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PHYSICS
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Physics Graduate (Ph.D.) Handbook

**BIGGER QUESTIONS
BETTER ANSWERS
BEAR DOWN**



THE UNIVERSITY
OF ARIZONA
ARIZONA.EDU/BEARDOWN

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This handbook covers requirements specific for the UA Physics Department. For any UA Graduate College rules and regulations you should consult: grad.arizona.edu and/or grad.arizona.edu/current-students and links therein.

Ph.D. Degree Requirements

1. COURSE WORK

What are the credit hour minimum requirements?

36 in the Physics major (or cross-listed) graduate-level courses

9 in the minor field (which also may be Physics)

18 Dissertation credits (PHYS 920)

At least 50% of the course work in major and minor need to be regularly (A, B...) graded.

Are there any required core courses? No, the core courses are strongly recommended for all students regardless of research direction, but are not required. However, the Comprehensive Examination is based upon the core courses.

PHYS 511 Analytical Mechanics

PHYS 515A/B Electromagnetic Theory

PHYS 570A/B Quantum Mechanics

PHYS 528 Statistical Mechanics

The material studied in the above courses represents what we expect every student to master. However, depending upon student preparation we may recommend to individual students that they take other courses.

For how many credit hours do I need to register each semester? Prior to passing the written portion of the Comprehensive Examination, students are required to take 9 credits per semester. After that, only 6 credits per semester are required.

What is the recommended curriculum?

Year 1, Fall semester: PHYS 570A (QM I), PHYS 511 (CM), PHYS 599

Year 1, Spring semester: PHYS 570B (QM II), PHYS 515A (EM I), PHYS 599

Year 2, Fall semester: PHYS 528 (SM), PHYS 515B (EM II), PHYS 599

What is PHYS 599? PHYS 599 is Independent Study, giving you the opportunity to engage in research with a group or individual faculty immediately after you have entered the program. The Independent Studies are meant for you to explore research areas or groups that you may be considering for your Ph.D. thesis.

Note that no more than half of the 36 required credit hours of graduate-level Physics courses may be taken as PHYS 599. Remaining courses consist of the core courses listed above as well as more advanced specialty courses.

I've entered the Ph.D. program with an MS degree. Can I transfer credits? Yes, you may be able to do so. The DGS will review credits you wish to transfer. Please provide: a detailed list of courses, credits or credit hours for each course, textbook used, grades received, and a syllabus (if available). For Graduate College regulations on transfer of credit visit grad.arizona.edu.

When can I start to register for thesis credits (PHYS 920)? Students may register for PHYS 920 only after they have passed both portions (written and oral) of the Comprehensive Examination. Note that you cannot register for more than 9 PHYS 920 credits per semester.

If I choose Physics as my minor, which courses should I take? If Physics is chosen as the minor as well as the major, the minor requirement is fulfilled by 9 additional credits consisting of at least 3 graduate-level courses. Together, these 3 courses should provide at least three credits from each of 3 of the following eight areas. Courses below are listed merely as examples, and additional courses (including courses from outside the Physics Department) may be considered as part of these areas with the approval of the Director of Graduate Studies.

Classical Mechanics and Mathematical Physics: 513, 541, 575, 576

Atomic, Molecular and Optical Physics: 535, 544(Op.Sci.), 642(Op.Sci.), 648(Op.Sci.)

Condensed Matter Physics: 505, 560A, 560B, 561, 562, 563, 564, 566

Quantum and Particle Physics: 579A, 579B, 581, 584A, 584C

Nuclear Physics: 551, 552

Gravity, Astrophysics and Cosmology: 571, 577, 582, 587, 589, 596b, 596F

Experimental Physics: 505, 545, 573, 574, 586, 685

Biological Physics: 531

It is expected that this minor requirement be satisfied through actual courses rather than Independent Studies. However, exceptions can be granted in special situations.

