Department of Physics and Astronomy

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Overview

Physics is that branch of science concerned with the study of natural phenomena at the fundamental level. Physicists study the smallest particles of matter (quarks and leptons), nuclei, and atoms; the fundamental forces; the properties of solids, liquids, gases, and plasmas; the behavior of matter on the grand scale in stars and galaxies; and even the origin and fate of the universe. Other disciplines such as chemistry, biology, medicine, and engineering often build upon the foundations laid by physics.

The Department of Physics and Astronomy offers introductory and advanced courses for students of various interests, from those in the humanities and social sciences, to those in biological sciences, and to those in physics, engineering, and other sciences. The Department offers majors in Physics and Applied Physics, with interdisciplinary concentrations and tracks that include astrophysics, engineering physics, science education, and courses taught by faculty in Biological Sciences, Chemistry, Engineering, and Medicine.

Furthermore, the faculty is vigorous, innovative, and engaged in a wide variety of research, education, and public service activities. The Department encourages student-faculty interaction and student involvement in undergraduate research. Faculty conduct active research in forefront research areas, providing students access to research opportunities in specialized areas like cosmology, particle physics, plasmas and fusion, condensed matter physics, biophysics, and medical physics.

Undergraduate Program

The goal of the undergraduate majors in Physics and Applied Physics is to develop expert problem solvers with a broad understanding of physical principles. The programs are flexible and prepare students for careers in industrial research, applications programming, education, law, or business, as well as for graduate study in astronomy, biomedical physics, engineering, or physics.

Students choose a major in either pure Physics or Applied Physics. The major in Physics includes a standard track for graduate study in physics, a Specialization in Astrophysics, and Concentrations in Computational Physics, the Philosophy of Physics, and Physics Education. The major in Applied Physics allows students to combine physics courses with courses from overlapping disciplines, such as materials science, electrical engineering, geosciences, biomedical imaging, or other fields. Annual mandatory meetings with faculty advisors assist students in selecting the right program for their aptitudes and interests.

Different sequences of lower-division physics courses are distinguished by their intended audience, their mathematical prerequisites, and the extent to which they offer preparation for more advanced courses. These aspects of the introductory courses are summarized as follows:

Physics 3: *Intended audience:* Premedical students, Biological Sciences majors. *Prerequisites:* concurrent enrollment in MATH 2A. *Preparation for advanced courses:* PHYSICS 7D with permission.

Physics 7: *Intended audience:* Physical Sciences and Engineering majors. *Prerequisite:* concurrent enrollment in MATH 2B. *Preparation for advanced courses:* PHYSICS 51A or PHYSICS 61A.

Physics 12-21: *Intended audience:* Nonscience majors. *Prerequisites:* none. *Preparation for advanced courses:* none.

Admission to the Physics or Applied Physics Majors

Students may be admitted to the Physics or Applied Physics majors upon entering the University as freshmen, via change of major, or as transfer students from other colleges and universities. Information about change of major policies is available in the Physical Sciences Student Affairs Office and at the UCI Change of Major Criteria website (http://www.changeofmajor.uci.edu). For transfer student admission, preference will be given to junior-level applicants with the highest grades overall and who have satisfactorily completed the following required courses: one year of approved calculus and one year of calculus-based physics with laboratory for engineering and physics majors.

Requirements for the B.S. Degree in Physics (with Concentrations and a Specialization)

All students must meet the University Requirements.

School Requirements: None.

Departmental Requirements

MATH 2A	Single-Variable Calculus
or MATH 5A	Calculus for Life Sciences
MATH 2B	Single-Variable Calculus

MATH 2D- 2E	Multivariable Calculus and Multivariable Calculus
MATH 3A	Introduction to Linear Algebra
MATH 3D	Elementary Differential Equations
PHYSICS 7C- 7D- 7E	Classical Physics and Classical Physics and Classical Physics
PHYSICS 7LC- 7LD	Classical Physics Laboratory and Classical Physics Laboratory
PHYSICS 50	Mathematical Methods for Physical Science
PHYSICS 52A- 52B- 52C	Fundamentals of Experimental Physics and Fundamentals of Experimental Physics and Fundamentals of Experimental Physics
PHYSICS 53	Introduction to C and Numerical Analysis (or another programming course)
PHYSICS 60	Thermal Physics
PHYSICS 61A	Modern Physics for Majors [1]
PHYSICS 61B	Modern Physics for Majors
or PHYSICS 61C	Introduction to Astrophysics
PHYSICS 111A- 111B	Classical Mechanics and Classical Mechanics
PHYSICS 112A- 112B	Electromagnetic Theory and Electromagnetic Theory
PHYSICS 113A	Quantum Physics
PHYSICS 115A	Statistical Physics
PHYSICS 121W	Advanced Laboratory
PHYSICS 125A	Mathematical Physics
PHYSICS 194	Research Communication for Physics Majors

And select five additional coherently related four-unit courses. (This requirement is normally satisfied by concentrations, specializations, and tracks, as listed below.)

