100. Field Experience in Teaching Physical Education (2)
Discussion—1 hour; fieldwork—4 hours. Prerequisite: upper division standing and appropriate course of 1 or 7. Tutoring or teacher’s aide in physical education activities, including athletic coaching, in public schools under the guidance of a regular teacher with supervision by a departmental faculty person. May be repeated one time for credit. (P/NP grading only)—F (F).

120. Sport in American Society (3)
Lecture—3 hours. Sociological approaches to the study of sport and contemporary American culture, including sport interaction with politics, economics, religion, gender, race, media and ethics. Socialization factors involving youth, scholastic, collegiate, and Olympic sport. (Same as Exercise Science 120.) GE credit: SocSci, Div. SS—F, W, S, Su. (F, W, S, Su.) Adams, Bronzan, Doten, Simpson

131. Physical Activity and the Disabled (4)
Lecture—3 hours; laboratory—3 hours. The study of the diverse and complex nature of individuals with disabilities and how they adapt to their disabilities in daily living. Integration of individuals with disabilities into the community, schools, and physical activity and recreational programs. Not open to credit to students who have completed Exercise Biology 131. —Su. (Su.)

135. Advanced Procedures in Evaluation and Management of Athletic Injuries (3)
Lecture—2 hours; laboratory—3 hours. Prerequisite: Cell Biology and Human Anatomy 101 (may be taken concurrently). Prevention, care, and rehabilitation of injuries incurred by athletes. Laboratory on anatomy, emergency care, physical therapy methods, and taping techniques. Not open for credit to students who have completed Exercise Biology 135. —Su. (Su.)

141. Coaching Principles and Methods (3)
Lecture/discussion—3 hours. Prerequisite: upper division standing; course 143. Technical, tactical, and strategic aspects of coaching. Methods for organizing and delivering effective information in coaching. Biomechanics, skills and motor learning principles applied to coaching. Classroom development of coaching skills and outside observations of coaching required. —S. (S.) Bronzan

142. Physical Education in the Public Schools (3)
Lecture—3 hours. Analysis and study of the principles and methods basic to teaching physical education at the elementary and secondary levels.

143. Coaching Effectiveness (3)
Lecture—2 hours. Prerequisite: upper division standing; 3 units of courses 1 and 6 combined. Synthesis and application of basic components of sport psychology, sport pedagogy, and sport physiology and basic management and administration of athletics in public high schools. (P/NP grading only)—F (F).

144. Principles of Health Education (2)
Lecture—2 hours. Prerequisite: course 44 and upper division standing and consent of instructor. Principles of teaching health education in the public schools. (P/NP grading only)—S. (S.)

150. Recreation in the Community (3)
Lecture—2 hours; discussion—1 hour; two Saturday field trips—8 hours. The nature and scope of community recreation programs in California emphasizing low income, highly populated areas, and poor rural communities.

197T. Tutoring in Physical Education (1-5)
Tutorial—1-5 hours. Prerequisite: consent of chairperson. Tutoring of students in lower division physical activity courses. Written reports on methods and materials required. May be repeated one time for credit. (P/NP grading only)—F, W, S, F, W. (F, S.)

199. Special Study for Advanced Undergraduates (1-5)
Prerequisite: consent of instructor. (P/NP grading only)—F, W, S, F, S, Su. (F, W, S, Su.)

300. The Elementary Physical Education Program (2)
Lecture—1 hour; laboratory—2 hours. Prerequisite: consent of instructor. Restricted to senior standing or credential student. Introduction to principles, theories, materials, and practices of elementary school physical education program. —S. (S.) Bronzan, Jokotai

380. Methods of Teaching Physical Education (3)
Lecture—1 hour; laboratory—6 hours. Prerequisite: course 142 and six units of course 7; or consent of instructor. The methods of teaching group and individual activities for grades K-12; program planning, class management, organization, and evaluation. (P/NP grading only)—W. (W.)

Physical Medicine and Rehabilitation

See Medicine, School of, on page 427.

Physics

[College of Letters and Science]
Andreas Albrecht, Ph.D., Chairperson of the Department
Lori Lubin, Ph.D., Vice Chairperson of the Department (Administration and Undergraduate Matters
Rena Zieve, Ph.D., Vice Chairperson of the Department (Graduate Matters)

Department Office, 174 Physics Building 530-752-1500; http://www.physics.ucdavis.edu

