

# Comparison of Qualifying Exams Between Leading Universities

MIT Physics Graduate Student Council

## Introduction

The following is a brief review of the written and oral examination requirements for Ph.D. candidacy at MIT and ten other top physics departments (according to the 2005 US News and World Report rankings). Coursework requirements have also been included for completeness, though only to assess them in relation to examinations. No claim of exact accuracy is made with regard to the course requirements; specifically, information such as teaching and research seminars may have been omitted. Also not always explicitly included are the number of attempts allowed per exam, the dates and number of times per year that tests are offered, the term schedule of the university, and student teaching requirements.

We have referred to written exam questions as either “short form” or “long form.” “Short form” is to be understood as the typical MIT Part I questions—single part questions that are answered in about fifteen minutes. “Long form” questions are multipart and answered in at least a half-hour, and typically longer (75 minutes for MIT’s Part II questions).

The categories for each of the universities below are “written” for the written exam requirements, “oral” for the oral exam requirements, and “courses” for the coursework requirements.

This information has been compiled using information available on physics departments’ websites and from personal correspondence with faculty and students.

## Massachusetts Institute of Technology

### Written

There are two components to the written examination, typically taken at different times. Part I is a five-hour test composed of twenty “short form” questions and tests the standard undergraduate curriculum of mechanics, electrodynamics, quantum mechanics, and thermodynamics/statistical mechanics. Also included is basic undergraduate material such as optics and special relativity. Part II is a five-hour exam composed of eight questions. Each student is required to choose four, one in each of the four previously mentioned areas. The Part II questions are “long form.”

### Oral

There is a Part III oral examination given by a committee within each student’s division. The examination tests students’ “broad general knowledge within their field.” Typically, the student is given a topic a week before the exam, about which he or she gives a short talk. Following, the committee asks questions about the presentation and about the student’s general field. The Part III subject areas are astrophysics, atomic/optical physics, biophysics, condensed matter experiment, condensed matter theory, nuclear and particle experiment, nuclear theory, particle theory, plasma physics, and quantum information.

### Courses

Students are required to take two basic one-semester subjects in their research specialty (three in Nuclear and Particle Theory). In addition, students must complete two breadth requirement subjects, outside of their specialty areas. The list of acceptable courses for each is extensive.

## California Institute of Technology

### Written

Upon entering, incoming students are given placement exams (which have no further bearing on their graduate career) as a guideline for selecting courses. There are two qualifying examinations, given concurrently. The first covers “mostly classical mechanics and electrodynamics” (including special relativity, basic optics, basic continuum physics), and the second covers “mostly quantum and statistical mechanics.” Information on the specific form of the questions could not be obtained. (Apparently only three exams exist. They are cycled through and are confidential.)

### Oral

There is an oral candidacy exam in which a student presents his or her thesis topic.

### Courses

Two terms of “physics seminar” are required, which seems to be an introduction to department research and faculty. A student also needs to take a one-quarter course in six of eight categories (elementary particle physics, nuclear physics, atomic/molecular/optical, condensed matter, gravitational, astrophysics, mathematical physics and interdisciplinary physics).

## Harvard University

### Written

None

### Oral

There is a qualifying oral examination in which a student must select, prepare, discuss, and answer questions on some specific topic and closely related problems.

### Courses

Eight courses are required, at least four of them being physics courses. These must be of “suitable depth and breadth.”

## Princeton University

### Written

The Princeton written examination is extensive and consists of the following:

1. Part I : A three hour exam on mechanics and electromagnetism
2. Part II: A three hour exam on quantum mechanics, and statistical mechanics/thermodynamics
3. Part III: A three hour exam on condensed matter and elementary particle physics
4. Part IV: A three hour exam on relativity (special and general) and general and atomic physics

All questions are “long form,” consisting of three or four questions answered per exam, with some choice (examples appended). It seems that the “prelim” components (Parts I-II) are typically taken at different times than the “advanced” ones (III-IV).

## **Oral**

There are two oral components of the general examination. A student must complete an experimental project, and then pass an oral examination covering the material. There is also a pre-thesis project, done in a student's area of interest. The final product is a written report and an oral defense.

