics	4
PHYSICS 111A	Instrumentation Laboratory	4
PHYSICS 111B	Advanced Experimentation Laboratory (3.0 units required; additional units beyond the 3.0 required may be completed with approval)	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 110B	Electromagnetism and Optics [4]	
PHYSICS 129	Particle Physics [4]	
PHYSICS 130	Quantum and Nonlinear Optics [3]	
PHYSICS 138	Modern Atomic Physics [3]	
PHYSICS 139	Special Relativity and General Relativity [3]	
PHYSICS 141A	Solid State Physics [4]	
PHYSICS 141B	Solid State Physics [3]	
PHYSICS 142	Introduction to Plasma Physics [4]	
PHYSICS 151	Elective Physics: Special Topics [3]	
PHYSICS C161	Relativistic Astrophysics and Cosmology [4]	
PHYSICS 177	Principles of Molecular Biophysics [3]	

PHYSICS 188	Bayesian Data Analysis and Machine Learning for Physical Sciences [4]
PHYSICS C191	Introduction to Quantum Computing [4]

Recommended Courses

Students who are interested in graduate school should consult Physics Undergraduate Advisors for more information on additional recommended courses.

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.

General Guidelines

1. All minors must be declared before the first day of classes in your Expected Graduation Term (EGT). For summer graduates, minors must be declared prior to the first day of Summer Session A.
2. All upper-division courses must be taken for a letter grade.
3. A minimum of three of the upper-division courses taken to fulfill the minor requirements must be completed at UC Berkeley.
4. A minimum grade point average (GPA) of 2.0 is required in the upper-division courses to fulfill the minor requirements.
5. Courses used to fulfill the minor requirements may be applied toward the Seven-Course Breadth requirement, for Letters & Science students.
6. No more than one upper division course may be used to simultaneously fulfill requirements for a student's major and minor programs.
7. All minor requirements must be completed prior to the last day of finals during the semester in which the student plans to graduate. If students cannot finish all courses required for the minor by that time, they should see a College of Letters & Science adviser.
8. 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	Course Not Available (or equivalent)	4
MATH 1B	Course Not Available (or equivalent)	4
MATH 53	Multivariable Calculus (or equivalent)	4
PHYSICS 89	Introduction to Mathematical Physics	4
Upper Division		
PHYSICS 137A	Quantum Mechanics	4
PHYSICS 110A	Electromagnetism and Optics	4
or PHYSICS 105	Analytic Mechanics	
Select three additional upper division physics courses (9 units minimum) [1]		

[1] The following upper division courses will not fulfill minor requirements: PHYSICS 100, PHYSICS H190, PHYSICS H195A, PHYSICS H195B, PHYSICS 198, and PHYSICS 199.

Undergraduate students must fulfill the following requirements in addition to those required by their major program.

For a detailed lists of L&S requirements, please see Overview tab to the right in this guide or visit the L&S Degree Requirements (https://lsadvising.berkeley.edu/degree-requirements/) webpage. For College advising appointments, please visit the L&S Advising (https://lsadvising.berkeley.edu/home/) Pages.

University of California Requirements

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 and must be taken for a letter grade.

American History and American Institutions

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

Berkeley Campus Requirement

American Cultures

All undergraduate students at Cal need to take and pass this campus requirement course 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 are plentiful and offer students opportunities to be part of research-led, highly accomplished teaching environments, grappling with the complexity of American Culture.

College of Letters & Science Essential Skills Requirements

Quantitative Reasoning

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

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 taken for a letter grade.

Reading and Composition

In order to provide a solid foundation in reading, writing, and critical thinking the College of Letters and Science requires two semesters of

lower division work in composition in sequence. Students must complete parts A & B reading and composition courses in sequential order by the end of their fourth semester for a letter grade.

College of Letters & Science 7 Course Breadth Requirements

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
- 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 & Science. Most students automatically fulfill the residence requirement by attending classes at Cal for four years, or two years for transfer students. In general, there is no need to be concerned about this requirement, unless you graduate early, go abroad for a semester or year, or want to take courses at another institution or through UC Extension during your senior year. In these cases, you should make an appointment to meet an L&S College 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), Berkeley Summer Abroad, 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 UCEAP 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.