[1] For students transferring into the major after taking PHYSICS 51A-PHYSICS 51B, PHYSICS 51A-PHYSICS 51B will be accepted in place of PHYSICS 61A-PHYSICS 61B.

Upper-Division Writing Requirement: Physics majors are required to satisfy the upper-division writing requirement by completing PHYSICS 194 with a grade of C or better, followed by PHYSICS 121W with a grade of C or better.

Sample Program — Physics Core Curriculum

Freshman		
Fall	**Winter**	**Spring**
MATH 2B	MATH 2D	MATH 2E
PHYSICS 7C- 7LC	PHYSICS 7D- 7LD	PHYSICS 7E
(PHYSICS 99)		
Sophomore		
Fall	**Winter**	**Spring**
MATH 3A	MATH 3D	PHYSICS 50
PHYSICS 52A	PHYSICS 52B	PHYSICS 52C
PHYSICS 60	PHYSICS 61A	PHYSICS 61B or 61C
Junior		
Fall	**Winter**	**Spring**
PHYSICS 111A	PHYSICS 111B	PHYSICS 53
	PHYSICS 112A	PHYSICS 112B
		PHYSICS 113A
Senior		
Fall	**Winter**	
PHYSICS 115A	PHYSICS 121W	

PHYSICS 194	PHYSICS 125A

For a student planning graduate study in physics, additional courses in advanced physics are strongly recommended.

Concentration in Computational Physics

The **Computational Physics concentration** provides training for positions in software development in a wide variety of high-technology fields. For example, consider medical imaging software for magnetic resonance imaging. To write a first-rate program, one must understand the apparatus and analysis techniques (physics), use appropriate numerical techniques (numerical analysis), and employ a convenient object-oriented interface (computer science). The concentration develops this unique set of skills: physical and mathematical insight through the Physics curriculum, knowledge of modern computer programming techniques, and knowledge of numerical analysis.

Requirements:

Three courses in computer science:	
I&C SCI 31	Introduction to Programming
I&C SCI 32	Programming with Software Libraries
I&C SCI 33	Intermediate Programming
Two courses in numerical analysis plus the accompanying laboratories:	
MATH 105A- 105B	Numerical Analysis and Numerical Analysis
MATH 105LA- 105LB	Numerical Analysis Laboratory and Numerical Analysis Laboratory
One advanced computational course and accompanying laboratory:	
MATH 107- 107L	Numerical Differential Equations and Numerical Differential Equations Laboratory

Sample Program — Computational Physics Concentration

Junior		
Fall	**Winter**	**Spring**
I&C SCI 31	I&C SCI 32	I&C SCI 33
Senior		
Fall	**Winter**	**Spring**
MATH 105A- 105LA	MATH 105B- 105LB	MATH 107- 107L

Concentration in Philosophy of Physics

The **Philosophy of Physics concentration** is concerned with the study of the conceptual history of physics, the method of inquiry that has led to our best physical theories, and the structure and interpretation of the theories themselves. Students take courses in deductive and inductive logic, the philosophy and history of physics, and quantum mechanics. The emphasis on careful argument makes this concentration useful for anyone who wishes to pursue a graduate degree in philosophy or law, or for other careers that employ both verbal and quantitative analysis.

Requirements:

Select one from the following:	
LPS 40	The Nature of Scientific Inquiry
LPS 60	The Making of Modern Science
SOC SCI H1G	Honors: Critical Issues on the Social Sciences
LPS H125	What Is Time?
LPS H80	Scientific Realism and Instrumentalism
or another approved Campuswide Honors course	
Select one of the following:	
LPS 30	Introduction to Symbolic Logic
LPS 104	Introduction to Logic
LPS 105A- 105B- 105C	Elementary Set Theory and Metalogic and Undecidability and Incompleteness
MATH 150	Introduction to Mathematical Logic
Complete:	
LPS 31	Introduction to Inductive Logic
Select one from the following:	

LPS 104	Introduction to Logic
LPS 105A- 105B- 105C	Elementary Set Theory and Metalogic and Undecidability and Incompleteness
LPS 140	Topics in Philosophy of Science
MATH 150	Introduction to Mathematical Logic
HISTORY 135D	Maps from Prehistory to the Present (when the topic is physics; or another approved elective)
Complete:	
PHYSICS 113B	Quantum Physics
Select three from the following:	
LPS 141A	Topics in Philosophy of Physics
LPS 141B	Geometry and Spacetime
LPS 141C	Philosophy of Quantum Mechanics
LPS 141D	Probability and Determinism
or other approved Philosophy of Physics course	

Concentration in Physics Education

The **Physics Education concentration** is for students who plan a career in secondary education. An Education course, four general science courses, a research methods course, and two quarters of classroom experience complete the requirements for the concentration. Students are encouraged to take PHYSICS 191 (outreach).