Faculty
Andreas Albrecht, Ph.D., Distinguished Professor
Robert H. Becker, Ph.D., Distinguished Professor
Patricia C. Boenhaart, Ph.D., Associate Professor
Marusa Bradac, Ph.D., Associate Professor
Manuel Calderon de la Barca Sanchez, Ph.D., Professor
Steven Carlip, Ph.D., Professor
Daniel A. Cebra, Ph.D., Professor
Hsin-Chia Cheng, Ph.D., Professor
Maxwell B. Chertok, Ph.D., Professor
Shirley Chiang, Ph.D., Professor
Akademie Senate Distinguished Teaching Award
John Conway, Ph.D., Professor
Daniel L. Cox, Ph.D., Distinguished Professor
James Crutchfield, Ph.D., Professor
Nicholas Curro, Ph.D., Professor
Sergey Dubovsky, Ph.D., Associate Professor
Robin Erbacher, Ph.D., Professor
Charles S. Fadley, Ph.D., Distinguished Professor
Christopher D. Fassnacht, Ph.D., Professor
Daniel Ferenc, Ph.D., Professor
Ching-Yao Fong, Ph.D., Distinguished Professor
John T. Gunion, Ph.D., Distinguished Professor
Veronika Hubeny, Ph.D., Professor
Nemanja Kaloper, Ph.D., Professor
Lloyd E. Knox, Ph.D., Professor
Kai Liu, Ph.D., Professor
Lori Lubin, Ph.D., Professor
Markus Luty, Ph.D., Professor
Michael Mulhearn, Ph.D., Assistant Professor
Emilia Pantale, Ph.D., Assistant Professor
Warren E. Pickert, Ph.D., Distinguished Professor
Mukund Rangamani, Ph.D., Professor
John B. Rundle, Ph.D., Distinguished Professor
Sergey Savrasov, Ph.D., Professor
Richard T. Scalalett, Ph.D., Professor
Rajiv R.P. Singh, Ph.D., Professor
Robert Sloboda, Ph.D., Professor
John Terning, Ph.D., Professor
S. Mani Tripathi, Ph.D., Professor
Jaroslav Trnka, Ph.D., Assistant Professor
J. Anthony Tyson, Ph.D., Distinguished Professor
David J. Webb, Ph.D., Senior Lecturer
David Wittman, Ph.D., Associate Professor
Dong Yu, Ph.D., Associate Professor
Xiangdong Zhu, Ph.D., Professor
Rena J. Zieve, Ph.D., Professor
Gergely Zimanyi, Ph.D., Professor
Academic Senate Distinguished Teaching Award
Emeriti Faculty
Franklin P. Brady, Ph.D., Professor Emeritus
Thomas A. Cahill, Ph.D., Professor Emeritus
Ling-Lieh Chau, Ph.D., Professor Emeritus
Lawrence B. Coleman, Ph.D., Professor Emeritus
Academic Senate Distinguished Teaching Award
Linton R. Cuccinelli, Ph.D., Professor Emeritus
James E. Draper, Ph.D., Professor Emeritus
Greg W. Ericson, Ph.D., Professor Emeritus
Claude Garrod, Ph.D., Professor Emeritus
James P. Hurley, Ph.D., Professor Emeritus
Joseph E. Kissik, Ph.D., Professor Emeritus
Winston T. Kao, Ph.D., Professor Emeritus
Barry M. Klein, Ph.D., Professor Emeritus
Richard L. Lander, Ph.D., Distinguished Professor Emeritus
Douglas W. McColm, Ph.D., Senior Lecturer Emeritus, Academic Senate Distinguished Teaching Award
David E. Pellett, Ph.D., Professor Emeritus
David Pines, Ph.D., Distinguished Research Professor
Wendell H. Potter, Ph.D., Senior Lecturer Emeritus
Academic Senate Distinguished Teaching Award
Philip M. Yager, Ph.D., Professor Emeritus
Affiliated Faculty
Albert De Roeck, Ph.D., Adjunct Professor
Harry B. Rodauskis, Ph.D., Adjunct Professor
Ramona Vogt, Ph.D., Adjunct Professor
Tom Weideman, Ph.D., Lecturer
Dina Zhabinskaya, Ph.D., Lecturer

Fall 2011 and on Revised General Education (GE) ARTS=Arts and Humanities; SCI=Science and Engineering; SS=Social Sciences, AGCM=American Cultures, DD=Domestic Diversity, OL= Oral Skills, O/Q= Quantitative, SL= Scientific, VL=Visual, WC=World Cultures, WE=Writing Experience
Pre-Fall 2011 General Education (GE): ArtHum=Arts and Humanities, SciEng=Science and Engineering, SocSci=Social Sciences, Div=Domestic Diversity, Writ=Writing Experience
Quarter Offered: F=fall, W=Winter, S=Spring, Su=Summer; 2017/2018 offering in parentheses
The Major Program
From the smallest subatomic particles to atoms, molecules, stars, and galaxies, the study of physics is the study of what makes the universe work. Knowledge gained using atomic-scale microscopes and high-energy particle accelerators and nuclear reactors teaches us not only what holds the atomic nucleus together but also how proteins function and why stars shine.

The Program. The Department of Physics offers a Bachelor of Arts in Physics and two Bachelor of Science degree programs: in Physics (which also offers an emphasis in Astrophysics) and in Applied Physics. The Bachelor of Arts provides a broad coverage of classical and modern physics while permitting a broader liberal arts education than is possible with the other two programs. The B.S. degree in either Physics or Applied Physics should be followed by the student who plans to enter physics as a profession, and also provides excellent training for a wide variety of technical career options. The B.S. in Applied Physics provides the student with a solid introduction to a particular applied physics specialty. For the student who plans to enter the job market upon completing a B.S. degree, the applied physics orientation would be an asset. Either B.S. program provides a solid foundation in physics for the student interested in graduate work in either pure or applied physics.

Career Alternatives. Careers in physics and applied physics provide research and development, either in universities, government laboratories, or industry; teaching in high schools, junior colleges, and universities; management and administration in industrial laboratories in government agencies; and in production and sales in industry. A major in physics also provides a strong base for graduate-level work in such interdisciplinary areas as chemical physics, biophysics and medical physics, geo-physics and environmental physics, astrophysics and astronomy, computer science, and materials science.