What if I decide to do my minor in another department? Students choosing a minor in a different department must satisfy whatever minor course requirement(s) that other Department demands. In some cases the minor requirements may include you having to take the Comprehensive Exam in that department. Before you decide on a minor in a department other than Physics, please notify the Director of Graduate Studies (DGS) in Physics and inquire with the DGS in the other department about their minor requirements.

Note that the Graduate College requires you to have **a representative of the minor department on your committee for the Oral portion of the Comprehensive Exam.**

How long is this all going to take? Most of our students graduate during their 5th or 6th year here. Upon entering your 6th year the DGS may request a detailed plan/timeline for completion of the Ph.D..

2. THE COMPREHENSIVE EXAMINATION (WRITTEN AND ORAL PORTION)

2.1 WRITTEN PORTION

What topics does the exam cover? This exam covers classical mechanics, quantum mechanics, electromagnetism, and statistical mechanics at the graduate level. Courses that prepare you for this exam are PHYS 511—Classical Mechanics; PHYS 570A/B—Quantum Mechanics; PHYS 515A/B—E&M; and PHYS 528—Statistical Mechanics.

What is required to pass the written comp? Students need to pass all, 4 out of 4, subjects in order to pass at the **PhD** level. Passing 3 out of 4 subjects is considered a pass for a terminal MS degree.

What is the exam format? Each semester there will be an opportunity to sit for 4 exam subjects: Classical Mechanics, Quantum Mechanics, Electromagnetism, and Statistical Mechanics. Different subject exams are administered on different days (see below): one exam subject per day.

When are the subject exams offered?

Fall semester : Wk 1, Wk 2 ,Wk 3, Wk 4, Fridays 10am- 1pm (one subject per Friday)
Spring semester : Wk 6, Wk 7, Wk 8, Wk 9 Fridays 10am- 1pm (one subject per Friday)
Times are subject to change depending upon classes/labs/TA responsibilities etc.

When should I take the exam? You can start taking exam subjects immediately after you have arrived here. The recommended exam schedule is tied to core courses offerings:

Core Curriculum

Semester 1, Fall : CM, QM1
Semester 2, Spring : QM2, EM1
Semester 3, Fall : EM2, SM

Written Comp Subjects

CM (Spring, semester 2)
QM (Fall, semester 3)
EM, SM (Spring, semester 4)

How do I register for the exam? Exam sessions are announced each semester for the following semester, at which time you are being asked by email to register for the exam with the Graduate Coordinator (gklueders@email.arizona.edu).

Can I practice with previous exams? Yes, consult the senior graduate students and/or the Graduate Coordinator for access to previous exams.

How long is the written portion of the exam? 4 subjects; 3 hr exam per subject.

How are the exams graded? Grading is anonymous, *i.e.* grading faculty do not know the identity of the student. To avoid grading/interpretation errors etc, each problem is independently graded by two faculty members who then have to come to an agreement on the final grade for that problem.

Do I have access to the final graded exam? No. Keep in mind that the faculty and department have no interest in failing you unnecessarily.

What is the pass level per subject? Exams are designed assuming a 50% passing level. However, the precise pass level is set by the faculty after the exams have been graded and evaluated by the entire faculty.

How many attempts am I allowed? Unlimited, but students have to have passed all subjects **by the end of their third academic year**. To address special cases a student can petition faculty for an exemption (but this expected to be rare, and not automatically granted).

For students enrolled Fall 2015 or before:

- **Students who enrolled in Fall 2015** are expected to adopt the new format, but since they missed one exam opportunity (Spring 2016), they are expected to pass in their 7th and not their 6th semester here.
- **Students who enrolled before Fall 2015 and have attempted the old-format exam one time and did not pass the exam** will adopt the new format, but are expected to pass at the Spring 2017 exam dates at the latest (equivalent of 3 attempts in the old format).
- **Students who enrolled before Fall 2015 and have not sat yet for the written comp by May 2016**, should adopt the new format, and are expected to pass at the Fall 2017 exam dates at the latest (the equivalent of 3 attempts in the old format).
- **Students who already took the “old-format” exam**, did not pass the exam, are expected to continue in the new format. However, if these students passed individual physics subjects as part of the old exam format, then they may count these passes towards the new format exam. So if you passed for example CM in the old comp, we consider that a pass for CM in the new format. **Current students who took the old format exam and did not pass should come see me (before classes end in Spring 2016) so I can inform you about which subject you have passed.**
- It is not our intention to unnecessarily cause hardship or fail students. So, if you feel you will fall through the cracks somehow, please let us know ASAP, so we can take appropriate action.