Requirements:

EDUC 55	Knowing and Learning in Mathematics and Science
PHY SCI 5	California Teach 1: Introduction to Science and Mathematics Teaching
PHY SCI 105	California Teach 2: Middle School Science and Mathematics Teaching
PHYSICS 193	Research Methods
Select four courses from the following:	
BIO SCI 1A	Life Sciences
BIO SCI 93	From DNA to Organisms
BIO SCI 94	From Organisms to Ecosystems
CHEM 1A- 1B- 1C	General Chemistry and General Chemistry and General Chemistry
EARTHSS 1	Introduction to Earth System Science
EARTHSS 7	Physical Geology
PHYSICS 20A- 20B	Introduction to Astronomy and Cosmology: Humanity's Place in the Universe

NOTE: With this concentration, a Secondary Teaching Certification option is available.

Secondary Teaching Certification Option: With *additional* course work and field experience offered through the UCI Cal Teach program, students who complete the concentration in Physics Education can also earn a California Preliminary Single Subject Teaching Credential. Completing the bachelor's degree, concentration, and teacher certification in four years is possible with careful, early planning. Additional courses required for teacher certification are:

LPS 60	The Making of Modern Science
EDUC 109	Reading and Writing in Secondary Mathematics and Science Classrooms
EDUC 143AW	Classroom Interactions I
EDUC 143BW	Classroom Interactions II
EDUC 148	Complex Pedagogical Design [1]
EDUC 158	Student Teaching Mathematics and Science in Middle/High School (two quarters)

[1] Successful completion of EDUC 143AW-EDUC 143BW and EDUC 148 will be accepted in lieu of PHYSICS 125A and PHYSICS 194 for Cal Teach students.

For additional information about teacher certification requirements and enrollment procedures, see Preparation for Teaching Science and Mathematics. Interested students are strongly encouraged to contact the Cal Teach Resource and Advising Center or the Physical Sciences Student Affairs Office.

Sample Program — Concentration in Physics Education with Secondary Teaching Certification Option

Freshman		
Fall	**Winter**	**Spring**
MATH 2B	MATH 2D	MATH 2E
PHYSICS 7C- 7LC	PHYSICS 7D- 7LD	PHYSICS 7E
General Education	General Education	General Education
(PHYSICS 99)	PHY SCI 5	General Education
Sophomore		
Fall	**Winter**	**Spring**
MATH 3A	MATH 3D	PHYSICS 50
PHYSICS 60	PHYSICS 61A	PHYSICS 61B
PHYSICS 52A	PHYSICS 52B	PHYSICS 52C
PHY SCI 105	PHYSICS 193	LPS 60
Junior		
Fall	**Winter**	**Spring**
PHYSICS 111A	PHYSICS 111B	PHYSICS 53
General Science	PHYSICS 112A	PHYSICS 112B
General Science	General Science	PHYSICS 113A
EDUC 55	EDUC 143AW	EDUC 148
Senior		
Fall	**Winter**	**Spring**
PHYSICS 115A	General Education	PHYSICS 121W
General Science	EDUC 109	General Education
EDUC 143BW	EDUC 158	EDUC 158

Specialization in Astrophysics

The Astrophysics specialization is primarily taken by two types of students, those planning on going on to graduate school in astronomy or astrophysics and those planning to work in aeronautics or astrophysics-related industries or government research laboratories after receiving their bachelor's degree. It also is an excellent focus for students who anticipate careers in science journalism, teaching, science administration, or public relations. The course work includes:

A. Complete:	
PHYSICS 61C	Introduction to Astrophysics
PHYSICS 139	Observational Astrophysics
B. Select three courses from the following:	
PHYSICS 137	Introduction to Cosmology
PHYSICS 138	Extragalactic Astrophysics
PHYSICS 144	Stellar Astrophysics
PHYSICS 145	High-Energy Astrophysics
C. Two or more upper-division Physics courses. Of the Physics electives, students bound for graduate school are strongly advised to include:	
PHYSICS 113B	Quantum Physics
PHYSICS 115B	Thermodynamics
PHYSICS 125B	Mathematical Physics
Other recommended electives include:	
PHYSICS 116	Relativity and Black Holes
PHYSICS 134A	Physical and Geometrical Optics
PHYSICS 135	Plasma Physics
PHYSICS 136	Introduction to Particle Physics

Sample Program — Astrophysics Specialization

Junior		
Fall	**Winter**	**Spring**
PHYSICS 116	PHYSICS 137	PHYSICS 144 or 145

Senior		
Fall	**Winter**	**Spring**
PHYSICS 113B	PHYSICS 138	PHYSICS 115B
PHYSICS 139		PHYSICS 125B
		PHYSICS 144 or 145

Requirements for the B.S. Degree in Applied Physics (with Concentrations)

All students must meet the University Requirements.