Physics
A.B. Major Requirements:

Preparatory Subject Matter

<table>
<thead>
<tr>
<th>Units</th>
<th>Description</th>
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<tbody>
<tr>
<td>41-47</td>
<td>Preparation</td>
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</tbody>
</table>

Preparatory Subject Matter

- Physics 9A, 9B, 9C, 9D or 9HA, 9HB, 9HC, 9HD, 9HE
- 22 Depth Subject Matter

Depth Subject Matter

- Physics 104A, 105A, 110A, 110B, 112, 115A, 122A or 122B
- 28 At least one course from: 129A, 130A, 140A, 151, 152, 153
- 4 Physics 102 (1 unit) if waived if 104B
- 0.1 At least one additional fixed-unit upper division Physics course excluding 160...34

Total Units for the Major

76-84

B.S. Major Requirements:

Preparatory Subject Matter

<table>
<thead>
<tr>
<th>Units</th>
<th>Description</th>
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<tr>
<td>50-56</td>
<td>Preparation</td>
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</tbody>
</table>

Preparatory Subject Matter

- Physics 9A, 9B, 9C, 9D or 9HA, 9HB, 9HC, 9HD, 9HE
- 22 Computer Science Engineering 30 (or equivalent programming course)
- 4 Chemistry 2A or 2HA (2B-2C or 2HB-2HC highly recommended)

Depth Subject Matter

- 32 Physics 102 or 104B
- 1 Laboratory Requirement

Total Units for the Major

109-118

Applied Physics—Chemical Physics Concentration

B.S. Major Requirements:

Preparatory Subject Matter

<table>
<thead>
<tr>
<th>Units</th>
<th>Description</th>
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<tr>
<td>50-56</td>
<td>Preparation</td>
</tr>
</tbody>
</table>

Preparatory Subject Matter

- Physics 9A, 9B, 9C, 9D or 9HA, 9HB, 9HC, 9HD, 9HE
- 22 Computer Science Engineering 30 (or equivalent programming course)
- 4 Chemistry 2A or 2HA
- 5 Chemistry 2A or 2HA (2B-2C or 2HB-2HC)

Depth Subject Matter

- 32 Physics 102 (1 unit) or 104B
- 1 Laboratory Requirement

Total Units for the Major

109-121

Recommended

- Computer Science Engineering 40, Astronomy 25

Applied Physics—Atmospheric Physics Concentration

B.S. Major Requirements:

Preparatory Subject Matter

<table>
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<th>Units</th>
<th>Description</th>
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<tr>
<td>50-56</td>
<td>Preparation</td>
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</tbody>
</table>

Preparatory Subject Matter

- Physics 9A, 9B, 9C, 9D or 9HA, 9HB, 9HC, 9HD, 9HE
- 22 Computer Science Engineering 30 (or equivalent programming course)
- 4 Chemistry 2A or 2HA
- 5 Chemistry 2A or 2HA (2B-2C or 2HB-2HC)

Depth Subject Matter

- 32 Physics 102 (1 unit) or 104B
- 1 Laboratory Requirement

Total Units for the Major

110-120

Program Variance. Similar courses from other departments may be substituted for courses in the depth subject matter requirements by obtaining prior written permission from the Undergraduate Curriculum Committee Chairperson.

Applied Physics—Physical Electronics Concentration

B.S. Major Requirements:

Preparatory Subject Matter

<table>
<thead>
<tr>
<th>Units</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>49-55</td>
<td>Preparation</td>
</tr>
</tbody>
</table>

Preparatory Subject Matter

- Physics 9A, 9B, 9C, 9D or 9HA, 9HB, 9HC, 9HD, 9HE
- 22 Computer Science Engineering 100
- 8 Depth Subject Matter

Depth Subject Matter

- 32 Concentration Courses
- 16 Physics 104B, 116C, Computer Science Engineering 60, 122A
- 4 Additional Electives (choose three from the following)
- 19-25 Physics 105C or 112A or 118B or 128C

Total Units for the Major

122-127

Program Variance. Similar courses from other departments may be substituted for courses in the depth subject matter requirements by obtaining prior written permission from the Undergraduate Curriculum Committee Chairperson.

Applied Physics—Chemical Physics Concentration

B.S. Major Requirements:

Preparatory Subject Matter

<table>
<thead>
<tr>
<th>Units</th>
<th>Description</th>
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<tbody>
<tr>
<td>60-66</td>
<td>Preparation</td>
</tr>
</tbody>
</table>

Preparatory Subject Matter

- Physics 9A, 9B, 9C, 9D or 9HA, 9HB, 9HC, 9HD, 9HE
- 22 Computer Science Engineering 30 (or equivalent programming course)
- 4 Chemistry 2A, 2B, 2C

Depth Subject Matter

- Physics 102 or 122A or 116C
- 1 Laboratory Requirement

Total Units for the Major

109-118

Program Variance. Similar courses from other departments may be substituted for courses in the depth subject matter requirements by obtaining prior written permission from the Undergraduate Curriculum Committee Chairperson.
Total Units for the Major............... 110-116

Program Variance. Similar courses from other departments may be substituted for courses in the depth subject matter requirements by obtaining prior written permission from the Undergraduate Curriculum Committee Chairperson.

Applied Physics—Geophysics Concentration

B.S. Major Requirements:

Preparatory Subject Matter ............... 50-56
Physics 9A, 9B, 9C, 9D or 9HA, 9HB, 9HC, 9HD, 9HE .......... 19-25
Chemistry Engineering 30 (or equivalent programming course) ...... 4
Chemistry 2A or 2HA ............. 5

Depth Subject Matter ..................... 60-61
Lecture—3 hours. Prerequisites: five years of high school mathematics and physics courses. Physics 7A is most like the first quarter of traditionally taught courses which treat classical mechanics. Physics 7B is most like the first quarter of traditionally taught courses, treats optics, electricity and magnetism, and modern physics. The sequence of material in Physics 7 is different from that in most traditional courses. If you have completed one or two quarters of a traditionally taught physics course and want to continue with Physics 7, you should first take Physics 1 (and will receive full credit for Physics 7A). Then, either skip 7B, but self-study the last three weeks of material, or take 7B and receive reduced credit. Finally, take 7C for full credit.