Can I try again if I switch from Ph.D. to Master? Change in degree goal (*e.g.* from Ph.D. to MS) shall not entitle a student to additional attempts at the Written Comprehensive Exam; thus the scores from the same two attempts shall be used for determining eligibility for either the M.S. or Ph.D. degree.

What if I fail my attempts? A student who does not pass the written portion of Comprehensive Exam at the Ph.D. level but who completes all other requirements for a Master Degree (MS) may obtain a Master Degree if the student has passed *3 out of 4 subjects*.

2.2 ORAL PORTION

When do I take the oral portion of the exam? Within 6 months of successful passage of the written portion. Once you have found a suitable time to meet with your committee for the exam, make sure you submit the Oral Exam announcement form on GradPath (grad.arizona.edu/GradPath) 4 weeks before the exam so that our advisor may submit the result after the exam.

Who and how many faculty are on my committee? Together with your research advisor you choose 5 committee members (including the advisor). The majority of the committee members should have an appointment in Physics. The makeup of this committee shall conform to all regulations of the Graduate College.

Important note when your minor is NOT in Physics: you need to make sure that there is a representative of the minor department on your committee during the oral portion of the comprehensive exam.

Make sure to submit the committee form on GradPath well ahead of the exam (at least 4 weeks).

Following the comprehensive exam the committee will meet yearly with the student to evaluate progress towards the degree.

What is the format of the exam? The oral part of the comprehensive exam asks students to defend their **proposed** Ph.D. research to the student's intended **Ph.D. thesis committee** in a well prepared presentation (~45 minutes), which then is to be followed (and/or interspersed) with general Physics questions geared towards the research topic. Note: it is not necessary that you already have done parts of the research (although many students will have done so). You need to be able to defend a proposal for research. Therefore delaying your oral exam beyond the 6 months period in order to complete a research project (or part thereof) is not acceptable.

How long is the exam: The duration of the Oral Exam shall not be less than one hour or exceed three hours.

Is there anything I need to do before I meet with my committee for the exam? Yes, students will supply committee members with a short 1 page description of the research project (5 working days in advance of the exam). It is also advised you inquire if any of your committee members who are not closely related to your area of research wish to meet with you in advance so they may be introduced to your research (You are likely to have done so already when you assembled your committee).

What if I fail? Students shall be allowed a maximum of 2 attempts at passing the oral portion of the Comprehensive Exam, but shall not change the composition of the committee, except with the permission of the Director of Graduate Studies.

3. BETWEEN ORAL AND PH.D. DEFENSE: SATISFACTORY PROGRESS

I have completed all course requirements, Written and Oral Comprehensive Exams, and 18 dissertation units, can I register for less than 6 credits? If you have completed all course requirements, the written and oral portion of the Comprehensive Exam, and the 18 thesis credits you may register for 1 credit to maintain continued enrollment. However, certain rules apply. For example, for students holding teaching or research assistantships/associateships, the minimum enrollment required is 6 graduate units. Visa issues may apply for international students. Please consult: <http://grad.arizona.edu/academics/policies/enrollment-policies/minimum-enrollment> and <http://grad.arizona.edu/academics/policies/enrollment-policies/continuous-enrollment> for details and make sure to confirm with Gardie Lueders, our Graduate Coordinator (gklueders@email.arizona.edu).

Finding a thesis director. Starting no later than the fourth semester, each graduate student must have a substantive affiliation with a Ph.D. or research group and be making demonstrable progress towards the completion of the Ph.D. degree.

