Physics, Ph.D.

The Department offers and M.S. and a Ph.D. 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. 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. with a concentration in Chemical and Materials Physics, as described in a later section.

The principal requirements for the Ph.D. 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 and PHYSICS 235A-PHYSICS 235B, and take either PHYSICS 234C or PHYSICS 247 during their second year. Students pursuing research in plasma physics ordinarily complete PHYSICS 239A during their first year and PHYSICS 239B-PHYSICS 239C 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. 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 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. 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 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. 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.

The doctoral committee should be consulted on the proposed defense date one quarter in advance. At this stage, the doctoral committee should evaluate the preparedness of the student for the Ph.D. defense and provide appropriate feedback. This evaluation will typically include a review of the materials to be presented for the degree, such as published or submitted publications, drafts of planned submissions, or a detailed outline of the dissertation. A nearly final version of the dissertation should be shared with the committee at least one week prior to the scheduled defense.

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, Applied, 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 a B.S. in Physics, Chemistry, or Materials Science and Engineering, are encouraged to apply to the program. The goal of the concentration in Chemical, Applied, 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. 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. and Ph.D. programs 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 10 core courses and three electives (subject to advisor approval) as follows:

Core	
A. Complete:	
PHYSICS 206	Advanced Data Acquisition and Analysis
PHYSICS 207	Applied Physical Chemistry
PHYSICS 266	Current Topics in Chemical, Applied, and Materials Physics
B. Select one course from the following two Quantum Mechanics courses:	
CHEM 231A	Fundamentals of Quantum Mechanics

PHYSICS 215A	Quantum Mechanics
C. Select one course from the following ChAMP Chemistry courses:	
CHEM 231B	Applications of Quantum Mechanics
CHEM 231C	Molecular Spectroscopy
CHEM 263	Materials Chemistry
D. Select one course from the following Statistical Mechanics/Thermodynamics courses:	
CHEM 232A	Thermodynamics and Introduction to Statistical Mechanics
CHEM 232B	Advanced Topics in Statistical Mechanics
PHYSICS 214A	Statistical Physics
E. Select one course from the following Electromagnetism courses:	
PHYSICS 228	Electromagnetism
PHYSICS 213A	Electromagnetic Theory
F. Select one course from the following Computation/Machine Learning courses:	
PHYSICS 229A	Mathematical Methods for the Physical Sciences
PHYSICS 246	Special Topics in Astrophysics
CHEM 250	Computational Chemistry
G. Select one course from the following Communication courses:	
PHYSICS 273	Technical Communication Skills
PHY SCI 220	Science Communication Skills
PHYSICS 250	Physics and Astronomy Communications Skills
H. Select one course from the following ChAMP Physics courses:	
PHYSICS 133	Introduction to Condensed Matter Physics
PHYSICS 238A	Condensed Matter Physics
PHYSICS 239A	Plasma Physics
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
CHEM 267	Photochemistry
EECS 285B	Lasers and Photonics
ENGRMSE 259	Transmission Electron Microscopy
PHYSICS 134A	Physical and Geometrical Optics
PHYSICS 211	Classical Mechanics
PHYSICS 215B	Quantum Mechanics
PHYSICS 222	Continuum Mechanics
PHYSICS 230A	Biophysics of Molecules and Molecular Machines
PHYSICS 230B	Biophysics of Molecules and Molecular Machines
PHYSICS 238B	Condensed Matter Physics
PHYSICS 238C	Condensed Matter Physics
PHYSICS 239B	Plasma Physics
PHYSICS 239C	Plasma Physics
Electives may be chosen from other courses with the approval of the student's research advisor and ChAMP graduate advisor.	

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. The master's thesis requirement is waived for students who complete the requirements for advancement to Ph.D. candidacy.

Successful completion of the M.S. requirements may qualify students for the Ph.D. program. Progress toward the Ph.D. is assessed by a written comprehensive examination that is typically 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.

Concentration in Astronomy and Astrophysics

This program is focused on astronomical and astrophysical study and research. The course requirements are matched to excel in these disciplines. Students with a B.S. in Physics, Mathematics, Engineering, or other Physical Sciences are encouraged to apply to the program. The goal of the concentration in Astronomy and Astrophysics (A&A) is to provide students with a broad interdisciplinary education in the astronomical sciences that emphasizes modern computational and data analysis skills. The program accepts students for both the M.S. and the Ph.D. studies.

Requirements for the M.S.

The curriculum includes traditional astronomical courses; computational and data analysis courses; a research writing course to develop skills related to astronomical research and communication. The students are required to exhibit mastery of key concepts and demonstrate a clear understanding of astrophysical concepts.

