

# PH.D. REQUIREMENTS IN THE DEPARTMENT OF PHYSICS AND ASTRONOMY

Completion of the Ph.D. requires (1) completion of 72 semester hours of coursework with satisfactory grades in each course and an overall average of **B** (3.00) or higher; (2) successfully passing a Qualifying Examination administered by a committee of the Graduate Faculty; and (3) writing and defending the dissertation. The dissertation is to be an original, publishable contribution to the scientific literature in the student's field of specialization, and must be defended in a public forum. The following paragraphs provide details.

## 1. Course Requirements

The Graduate School requires a total of 72 hours of course credits prior to receiving the Ph.D. The Department of Physics and Astronomy requires 36 hours of formal course work<sup>1</sup> including:

- Seven core courses covering the foundations of physics or astronomy, listed below, totaling 19 credit hours;
- Two graduate-level courses totaling 6 or more hours in the Department but outside the student's field of specialization ("breadth courses"); and
- Additional graduate-level courses in any subject relevant to the student's overall program of graduate study and research to make a total of 36 semester-hours.

Core courses provide the foundation for deeper connections to elective course-work and research. Students in the Vanderbilt Physics and Astronomy Ph.D. program may choose to concentrate in either physics or astronomy; the core requirements for each concentration are listed below. To fulfill the core-course requirement, the student must pass the seven core courses with a grade-point average of B (3.00) or higher, and may not receive a grade of B- in more than one of those seven courses. A student who has an overall B average but receives a B- or lower grade in two courses must retake one of those two courses and earn a grade of B or higher to replace that one B- or lower grade. Students who fail to satisfy the core course requirement because of low grades may be dropped from the program at the discretion of the Graduate Program Committee.

### 1A. TRANSFER CREDIT

Students who have taken graduate courses elsewhere may petition the Graduate Program Committee to have those courses evaluated for transfer credit to avoid unnecessary duplication and speed the student's entry into research. In order to transfer any number of core courses for credit, transfer students must take any one of the three-credit core courses offered at Vanderbilt and earn a grade of A- or better.

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<sup>1</sup> The Graduate School requires only 24 semester-hours of formal coursework. The Departmental requirement is higher because of the number and breadth of core courses required to prepare properly for a career in physics or astronomy.

## 1B. PHYSICS CORE COURSE REQUIREMENTS

Students concentrating in physics must complete the following courses in the first two years of graduate study:

- **Physics 300:** Research Seminar
- **Physics 305:** Classical Mechanics
- **Physics 329a:** Electrodynamics I
- **Physics 330a:** Quantum Mechanics I
- **Physics 341:** Statistical Mechanics
- **Physics 329b:** Electrodynamics II
- **Physics 330b:** Quantum Mechanics II

## 1C. ASTRONOMY CORE COURSE REQUIREMENTS

Students concentrating in astronomy must complete these courses in the first two years of graduate study:

- **Physics 300:** Research Seminar
- **Physics 305:** Classical Mechanics
- **Physics 329a:** Electrodynamics I
- **Physics 330a:** Quantum Mechanics I
- **Physics 341:** Statistical Mechanics
- **Astro 352:** Stellar Astrophysics
- **Astro 310:** Radiative Processes in Astrophysics

## 1D. BREADTH COURSES AND ELECTIVES

Two “breadth courses” are required of all students. These are physics or astronomy electives outside the student’s field of specialization. The chart in Appendix A shows the courses that count for students pursuing any of the five research concentrations available in the Department. The remaining 36 hours of required course work may be filled from any set of graduate-level courses appropriate for the student’s program.

## 2. The Qualifying Examination

To be considered a candidate for the doctoral degree and be eligible to register for dissertation research credits (PHYS 399), students have to pass the Qualifying Examination. According to the Graduate School bulletin,

the purpose of the Qualifying Examination is to test the student’s knowledge of the field of specialization, to assess familiarity with the published research in the field, and to determine whether the student possesses those critical and analytical skills needed for a scholarly career. (page 58)

The Qualifying Examination is administered by the Ph.D. committee, and only the committee members and the student are present. Passing the Qualifying Examination marks the student’s formal entry into dissertation research under the supervision of her/his thesis advisor and the Ph.D. committee.

## 2A. PH.D. COMMITTEE

The Ph.D. committee administers the Qualifying Examination and monitors the student's progress towards the completion of the thesis. The committee comprises at least four members of the Graduate Faculty. The composition of the committee is proposed by the advisor in consultation with the student and must be approved in writing by the Director of Graduate Studies to ensure breadth and level of expertise. At least one member of the committee be from outside the Department or program in which the student plans to do her/his dissertation research.