Major maps are experience maps that help undergraduates plan their Berkeley journey based on intended major or field of interest. Featuring student opportunities and resources from your college and department as well as across campus, each map includes curated suggestions for planning your studies, engaging outside the classroom, and pursuing your career goals in a timeline format.

Use the major map below to explore potential paths and design your own unique undergraduate experience:

View the Physics Major Map. (https://discovery.berkeley.edu/getting-started/major-maps/physics/)

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.

Undergraduate Advisor

Kathleen Cooney
kathleen.cooney@berkeley.edu (kathyl@berkeley.edu)
374 Physics North
510-664-7557

Nitin Srivastava
nitin.srivastava@berkeley.edu
368 Physics North
510-642-0481

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 graduate 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 unit 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 5A Introductory Mechanics and Relativity 3 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Kinematics, dynamics, work and energy, rotational motion, oscillations, fluids and relativity. Use of calculus and vector algebra will be emphasized. Intended for students with an interest in pursuing a major in physics, astrophysics, engineering physics, or related disciplines. Successor to the Physics H7 series. Start of three semester 5A-5B-5C sequence.

Rules & Requirements

Prerequisites: Prerequisites: Math 51; Math 52 (which may be taken concurrently)

Repeat rules: Course may be repeated for credit under special circumstances: Only repeatable to replace deficient grade.

Hours & Format

Fall and/or spring: 15 weeks - 3 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 5B Introductory Electromagnetism, Waves, and Optics 3 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Electric fields and potential, circuits, magnetism and induction. Introduction to optics including light propagation, reflection, refraction and interference. Intended for students with an interest in pursuing a major in physics, astrophysics, engineering physics, or related disciplines. Successor to the Physics H7 series. Continuation of 5A-5B-5C sequence.

Rules & Requirements

Prerequisites: Prerequisites: Physics 5A or 7A; Math 53 (which may be taken concurrently)

Repeat rules: Course may be repeated for credit under special circumstances: Only repeatable to replace deficient grade.

Hours & Format

Fall and/or spring: 15 weeks - 3 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 5BL Introduction to Experimental Physics I 2 Units

Terms offered: Fall 2025, Summer 2025 First 6 Week Session, Spring 2025
Part one of a two-semester laboratory sequence to introduce students to experimental physics and prepare them for research. Covers a variety of modern and historical experiments, emphasizing data analysis, clear scientific communication, and development of skills on modern equipment. Successor to the Physics H7 series.

Rules & Requirements

Prerequisites: Prerequisites: Physics 5A or 7A; 5B or 7B (which may be taken concurrently)

Repeat rules: Course may be repeated for credit under special circumstances: Only repeatable to replace deficient grade.

Hours & Format

Fall and/or spring: 15 weeks - 5 hours of laboratory per week

Summer: 6 weeks - 12.5 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

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

PHYSICS 5C Introductory Thermodynamics and Quantum Mechanics 3 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Temperature, kinetic theory, entropy; particle/wave nature of matter, Schrodinger equation, hydrogen atom, applications of quantum physics. Intended for students with an interest in pursuing a major in physics, astrophysics, engineering physics or related disciplines. Continuation of 5A-5B-5C sequence. Successor to the Physics H7 series.

Rules & Requirements

Prerequisites: Prerequisites: Physics 5B or 7B; Physics 89 or Math 54 (which may be taken concurrently)

Repeat rules: Course may be repeated for credit under special circumstances: Only repeatable to replace deficient grade.

Hours & Format

Fall and/or spring: 15 weeks - 3 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 5CL Introduction to Experimental Physics II 2 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Part two of a two-semester laboratory sequence to introduce students to experimental physics and prepare them for research. Covers a variety of modern and historical experiments, emphasizing iterative experimental design, clear scientific communication, and development of skills on modern equipment. Successor to the Physics H7 series.
Rules & Requirements

Prerequisites: Physics 5B & 5BL or 7B; Physics 5C or 7C (which may be taken concurrently)

Repeat rules: Course may be repeated for credit under special circumstances: Only repeatable to replace deficient grade.