Physics 7 is a one-year (three-quarter) introductory physics course with laboratory intended for students majoring in the biological sciences. It has a calculus prerequisite. If you don’t want a full year of introductory physics, you should take Physics 1 instead. Read the following information carefully if you are using Physics 7 to complete an introductory course you have already begun. The sequence of material in Physics 7 is different from that in most traditional courses. If you have completed one or two quarters of a traditionally taught physics course and want to continue with Physics 7, you should first take Physics 1 (and will receive full credit for Physics 7A). Then, either skip 7B, but self-study the last three weeks of material, or take 7B and receive reduced credit. Finally, take 7C for full credit.

If you have taken two quarters of a year-long introductory physics course and have not had extensive work in optics, electricity and magnetism, and modern physics, you should take Physics 7C instead. In no case should you take Physics 7B without first taking Physics 7A. All other situations should be discussed directly with a Physics 7 instructor.

Physics 7C is most like the first quarter or semester of traditionally taught calculus courses which treat classic mechanics. Physics 7C is most like the first quarter or semester which, in traditionally taught courses, treats optics, electricity and magnetism, and modern physics. The content and sequence of Physics 7A is that of most other traditionally taught courses.

If you have completed one introductory quarter or semester of a traditionally taught physics course and want to continue with Physics 7, you should first take Physics 1 (and will receive full credit for Physics 7A). Then, either skip 7B, but self-study the last three weeks of material, or take 7B and receive reduced credit. Finally, take 7C for full credit.

If you have taken two quarters of a year-long introductory physics course and have not had extensive work in optics, electricity and magnetism, and modern physics, you should take Physics 7C instead. In no case should you take Physics 7B without first taking Physics 7A. All other situations should be discussed directly with a Physics 7 instructor. Students not intending to take the entire sequence should instead take Physics 1.

Physics 9 is a four-quarter sequence using calculus throughout and including laboratory work as an integral component. The course is primarily for students in the physical sciences and engineering.

Physics 9H is a five-quarter honors physics sequence, which may be taken instead of Physics 9. It is intended primarily for first-year students with a strong interest in physics and with advanced placement in mathematics to MAT218. Students who plan to major in physics, and also motivated non-majors, should take Physics 9H instead of Physics 9 if they are ready to begin MAT218 in fall quarter. In course requirements and prerequisites, Physics 9HA/9HE can be substituted for Physics 9A/9D. Students may not switch between the 9H and 9 series beyond 9HA or 9A.

Lower Division

A1. Principles of Physics (3) Lecture—3 hours. Prerequisite: trigonometry or consent of instructor. Mechanics. Introduction to general principles and analytical methods used in physics, with emphasis on applications in applied agricultu...
1B. Principles of Physics (3) Lecture—3 hours, discussion/lab—4 hours. Prerequisite: course 1A or 9A. Continuation of course 1A. Heat, optics, electricity, modern physics. Not open for credit to students who have completed course 7B or 9A. GE credit: SciEng|SE — F, W, F. W. W.  

7A. General Physics (4) Lecture—1.5 hours; discussion/lab—5 hours. Prerequisite: consent of instructor. Electrons in solids, quantum mechanics, 16B, 17B, or 21B. Introduction to general principles and analytical methods used in physics for students majoring in a biological science. Only two units of credit allowed to students who have completed course 7A, 7B, 7C, 9B, 9C, or 9D. GE credit: SciEng|SE — W. W. (W. I)  

7B. General Physics (4) Lecture—1.5 hours; discussion/lab—5 hours. Prerequisite: course 7A. Continuation of course 7A. Only two units of credit allowed to students who have completed course 9A, or 1A. GE credit: SciEng|SE — F, W, F. W. S.  

7C. General Physics (4) Lecture—1.5 hours; discussion/lab—5 hours. Prerequisite: course 7B. Continuation of course 7B. Only two units of credit allowed to students who have completed course 9C or 9D. GE credit: SciEng|SE — F, W, W. S.  

9A. Classical Physics (5) Lecture—3 hours; laboratory—2.5 hours; discussion—1 hour. Prerequisite: Mathematics 21B. Introduction to general principles and analytical methods used in physics. Fluid mechanics, thermodynamics, wave phenomena, optics. Only two units of credit allowed to students who have completed course 7A; not open for credit to students who have completed course 9A. GE credit: SciEng|SE — F, F. F.  

9B. Classical Physics (5) Lecture—3 hours; laboratory—2.5 hours; discussion—1 hour. Prerequisite: course 9A, Mathematics 21C, 21D (may be taken concurrently). Continuation of classical physics. Continuation of course 9A. GE credit: SciEng|SE — F, F. F.  

9C. Classical Physics (5) Lecture—3 hours; laboratory—2.5 hours; discussion—1 hour. Prerequisite: course 9B, Mathematics 21D, 102A (may be taken concurrently). Electricity and magnetism including circuits and Maxwell’s equations. Only 3 units of credit to students who have completed course 7C. Not open for credit to students who have completed course 9B, 9HC, or Engineering 105. GE credit: SciEng|SE — F, W, F, W.  

9D. Modern Physics (4) Lecture—3 hours; discussion—1.5 hours. Prerequisite: course 9C and Mathematics 22A; Mathematics 22B recommended (may be taken concurrently). Introduction to physics concepts developed since 1900. Special relativity, quantum mechanics, atoms, molecules, condensed matter, nuclear and particle physics. Not open for credit to students who have completed course 9B, 9HC, or 9HE. GE credit: SciEng|SE — F, F. F.  