A. Complete:	
PHYSICS 215A	Quantum Mechanics
PHYSICS 213A	Electromagnetic Theory
PHYSICS 240C	Radiative Processes in Astrophysics
PHYSICS 242	Astro Fundamentals
PHYSICS 250	Physics and Astronomy Communications Skills
B. Select six courses from the following list of electives, with at least two courses from PHYSICS 240A-PHYSICS 241E:	
PHYSICS 211	Classical Mechanics
PHYSICS 214A	Statistical Physics
PHYSICS 215B	Quantum Mechanics
PHYSICS 223	Machine Learning and Statistics
PHYSICS 234A	Elementary Particle Physics
PHYSICS 234B	Advanced Elementary Particle Physics
PHYSICS 235A	Quantum Field Theory
PHYSICS 235B	Advanced Quantum Field Theory
PHYSICS 239A	Plasma Physics
PHYSICS 240A	Galactic Astrophysics
PHYSICS 240B	Cosmology
PHYSICS 241A	Solar System and Extrasolar Planets
PHYSICS 241B	Stellar Astrophysics
PHYSICS 241C	Extragalactic Astrophysics
PHYSICS 241D	Early Universe Physics
PHYSICS 255	General Relativity
C. 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 examination in the astronomy and astrophysics concentration	

Three quarters of residence are required.

Students interested in astro-particle physics, theoretical cosmology, and early universe physics are advised to take PHYSICS 215B as the first elective during the winter quarter of first year of study. More advanced electives can be chosen in consultation with the Program Director and/or research advisor.

Students interested in observational astronomy and experimental cosmology are advised to take the astronomy series beginning with either PHYSICS 240A and PHYSICS 241C. More advanced electives can be chosen in consultation with the Program Director and/or research advisor.

Requirements for the Ph.D.

The principal requirements for the Ph.D. are a minimum of six quarter 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.

Students who do not have a prior Master's degree (or other equivalent degree) in Physics or Astronomy from UCI or another institution must take a minimum of 11 quarter courses. The required courses include five core courses and six electives as follows:

A. Complete:	
PHYSICS 215A	Quantum Mechanics
PHYSICS 213A	Electromagnetic Theory
PHYSICS 240C	Radiative Processes in Astrophysics
PHYSICS 242	Astro Fundamentals
PHYSICS 250	Physics and Astronomy Communications Skills
B. Select six courses from the following, with at least two courses from PHYSICS 240A-PHYSICS 241E	
PHYSICS 211	Classical Mechanics
PHYSICS 214A	Statistical Physics
PHYSICS 215B	Quantum Mechanics
PHYSICS 223	Machine Learning and Statistics
PHYSICS 234A	Elementary Particle Physics
PHYSICS 234B	Advanced Elementary Particle Physics
PHYSICS 235A	Quantum Field Theory
PHYSICS 235B	Advanced Quantum Field Theory
PHYSICS 239A	Plasma Physics
PHYSICS 240A	Galactic Astrophysics
PHYSICS 240B	Cosmology
PHYSICS 241A	Solar System and Extrasolar Planets
PHYSICS 241B	Stellar Astrophysics
PHYSICS 241C	Extragalactic Astrophysics
PHYSICS 241D	Early Universe Physics
PHYSICS 255	General Relativity

Three quarters of residence are required. All courses must be passed with a B or better.

Students interested in astroparticle physics, theoretical cosmology, and early universe physics are advised to take PHYSICS 215B as the first elective during the winter quarter of the first year of study. More advanced electives can be chosen in consultation with the Program Director and research advisor.

Students interested in observational astronomy and experimental cosmology are advised to take the astronomy series beginning with either PHYSICS 240A or PHYSICS 241C. More advanced electives can be chosen in consultation with the Program Director and research advisor.

Students who have obtained a prior Master's degree (or other equivalent degree) in Physics and/or Astronomy from UCI or another institution must take a minimum of four courses from the Concentration, including two core courses among the five required, and two courses from the list of 16 electives with at least one from the PHYSICS 240 or PHYSICS 241 series. Students who have taken four or five of the core courses, or their equivalent, elsewhere in the process of earning their Master's will be required to replace them with one or two additional electives, respectively, in consultation with their research advisor.

Progress toward the Ph.D. is assessed by a comprehensive examination usually taken during the second year of studies. The comprehensive examination covers broad knowledge in astronomy and astrophysics, based on a written project of a topic in astronomy and astrophysics chosen by the Program Director in consultation with the Departmental Committee on Astrophysics Qualifying Exam, and an oral examination of the written document by a committee.

Participants in the Ph.D. program also 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 an oral report on research accomplished and plans for completion of the Ph.D. dissertation.