Hours & Format

Fall and/or spring: 15 weeks - 5 hours of laboratory per week

Summer: 6 weeks - 12.5 hours of laboratory per week

Additional Details

Subject/Course Level: Physics/Undergraduate

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

PHYSICS 7A Physics for Scientists and Engineers 4 Units

Terms offered: Fall 2025, Summer 2025 8 Week Session, Spring 2025
Mechanics and wave motion.
Rules & Requirements

Prerequisites: High school physics; Math 51; Math 52 (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

Terms offered: Fall 2025, Summer 2025 8 Week Session, Spring 2025
Heat, electricity, and magnetism.
Rules & Requirements

Prerequisites: 7A, Math 51-52, 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

Terms offered: Fall 2025, Spring 2025, Fall 2024
Electromagnetic waves, optics, relativity, and quantum physics.
Rules & Requirements

Prerequisites: 7A-7B, Math 51-52, Math 53, Physics 89 (Physics 89 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

Terms offered: Fall 2015, Fall 2014, Fall 2013
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

Terms offered: Fall 2016, Spring 2016, Fall 2015
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

Terms offered: Fall 2016, Spring 2016, Fall 2015
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

Terms offered: Fall 2025, Summer 2025 10 Week Session, Spring 2025
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 51, 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
10 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

Terms offered: Fall 2025, Summer 2025 8 Week Session, Spring 2025
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 10 Descriptive Introduction to Physics 3 Units

Terms offered: Fall 2025, Spring 2025, Spring 2024
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.

PHYSICS C10 Descriptive Introduction to Physics 3 Units

Terms offered: Spring 2024, Fall 2023, Spring 2023, Fall 2022, Spring 2022
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

Terms offered: Spring 2003, Spring 2002, Spring 2000
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

Terms offered: Spring 2025, Spring 2024, Spring 2023, Spring 2022
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

Terms offered: Fall 2025, Fall 2024, Fall 2023
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 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

Terms offered: Spring 2010, Spring 2009, Fall 2008
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 without restriction.

Hours & Format

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

Summer: 6 weeks - 3.5-10 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

Terms offered: Spring 2021, Fall 2018, Spring 2018
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 without restriction.

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 3 Units

Terms offered: Fall 2025, Summer 2025 10 Week Session, Spring 2025
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 51, Math 52 (can be taken concurrently); 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 88 Data Science Applications in Physics 2 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
Introduction to data science with applications to physics. Topics include: statistics and probability in physics, modeling of the physical systems and data, numerical integration and differentiation, function approximation. Connector course for Data Science 8, room-shared with Physics 77. Recommended for freshmen intended to major in physics or engineering with emphasis on data science.

Objectives & Outcomes

Student Learning Outcomes: Learning goals for Physics 88
The following learning goals will guide the presentation of material as well as development of HWs, rubrics for assessment, and practice problems for use in discussion section: 1) Use of representations, 2) Communication, 3) Tools, 4) Problem-Solving, 5) Making connections, 6) Intellectual maturity and metacognition, 7) Resourcefulness.

Rules & Requirements

Prerequisites: Math 51, 52 (52 can be taken concurrently), Physics 5A or 7A (may be taken concurrently), Data Science 8 (may be taken concurrently), or permission of instructor

Hours & Format

Fall and/or spring: 9 weeks - 2 hours of lecture and 2 hours of workshop per week

Summer: 6 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

Terms offered: Fall 2025, Summer 2025 10 Week Session, Spring 2025
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; Physics 5A or 7A (can be taken concurrently) or instructor's consent

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
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 W89 Introduction to Mathematical Physics 4 Units

Terms offered: Summer 2023 10 Week Session, Summer 2022 10 Week Session, Summer 2021 10 Week Session
Math is the natural language of physics. Of central importance to nearly all areas of physics are the fields of linear algebra and differential equations. A solid understanding of the structure and techniques of these fields will allow you to dig deeper into all of your physics courses and give you a greater appreciation of the beauty of physical theory. In this course we will develop and explore a collection of tools including complex numbers, linear algebra, differential equations, Fourier series and transform methods, and tensors. Along the way this course will explore many example systems you were exposed to in your introductory physics classes including waves, circuits, rotations, and oscillations.

Rules & Requirements

Prerequisites: Math 53; Physics 5A or 7A (can be taken concurrently) or Instructor's Consent

Credit Restrictions: Students will receive no credit for PHYSICS W89 after completing PHYSICS 89. A deficient grade in PHYSICS W89 may be removed by taking PHYSICS 89, or PHYSICS 89.

Hours & Format

Summer: 10 weeks - 6 hours of web-based lecture and 2 hours of web-based discussion per week

Online: This is an online course.