9HA. Honors Physics (5) Lecture—3 hours; discussion/lab—4 hours. Prerequisite: Mathematics 21B (may be taken concurrently) or consent of instructor. Classical mechanics. Same material as course 9A in greater depth. For students in physical sciences, mathematics, and engineering. Only two units of credit allowed to students who have completed course 9B, 9HC, or 9HE. GE credit: SciEng|SE — F, F. F.  

9HB. Honors Physics (5) Lecture—3 hours; discussion/lab—4 hours. Prerequisite: Physics 9HA or 9A, Mathematics 21C (may be taken concurrently). Special relativity, modern physics. Continuation of course 9HA. Only 2 units of credit to students who have completed course 7A. Not open for credit to students who have completed course 9B or 9D. GE credit: SciEng|SE — W. W.  

9HC. Honors Physics (5) Lecture—3 hours; discussion/lab—4 hours. Prerequisite: course 9HB and Mathematics 21D (may be taken concurrently). Continuation of physics 9HB. Only 2 units of credit to students who have completed course 7C. Not open for credit to students who have completed course 9B or 9D. GE credit: SciEng|SE — S. (S.)  

9HD. Honors Physics (5) Lecture—3 hours; discussion/lab—4 hours. Prerequisite: course 9HC and Mathematics 21D. Electricity and magnetism. Continuation of Physics 9HC. Not open for credit to students who have completed course 9D. GE credit: SciEng|SE — S. (S.)  

10. Topics in Physics for Nonscientists (4) Lecture—3 hours; discussion—1 hour. Prerequisite: high school algebra. Emphasis varies: survey of basic principles or a deeper exploration of some particular topics in physics. Common topics include black holes, space time, and relativity; physics of music; history and philosophy; energy and the environment; and natural phenomena. Check with the Department office for the current emphasis. No units of credit allowed if taken after any other physics course. GE credit: SciEng, Writ|SE.  

10C. Physics of California (3) Lecture—3 hours. Atmospheric phenomena common in CA, mountains, and microclimates. Applications to CA energy, water, and resource management policies. Physics underlying regional aspects in CA. Not open for credit to students who have completed any quarter of Physics 9 or 9H, or any upper division physics course. GE credit: SciEng|SE, VL, SL. F. F. (F.) Bradac  

12. Visualization in Science (3) Lecture—3 hours. Class size limited to 20-50 students. Problem solving, and use of images in physics, astronomy, biology, and chemistry as scientific evidence and for communication of research results. Offered irregularly. GE credit: SciEng|SE, VL, S. (S.)  

30. Fractals, Chaos and Complexity (3) Lecture/discussion—3 hours. Prerequisite: Mathematics 16A or 21A. Modern ideas about the unifying ideas of fractal geometry, chaos and complexity. Basic theory and applications with examples from physics, earth sciences, mathematics, population dynamics, ecology, history, economics, biology, computer science, art and architecture. Offered in alternate years (same course as Geology 20) GE credit: SciEng|QL, SE. — W. Rundle  

49. Supplementary Work in Lower Division Physics (1-3) Students with partial credit in lower division physics courses may, with consent of instructor, complete the credit under this heading. May be repeated for credit. GE credit: SciEng|SE — F, W, S, F, W. S.  

90X. Lower Division Seminar (2) Seminar—2 hours. Prerequisite: lower division standing; consent of instructor; limited enrollment. Examination of a special topic in Physics through shared readings, discussions, written assignments, or special activities such as laboratory work. May be repeated for credit. GE credit: SciEng|SE.  

98. Directed Group Study (1-5) Prerequisite: consent of instructor; primarily for lower division students. (P/NP grading only) GE credit: SE.  

99. Special Study for Undergraduates (1-5) Prerequisite: consent of instructor. (P/NP grading only) GE credit: SE.  

Upper Division  

102. Computational Laboratory in Physics (1) Laboratory—4 hours. Prerequisite: Mathematics 21D, 22A, 22B, and 228 with grade C– or better in consent of instructor. Introduction to computer languages used in the mathematics used in upper-division physics courses, including applications of vector spaces, Fourier analysis, partial differential equations. — F. F.  

104B. Computational Methods of Mathematical Physics (4) Lecture—3 hours; extensive problem solving. Prerequisite: courses 9B, 9C, 9D and Mathematics 21D, 22A, and 228 with grade C– or better in consent of instructor. Introduction to the computational techniques to solve the mathematical problems that arise in advanced physics courses, complementing the mathematical approaches emphasized in course 104A. GE credit: SciEng|SE — W, W.  

104C. Intermediate Methods of Mathematical Physics (4) Lecture—3 hours; extensive problem solving. Prerequisite: course 104A with grade C– or better and consent of instructor. Applications of complex analysis, conditional probability, integral transformations and other advanced topics. Offered in alternate years. — (S) Cheng, Kaloper  

105A. Analytical Mechanics (4) Lecture—3 hours; extensive problem solving. Prerequisite: courses 9B, 9C, 9D and Mathematics 21D, 22A, and 228 with grade C– or better, or consent of department; course 104A and 105A passed with a grade C– or better or consent of department required in other upper division physics classes. Not open to students who have completed course 105B or 105A. GE credit: SciEng|SE — W. W.  

