APPLIED PHYSICS

Courses offered by the Department of Applied Physics are listed under the subject code APPPHYS on the Stanford Bulletin's ExploreCourses web site.

The Department of Applied Physics offers qualified students with backgrounds in physics or engineering the opportunity to do graduate course work and research in the physics relevant to technical applications and natural phenomena. These areas include accelerator physics, biophysics, condensed matter physics, nanostructured materials, quantum electronics and photonics, quantum optics and quantum information, space science and astrophysics, synchrotron radiation and applications.

Student research is supervised by the faculty members listed above and also by various members of other departments such as Biology, Chemistry, Electrical Engineering, Materials Science and Engineering, Physics, the SLAC National Accelerator Laboratory, and faculty of the Medical School who are engaged in related research fields.

Research activities are carried out in laboratories including the Geballe Laboratory for Advanced Materials, the Edward L. Ginzton Laboratory, the Hansen Experimental Physics Laboratory, the SLAC National Accelerator Laboratory, the Center for Probing the Nanoscale, and the Stanford Institute for Materials and Energy Science.

The number of graduate students admitted to Applied Physics is limited. Applications to the Master of Science and Ph.D. programs should be received by December 12, 2017. M.S. and Ph.D. students normally enter the department only in Autumn Quarter.

Graduate Programs in Applied Physics

The Department of Applied Physics offers three types of advanced degrees:

- the Doctor of Philosophy
- the coterminal Master of Science in Applied and Engineering Physics
- the Master of Science in Applied Physics, either a terminal degree or an en route degree to the Ph.D. for students enrolled in the Applied Physics Department

Admission requirements for graduate work in the Master of Science and Ph.D. programs in Applied Physics include a bachelor's degree in Physics or an equivalent engineering degree. Students entering the program from an engineering curriculum should expect to spend at least an additional quarter of study acquiring the background to meet the requirements for the M.S. and Ph.D. degrees in Applied Physics.

Learning Outcomes (Graduate)

The purpose of the master's program is to further develop knowledge and skills in Applied Physics and to prepare students for a professional career or doctoral studies. This is achieved through completion of courses, in the primary field as well as related areas, and experience with independent work and specialization.

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research and analysis in Applied Physics. Through completion of advanced course work and rigorous skills training, the doctoral program prepares students to make original contributions to the knowledge of Applied Physics and to interpret and present the results of such research.

Coterminal Master of Science in Applied and Engineering Physics

Stanford undergraduates, regardless of undergraduate major, who are interested in a M.S. degree at the intersection of applied physics and engineering may choose to apply for the coterminal Master of Science program in Applied and Engineering Physics. The program is designed to be completed in a fifth year at Stanford. Students with accelerated undergraduate programs may be able to complete their B.S. and coterminal M.S. in four years.

Application and Admission

Undergraduates must be admitted to the program and enrolled as a graduate student for at least one quarter prior to B.S. conferral. Applications will be due on the last day of class of the Spring Quarter for Autumn matriculation and at least four weeks before the last day of class in the previous quarter for Winter or Spring matriculation. All application materials must be submitted directly to the Applied Physics department office by the deadlines. To apply for admission to the Applied and Engineering Physics coterminal M.S. program, students must submit the coterminal application which consists of the following:

- Application for Admission to Coterminal Master's Program (https://registrar.stanford.edu/students/coterminal-degree-programs/applying-coterm)
- Statement of Purpose
- Unofficial Transcript
- Two Letters of Recommendation from members of the Stanford faculty
- Supplemental Form (http://www.stanford.edu/dept/app-physics/cgi-bin/aep-application-process)

University Coterminal Requirements

Coterminal master's degree candidates are expected to complete all master's degree requirements as described in this bulletin. University requirements for the coterminal master's degree are described in the "Coterminal Master's Program (http://exploredegrees.stanford.edu/cotermdegrees)" section. University requirements for the master's degree are described in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/#masterstext)" section of this bulletin.

After accepting admission to this coterminal master's degree program, students may request transfer of courses from the undergraduate to the graduate career to satisfy requirements for the master's degree. Transfer of courses to the graduate career requires review and approval of both the undergraduate and graduate programs on a case by case basis.

In this master's program, courses taken three quarters prior to the first graduate quarter, or later, are eligible for consideration for transfer to the graduate career. No courses taken prior to the first quarter of the sophomore year may be used to meet master's degree requirements.

Course transfers are not possible after the bachelor's degree has been conferred.

The University requires that the graduate adviser be assigned in the student's first graduate quarter even though the undergraduate career may still be open. The University also requires that the Master's Degree Program Proposal be completed by the student and approved by the department by the end of the student's first graduate quarter.

Program Requirements

Coterminal M.S. students are required to take 45 units of course work during their graduate career. Of these 45 units, the following are required.

