Graduate Student Handbook

Department of Physics and Astronomy

University of Pittsburgh

Graduate Program Regulations Pertaining to the M.S. and Ph.D. Programs in Physics and Astronomy

Latest Revision: July 2023

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UNIVERSITY OF PITTSBURGH

Regulations and General Information Pertaining to the M.S. and Ph.D. Programs for the Department of Physics and Astronomy

The graduate program in physics and astronomy at the University of Pittsburgh is designed to enable students to develop the special qualifications that distinguish M.S. and Ph.D. physicists and astronomers. These include creativity, capability for critical thought and articulate expression, a strong knowledge base, technical skills, and familiarity with the methodology and literature of their field.

The general regulations that apply to all students pursuing M.S. or Ph.D. degrees in any department of the Faculty of Arts and Sciences are set forth in the University's *Graduate and Professional Studies Catalog*. **Every graduate student is responsible for understanding these requirements, most importantly the section on academic regulations**. In several instances, details are left in the hands of the student's major department. The present document explains those regulations specific to the Department of Physics and Astronomy and elaborates on other regulations referred to in the *Catalog*.

The current Director of Graduate Studies (DGS) is Professor Ayres Freitas, padgs@pitt.edu, who can answer questions about procedures and policies which are not explicitly addressed in this document. The current graduate administrator is Brandi McClain, pagrad@pitt.edu, who assists graduate students with all administrative and program issues and helps them resolve any problems they encounter, as well as providing general advice and a kind ear. The current Chair of Physics and Astronomy is Professor Arthur Kosowsky, phyast-chair@pitt.edu, who is available to discuss any issue related to the Department or the graduate program.

The Department of Physics and Astronomy has adopted a Code of Conduct with principles designed to ensure a welcoming, respectful and professional environment for everybody. All members of the department are expected to follow theses standards.

1. STUDENT ADVISING AND MENTORING

The Department of Physics and Astronomy has always placed strong emphasis on advising its graduate students. The Department's advising system has evolved over time and now includes all mandatory procedures and almost all other aspects that are outlined in the document "Elements of Good Academic Advising" (https://www.gradstudies.pitt.edu/academics/elements-good-academic-advising) issued by the Office of the Provost.

A. Advising Prior To Enrollment

The Admissions Committee provides all prospective graduate students with an online copy of this Graduate Student Handbook, which details our degree requirements. The Admissions Committee and the graduate administrator also make available other information that any applicant may request.

Newly admitted students are encouraged to contact the Graduate Administrator with any questions about course or research preparation. Students will be put in touch with relevant faculty members and advisors prior to arrival on campus.

B. Advising of New Students

Upon entering the Department, each new graduate student is assigned to one of the faculty members who serve as academic advisors. The advisors are provided with the application files of their assigned students, including copies of all correspondence that occurred before enrollment. During the orientation week the academic advisors meet with each new student individually for about one hour to explain our requirements, advise them on courses, review results of their pretest and answer any other questions that the students may have. The assigned academic advisor remains the new graduate student's principal faculty advisor until the student has completed the core course requirements and begins to work with a research advisor. Once a Research Agreement has been executed, the research advisor takes over as the student's principal faculty advisor through the completion of the doctoral dissertation. The Director of Graduate Studies always remains available for consultation as an optional additional advisor.

In addition to the faculty advisors, advanced graduate students act as mentors of new students. Their perspective on teaching and choosing a research advisor can be invaluable to beginning students. One of these advanced graduate students may hold the title of Arts and Sciences TA Mentor for the department.

C. Student Mentoring

Our department has a faculty mentoring committee which provides informal professional mentors for all students who are interested. Having a mentor who is separate from your research advisor can be quite useful, especially in cases where students may be less comfortable discussing issues outside of research with their academic advisor, or in cases where students may have difficulties with their advisor. First-year students and faculty advisors are introduced at an informal meeting near the beginning of the first semester. Students can request particular mentors or change mentors at their discretion. Once a student identifies a mentor, the department encourages regular informal meetings a few times each semester. Mentors can provide career advice, life advice, general support, and help navigating the university and professional relationships.

The Department also supports a mentoring program for beginning graduate students in which the mentors are more senior graduate students. These peer mentors can be valuable sources of support and advice for preparing for the comprehensive exam, establishing relationships with faculty members, finding thesis advisors, and how to balance competing demands of being a graduate student. In addition, the Dietrich School of Arts and Sciences asks departments to recognize and nominate an experienced capable Teaching Assistant or Teaching Fellow to be part of their voluntary TA/TF Mentor Program. A variety of tasks are provided by the TA/TF Mentor to their junior counterparts who may be inexperienced in serving in a teaching role.