School Requirements: None

Departmental Requirements

A. Complete the following:	
MATH 2A	Single-Variable Calculus
or MATH 5A	Calculus for Life Sciences
MATH 2B	Single-Variable Calculus
MATH 2D- 2E	Multivariable Calculus and Multivariable Calculus
MATH 3A	Introduction to Linear Algebra
MATH 3D	Elementary Differential Equations
PHYSICS 50	Mathematical Methods for Physical Science
PHYSICS 61A	Modern Physics for Majors
or PHYSICS 51A	Modern Physics
PHYSICS 111A	Classical Mechanics
PHYSICS 112A	Electromagnetic Theory
PHYSICS 113A	Quantum Physics
PHYSICS 115A	Statistical Physics
B. Complete one of the following series:	
PHYSICS 7C- 7LC- 7D- 7LD- 7E	Classical Physics and Classical Physics Laboratory and Classical Physics and Classical Physics Laboratory and Classical Physics
or	
PHYSICS 3A- 3B- 3LB- 3C- 3LC	Basic Physics I and Basic Physics II and Basic Physics Laboratory and Basic Physics III and Basic Physics Laboratory
C. Complete one of the following:	
PHYSICS 53	Introduction to C and Numerical Analysis
I&C SCI 45C	Programming in C/C++ as a Second Language
MATH 9	Introduction to Programming for Numerical Analysis
EECS 10	Computational Methods in Electrical and Computer Engineering
EECS 12	Introduction to Programming
D. Complete one of the following:	
PHYSICS 60	Thermal Physics
CHEM 1C	General Chemistry
CHEM H2C	Honors General Chemistry
CHEM M3C	Majors Quantitative Analytical Chemistry
ENGRMAE 91	Introduction to Thermodynamics
E. Complete six units of lower-division laboratory using any combination of the following courses:	
PHYSICS 52A- 52B- 52C	Fundamentals of Experimental Physics and Fundamentals of Experimental Physics and Fundamentals of Experimental Physics
CHEM 1LC- 1LD	General Chemistry Laboratory and General Chemistry Laboratory

CHEM H2LA- H2LB	Honors General Chemistry Laboratory and Honors General Chemistry Laboratory
CHEM M2LA- M2LB	Majors General Chemistry Laboratory and Majors General Chemistry Laboratory
CHEM 51LB- 51LC	Organic Chemistry Laboratory and Organic Chemistry Laboratory
CHEM H52LA- H52LB	Honors Organic Chemistry Laboratory and Honors Organic Chemistry Laboratory
CHEM M52LA- M52LB	Majors Organic Chemistry Laboratory and Majors Organic Chemistry Laboratory
ENGR 7A- 7B	Introduction to Engineering I and Introduction to Engineering II
EECS 70LA- 70LB	Network Analysis I Laboratory and Network Analysis II Laboratory
F. Complete eight units of upper-division laboratory using any combination of the following courses:	
PHYSICS 106	Laboratory Skills
PHYSICS 120	Electronics for Scientists
PHYSICS 121W	Advanced Laboratory
PHYSICS 139	Observational Astrophysics
PHYSICS 193	Research Methods
PHYSICS 196C	Thesis in Physics III
or one approved upper-division laboratory course outside of Physics	
G. Complete two units of writing communication from the following courses:	
PHYSICS 194	Research Communication for Physics Majors [1]
PHY SCI 139W	Technical Writing and Communication Skills
EDUC 143BW	Classroom Interactions II
or alternate upper-division writing course with department approval	
E. Complete 32 additional units of coherently-related electives in accord with the following rules:	
- Up to eight units may be lower-division electives in physics such as PHYSICS 20, PHYSICS 61B, or PHYSICS H90	
- Any upper-division physics courses PHYSICS 100-150	
- Any graduate level physics courses PHYSICS 200-299 with approval of the Department Undergraduate Advisor	
- Any combination of physics and non-physics courses pre-approved as a formal Concentration or Specialization	
- Any other combination of physics and non-physics courses approved by the Physics Department Undergraduate Committee.	

[1] PHYSICS 194 does not satisfy the University's upper-division writing requirement. It is a prerequisite course for PHYSICS 121W, which does satisfy the upper-division writing requirement.

NOTE: Students may not double major in Physics and Applied Physics.