105B. Analytical Mechanics (4) Lecture—3 hours; extensive problem solving. Prerequisite: courses 9B, 9C, 9D and Mathematics 21D, 22A, and 228 with grade C– or better, or consent of department; course 104A and 105A passed with a grade C– or better or consent of department required for 105B. Principles and applications of Newtonian mechanics; introduction to Lagrange’s and Hamilton’s equations. GE credit: SciEng|SE — F, F. (F.) Svalbe-Borda  

105C. Continuum Mechanics (4) Lecture—3 hours; extensive problem solving. Prerequisite: courses 9B, 9C, 9D and Mathematics 21D, 22A, and 228 with grade C– or better, or consent of department; course 104A and 105A passed with a grade C– or better or consent of department required for 105B. Principles and applications of Newtonian mechanics; introduction to Lagrange’s and Hamilton’s equations. GE credit: SciEng|SE — W, W. (W.) Conway  

108. Optics (3) Lecture—3 hours. Prerequisite: course 9 or 7 sequence and Mathematics 21 sequence or consent of instructor. The phenomena of diffraction, interference, and polarization of light, with applications to current problems in astrophysics, material science,
115A. Foundation of Quantum Mechanics (4)
Lecture—3 hours; extensive problem solving. Prerequisite: courses 104A and 105A passed with a grade of C or better, or consent of department. Introduction to the methods of quantum mechanics applicable to the atomic, solid state, and nuclear and elementary particle physics. Extensive problem solving. GE credit: Scien|SE, SS.

115B. Applications of Quantum Mechanics (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: course 115A. Topics include: Quantum mechanics of the hydrogen atom; Quantum mechanics of finite systems; Quantum mechanics of systems with continuous degrees of freedom; Applications of quantum mechanics to solids, gases, and fields; Introduction to the use of computer programming in mathematical physics, with particular emphasis on wave packet methods.

122A. Advanced Laboratory in Condensed Matter Physics (4)
Laboratory—8 hours. Prerequisite: course 104A, 105A, 110B, 110A and 112 may be taken concurrently or consent of the department. Experimental techniques and measurements in solid-state physics. Student performs experiments depending on difficulty. Individual work is stressed. Thorough write-ups of the experiments are required. GE credit: Scien|SE, SS.

123. Signals and Noise in Physics (4)
Lecture—3 hours; project—1 hour. Prerequisite: courses 9A, B, C, D and 104A, or consent of instructor. Techniques of measurement and analysis designed to avoid systematic error and maximize signal-to-noise ratio. Illustrative examples of optimal filters ranging from condensed matter to cosmology. Not open to students who have completed this course previously as course 198. Offered in alternate years. GE credit: Scien|SE.

129A. Introduction to Nuclear Physics (4)
Lecture—3 hours. Prerequisite: course 115A passed with a grade of C or better, or consent of instructor. Survey of basic nuclear properties and concepts requiring introductory knowledge of quantum mechanics: nuclear models and forces, radioactive decay and detecting nuclear reaction products, alpha, beta and gamma decay. GE credit: Scien|SE, SS.

129B. Nuclear Physics, Extensions and Applications (4)
Lecture—3 hours; term paper. Prerequisite: course 129A. Continuation of course 129A. Nuclear reactions, neutrons, fission, fusion accelerators, introduction to meson and particle physics, nuclear astrophysics, and applications of nuclear physics and techniques to mass spectrometry, nuclear medicine, trace element analysis. GE credit: Scien|SE.

130A. Elementary Particle Physics (4)
Lecture—3 hours; extensive problem solving. Prerequisite: course 115A passed with a grade of C or better, or consent of instructor. Properties and classification of elementary particles and their interactions. Experimental techniques. Conservation laws and symmetries. Strong, electromagnetic, and weak interactions. Introduction to quantum field theory. GE credit: Scien|SE.

130B. Elementary Particle Physics (4)
Lecture—3 hours; extensive problem solving. Prerequisite: course 115A passed with a grade of C or better, or consent of instructor. Properties and classification of elementary particles and their interactions. Experimental techniques. Conservation laws and symmetries. Strong, electromagnetic, and weak interactions. Introduction to quantum field theory. GE credit: Scien|SE, SS.

140A. Introduction to Solid State Physics (4)
Lecture—3 hours; extensive problem solving. Prerequisite: course 115A or the equivalent passed with a grade of C or better or consent of instructor. Survey of fundamental ideas in the physics of solids, with selected device applications. Crystal structure, x-ray and neutron diffraction, phonons, simple metals, energy bands and Fermi surface, semiconductors, optical properties, magnetism, superconductivity. GE credit: Scien|SE.

140B. Introduction to Solid State Physics (4)
Lecture—3 hours; extensive problem solving. Prerequisite: course 115A or the equivalent passed with a grade of C or better or consent of instructor. Survey of fundamental ideas in the physics of solids, with selected device applications. Crystal structure, x-ray and neutron diffraction, phonons, simple metals, energy bands and Fermi surface, semiconductors, optical properties, magnetism, superconductivity. GE credit: Scien|SE.
imaging, photometry and/or spectroscopy. Students perform three experiments. Individual work stressed. Minimum 10-15 page beyond articles of two experiments are required. Offered in alternate years. GE credit: SciEng | SE, WE. — (S.) Boeshaar, Tyson

160. Environmental Physics and Society (3)
Lecture—3 hours. Prerequisite: course 90 or 7C; or course 10B and 18 or Mathematics 16B or the equivalent. Impact of humankind on the environment will be discussed from the point of view of the physical sciences. Calculations based on physical principles will be made, and the resulting policy implications will be considered. (Same course as Engineering 160.) GE credit: SciEng | SE, SL. — (S.) Cox

185. Alummi Seminar Series (1)
Seminar—1 hour. Weekly guest speakers [usually a physics alumus or alumna] tell students about their careers. Speakers use their experience to give students insights into life after a degree in physics. May be repeated two times for credit. (P/NP grading only.) GE credit: SciEng | SE. — (S.) Knox

190. Careers in Physics (1)
Seminar—2 hours. Restricted to Physics and Applied Physics majors only. Overview of important research areas in physics, discussions of research opportunities and internships, strategies for graduate school and industrial careers, the fellowship and assistantship selection process, preparation of resumes, personal statements, and letters of recommendation. (P/NP grading only.) GE credit: SE. — (F.)