## 2B. PREPARING FOR THE QUALIFYING EXAMINATION

The Qualifying Examination in the Department is normally taken during the fifth semester and in no case later than the sixth semester.<sup>2</sup> By Graduate School rules, students taking the qualifying exam must have completed all requirements for formal course work (Section 1), must have a GPA of 3.0 or better in all courses taken for credit. The required 36 hours of graduate work may include research hours (PHYS 379). The steps needed to prepare for the Qualifying Examination are:

- The student selects a faculty Ph.D. supervisor at least one semester before an anticipated Qualifying Examination date. The student and the advisor agree on the other members of the Ph.D. committee. The student then contacts members of the committee to ascertain their willingness to serve and to set a date for the Qualifying Examination. The student is advised that getting a committee of five faculty persons to be available simultaneously in time and space is not a trivial task!
- Once the composition of the Ph.D. committee is decided and all the proposed committee members have agreed to serve, the **advisor** completes the "Request to Appoint Committee" form (Appendix B) to the DGS for approval and notification of the Graduate School. This form should be submitted **by the advisor** no later than three weeks before the proposed date for the Qualifying Examination, since the Graduate School issues the notice of the Examination at least two weeks in advance.
- One month before the Qualifying Examination the student and the committee meet to discuss the Examination. During this meeting, the student and the committee agree on the general scope of the examination, including the sub-fields of physics to be covered, the background in computational, experimental and theoretical techniques to be assumed, and the format of the Examination.
- *At least* one week before the Qualifying Examination, the student distributes a 15-25 page written report to the committee members. The report is to be written in the form of a camera-ready scientific review paper, and should include a descrip-

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<sup>2</sup> The Graduate School requirement is that the Qualifying Examination must be passed by the end of the 8th semester, but postponing it is too late to permit completion of an acceptable dissertation project in the desired time frame of approximately five years.

tion of the research field, an assessment of the current state of knowledge with citations to the relevant literature, and a description of any preliminary research carried out by the student. Examples of appropriate papers are available from the secretary to the Graduate Program Committee.

## 2C. THE QUALIFYING EXAMINATION

At the beginning of the Qualifying Examination, the student gives a presentation about a half hour in duration that demonstrates his/her knowledge of the research field and its current directions. Copies of the presentation must be made available to the committee members at least one working day before the examination. Committee members ask questions both during and after the presentation that probe the student's basic knowledge of this research field and her/his grasp of the important contemporary research issues that motivate research in that field. By rule of the Graduate School, attendance at the Qualifying Examination is limited to only the Ph.D. committee members and the student.

The committee will decide within one day whether or not the student has passed the Qualifying Examination. Within one week, the committee will provide a written report to the student and to the GPC describing the student's performance on the examination. Even if the student was judged to have passed the examination, the report should address any deficiencies in preparation that were evident during the examination. If the student was judged to have failed the examination, the report should note the serious deficiencies that caused this failure; the committee may also offer their judgment on whether retaking the examination would be in the best interest of the student. A second attempt at passing the Qualifying Examination must be completed within four months of the first attempt. By Graduate School rule, only two attempts are allowed for passing the Qualifying Examination.

## 3. The Ph.D. Dissertation

### 3A. PROPOSAL FOR THE PH.D. DISSERTATION

After passing the Qualifying Examination, the student is officially admitted to candidacy for the Ph.D. He/she will develop a topical focus for the Ph.D. dissertation grounded in the subfield chosen for that Examination. The dissertation topic should be an original research proposition that advances the frontiers of science in the field of specialization. While consultation with the advisor will be crucial to this process, it is to be emphasized that *the proposal for the dissertation is the responsibility of the student*. Within two semesters of passing the Qualifying Examination, the student will present a specific proposal to the Ph.D. committee; the proposal should contain at the minimum a chapter-by-chapter outline of the dissertation, a report on research already carried out, and a specific plan for completing the remainder. As a general rule, students should plan to complete the dissertation within three years of passing the Qualifying Examination, so that the dissertation can be submitted five to six years after entering the Graduate School. By Graduate School rule, all requirements for the degree of Doctor of Philosophy must be completed within four years of passing the Qualifying Examination.

### 3B. ANNUAL MEETINGS OF THE PH.D. COMMITTEE

After the dissertation topic is approved, the student will meet with the Ph.D. committee at least annually to report on research completed to date, publications planned or in progress, and an estimate of the time, resources and analysis required to complete the dissertation project. The committee members may ask questions, critique the work presented by the student, or make suggestions about the project. The Chair of the Ph.D. committee (usually the Ph.D. advisor) is responsible for preparing a brief written report of the meeting that will be sent to the candidate and to the Director of Graduate Studies. This report may also be reviewed by the Graduate Program Committee as it monitors student progress.