Additional Details

Subject/Course Level: Physics/Undergraduate

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

PHYSICS 98 Directed Group Study 1 - 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024

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 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

Terms offered: Fall 2025, Spring 2025, Fall 2024

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 without restriction.

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

Terms offered: Spring 2017, Spring 2016, Fall 2015

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 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

Terms offered: Spring 2010, Spring 2009, Spring 2008

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

Terms offered: Fall 2025, Summer 2025 8 Week Session, Spring 2025
Newtonian mechanics, motion of a particle in one, two, and three dimensions, Lagrange's equations, Hamilton's equations, central force motion, moving coordinate systems, mechanics of continuous media, oscillations, normal modes, rigid body dynamics, tensor analysis techniques. Some knowledge of Python required for homework assignments. Students who have not taken Physics 77 or Data Science 8 are encouraged to complete the Python tutorials provided by the Physics Department.

Rules & Requirements

Prerequisites: Physics 5A, 5B, 5C or 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 110A Electromagnetism and Optics 4 Units

Terms offered: Fall 2025, Spring 2025, Fall 2024
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 5A, 5B, 5C or 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 110B Electromagnetism and Optics 4 Units

Terms offered: Spring 2025, Spring 2024, Fall 2023
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 5A, 5B, 5C or 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 4 Units

Terms offered: Fall 2025, Summer 2025 10 Week Session, Spring 2025
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 1.5 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

Terms offered: Fall 2025, Spring 2025, Fall 2024
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 credit with instructor consent.

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

Terms offered: Fall 2025, Spring 2025, Fall 2024
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. Some knowledge of Python required for homework assignments. Students who have not taken Physics 77 or Data Science 8 are encouraged to complete the Python tutorials provided by the Physics Department.
Rules & Requirements

Prerequisites: Physics 5A, 5B, 5C or 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 129 Particle Physics 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
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. Some knowledge of Python required. Students who have not taken Physics 77 or Data Science 8 are encouraged to complete the Python tutorials provided by the Physics Department.
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. Alternative to final exam.

Formerly known as: 129A

PHYSICS 130 Quantum and Nonlinear Optics 3 Units

Terms offered: Spring 2024, Spring 2022, Spring 2020
The detailed theory and experimental basis of quantum and nonlinear optics is presented and used to exhibit basic concepts of quantum measurements and noise, stochastic processes and dissipative quantum systems. Topics covered may include the second-quantization treatment of electromagnetic fields, photodetection, coherence properties of quantum-optical fields, light-atom interactions, cavity quantum electrodynamics, several non-linear optical systems, squeezed light and its applications, aspects of quantum information science, and selected topics at the forefront of modern optics 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

Terms offered: Fall 2025, Summer 2025 8 Week Session, Spring 2025
Postulates and principles of quantum mechanics. Basic concepts including Hilbert space and superposition, Dirac notation and wavefunctions, operators and observables, measurements, time evolution and Schroedinger's equation, Hamiltonians and energy, uncertainty principle, symmetries and conserved quantities. Analysis of two-state systems (qubits), spin-½ particles, Stern-Gerlach experiment. Other basic systems including a free particle, finite and infinite potential wells, the harmonic oscillator, 3D quantum mechanics, angular momentum, and the hydrogen atom. Bipartite systems, density matrix and introduction to quantum entanglement, and interpretation of quantum mechanics.

Rules & Requirements

Prerequisites: Physics 5A, 5B, 5C or 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

Terms offered: Fall 2025, Spring 2025, Fall 2024
Complex and dynamical quantum systems with applications to atomic, molecular, and particle physics. Multiparticle systems, bosons and fermions, Pauli exclusion principle. Approximation techniques including time-independent, degenerate and time-dependent perturbation theory, Fermi golden rule, WKB approximation, Born-Oppenheimer approximation, and the variational principle. The Helium atom, Spin-Orbit interaction, fine and hyperfine structure, higher Z atoms, molecules and the Linear Combination of Atomic Orbitals approximation. Atoms in electric and magnetic fields (Stark and Zeeman effects), and radiation (absorption, spontaneous and stimulated emissions). Exchange forces and van der Waals interaction. Introduction to scattering theory.