194HA. Special Study for Honors Students (4)
Independent study—12 hours. Prerequisite: consent of instructor required. Open only to Physics and Applied Physics majors who satisfy the College of Letters and Science requirements for entrance into the Honors Program. Independent research project at a level significantly beyond that defined by the normal physics curriculum. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE, F, W, S. — (F, S.)

194HB. Special Study for Honors Students (4)
Independent study—12 hours. Prerequisite: consent of instructor required. Open only to Physics and Applied Physics majors who satisfy the College of Letters and Science requirements for entrance into the Honors Program. Independent research project at a level significantly beyond that defined by the normal physics curriculum. (Deferred grading only, pending completion of sequence.) GE credit: SciEng | SE, F, W, S. — (F, S.)

195. Senior Thesis (5)
Independent study—15 hours. Prerequisite: consent of instructor required. Open only to Physics and Applied Physics majors with senior standing. Preparation of a senior thesis on a topic selected by the student with approval of the department. May be repeated for a total of 15 units. GE credit: SciEng | SE. — (F, W, S.)

197T. Tutoring in Physics and Astronomy (1-5)
Tutoring of students in lower division courses. Leading of small voluntary discussion groups affiliated with one of the department’s regular courses. Weekly meeting with instructor. (P/NP grading only.) GE credit: SE. — (F, W, W, S.)

198. Directed Group Study (1-5)
Prerequisite: consent of instructor. (P/NP grading only.) GE credit: SE. — (F, W, S.)

199. Special Study for Advanced Undergraduates (1-5)
(P/NP grading only.) GE credit: SE. — (F, W, S.)

Graduate

200A. Theory of Mechanics and Electromagnetism (4)
Lecture—3 hours; independent study—1 hour. Prerequisite: courses 104B, 105B, and 110C or the equivalent; course 204A concurrently. Theoretical approaches in classical mechanics including the use of generalized coordinates and virtual work; variational calculus, Lagrangian equations, symmetries, conservation laws, and Noether theorem; Lagrangian density; Hamilton formalism; canonical transformations; Poisson brackets; and Hamilton-Jacobi equations. Offered irregularly. 201B. Statistical Mechanics (4)
Lecture—3 hours; extensive problem solving. Prerequisite: course 219A. Further applications of thermodynamics and classical and quantum statistical mechanics. The modern theory about the equilibrium state, phase transitions and critical phenomena. — (F.) Singh

223A. Group Theoretical Methods of Physics—Condensed Matter (3)
Lecture—3 hours. Prerequisite: courses 215A, 215B, 215C is corequisite) or consent of instructor. Theory of groups and their representations with applications in condensed matter. Offered irregularly.

223B. Group Theoretical Methods of Physics—Elementary Particles (3)
Lecture—3 hours. Prerequisite: courses 215A, 215B, 215C is corequisite) or consent of instructor. Theory of groups and their representations with applications in elementary particle physics. Offered irregularly.

224A. Nuclear Physics (3)
Lecture—3 hours. Prerequisite: course 215B. Comprehensive study of the nucleon-nucleon interaction including the deuteron, nucleon-nucleon scattering, polarization, determination of dynamical parameters of S-matrix, and related topics. Offered irregularly.

224B. Nuclear Physics (3)
Lecture—3 hours. Prerequisite: course 224A. Study of nuclear scattering and reactions including the optical model and direct interactions. Beta decay and an introduction to weak interactions. Offered irregularly.

229A. Advanced Nuclear Theory (3)
Lecture—3 hours. Prerequisite: course 224C. Advanced topics in nuclear theory; theory of quantum-mechanical scattering processes. Exact formal theory and models for two-body scattering. Offered irregularly.

229B. Advanced Nuclear Theory (3)
Lecture—3 hours. Prerequisite: course 229A. Advanced topics in nuclear theory; theory of quantum-mechanical scattering processes. Exact formal theory and models for three-body scattering. Offered irregularly.

230A. Quantum Theory of Fields (3)
Lecture—3 hours. Prerequisite: course 215C. Relativistic quantum mechanics of particles; techniques and applications of second quantization; Feynman diagrams; renormalization. Offered irregularly.

230B. Quantum Theory of Fields (3)
Lecture—3 hours. Prerequisite: course 230A. Continuation of 230A, with selected advanced topics, such as S-matrix theory, dispersion relations, axiomatic formulations. — (F.)

230C. Quantum Theory of Fields (3)
Lecture—3 hours. Prerequisite: course 230A and B, or consent of instructor. Renormalization theory and applications, including dimensional regularization, Ward identities, renormalization group equations, coupling constant unification, and precision electroweak calculations. May be repeated for credit with consent of instructor. — (W.) Gunia

240A. Condensed Matter Physics A (3)
Lecture—3 hours. Prerequisite: course 215C, 219A; course 140AB or equivalent recommended. Topics in condensed matter physics: Crystal structure; electron theory; transport and optical properties of semiconductors; phonons, electron-phonon scattering. — (F.) Pickett
Plant Biology

See Environmental Horticulture, on page 323; Plant Biology, on page 509; and Plant Biology (A Graduate Group), on page 511.

Plant Biology

(College of Biological Sciences)

William J. Lucas, Ph.D., Chairperson of the Department
Anne B. Britt, Ph.D., Vice Chairperson of the Department

Graduate Program. See Plant Biology (A Graduate Group), on page 511.