### 3C. PUBLICATION REQUIREMENTS

The research in any dissertation project is expected to contribute measurably to scientific progress in the field of specialization, thus publication in peer-reviewed journals is an essential component of the Ph.D. research program. While the venue, number and timing of publications varies according to subfield, students should expect to play a major role in a first paper no later than the end of the third year of graduate study. By the time the dissertation is completed, the student must present to the Ph.D. committee at least one paper that has been accepted in a peer-reviewed journal. The Ph.D. committee may make an exception when the student is a member of a large collaboration that has long lead-times for publication. In such cases, the student must present a manuscript that has been approved by the appropriate review committee for submission to a refereed journal. The Ph.D. committee is responsible for verifying that the number and quality of the student's publication record is appropriate for the field of specialization.

### 3D. COMPLETION OF THE DISSERTATION AND THE PH.D. DEFENSE

The *Graduate School Bulletin* and the Graduate School Web site give the essential information about the format of the Ph.D. dissertation and the defense. The defense is a public examination, and should be characterized by a spirited scientific debate on the strengths and weaknesses of the thesis presented by the student. In addition, the Department stipulates the following:

- The **Ph.D. advisor** will inform the Dean of the Graduate School at least two weeks in advance of the date and place of the defense, so that the event can be published in the Vanderbilt University electronic calendar. The Department administrative staff will advertise the dissertation title, and the date and place of the defense in order to promote attendance by faculty, research staff and other students.
- The **Ph.D. candidate** must present a complete copy of the thesis to the committee members *at least* two weeks before the defense. *This is both a Departmental and Graduate School requirement.*
- At the defense, the candidate will present the critical points of the dissertation for no more than 45 minutes; during this presentation, questioning will be generally restricted to matters of clarification. After the presentation is finished, questioning by attendees other than the Ph.D. committee will be permitted for about half an hour.

- After the public questioning is concluded, the Committee will continue the questioning of the candidate in executive session for approximately an hour. The Committee will then caucus in private to evaluate the defense and assign a grade.

The possible grade outcomes for the defense are (1) pass, (2) pass conditional upon changes made to the dissertation recommended by members of the committee, or (3) fail. In case (2) the committee may grant discretion to the principal advisor to enforce the changes to be made to the thesis recommended by the committee. The members may sign the paperwork certifying completion of a passing dissertation, but the advisor will submit the committee's report to the Graduate School only after the changes made are satisfactory in the opinion of the advisor.

**Core, Trans-Core and Breadth Course Selection — August 2008**

		Core Courses			Electives	nucl/part	Available breadth courses			
		Physics	Astrophys				bio	cmo	astro	medical
303	Experimental Nuclear Physics						x	x	x	x
305	Particle and Continuum Mechanics	x	x							
306	Biomolecular Physics				x			x	x	
308	Mathematical Methods of Physics			x						
325	Physical Measurements on Bio Systems				x			x	x	
329a	Advanced Electrodynamics I	x	x							
329b	Advanced Electrodynamics II	x		x						
330a	Quantum Mechanics I	x	x							
330b	Quantum Mechanics II	x		x						
333a-d	Theoretical Physics Seminar									
340a-b	Nuclear and Heavy-Ion Theory				0/x	x	x	x	x	
341	Statistical Mechanics	x	x							
343	High-Performance Computing			x						
350	Selected Topics in Theoretical Physics									
351a-d	Special Topics in Particle Physics				x/0	x	x	x		
354	Condensed Matter Theory				x	x		x		
356	Biophysical Electrodynamics				x		x	x		
357	Photons, Atoms, Molecules and Solids				x	x		x	x	
358	Electromagnetic Spectroscopy				x	x		x	x	
359	Nanoscale Condensed-Matter Physics				x	x		x	x	
360a	General Relativity				x	x	x	x	x	
360b	Cosmology				x	x	x		x	
361	Nonlinear Dynamics			x						
365	Many-Body Quantum Mechanics			x						
370a-b	Quantum Field Theory			x						
A310	Radiative Processes		x		x	x	x		x	
A322	Observational and Computational Astro				x	x	x		x	
A352	Stellar Astrophysics		x		x	x	x		x	
A353	Structure and Dynamics of Galaxies				x	x	x		x	
A354	Structure Formation in Universe				x	x	x		x	
A355	Order-of-Magnitude Astrophysics				x	x	x		x	