Yearly report of your progress. Once students have passed their Comprehensive Exam, they are required to meet yearly with their Ph.D./Oral Exam committee and give a short (~15 minutes) seminar to report on progress made. Students have to bring the report form, <http://w3.physics.arizona.edu/sites/default/files/forms/GradStudentProgressReport.pdf>, to this meeting. At the time of signing your TA or RA contract, it will be checked if you are in compliance. If not, contract signing will be delayed until a committee meeting date (within 4 weeks of contract signing) has been set. If necessary, the student may consult with the Director of Graduate Studies or the Graduate Coordinator, if special circumstances exist.

Changing research direction. While students remain free to change Ph.D.s or alter the direction of their research program, there must be constant, forward progress towards the Ph.D. degree. Maintaining active status in the Ph.D. program shall be contingent on continuing satisfactory progress.

What happens if research progresses slowly? Note that according to Graduate College regulations, students who do not complete all requirements for the Ph.D. within five years of passing the Comprehensive Exam will be required to retake the Comprehensive Exam, with the permission of the Physics Department. In such situations, students are strongly encouraged to consult the Director of Graduate Studies to see if waivers can be granted. You should also check the Graduate College website for any recent changes in policies.

Alternatively, in some cases the 10-year rule can be applied, in which case graduation should occur within 10 years of having started in the degree program.

4. THE DISSERTATION DEFENSE

Ph.D. students are required to defend their dissertation in an oral examination before their degree can be granted.

When am I ready to defend my thesis? This examination is distinct from the Comprehensive Exam and occurs at the end of the dissertation work, by mutual agreement between the student and the dissertation director. In the rare occasion that such agreement cannot be reached, please contact the DGS. The DGS will then contact the dissertation director as well as the committee to whom you reported your yearly progress in order to resolve the issue.

I have no publications. Can I defend my thesis? Almost all students graduate with either published work, or work submitted for publications. However, the Ph.D. program does not require a minimum number of publications as this may vary strongly among the different Physics disciplines. Your dissertation director and thesis committee will advise you about their expectations for publications. Note that publications are of the utmost importance for a post-doctoral academic career.

The Ph.D. Thesis Committee. The makeup of this committee shall conform to all regulations of the Graduate College (see <http://grad.arizona.edu>), and consist of a minimum of five members primarily of the faculty in the Physics Department. Exceptions are possible when students perform research in a department other than Physics. However, at all times a majority of the committee needs to hold an appointment in Physics. It is advised that this committee is identical or similar in make-up to the Oral Comprehensive Exam Committee that also monitors your yearly progress towards the degree.

Time-critical events before the exam takes place:

At least **4 weeks** before your planned date of the thesis defense you must:

- 1) check if your plan-of-study has been approved and is up to date in GradPath,
- 2) submit the Doctoral Dissertation Committee form in GradPath,
- 3) submit the planned date of the defense to the Graduate College in GradPath,
- 4) reserve a room for the defense (for PAS 218 see the Physics front office).

At least **2 weeks** before the exam: your committee receives a copy of your thesis.

One week before the exam: email an announcement with time and place of your defense to the Physics Department.

Archiving your dissertation:

We are happy to inform you that the Graduate College will no longer assess any fees for students to archive their dissertations and theses upon completion of their degree programs. In the past, these fees were charged to doctoral students at the time they advanced to doctoral candidacy. The submission process is explained in detail at <http://grad.arizona.edu/gsas/dissertations-theses/submitting-your-dissertation>.

All doctoral dissertations are available to the public through the UA Campus Repository <http://arizona.openrepository.com/arizona/handle/10150/129651> and available through ProQuest's Dissertations and Theses subscription database (subject to any restrictions requested by the students).

Please direct any questions to Mike Renning in the Graduate Student Academic Services office: mrenning@grad.arizona.edu or 621-9227.