Concentration in Biomedical Physics

The **Biomedical Physics Concentration** in Applied Physics is designed for the student who anticipates a career in physics applied to biology and medicine, such as health physics or radiological physics, or who intends to work in a scholarly field which deals with the physical aspects of biology or medicine, such as molecular biology or physiology. Completion of requirements for the Physics major is required, as are nine quarters of basic courses in biology and chemistry. Students who wish to follow the Biomedical Physics Concentration are advised to seek guidance early in their college careers. The requirements are such that coordination of a program in the second year is essential.

A. Complete the following:	
BIO SCI 97	Genetics
BIO SCI 98	Biochemistry
BIO SCI 99	Molecular Biology
B. Select one of the following:	
CHEM 1A- 1B- 1C	General Chemistry and General Chemistry and General Chemistry
or	

CHEM H2A- H2B- H2C	Honors General Chemistry and Honors General Chemistry and Honors General Chemistry
C. Select one of the following:	
CHEM 1LC- 1LD	General Chemistry Laboratory and General Chemistry Laboratory
or	
CHEM H2LA- H2LB	Honors General Chemistry Laboratory and Honors General Chemistry Laboratory
or	
CHEM M2LA- M2LB	Majors General Chemistry Laboratory and Majors General Chemistry Laboratory
D. Select one of the following:	
CHEM 51A- 51B	Organic Chemistry and Organic Chemistry
or	
CHEM H52A- H52B	Honors Organic Chemistry and Honors Organic Chemistry

Sample Program - Biomedical Physics Concentration in Applied Physics

Freshman		
Fall	**Winter**	**Spring**
CHEM 1A	CHEM 1B	CHEM 1C- 1LC
Sophomore		
Fall	**Winter**	**Spring**
CHEM 1LD	CHEM 51B	N/A
CHEM 51A		
Junior		
Fall	**Winter**	**Spring**
BIO SCI 97	BIO SCI 98	BIO SCI 99

Concentration in Engineering Physics

The **Engineering Physics Concentration** in Applied Physics is designed to provide appropriate education to students who anticipate a career in industrial or technological research. It combines the fundamental knowledge of physical processes obtained from physics courses with the technical knowledge obtained from engineering courses.

Students in the Engineering Physics Concentration must complete 32 units of coherently related electives, with at least 24 of these units from courses in the Henry Samueli School of Engineering. Students may propose any sequence for approval by the Department Undergraduate Advisor. Pre-approved courses include:

EECS 70A	Network Analysis I
EECS 70B- 70LB	Network Analysis II and Network Analysis II Laboratory
EECS 170A- 170LA	Electronics I and Electronics I Laboratory
EECS 170B- 170LB	Electronics II and Electronics II Laboratory
EECS 170C- 170LC	Electronics III and Electronics III Laboratory
EECS 174	Semiconductor Devices
EECS 188	Optical Electronics
ENGRMAE 120	Heat and Mass Transfer
ENGRMAE 130A	Introduction to Fluid Mechanics
ENGRMAE 147	Vibrations

Sample Program - Engineering Physics Concentration in Applied Physics

Junior		
Fall	**Winter**	**Spring**
N/A	EECS 70A	EECS 70B- 70LB
Senior		
Fall	**Winter**	**Spring**
EECS 170A- 170LA	EECS 170B- 170LB	PHYSICS 106
	EECS 188	EECS 170C- 170LC

Additional Information

Honors Program in Physics

The Honors Program in Physics provides an opportunity for selected students majoring in Physics or Applied Physics to pursue advanced work in one of the research areas of the Department. Admission to the program is based on an application normally submitted by the sixth week of the spring quarter of the junior year. Applicants must have an overall grade point average of at least 3.4 and a grade point average in physics courses of 3.5 or better. (Exceptions to these procedures and standards may be granted in unusual circumstances.) In selecting students for the program, the Department considers evidence of ability and interest in research.

Students admitted to the program participate in a year-long course, PHYSICS H196A-PHYSICS H196B-PHYSICS H196C, which includes two quarters of research and a final quarter in which a written thesis is submitted. If this work and the student's final GPA are deemed of honors quality by the program advisor, the student then graduates with Departmental Honors in Physics.

Planning a Program of Study

Physics 3 is a one-year course suitable for premedical students, students majoring in Biological Sciences, and nonscience majors. It surveys most of the important branches of physics. Laboratory work accompanies the course. Nonscience majors with some mathematical skill may wish to consider Physics 3 as an alternative to PHYSICS 12 through PHYSICS 21.

A student who decides to major in Physics after completing Physics 3 should meet with the Department Undergraduate Advisor for placement information.

Physics 7 is an intensive three-quarter course for students in Physical Sciences and Engineering who are interested in a more quantitative approach to introductory physics. Two units of laboratory work accompany the course.