2. ENTERING STUDENT PLACEMENT

Students enter our program with variations in their background preparation. We strive to place students into an academic program of classes and research which will be the most productive for each student and consistent with their level of preparation. **Note that the provisions in sections A-C do not apply to PhD students who choose the Astrophysics Track** (see chapter 4 for more details about this track).

A. Pretests

(Physics Track only) The department requires that prior to the start of Fall classes the incoming students are tested on their mastery of the undergraduate prerequisites of the graduate core courses PHYS 2541 (Statistical Mechanics & Thermodynamics), PHYS 2555 (Advanced Electricity and Magnetism), and PHYS 2565 (Non-rel. Quantum Mechanics I). These pre-tests are used for **diagnostic purposes only** and do not bear on the standing of the student in the program. The student's academic advisor, in consultation with the core course instructor(s), may advise students depending on the pre-test(s) results, to enroll in preparatory course(s), which are comparable to advanced undergraduate-level course(s), before taking the graduate-level core course(s) the following year. These preparatory courses are: PHYS 2341 (Intro to Themodyn. and Stat. Mech.), PHYS 2370 and 2371 (Intro to Quantum Mech. I and II), and PHYS 2372 (Electromagnetic Theory). In exceptional cases in which the student's academic advisor deems the student to lack sufficient undergraduate background to be in a position to succeed in the graduate courses, the student's academic advisor may **require** the student take the preparatory course before taking the corresponding graduate core course in order to remain in good academic standing. This decision will be based on the student's performance on the diagnostic pre-test and an interview with the student and will be made in consultation with the core course instructor(s).

Some entering students may benefit from additional instruction in the mathematical techniques commonly used in physics. These students will be advised to take PHYS 2373 (Mathematical Methods in Physics) in their first year.

B. Students with Prior Graduate Work

(Physics Track only) Students may take a written advancement exam for any (or all) of the core courses if they have completed a similar graduate-level course elsewhere before joining our program. The advancement exam is similar in level to a core course final exam, and it will be administered during the orientation period before the start of fall semester classes.

Students must notify the Director of Graduate Studies and the Graduate Administrator of their intent to take one or more advancement exams prior to 1 August. An attempt at a written advancement exam is a "free shot" at the passing the Comprehensive Examination and does not count toward the two attempts that each student is given to pass the Comprehensive Examination. **For detailed regulations on the written advancement exam, see section 4.B.1 on page** 11**.**

C. Students Entering with a Master's Degree

(Physics Track only) Students entering the PhD program with a MS degree from another institution may take an oral advancement exam covering the core courses for the Comprehensive Examination. In this way, these students may be exempted from the core courses and may be deemed to have passed the Comprehensive Examination. This oral exam is designed to streamline the transition into PhD research for students that have taken their MS coursework elsewhere.

In order to be eligible to take these oral examinations, the student must (a) have a MS degree from an academic institution with an academic standing similar or exceeding that of the University of Pittsburgh, and (b) notify the Director of Graduate Studies and the Graduate Administrator of their intent to take an oral exam prior to 1 August. An attempt at an oral exam is a "free shot" at the passing the Comprehensive Examination and does not count toward the two attempts that each student is given to pass the Comprehensive Examination.

A committee of three faculty members will administer the oral exam at the beginning of the fall semester. The committee may recommend that the student pass all of some of the core physics subjects. For any subject that a student did not pass in the oral exam, the student will generally be required to take the corresponding course. **For detailed regulations on the oral advancement exam, see section 4.B.2 on page** 12**.**