Department Office. 1002 Life Sciences 530-752-0617; http://www.plb.ucdavis.edu

Advising. 1023 Sciences Laboratory Building; 530-752-1630; http://bio.as.ucdavis.edu/

Committee in Charge of the Major
Bo Liu, Ph.D.
Anne Britt, Ph.D.
Steven Theg, Ph.D.

Faculty

Faculty includes members of the Departments of Plant Biology, Molecular and Cellular Biology, and Evolution and Ecology in the College of Biological Sciences.

Primary Department Members
Siobhan Brady, Associate Professor
Anne Britt, Ph.D., Professor
Luca Comai, Ph.D., Professor
S. P. Dinesh-Kumar, Professor
John J. Harada, Ph.D., Professor
Academic Senate Distinguished Teaching Award
Stacey Harmer, Ph.D., Professor
Bo Liu, Ph.D., Professor
William J. Lucas, Ph.D., Professor
Julin Maloof, Ph.D., Professor
Sharman O’Neill, Ph.D., Professor
Neelima Sinha, Ph.D., Professor
Venkatesan Sundaresan, Ph.D., Professor
Steven M. Theg, Ph.D., Professor

Secondary Department Members
Judy Callis, Ph.D., Professor
Academic Senate Distinguished Teaching Award
James A. Doyle, Ph.D., Professor
Marylinn E. Etzler, Ph.D., Professor
Charles S. Gasser, Ph.D., Professor
J. Clark Lagarias, Ph.D., Professor
Marcel Rejmanek, Ph.D., Professor
Raymond L. Rodriguez, Ph.D., Professor
Irwin Segel, Ph.D., Professor

Emeriti Faculty

Michael Barbour, Ph.D., Professor Emeritus
David E. Bayer, Ph.D., Professor Emeritus
Deborah Canington, Ph.D., Lecturer
Academic Federation Excellence in Teaching Award
Paul A. Castelfranco, Ph.D., Professor Emeritus
Deborah F. Delmer, Ph.D., Professor Emerita
Emanuel Epstein, Ph.D., Professor Emeritus
Richard H. Falk, Ph.D., Professor Emeritus
Donald W. Kyhos, Ph.D., Professor Emeritus
Terence M. Murphy, Ph.D., Professor Emeritus
Thomas L.Ross, Ph.D., Professor Emeritus
Academic Senate Distinguished Teaching Award
Alan J. Stemler, Ph.D., Professor Emeritus
Kenneth Wells, Ph.D., Professor Emeritus

Affiliated Faculty

John L. Bowman, Ph.D., Professor
Andrew Groover, Ph.D., Adjunct Associate Professor
Joel Ledford, Ph.D., Academic Coordinator

The Major Program

As organisms that sequester carbon and convert solar energy to usable forms, plants are the primary source of food on the planet as well as important buffers against climate change. The Plant Biology major focuses on fundamental aspects of how plants function as organisms and interact with their environment. A wide variety of scientific disciplines are integrated within the Plant Biology major, including physiology, cell and molecular biology, development, genetics and genomics.

The Program. The plant biology major consists of a Biosciences core covering the general principles of biology plus four plant-specific classes dealing with advanced aspects of plant biology including physiological, development, and anatomy. Two required electives allow students to tailor the degree to suit their interests. Independent research in a laboratory setting is a requirement, and majors in Plant Biology are guaranteed this opportunity. Because of the value of plants as a model system for research in many related genetics, cell biology, and biochemistry, Plant Biology makes an excellent minor or second major for student in these fields.

Career Alternatives. A degree in Plant Biology serves as an excellent launching point for a wide range of career options, including domestic and international opportunities in business, research and teaching in both governmental and private sectors. The program is excellent preparation for students wishing to enter graduate or other professional schools, including medicine, law (particularly environmental or patent law) or journalism. Plant biologists work in the laboratory, in the field, in botanic gardens or nurseries, in agricultural companies, or in biotechnology, pharmaceutical, energy or chemical industries, or in the area of environmental protection.

A.B. Major Requirements:

Preparatory Subject Matter ........................................ 34

UNITED STATES

Biological Sciences 2A-2B-2C ........................................ 14
Chemistry 2A-2B, 8A-BB ........................................ 16
Mathematics 17A-17B-17C or 118C ............................ 6-12

UNITED KINGDOM

Chemistry 2A-2B, 8A-BB ........................................ 16
Mathematics 17A-17B-17C or 21A-21B (21C recommended) ... 8-12

Total Units for the Major ........................................ 75-76

Recommended

Biological Sciences 101, 102 or 108 ................................ 5
Evolution and Ecology 140 or Plant Biology 116 ................. 4-5
Plant Biology 105, 111, 112, 117 ................................ 15

Additional upper division units in Plant Biology or related natural science courses ........................................ 13

Recommended

Biological Sciences 102Q, 148 ...................................... 4-5

B.S. Major Requirements:

Preparatory Subject Matter ........................................ 55-65

UNITED STATES

Biological Sciences 2A-2B-2C ........................................ 14
Chemistry 2A-2B-2C ........................................ 15
Chemistry 8A-BB or 118B-118C .................................. 6-12

UNITED KINGDOM

Mathematics 17A-17B-17C or 21A-21B (21C recommended) ... 8-12
Physics 7A-7B-7C ........................................ 12

Recommended

Biological Sciences 20Q ........................................ 6-12

Depth Subject Matter ........................................ 43-46

Biological Sciences 101, 105 ........................................ 10

Fall 2011 and on Revised General Education (GE) AAH—Arts and Humanities; SE—Science and Engineering; SS—Social Sciences; AGCH—American Cultures; DD—Domestic Diversity; OL—Other Skills; DL—Quantitative; SL—Scientific; VL—Visual; WC—World Cultures; WE—Writing Experience