Physics courses numbered between 12 and 21 are general education courses intended for nonscience majors. The content and format of PHYSICS 21 may vary from year to year.

The introduction to mathematical methods (MATH 2E, MATH 3A, MATH 3D, and PHYSICS 50), microscopic physics (PHYSICS 61A-PHYSICS 61B), and experimental physics (PHYSICS 52A-PHYSICS 52B-PHYSICS 52C) are normally taken in the sophomore year.

Courses numbered 100 and above are for Physics majors and other qualified students. Courses numbered between 111 and 115 emphasize the mathematical and theoretical structures that have unified our understanding of nature. It should be noted that multi-quarter courses such as 111A-B must be taken and passed in sequential order. Any student who is so inclined may take more than the minimum one quarter of advanced laboratory work. Courses numbered between 133 and 149 introduce active subdisciplines in current research. Independent research (PHYSICS 195, PHYSICS 196) is strongly encouraged. In PHYSICS 194, students learn the basics of writing about science, proper use of references and background material, presentation of research proposals, and more.

Transfer students are specifically advised to seek individual consultation with the Department Undergraduate Advisor before deciding on a program of courses.

All Physics and Applied Physics majors must complete the core courses listed with the sample programs. By the end of the junior year, each student is encouraged to select a concentration or track.

Note that alternatives to Physics major requirements can be approved upon petition to the Department and the Office of the Associate Dean. Furthermore, exceptionally prepared students are allowed to enroll in graduate-level courses; to do so requires the approval of the Department Undergraduate Advisor.

Sample Program — Physics Graduate School Track

Junior	
Fall	
PHYSICS 115A or 116	

Senior		
Fall	**Winter**	**Spring**
PHYSICS 113B	PHYSICS 113C	PHYSICS 115B
PHYSICS 115A or 116	Physics Elective	PHYSICS 125B
Physics Elective		Physics Elective

Students preparing for graduate school in atmospheric science or physical oceanography should complete the minor in Earth and Atmospheric Sciences.

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Graduate Program

The Department offers the M.S. and Ph.D. degrees in Physics. These degrees are awarded in recognition of demonstrated knowledge of the basic facts and theories of physics and of a demonstrated capacity for independent research. Active programs of research are underway in particle physics, nanophysics, biophysics, medical physics, condensed matter physics, low-temperature physics, plasma physics, gravitational physics, astrophysics, and cosmology.

In general, graduate study in the physics Ph.D. program is expected to be a full-time activity. Other proposed arrangements should be approved by the Graduate Committee. The normative time for completion of the Ph.D. is six years of full-time study, and the maximum time permitted is seven years. Students may pursue the M.S. degree on either a full-time or part-time basis.

Complementing the formal courses, the Department offers regular colloquia and informal seminars. Graduate students are members of an intellectual community and are expected to participate fully in departmental activities. Attendance at colloquia is considered an essential part of graduate study. In addition, there are regular weekly research seminars in condensed matter, particle, and plasma physics, and astrophysics.

Sources of support available to graduate students include teaching assistantships, research assistantships, and fellowships. Students planning to pursue graduate work in Physics should visit the Physics Department website (http://www.physics.uci.edu).

Students admitted into the graduate program in Physics and Astronomy may elect to pursue the M.S. or Ph.D. degree with a concentration in Chemical and Materials Physics, as described in a later section.

Master of Science in Physics

Requirements for the M.S. Degree:

All courses must be passed with a grade of B or better.

A. Three quarters of residence.	
B. Seven quarter courses including:	
PHYSICS 211	Classical Mechanics
PHYSICS 212A	Mathematical Physics
PHYSICS 213A	Electromagnetic Theory
PHYSICS 213B	Electromagnetic Theory
or PHYSICS 240C	Radiative Processes in Astrophysics
PHYSICS 214A	Statistical Physics
PHYSICS 215A- 215B	Quantum Mechanics and Quantum Mechanics
C. Two courses numbered between 200 and 259	
D. Two other courses approved by the graduate advisor	
E. Select Option A or Option B below:	
Option A. Research project and written thesis (three quarters)	
PHYSICS 295	Experimental Research
or PHYSICS 296	Theoretical Research
Option B. Comprehensive written examination	

PHYSICS 215B	Quantum Mechanics

The requirements for the M.S. degree with a concentration in Chemical and Materials Physics differ from these.

Doctor of Philosophy in Physics

The principal requirements for the Ph.D. degree are a minimum of six quarters of residence, passage of a written and an oral examination, and successful completion and defense of a dissertation reporting results of original research. In addition, the Ph.D. candidate must complete certain graduate course requirements. There is no foreign language requirement.

Course Requirements. Students are required to exhibit mastery of the basic sequences—Classical Mechanics, Electromagnetic Theory, Quantum Mechanics, Mathematical Physics, and Statistical Physics.

