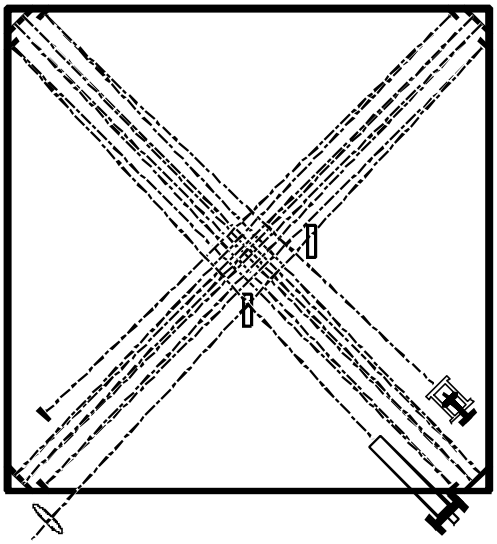
Case Western Reserve University
Graduate Programs in Physics



Schematic representation of the Michelson-Morley experiment, performed on the CWRU campus in 1887. A.A. Michelson was awarded America's first Nobel Prize in Physics in 1907. (Am. J. Sci. — Third Series, Vol. 34, No. 23, November 1887)

Overview

The graduate student in physics has two primary responsibilities: to broaden and deepen his or her own understanding of physics, and to contribute in a significant way to the progress of physics as a research discipline. Neither of these efforts can be completely separated from the other. Your understanding of physics is necessarily reflected in your research: your research will help to deepen your understanding of physics. However, the relative emphasis gradually shifts during graduate study from early concentration on formal course work to the original research necessary for a Ph.D. dissertation.

At Case Western Reserve University, the formal requirements for the Ph.D. degree are a course requirement, a qualifying examination, and a dissertation requirement. Exceptions to these departmental requirements are possible, and individual requests for changes will be carefully considered. There is no foreign language requirement.

Although most students apply to the department's Ph.D. program, the department maintains a Master's degree program as well. This program involves fewer courses than the Ph.D. program, and may or may not involve a dissertation, depending upon the student's needs and interests. Requirements for this program are outlined in this brochure.

The Department has inaugurated a new Master's track in Physics Entrepreneurship. This program, directed at students with a background in physics and a vision for new and growing ventures, is designed to empower physicists as entrepreneurs with the skill to start new high tech businesses and grow them successfully. The requirements for this Master's track are also outlined in this brochure.

Rev. 6/00

Requirements for Graduation

Requirements for the Ph.D. degree include coursework, the Ph.D. qualifying examination, a topical oral examination, and submission and defense of a written thesis

Requirements for the Master's degree include coursework, a comprehensive examination, and an optional thesis.

Requirements for the Master's degree, Entrepreneurship Track, include coursework, a qualifying examination, and a required thesis.

Required Courses for Ph.D. Degree

The following courses are required of all Ph.D. degree candidates. Credit for courses taken at other institutions may be given at the discretion of the Graduate Committee. Proficiency credit for any of the required graduate courses can be established by passing the final examination in that course with a grade of B or better.

Phys 581	3 hours	Quantum Mechanics III
Phys 441	3 hours	Physics of Condensed Matter I
Phys 451	3 hours	Empirical Foundations of the Standard Model I
Phys 442 *or* 591	3 hours	Physics of Condensed Matter II *or* Gauge Field Theory I
Phys 472	3 hours	Graduate Physics Laboratory
	6 hours	Advanced graduate courses

Although there is no formal requirement of introductory courses for the Ph.D., it is expected that most students will need courses in the material on which the qualifying examination is based: Quantum Mechanics I & II; Classical Electromagnetism; and Classical and Statistical Mechanics I & II. A student with a good background in undergraduate physics, but no exposure to graduate level courses, would normally take the following schedule of courses:

	Fall	*Spring*
1st year	Quantum Mechanics I	Quantum Mechanics II
	Classical Electromagnetism	Graduate Physics Laboratory
	Classical and Statistical Mechanics I	Classical and Statistical Mechanics II
2nd year	Quantum Mechanics III	Advanced Course
	Physics of Condensed Matter I *or* *Empirical Foundations of the Standard Model I*	Physics of Condensed Matter II *or* *Gauge Field Theory I*
3rd year	Advanced Course	
	Empirical Foundations of the Standard Model I, *or* *Physics of Condensed Matter I*	

The sequence in block letters (Condensed Matter I & II and Standard Model I) is intended primarily for students interested in condensed matter physics, and the sequence in italics (Standard Model I, Gauge Field Theory I, and Condensed Matter I) is intended for those interested in nuclear, particle, and astrophysics. Additionally, as the Physics of Condensed Matter sequence and the Standard Model/Gauge Field Theory sequence are offered in alternate years, the second and third year courses may be interchanged.

The classroom lecture courses will be augmented by official reading courses, which will have specified syllabi (published in the catalogue and monitored by the Graduate Committee), graded homework, and final examinations. Courses in special topics, as well as individualized study, can be arranged by mutual consent when the demand is sufficient.

Required Courses for Master's Degree

The requirements for the M.S. degree depend on whether or not the candidate completes the research and writing for a Master's thesis.

Program A: M.S. with thesis:

Quantum Mechanics I	3 hours
Classical Electromagnetism	3 hours
Thesis Research	6 to 9 hours
Other courses	15 to 12 hours, of which at least 6 must be in physics
Thesis and oral defense	

Program B: M.S. without thesis:

Quantum Mechanics I	3 hours
Classical Electromagnetism	3 hours
Other courses	21 hours, of which at least 9 must be in physics
Comprehensive examination	

The 27 hours of required courses can generally be completed in three semesters, though thesis research and writing may take longer. Candidates must be in residence (paying tuition) in the semester in which they complete requirements and receive the degree; applications should be filed early in the third semester. Candidates for the Ph.D. degree may apply for and receive M.S. degrees on the basis of work completed for the Ph.D. degree.

Required Courses for Master's Degree, Entrepreneurship Track

The requirements for the Master's degree, Entrepreneurship Track, are as follows:

Modern Physics for Innovation I	3 hours
Modern Physics for Innovation II	3 hours
New Venture Creation	3 hours
Technology Entrepreneurship	3 hours
Technical Elective	3 hours
Restricted Elective	3 hours
Thesis work	9 hours

The program is nominally a two year program.

Ph.D. Qualifying Examination and Master's Comprehensive Examination

The Ph.D. qualifying examination is based on advanced undergraduate material and that covered in the introductory courses: Quantum Mechanics I & II; Classical Electromagnetism; and Classical and Statistical Mechanics I & II. Additionally, written material from the graduate laboratory course and undergraduate courses (such as relativity) may be incorporated into the qualifying exam. A normally prepared student will be expected to take the qualifying examination in May at the end of the first year of graduate study. Students who fail the first time will speak with the chair of the qualifying committee and Director of Graduate Studies to ascertain if there is a disconnect between knowledge and performance on the exam. They will discuss with the student how best to maximize the chance of passing on the student's second attempt, generally in mid to late

August. For students not passing the second time, the chair of the qualifying committee and Director of Graduate Studies will discuss the student's plans for leaving the program, or for the unusual possibility of a third exam.

Program B candidates for the Master's degree (*not* Entepreneurship Track) must complete a comprehensive examination. This examination is identical to, and offered the same time as, the Ph.D. qualifying examination. The passing grade for the Master's exam is set lower than the passing grade for the Ph.D. qualifying examination. Students who fail the first time will be allowed a second opportunity in August. Under special circumstances, students may be given an oral examination instead of a written exam.

The Ph.D. qualifying and Master's comprehensive examination consists of a written one-day examination. Several months in advance of the date for the qualifying examination a written announcement is made which gives more specific details about the forthcoming examination. Previous examinations are on file and available to students.

The qualifying exam for the Physics Entrepreneurship Programp is a distinct exam, reflecting the distinctive character of the program.

Admission to Ph.D. Candidacy

A student will be admitted to Ph.D. candidacy upon passing the qualifying exam *and* upon a vote of the faculty to determine whether the student is making satisfactory academic progress.