		Units
Four Breadth Courses (required)		
APPPHYS 201	Electrons and Photons	4
APPPHYS 203	Atoms, Fields and Photons	4
APPPHYS 204	Quantum Materials	4
APPPHYS 205	Introduction to Biophysics	4
Three Engineering Depth Courses		9
At least one must be at the 300 level and the other courses must be at the 200 level or above to provide depth in one area. To be approved by the Applied Physics academic adviser.		
One Laboratory or Methods Course		3-4
APPPHYS 207	Laboratory Electronics	
APPPHYS 208	Laboratory Electronics	
APPPHYS 215	Numerical Methods for Physicists and Engineers	
APPPHYS 217	Estimation and Control Methods for Applied Physics	
APPPHYS 232	Advanced Imaging Lab in Biophysics	
EE 234	Photonics Laboratory	
EE 251	High-Frequency Circuit Design Laboratory	
EE 312	Integrated Circuit Fabrication Laboratory	
ENGR 341	Micro/Nano Systems Design and Fabrication	
ENGR 342	MEMS Laboratory II	
MATSCI 322	Transmission Electron Microscopy Laboratory	
MATSCI 331	Atom-based computational methods for materials	
Seminar [1]		3
Approved Technical Electives [2]		6-12
6 units minimum that brings up the total units to 45		
Total Units		45

1 The seminar requirement can be fulfilled by either (i) taking one formal seminar course for credit each term, and/or (ii) enrolling in Applied Physics 290 and attending a minimum of 8 informal talks or formal research seminars during each of the three terms. Students enrolling in Applied Physics 290 must submit with their final M.S. program proposal a list of the 8 talks/seminars with a paragraph describing the content, signed by their academic adviser.

2 These include APPPHYS, CS, CME, EE, ME, BIOE, MATSCI, PHYSICS courses (see http://www.stanford.edu/dept/app-physics/cgi-bin/academic-programs/) as well as those courses that are formally approved by the Applied Physics Graduate Studies Committee through petition.

Any request for a course transfer from the undergraduate career is subject to approval of the undergraduate and graduate departments.

Master of Science in Applied Physics

The University's basic requirements for the master's degree are discussed in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin. The minimum requirements for the degree are 45 units, of which at least 39 units must be graduate-level courses in applied physics, engineering, mathematics, and physics. The required program consists of the following:

		Units
Advanced Mechanics		3
Select one of the following:		
PHYSICS 210	Advanced Mechanics	
PHYSICS 211	Continuum Mechanics (approved substitute)	
Electrodynamics		3
PHYSICS 220	Classical Electrodynamics	
Quantum Mechanics		6
Select two of the following:		
PHYSICS 230	Graduate Quantum Mechanics I	
PHYSICS 231	Graduate Quantum Mechanics II	
EE 222	Applied Quantum Mechanics I (approved substitute)	
EE 223	Applied Quantum Mechanics II (approved substitute)	
PHYSICS 234	Advanced Topics in Quantum Mechanics (approved substitute)	
PHYSICS 330	Quantum Field Theory I (approved substitute)	
PHYSICS 331	Quantum Field Theory II (approved substitute)	
PHYSICS 332	Quantum Field Theory III (approved substitute)	

		Units
APPPHYS 290	Directed Studies in Applied Physics	
1-unit seminar courses		
Examples of suitable courses include:		
EE 222	Applied Quantum Mechanics I	
EE 223	Applied Quantum Mechanics II	
EE 236A	Modern Optics	
EE 236C	Lasers	
EE 332	Laser Dynamics	
EE 346	Introduction to Nonlinear Optics	
PHYSICS 372	Condensed Matter Theory I	
PHYSICS 373	Condensed Matter Theory II	

1. Courses in Physics and Mathematics to overcome deficiencies, if any, in undergraduate preparation.
2. Basic graduate courses (letter grade required):
   - 33 units of additional advanced courses in science and/or engineering. May be any combination of APPPHYS 290 Directed Studies in Applied Physics, any 1-unit course, and regular courses. At least 18 of these 33 units must be taken for a letter grade. 15 of these 18 units must be at the 200-level or above. Only 6 units below the 200-level are permitted without approval by the Applied Physics Graduate Study Committee.
3. A final overall grade point average (GPA) of 3.0 (B) is required for courses used to fulfill degree requirements.

There are no department nor University examinations. There is no thesis component. If a student is admitted to the M.S. program only, but later wishes to change to the Ph.D. program, the student must apply to the department's admissions committee.

Doctor of Philosophy in Applied Physics

The University's basic requirements for the Ph.D. including residency, dissertation, and examinations are discussed in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin. The program leading to a Ph.D. in Applied Physics consists of course work, research, qualifying for Ph.D. candidacy, a research progress report, a University oral examination, and a dissertation as follows:

1. *Course Work:*

		Units
Statistical Physics		3-4
Select one of the following: [1]		
APPPHYS 217	Estimation and Control Methods for Applied Physics	