5. DOCTORAL CONTINUOUS ENROLLMENT POLICY

A student admitted to a doctoral program must register each Fall and Spring semester for a minimum of 3 graduate units from original matriculation until the completion of all course requirements, written and oral comprehensive exams, and 18 dissertation units. When these requirements are met, doctoral students not on financial assistance and/or needing to maintain appropriate visa status, must register for a minimum of 1 unit of dissertation credit each semester until final copies of the dissertation are submitted to the Graduate Student Academic Services Office. Please see the Graduate Coordinator to confirm that your requirements are met, before you register for the 1 unit of dissertation credit.

If only the Final Oral Exam (the defense) is completed during the summer or winter term, the student has maintained continuous enrollment, and has fulfilled all 18 required dissertation credits, registration is not required.

Students receiving funding such as assistantships, fellowships, loans, grants, scholarships or traineeships may be required by their funding source to register for more than 1 unit to

meet full-time status requirements, and should check with their program advisor regarding such requirements to ensure that they remain qualified for funding.

Doctoral students who have maintained continuous enrollment and are taking only comprehensive exams during either summer or winter term do not have to register for graduate credit during that summer or winter session.

Doctoral students who have maintained continuous enrollment, fulfilled all their other degree requirements as well as the 18 hours of dissertation and were enrolled in the prior semester may defend in the summer or winter term without registration. If, however, a student needs library privileges in the final semester, enrollment is required.

6. OTHER

Colloquium

In the first year, graduate students are required to attend all Physics Department Colloquia (usually held Friday afternoons) as an introduction to the excitement and breadth of current research in Physics.

EOAA meeting

As one step towards the Department's goal of maintaining a healthy and supportive working environment for all Department members, including women and minorities, the Department will schedule periodic meetings between graduate students and a representative of the University's Equal Opportunity and Affirmative Action (EOAA) Office. These information sessions are designed to explain University policies and procedures, and to educate students concerning their rights and obligations under these policies. In order to ensure that all graduate students receive this training, all graduate students are required to attend at least one of these scheduled meetings during their residence, preferably soon after their entrance into the graduate program. The EOAA meeting is a required component of the Physics graduate orientation for incoming students.

"Grandfather" policy:

These rules, as well as any subsequent versions of these rules, shall apply to only those students entering the Ph.D. program after these rules are enacted. Students already in the program shall have the option of conforming to either the new rules or the rules that were already in force at the time of their entry into the program.

As a general policy, all rules and regulations are intended to be interpreted as broadly and flexibly as possible while remaining consistent with the intellectual (educational and research) missions of the Ph.D. program. Special cases and exemptions can be granted, when appropriate, by the Director of Graduate Studies, and students are encouraged to discuss such options with the Director of Graduate Studies or with any of the Graduates. Students must also ensure that they satisfy all rules determined by the Graduate College, which may be independent of those rules listed here. Students can also file petitions with the Department of Physics or the Graduate College to seek exceptions to these policies.

Departmental requirements for the Master of Science degree (Physics)

The conventional Master's degree is intended for those students who wish to certify their mastery of Physics coursework at the graduate level; such students may or may not go on for a Ph.D. in Physics. This document applies exclusively to the requirements for the M.S. degree in Physics.

For graduate college policies/rules make sure to check

<http://grad.arizona.edu/academics/program-requirements/masters-degrees>

- 1) 30 credits
- 2) Students are required to have passed the Written Comprehensive Exam (see Ph.D. requirements) at the MS level or Ph.D. level.
- 3) Students are required to have passed the Oral Comprehensive Exam. The Oral Comprehensive Exam may entail either:
 - a) an oral defense of a Master's Report; or
 - b) an oral examination on the core Physics knowledge tested as part of the Written Comprehensive Exam.

Students choosing to write a Master's Report may enroll in up to 3 units of PHYS 909 (Physics Master's Report) for credit. Since this is considered an internal report and not an official "thesis", you should not report a thesis committee in GradPath. See the Graduate Coordinator to enroll in PHYS 909.

Students completing a Master's Report (PHYS 909), will not submit their report for archiving.