Topical Oral Exam

Within one year of formal association with a research advisor (see next section), each student will have an oral examination of her/his research progress with the dissertation committee. The examination will consist of a presentation by the student relating to literature in her/his thesis topic, a proposed direction for work, and a progress report. Passing this examination is a requirement for the Ph.D. degree.

Advising

Upon entry to graduate school the Master's and Ph.D. student's academic advisor will be the department's Director of Graduate Studies. Eventually, each successful student will acquire a research advisor and dissertation committee. At that time the responsibility of the Director of Graduate Studies will greatly diminish, but not vanish entirely. It will remain the Graduate Studies Director's responsibility to assist the research advisor in academic matters. The Director of Graduate Studies, as well as the research advisor, will countersign the student's course program. It is the responsibility of the Director of Graduate Studies to follow the career of the student and see that all requirements for the degree are fulfilled.

The Director of the Physics Entrepreneurship Program will be the academic advisor for the student's in the Entrepreneurship Track of the Master's program. Each successful student will also acquire a research advisor and thesis committee, which will meet with the student at least once per semester. It is the responsibility of the Director of the Physics Entrepreneurship Program to follow the career of the students in this track and see that all requirements for the degree are fulfilled.

Ph.D. Research and Dissertation

A Ph.D. degree implies, in addition to the course and qualifier requirements, the performance of a piece of original research and its presentation as a doctoral dissertation. The research requirement for the Ph.D. is at the heart of the doctoral program. The final requirement for the Ph.D. degree is the written doctoral dissertation and oral defense.

Entering students should interest themselves in the available research possibilities in this department at an early state of their careers. They should be thinking about the area of interest, the kind of problem they would like to tackle, and the faculty member under whose direction they would like to work. As soon as they have passed the qualifier, they should devote themselves more and more to research.

By January or February of the first year the student should begin to speak with faculty members about their research, and ultimately find a faculty member who will sponsor and supervise the student's work. The relationship between a student and research advisor is a very close one. It is in the course of this relationship that students develop their skills in the actual doing of physics. Students should give much thought to their choice of research area and research advisor. Once a student has made this commitment, it takes the highest priority. Students must understand that they are unlikely to bring their thesis research to a successful conclusion without a total commitment on their part. Our policy on financial support of graduate students reflects the importance of such a commitment. Renewal of a student's support will be contingent upon evidence of progress toward a degree.

Colloquia and Seminars

In addition to course work and individualized direction in research, the Physics Department provides a third medium of teaching, one which is shared by students and faculty alike.

Colloquia are talks of a general nature, given at a level that all graduate students in all areas of physics should be able to follow. They are usually held on Thursdays. Notices (and whenever possible brief introductions to the subject) will be distributed well in advance of each colloquium. Graduate students are urged and expected to attend all of these colloquia. (All graduate students are required to register each semester for the zero credit-hour course "Frontiers in Physics," PHYS 666, which consists of attendance at colloquia).

Seminars tend to deal more narrowly with specific topics, and often require some expertise in the field. Some groups hold weekly luncheon seminars; others meet whenever a speaker is available. Advanced students are expected not only to attend, but to participate in the seminars in their fields. Students who have not yet chosen a field of research may find the seminars a valuable means of sampling the types of research available. Students in the Entrepreneurship Track are expected to attend all of that Program's seminars, and are encouraged to attend other relevant seminars.

Policy on Working outside the Department

The teaching and research assistantships represent a rich and exciting experience and a total time commitment on the part of both the graduate student and his or her advisor. It is generally not advisable for a student to accept other employment or non-family responsibilities, inside or outside of the department or university. If a student nevertheless desires an additional position, written approval must first be obtained from the student's advisor, and a petition then made to the Graduate Committee. Prior approval of the committee is required in order to avoid a possible reduction or termination in assistantship financial support.

A variety of special circumstances may arise in the case of students in the Entrepreneurship Track. Oversight will be provided by the Physics Entrepreneurship Committee, and approval of the Director of the Physics Entrepreneurship Program Director is required.