## **Courses**

A student needs to pass three courses out of the "core requirements," which seem to be courses tested by the advanced part of the general examination.

## **Stanford University**

### **Written**

There is a written examination of "long form" questions covering mechanics, statistical mechanics, electromagnetism, quantum mechanics, general physics, and special relativity (example appended). The exam is taken over the course of two days.

### **Oral**

There is an oral thesis proposal.

### **Courses**

Required courses are advanced particle mechanics/continuum mechanics, statistical mechanics, classical electrodynamics I and II, quantum mechanics I and II, research activities at Stanford (a review of the departmental research activities) and a teaching of physics seminar. In addition, students must take at least one course from two breadth areas.

## **University of California, Berkeley**

### **Written**

There are two preliminary examinations of six hours each, divided into classical and modern physics. There are no available example questions.

### **Oral**

There are two oral examinations associated with the written preliminary examination, again divided into classical and modern physics. One passes all four components (oral/written, modern/classical) together. The oral component emphasizes the student's ability to analyze physical situations rather than perform specific calculations. There is also a separate qualifying oral examination, which covers the student's research field and related areas.

### **Courses**

Electrodynamics, statistical mechanics, and quantum mechanics are required. Five semester-long upper level courses (selected from an extensive list), are also required.

## **Cornell University**

### **Written**

None

## Oral

There is an oral qualifying examination taken by the end of the third semester. This exam covers the usual basic physics canon. There is also an ACE (admission to candidacy exam) that covers more specialized topics. This exam is conducted by a “special committee” and may be oral, written, or both written and oral. Our understanding is that it is almost always oral.

## Courses

The only required class is a graduate lab, although each student has a “special committee” that oversees course development. The committee makes sure that the student has command of a sufficient amount and breadth of course material.

## University of Chicago

### Written

There is one exam, given in two six-hour sessions. Students are allowed to have one sheet of notes, and they are also provided with a sheet of constants and conversion factors. The exams (example appended) are typical “long form.” The material covered seems to be the usual canon, along with perhaps basic special relativity, particle physics, and experimental physics (though this may not be complete, as only one example is available).

### Oral

None

### Courses

An experimental laboratory class is required. There are six breadth classes required, four from pre-designated areas (condensed matter, particle, and “large scale” physics).

## University of Illinois at Urbana-Champaign

### Written

There is a qualifying examination that is administered in two evening sections. Each section covers (one question each) classical mechanics (including relativity), electrodynamics, quantum mechanics and thermodynamics/statistical mechanics. Though each student gets two attempts at the exam, he has the option of a “free shot” upon entering. A student is allowed to bring an integral table. Style of the questions is typical “long form” (examples appended).

### Oral

There is a report/oral thesis proposal.

### Courses

There are two breadth requirements, chosen from the following list: subatomic physics, theoretical astrophysics, biomolecular physics, emergent states of matter, and condensed matter physics.

## Columbia University

### Written

The examination is three parts; each part is four hours long. Part I is classical physics (mechanics, electrodynamics), Part II is modern physics (quantum mechanics and relativity), and Part III is general physics (thermodynamics, high energy physics, astrophysics, atomic, nuclear, and condensed matter physics). All three parts are taken together. No sample questions are available, but the style is “long form,” with eight questions per exam.

### Oral

There is an oral component of the general exam, which is the Wednesday of the week following the written exam (the last component of which is given on Friday). The exam may focus on general physics or specific questions from the written exam. One can generally overcome a poor performance on one or two of the components by doing well on the oral exam.

### Courses

Students must take quantum mechanics I and II, electromagnetic theory, statistical mechanics, and either the classical theory of waves or quantum field theory I. There are also two “specialty requirements” chosen from one’s field.

## University of California, Santa Barbara

### Written

None

### Oral

There is an Advancement to Candidacy Exam, usually taken in the third year. It is a presentation in which the student assesses the overall situation in the field and proposes a possible line of research. The exam committee may then ask more general background questions.

### Courses

Required courses are classical mechanics, electromagnetism, quantum mechanics, and statistical mechanics. There are also three or five advanced courses required (theoretical or experimental, respectively), at least one of which must be taken from outside of one’s area.