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

Terms offered: Spring 2025, Spring 2023, Spring 2021
Atomic, molecular, and optical physics is at once a precise and quantitative description of atoms, molecules and light; a generalized toolbox for manipulating and probing quantum systems; and an active field of contemporary research. This course exposes students to all these aspects. Lectures will cover topics such as atomic structure and spectra, the interaction of atoms with static and time-varying electromagnetic fields, some topics in quantum electrodynamics, methods of resonant manipulation of quantum systems, and resonance optics. Through lectures, discussion sessions, and homework assignments, students encounter contemporary research foci.

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

Terms offered: Spring 2025, Spring 2024, Spring 2023
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

Terms offered: Fall 2025, Spring 2025, Fall 2024
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

Terms offered: Spring 2025, Spring 2024, Spring 2023
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

Terms offered: Spring 2024, Spring 2022, Spring 2021
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

Terms offered: Spring 2025, Fall 2023, Spring 2023
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 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 153 Foundational Course for Physical Science Transfer Students 1 Unit

Terms offered: Fall 2025, Fall 2024, Fall 2023
This course is designed to assist physics and other physical sciences transfer students in their transition to UC Berkeley. Over the course of a semester, students will learn about campus resources, how to navigate the campus, establish connections with other students in their cohorts, receive physics transfer peer mentorship and advising. Students will work in small-groups to solve challenging mathematical and physics concepts to assist with academic success.
Rules & Requirements

Prerequisites: Open only to physics and other physical sciences transfer students

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 1 hour of lecture 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 C161 Relativistic Astrophysics and Cosmology 4 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
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: Astro 7B recommended; Physics 7A-7B-7C (7C may be taken concurrently) or Physics 5A-5B-5C (5C 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: Lee, Ma, Kasen

Also listed as: ASTRON C161

PHYSICS 177 Principles of Molecular Biophysics 3 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
We will describe how concepts of free energy and entropy help us understand cooperative folding, conformational switching, and phase separation of proteins and explain the dynamics of biological molecules in a viscous and crowded cellular environment. We will then develop analytical approaches to a wide range of collective biophysical phenomena, including bacterial chemotaxis, swimming of sperm, stepping of molecular motors, neuronal firing, vision, photosynthesis, biological networks, pattern formation, and evolution. The course will also introduce advanced biophysical methods, such as single-molecule imaging and manipulation, and electrophysiology.
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 C180 Order-Of-Magnitude Physics 4 Units

Terms offered: Fall 2025, Fall 2024
Learn how to understand the world around you to within a factor of 10, how to solve real-life problems from physical first principles, how to make ill-posed questions well-posed, and how to sketch solutions quickly and avoid long and formal derivations. These skills build physical intuition and are crucial for all lines of work, especially research. You will learn how to guess intelligently, how to follow your hunches while guided by the laws of physics, and how to maximize understanding from just a modicum of information --- how to reason inductively and quantitatively. All of undergraduate physics --- mechanics, E&M, quantum mechanics, statistical mechanics --- will be covered in useful, memorable, and entertaining ways.
Rules & Requirements

Prerequisites: Physics 7A, 7B, 7C (or 5 equivalent) + preferably at least 1 upper-division course in the physical sciences. Suitable also for graduate students

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, with common exam group.

Formerly known as: Physics C101/Astronomy C101

Also listed as: ASTRON C180

PHYSICS 188 Bayesian Data Analysis and Machine Learning for Physical Sciences 4 Units

Terms offered: Fall 2025, Fall 2024, Fall 2023
The course design covers data analysis and machine learning, highlighting their importance to the physical sciences. It covers data analysis with linear and nonlinear regression, logistic regression, and gaussian processes. It covers concepts in machine learning such as unsupervised and supervised regression and classification learning. It develops Bayesian statistics and information theory, covering concepts such as information, entropy, posteriors, MCMC, latent variables, graphical models and hierarchical Bayesian modeling. It covers numerical analysis topics such as integration and ODE, linear algebra, multi-dimensional optimization, and Fourier transforms.
Rules & Requirements

Prerequisites: Physics 77 or Data Science 8 or Computer Science 61A or an introductory Python course, or equivalent, or permission from instructor; Physics 89 or Mathematics 54 or Electrical Engineering 16A/B

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. Alternative to final exam.