Students who have passed both the written and oral portions of the Comprehensive Exam at the Ph.D. level are encouraged to obtain the MS degree en route to the Ph.D.

Important: Contact the Physics Graduate Coordinator (gklueders@email.arizona.edu) for a change of program form to add the Master's program.

Resources

Where do I go if I need help resolving problems with a faculty or staff member, or with one of my fellow students? You should always feel free to contact your advisor, fellow students or the Director of Graduate Studies for advice. However, if you are not 100% comfortable with that, the Ombuds Committee is a UA service for informal, confidential problem resolution. Information on how they can help may be found at <http://ombuds.arizona.edu>. Alternatively you may contact the Dean of Students office, <https://deanofstudents.arizona.edu/> and/or <http://titleix.arizona.edu/> if appropriate.

Coping with the stress of graduate studies. Professional help is available at <http://www.health.arizona.edu/caps.htm>

Graduate and Professional Student Council. The GPSC has many resources of value to Ph.D. students. It should be your first resource when looking for grants for student travel to conferences, student clubs, and other resources. Make sure to visit their website <http://www.gpsc.arizona.edu/>

Women in Physics is an active graduate student-run club that aims to promote the inclusion of women and the awareness of gender biases in Physics. All students are welcome to join and attend any of the meetings and events. We organize events ranging from social activities, such as BBQs; Physics outreach such as helping with elementary school science fairs; and professional events such as hosting invited speakers from academia and industry. For more information about the group and upcoming events please visit <https://sites.google.com/a/email.arizona.edu/uawip/home>

Teaching and Research Assistantships (TA, RA)

Is there a maximum number of hours I am allowed to get paid for as a TA or an RA? Yes, graduate assistant/associate appointments in Physics may not exceed a maximum .50 FTE (20 hrs/wk), during Fall and Spring semester. Enrolled graduate assistant/associates with .50 FTE (20 hours per week) or less during the academic year may work during the summer months. The standard for summer supplemental compensation is 155 hrs/mo. However, make sure to check with your research advisor and the business office because precise hours and regulations can change.

How much will I get paid (precise amounts may change w/o notice)?

At 0.5 FTE (20 hrs/wk): \$9,000 per semester (based on annualized 1.0 FTE salary of \$36,000).

Summer supplemental compensation rates are typically \$22.31/hr (pre-comp) and \$24.45/hr (post-comp). Summer positions must be approved by the supervisor and arranged through the physics business office.

For benefits/health care see <http://grad.arizona.edu/financial-resources/ua-resources/employment/ga-manual/ga-benefits>

Other related GA/TA information at <http://grad.arizona.edu/financial-resources/ua-resources/employment/GA>

I have little teaching experience. Is there any TA training available? Yes, all incoming graduate students are required to participate in TA training provided by the Physics department. You will receive a schedule of training dates. In addition, your teaching will be evaluated by a faculty member who will visit one (or more) of your labs.

What are my TA duties?

- 1) Most TA will teach labs, and/or grade homework
- 2) Office hours and consultation room hours:
 - 0.25 FTE Lab TA's are expected to have 1 office hour and 1 consultation room hour per week.
 - 0.50 FTE Lab TA's are expected to have 2 office hours and 1 consultation room hour per week.
 - Sign up for consultation room hours at ASO, PAS 260.
 - Office Hours should not conflict with the associated lecture time.
- 3) Attendance at the weekly lab meeting is required.
- 4) Miscellaneous requirements
 - Teach as directed.
 - Be in the room/lab 5 minutes early when teaching
 - If unfamiliar with the experiment, do a practice run, and write an outline of the lab report.

- Grade and return lab reports in **one** week.
- Grade tests and homework in time frame requested by the instructor.
- Provide to lab manager, faculty member and ASO copies of 1) your course information sheet, and 2) recorded grades weekly.
- Contact Roger Haar, and find a replacement, if you cannot make your assigned lab section.
- Find a replacement if you cannot make consultation room hours.

Note: Priorities in future TA assignments are dependent upon your performance/behavior as a TA in previous semesters.