D. Transfer Credits

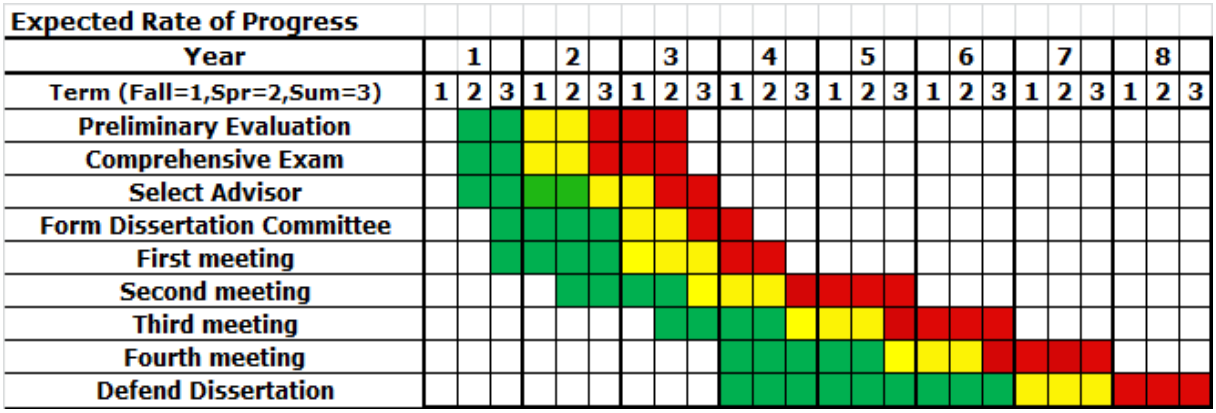
According to Dietrich School regulations, students may apply credits earned at another approved degree-granting graduate program toward the credit requirement for an advanced degree at the University of Pittsburgh. Six credits may be transferred toward a master's degree, and up to 30 credits of master's level work can be transferred toward the Ph.D. (with a maximum of 12 additional credits of work beyond the master's level), subject to the restrictions set out in the Graduate and Professional Studies Catalog on-line.

Any requests from students recommending transfer credits older than the statute of limitations for the degree (10 years for the PhD and 4 years for the Master's degree) must have a letter from the Director of Graduate Studies and approved by the Department Chair, certifying that the credits represent current knowledge in the field.

A student who has received approval for the transfer of 30 credits based upon master's level work at another institution cannot then apply for a master's degree in the same program that requested the transfer credits at the University of Pittsburgh. However, if a student has received approval for 30 transfer credits, and subsequently wishes to earn a master's degree in that discipline from the University of Pittsburgh, the student must petition the Dean's office to remove all but 6 of the transfer credits from his/her record.

3. THE Ph.D. DEGREE TIMELINE

This is the expected timeline for the program. This table outlines the rate at which students are expected to progress through the milestones associated with the Department's graduate program. The department recognizes that the progress of each student will vary, and for this reason, rates of progress are defined in terms of various "zones," rather than specific, department-wide cut-off dates for each milestone requirement. The three zones – green, yellow, and red – are defined below.



Green (optimal) zone:

Completing each milestone requirement within a Year/Term that is color-coded as green will yield a doctoral thesis in the expected 4-7 years.

Yellow (cautionary) zone:

This is considered to be a cautionary zone. This is especially true if performance is otherwise high (e.g., coursework is strong, the student has multiple research projects, the work has resulted in conference presentations and journal submissions), if research is delayed due to a sabbatical of an advisor, or if the student experienced a temporary research or personal setback that stalled progress for a short while. For other students, time in the Yellow Zone may be viewed with a degree of concern by faculty. This is especially true when the outer range of the Yellow Zone is approaching without a successful Milestone event in sight, or when slow progress toward the degree is coupled with other signs of lackluster performance.

Multiple factors may place a student in this less optimal position. These include unanticipated research setbacks, a nonproductive student-advisor relationship, personal setbacks caused by physical or mental health problems, a low degree of enthusiasm about the academic research track, or a sense of isolation from the departmental faculty and graduate student peers. Regardless of the cause, it is imperative that students and faculty work together to identify the causes behind a problematic level of performance and develop a plan for positive change. Students should not wait for faculty to determine that a problem exists – instead, if they are concerned about their progress they should confer with their advisor, Dissertation Committee members, the Director of Graduate Studies, and/or the Departmental Chair. Depending upon the factors that have slowed performance, appropriate actions might include changing research projects, adjusting the scope of a Milestone, switching advisors, seeking clinical care, or taking a leave of absence from the program.

Red (danger) zone:

Students who reach the Red Zone will be placed on Provisional Status. Entry into Provisional Status will trigger a formal letter outlining the performance criteria that need to be met (including dates for successful completion) to avoid even more formal actions, such as progression to University Probation or termination from the student's doctoral training program. Students on provisional status may be unable to be assigned as a Teaching Assistant or be eligible for other departmental funding. Students may, however, be supported as a GSR, if the faculty member is so inclined.

Note: The School of Arts and Sciences at the University of Pittsburgh mandates that any graduate student who does not finish and defend their dissertation within seven years of completing the Comprehensive Examination must retake the Examination.

4. REQUIREMENTS FOR THE PH.D. DEGREE

The requirements for the Doctor of Philosophy (Ph.D.) degrees as described here supersede all previous versions. University requirements are described in detail in the University of Pittsburgh Graduate and Professional Studies Catalog, in particular in the section on academic regulations.