APPPHYS 315	Methods in Computational Biology	
PHYSICS 212	Statistical Mechanics	
Electrodynamics [1]		3
PHYSICS 220	Classical Electrodynamics	
Quantum Mechanics		3
Select one of the following: [1]		
PHYSICS 230	Graduate Quantum Mechanics I	
PHYSICS 231	Graduate Quantum Mechanics II	
EE 222	Applied Quantum Mechanics I (approved substitute)	
EE 223	Applied Quantum Mechanics II (approved substitute)	
PHYSICS 234	Advanced Topics in Quantum Mechanics (approved substitute)	
PHYSICS 330	Quantum Field Theory I (approved substitute)	
PHYSICS 331	Quantum Field Theory II (approved substitute)	
PHYSICS 332	Quantum Field Theory III (approved substitute)	
Laboratory		3-4
Select one of the following: [2]		
APPPHYS 207	Laboratory Electronics	
APPPHYS 208	Laboratory Electronics	
APPPHYS 232	Advanced Imaging Lab in Biophysics	
BIOE 370	Microfluidic Device Laboratory	
EE 234	Photonics Laboratory	
EE 312	Integrated Circuit Fabrication Laboratory	
MATSCI 171	Energy Materials Laboratory	
MATSCI 172	X-Ray Diffraction Laboratory	
MATSCI 173	Mechanical Behavior Laboratory	
PHYSICS 301	Astrophysics Laboratory	

1 Additional courses to fulfill this requirement are being reviewed by the department curriculum committee and will be added here when they have been approved.

2 Students who took APPPHYS 304 or APPPHYS 305 in previous years may also count these courses towards this requirement.

a. Courses in Physics and Mathematics to overcome deficiencies, if any, in undergraduate preparation.
b. *Basic graduate courses:* These requirements may be totally or partly satisfied with equivalent courses taken elsewhere, pending the approval of the graduate study committee. Letter grades required for all courses:
c. 18 units of additional advanced courses in science and/or engineering. At least one course in each of two areas other that those of the student's research specialization is required. Only 3 units at the 300 or above level may be taken on a satisfactory/no credit basis. Units fromAPPPHYS 290, APPPHYS 390, and any 1-unit courses do not count towards this requirement. Examples of suitable courses include:

		Units
EE 222	Applied Quantum Mechanics I	3
EE 223	Applied Quantum Mechanics II	3
EE 236A	Modern Optics	3
EE 236C	Lasers	3
EE 332	Laser Dynamics	3
EE 346	Introduction to Nonlinear Optics	3
PHYSICS 372	Condensed Matter Theory I	3
PHYSICS 373	Condensed Matter Theory II	3

d. Additional units of courses as needed to meet the minimum residency requirement of 135. Directed study and research units as well as 1-unit seminar courses can be included.
e. A final average overall grade point average (GPA) of 3.0 (B) is required for courses used to fulfill degree requirements.
f. Students are normally expected to complete the specified course requirements by the end of their third year of graduate study.

2. *Research:* may be conducted in a science/engineering field under the supervision of a member of the Applied Physics faculty or appropriate faculty from other departments.
3. *Ph.D. Candidacy:* satisfactory progress in academic and research work, together with passing the Ph.D. candidacy qualifying examination, qualifies the student to apply for Ph.D. candidacy, and must be completed before the third year of graduate registration. The examination consists of a seminar on a suitable subject delivered by the student before the faculty academic adviser (or an approved substitute) and two other members of the faculty selected by the department.
4. *Research Progress Report:* normally before the end of the Winter Quarter of the fourth year of enrollment in graduate study at Stanford, the student arranges to give an oral research progress report of approximately 45 minutes, of which a minimum of 15 minutes should be devoted to questions from the Ph.D. reading committee.
5. *University Ph.D. Oral Examination*: consists of a public seminar in defense of the dissertation, followed by private questioning of the candidate by the University examining committee.
6. *Dissertation:* must be approved and signed by the Ph.D. reading committee.

Emeriti: (Professors) Malcolm R. Beasley, Arthur Bienenstock, Alexander L. Fetter, Theodore H. Geballe, Stephen E. Harris, Walter A. Harrison, Peter A. Sturrock, Yoshihisa Yamamoto; (Professors, Research) Calvin F. Quate, Helmut Wiedemann, Herman Winick; (Courtesy) Gordon S. Kino, Douglas D. Osheroff

Chair: Martin M. Fejer

Professors: Steven M. Block, Philip H. Bucksbaum (on leave Autumn), Robert L. Byer, Sebastian Doniach (on leave Spring), Martin M. Fejer, Daniel S. Fisher, Ian R. Fisher, Tony F. Heinz, Harold Y. Hwang, Aharon Kapitulnik, Mark A. Kasevich, Young S. Lee, Hideo Mabuchi, Kathryn A. Moler, Vahé Petrosian, Stephen R. Quake, Zhi-Xun Shen, Yuri Suzuki

Associate Professors: Benjamin L. Lev, David A. Reis, Mark J. Schnitzer (on leave Autumn, Winter)

Assistant Professors: Surya Ganguli, Amir H. Safavi-Naeini

Professor (Research): Michel J-F. Digonnet

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Adjunct Professors: Thomas M. Baer, Raymond G. Beausoleil, John D. Fox, Richard M. Martin