PHYSICS H190 Physics Honors Course 2 Units

Terms offered: Spring 2025, Spring 2024, Spring 2023
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 without restriction.

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 Introduction to Quantum Computing 4 Units

Terms offered: Spring 2025, Spring 2024, Fall 2023
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.
Rules & Requirements

Prerequisites: Linear Algebra (EECS 16A or PHYSICS 89 or MATH 54) AND either discrete mathematics (COMPSCI 70 or MATH 55), or quantum mechanics (PHYSICS 7C or PHYSICS 137A or CHEM 120A)

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. Alternative to final exam.

Also listed as: CHEM C191/COMPSCI C191

PHYSICS C191A Introduction to Quantum Computing I 4 Units

Terms offered: Fall 2025
This is the first semester of a multidisciplinary two-semester sequence in Quantum Computing. This semester provides an introduction to fundamental conceptual aspects of quantum mechanics in the language of qubits and quantum gates, and a first introduction to quantum computation. Topics in part one include basic concepts and results in quantum information, quantum algorithms, and an introduction to quantum error correction.
Rules & Requirements

Prerequisites: Linear Algebra: Either EECS 16A, Physics 89, Math 54, or equivalent. Some background in either quantum mechanics (Physics 137A, Chemistry 120A, or equivalent) or discrete mathematics (CS 70, Math 55, or equivalent) is expected

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. Alternative to final exam.

Also listed as: CHEM C191A/EECS C191A

PHYSICS C191B Introduction to Quantum Computing II 4 Units

Terms offered: Not yet offered
This is the second semester of a multidisciplinary two-semester sequence in Quantum Computing. This second semester covers fundamentals of control of qubits, methods of quantum error mitigation, quantum benchmarking, quantum supremacy and tests of quantumness, advanced quantum error correction including fault-tolerant quantum computing and error thresholds, theory/practice of near-term fault fault tolerance, discussions of different physical platforms for quantum computing, and alternative paradigms for quantum computing.
Rules & Requirements

Prerequisites: C191A or equivalent (with permission 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. Alternative to final exam.

Also listed as: CHEM C191B/EECS C191B

PHYSICS H195A Senior Honors Thesis Research 2 Units

Terms offered: Fall 2022, Fall 2019, Spring 2016
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

Terms offered: Spring 2025, Spring 2016, Fall 2015
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

Terms offered: Fall 2025, Summer 2025 Second 6 Week Session, Fall 2024
Enrollment restrictions apply; see the Introduction to Courses and Curricula section in this catalog.
Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

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

Terms offered: Fall 2025, Spring 2025, Fall 2024
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 without restriction.

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 198F Frontiers of Physics 2 Units

Terms offered: Prior to 2007
Discussion-based introduction to contemporary research in physics for advanced undergraduates. Presentation of different weekly topics in physics research led by graduate students, postdocs, or professors in a particular field to connect upper division physics majors with contemporary research and to increase dialogue between upper division undergraduates and researchers in the department.

Objectives & Outcomes

Course Objectives: -- To connect upper division physics majors with contemporary research in a way that traditional coursework does not.
-- To connect upper division physics majors with contemporary research in a way that traditional coursework does not.
-- To increase dialogue between upper division undergraduates and researchers in the department.
-- To help undergraduates make more informed career choices.

Student Learning Outcomes: -- Students left the course with a more broadened and more concrete understanding of what “pursuing research in physics” consists of. They also found themselves interested in areas of physics they didn’t expect or hadn’t known existed.
-- Students gained connections in the department. This has resulted in research projects for several students
-- Students received mentoring from the graduate student on many career path issues.
-- Small class size and discussion format strengthened the physics community both laterally and vertically.

Rules & Requirements

Prerequisites: Physics 7A, 7B, 7C or consent of instructor

Hours & Format

Fall and/or spring: 15 weeks - 2 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. Alternative to final exam.

PHYSICS 199 Supervised Independent Study 1 - 3 Units

Terms offered: Summer 2025 10 Week Session, Spring 2025, Summer 2024 10 Week Session
Enrollment restrictions apply; see the Introduction to Courses and Curricula section in this catalog.

Rules & Requirements

Repeat rules: Course may be repeated for credit without restriction.

Hours & Format

Fall and/or spring: 15 weeks - 2-6 hours of independent study per week

Summer:
3 weeks - 10-25 hours of independent study per week
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.