All courses must be passed with a grade of B or better.

Students who do not have a prior Master's degree (or other equivalent degree) in Physics from UCI or another institution must take a minimum of 11 quarter courses including:	
PHYSICS 211	Classical Mechanics
PHYSICS 212A	Mathematical Physics
PHYSICS 213A	Electromagnetic Theory
PHYSICS 213B	Electromagnetic Theory
or PHYSICS 240C	Radiative Processes in Astrophysics
PHYSICS 214A	Statistical Physics
PHYSICS 215A- 215B	Quantum Mechanics and Quantum Mechanics
and select at least two other courses numbered between 200 and 259;	
and select two other courses approved by the graduate advisor.	
or	
Students who have obtained a prior Master's degree (or other equivalent degree) in Physics from UCI or another institution:	
Take a minimum of 4 quarter courses including: two courses numbered between 200 and 259 and two other courses approved by the graduate advisor. These students are strongly encouraged to take the qualifying exam in the Fall quarter of entrance.	

Students are strongly encouraged to take PHYSICS 211, PHYSICS 212A, PHYSICS 213A, PHYSICS 214A, PHYSICS 215A-PHYSICS 215B, and either PHYSICS 213B or PHYSICS 240C in their first year of study. It is expected that students, having selected a research specialty, will ordinarily take the core courses in that subject in their second year of study. Students pursuing research in elementary particle physics ordinarily complete PHYSICS 234A-PHYSICS 234B-PHYSICS 234C and PHYSICS 235A-PHYSICS 235B during their second year. Students pursuing research in plasma physics ordinarily complete PHYSICS 239A during their first year and PHYSICS 239B-PHYSICS 239C-PHYSICS 239D their second year; PHYSICS 249 is also recommended. Students pursuing research in condensed-matter physics ordinarily take PHYSICS 238A-PHYSICS 238B-PHYSICS 238C during their second year; PHYSICS 133 should be taken in the first year by those students who have not had an equivalent course. Students pursuing research in astrophysics/cosmology ordinarily complete PHYSICS 240A during spring of their first year; PHYSICS 240B, PHYSICS 240C in their second year; and one or more of PHYSICS 241B, PHYSICS 241C, PHYSICS 241D in their second or subsequent years. Students interested in medical imaging should take PHYSICS 233A-PHYSICS 233B-PHYSICS 233C in the second year. Students pursuing research in biological physics should take PHYSICS 230A-PHYSICS 230B in the second year. Students who have earned grades of B or better in equivalent graduate-level courses prior to entering UCI may be exempted from required courses by the graduate advisor. Equivalency will be determined by the instructor of each course for which an exemption is sought.

NOTE: The requirements for the Ph.D. degree with a concentration in Chemical and Materials Physics (ChaMP) differ from these and are outlined in a later section.

Comprehensive Examination. Progress toward the degree is assessed by a written comprehensive examination covering a broad range of fundamentals of physics at the graduate and advanced undergraduate levels. It is offered twice a year, and a student is allowed a maximum of three attempts. The first attempt must occur before the end of the fall quarter of the student's second year, and the examination must be passed by the end of spring quarter of the student's second year.

Advancement to Ph.D. Candidacy. For advancement to Ph.D. candidacy, a student must pass an oral advancement examination. It is typically taken within one year of successful completion of the comprehensive examination. To satisfy normative progress toward the degree, it must be taken by the end of the student's third year. The candidacy committee that administers this examination will contain one or two faculty members from outside the Department. This oral examination will cover material principally related to the broad and general features of the student's dissertation area.

Teaching Program. Experience in teaching is an integral part of the graduate program, and all Ph.D. students are required to participate in the teaching program for at least one quarter during their graduate careers. All new teaching assistants are required to enroll in PHYSICS 269 and must pass in

order to be allowed to TA in future quarters. Students are required to enroll in PHYSICS 399 while serving as a TA. Lab TAs are required to enroll in PHYSICS 395 as well as PHYSICS 399.

Students who are not citizens from countries where English is either the primary or dominant language as approved by the UCI Graduate Council must pass either the Test of Spoken English (TSE) or the UCI SPEAK (Speaking Proficiency English Assessment Kit) examination. One of these tests must be passed before such a student can qualify for a teaching assistantship in order to fulfill the Department's teaching requirement. The Department expects one of these tests to be passed by the end of the student's second year at UCI.

Dissertation. A dissertation summarizing the results of original research performed by the student under the supervision of a doctoral committee, appointed by the Department Chair on behalf of the Dean of the Graduate Division and the Graduate Council, will be required for the Ph.D. degree. A criterion for the acceptability of a dissertation by the Department is that it be suitable for publication in a scientific journal. The dissertation must not have been submitted to any other institution prior to its submission to the UCI Physics and Astronomy Department.

Defense of Dissertation. Upon completion of the dissertation, the student will take an oral examination, open to the public, before the doctoral committee.

Concentration in Chemical and Materials Physics

This is an interdisciplinary program between condensed matter physics and physical chemistry, which is designed to eliminate the barrier between these two disciplines. Students with B.S. degrees in Physics, Chemistry, or Materials Science and Engineering, are encouraged to apply to the program. The goal of the concentration in Chemical and Materials Physics (ChaMP) is to provide students with a broad interdisciplinary education in the applied physical sciences that emphasizes modern laboratory and computational skills. The program accepts students for both the M.S. and the Ph.D. degrees. Upon admission to the program, students are assigned two faculty advisors, one from the Department of Physics and Astronomy, and one from the Department of Chemistry, to provide guidance on curriculum and career planning.

The curriculum for the M.S. program includes a summer session to assimilate students with different undergraduate backgrounds; formal shop, laboratory, and computational courses; a sequence on current topics to bridge the gap between fundamental principles and applied technology; and a course to develop communication skills. The required courses include thirteen core courses and three electives (subject to advisor approval) as follows:

Core	
CHEM 231A	Fundamentals of Quantum Mechanics
or PHYSICS 215A	Quantum Mechanics
CHEM 231B	Applications of Quantum Mechanics
or PHYSICS 215B	Quantum Mechanics
CHEM 231C	Molecular Spectroscopy
CHEM 232A- 232B	Thermodynamics and Introduction to Statistical Mechanics and Advanced Topics in Statistical Mechanics
PHYSICS 206	Laboratory Skills
PHYSICS 207	Chemistry for Physicists
PHYSICS 228	Electromagnetism
PHYSICS 229A	Computational Methods
PHYSICS 266	Current Topics in Chemical and Materials Physics
PHYSICS 273	Technical Communication Skills
or CHEM 273	Technical Communication Skills
Select one course from each of the following two groups:	
PHYSICS 133	Introduction to Condensed Matter Physics
or PHYSICS 238A	Condensed Matter Physics
PHYSICS 211	Classical Mechanics
or PHYSICS 222	Continuum Mechanics
Electives	
CHEM 213	Chemical Kinetics
CHEM 225	Polymer Chemistry: Synthesis and Characterization of Polymers
CHEM 232C	Non-Equilibrium Statistical Mechanics
CHEM 233	Nuclear and Radiochemistry
CHEM 243	Advanced Instrumental Analysis
CHEM 248	Electrochemistry
CHEM 249	Analytical Spectroscopy
EECS 285B	Lasers and Photonics
ENGRMSE 259	Transmission Electron Microscopy

PHYSICS 134A	Physical and Geometrical Optics
PHYSICS 229B	Computational Methods
PHYSICS 233A	Principles of Imaging
PHYSICS 233B	Techniques in Medical Imaging I: X-ray, Nuclear, and NMR Imaging
PHYSICS 238A	Condensed Matter Physics
PHYSICS 238B	Condensed Matter Physics
PHYSICS 238C	Condensed Matter Physics

In addition to the required courses, M.S. students complete a master's thesis. Students are required to advance to candidacy for the master's degree at least one quarter prior to filing the master's thesis. There is no examination associated with this advancement, but the thesis committee needs to be selected and appropriate forms need to be filed. The M.S. program prepares students to compete for high-tech jobs or to begin research toward a Ph.D. degree.

Successful completion of the M.S. degree requirements qualifies students for the Ph.D. program. Progress toward the Ph.D. degree is assessed by a written comprehensive examination administered in the summer after completion of the first year of study. This examination covers comprehensive knowledge acquired in course work, and the content of the examination depends upon the student's specific area of interest.

Participants in the Ph.D. program take an examination for formal advancement to candidacy. It is typically taken within one year of successful completion of the comprehensive examination. To satisfy normative progress toward the degree, it must be taken by the end of the student's third year. The examination is comprised of two parts: (a) a written report on a topic to be determined in consultation with the research advisor and (b) an oral report on research accomplished and plans for completion of the Ph.D. dissertation.

Faculty

Kevork N. Abazajian, Ph.D. University of California, San Diego, *Associate Professor of Physics and Astronomy*

Jun F. Allard, Ph.D. University of British Columbia, *Assistant Professor of Mathematics; Physics and Astronomy* (mathematical and computational biology)

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Enrico Gratton, Ph.D. University of Rome, *Professor of Biomedical Engineering; Developmental and Cell Biology; Physics and Astronomy* (design of new fluorescence instruments, protein dynamics, single molecule, fluorescence microscopy, photon migration in tissues)

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