There are two possible tracks for the required core courses, which all PhD students are expected to complete in the first 1-2 years in the program. The **Physics Track** is the default choice for most students. Students interested in doing research in astronomy and astrophysics can instead choose the **Astrophysics Track**. Note that it is not possible to mix and match elements of the two tracks. If you are considering the Astrophysics Track, please discuss this choice with your academic advisor before the start of classes in your first semester.

Research advisors in fields outside of astrophysics will expect you to complete the requirements of the Physics Track, whereas research advisors within astrophysics will expect you to complete the requirements of the Astrophysics Track. Therefore, if you later decide to switch research

fields, you typically will need to take the required courses of the other track, which will take additional time. Therefore, you should carefully consider the choice of track.

A. Required Courses

Physics Track: Each PhD candidate is normally expected to take the following physics courses for credit preferably in the first year of graduate study, but certainly within the first two years of graduate study.

Physics Core Courses (3 credits each unless noted otherwise)

PHYS 2541 Statistical Mechanics & Thermodynamics
PHYS 2555 Advanced Electricity & Magnetism (4 credits)
PHYS 2565 Non-relativistic Quantum Mechanics I
and at least one of the following two:
PHYS 2513 Dynamical Systems
PHYS 2566 Non-relativistic Quantum Mechanics II

Astrophysics Track: Each PhD candidate must take at least four of the following courses within the first two years of graduate study:

Astrophysics Core Courses (3 credits each)

PHYS 2531 Dynamical Systems
PHYS 3274 Computational Methods
ASTRON 3101 Introduction to Astronomy
ASTRON 3550 Stellar Structure
ASTRON 3580 Galactic and Extragalactic Astronomy
ASTRON 3705 Astronomical Techniques
ASTRON 3785 Cosmology

Courses Required for Acceptance to Candidacy in both tracks:

PHYS 2997 Teaching of Physics (1 credit)
PHYS 2998 Teaching Practicum (two semesters)
PHYS 2999 Physics and Astronomy Colloquium (two semesters)

Since the majority of the entering graduate students are supported by teaching assistantships during their first year, and all must teach for two terms at some point, all incoming students are required to take a one-credit course (PHYS 2997) on "Teaching of Physics and Astronomy" during the Fall semester of their first year. This course tells them about their responsibilities as Teaching Assistants, introduces them to effective teaching methods, and incorporates extensive teaching practice sessions. The faculty members who teach the lecture and/or laboratory courses in which the graduate students assist also provide guidance to them with regard to teaching issues. In addition, first-year students take PHYS 2999 during the first Fall and Spring semester, which requires students to attend departmental colloquia to further expose beginning graduate students to current physics research. The colloquia are typically scheduled on Monday afternoons (see department calendar).

In order to inform the first-year students about the wide range of research opportunities available to them in the Department, there is also a series of informal talks by faculty members about their research programs. The specific days and times for these talks in the 2023/24 academic year will be announced in due time.

All students must enroll in at least 9 (but no more than 15) credits per semester. Depending on their selection of core courses, they may enroll in a discipline-specific advanced course or try out a research group to fulfill this requirement (see section F below for more details on these options).

Students with fellowships in the first year are expected to engage in research or additional courses beyond the 9-credit minimum.

A minimum of 72 credits is required for the PhD degree, including any credits transferred. As part of these 72 credits, all students must take at least four advanced level (3000-level) graduate courses offered within our Department as described below in Section F.

B. Possible Exemptions from the Core Courses in the Physics Track

1. WRITTEN ADVANCEMENT EXAMS FOR NEW PHD STUDENTS. New graduate students in the Physics Track, entering our program for the first time, may elect to take a written advancement exam in order to earn exemption from any (or all) of the core physics courses. Each exam will be set at a level comparable to the level of the Comprehensive Examinations in each of the courses (see Section 4.E below). The exams will take place during the orientation period prior to the start of the fall semester each academic year. In order to earn exemption from a course and pass the Comprehensive Examination in that course, a student must earn a grade of B+ or higher in the examination. Any student earning a grade below B+ in an advancement exam will be required to take the corresponding course and pass the Comprehensive Examination in that course during their first academic year in the program.

The following rules shall apply to all advancement examinations.

1. Exams will be written, administered, and graded by a member of the faculty that has taught the relevant course within the 10 years immediately preceding the exam. This will be the faculty member that last taught the course unless unusual circumstances render this impossible.
2. Exam results will be final and will not be subject to appeal.
3. Students must notify the Department (via email to the Director of Graduate Studies *and* the Graduate Administrator) of their intent to take an advancement exam prior to 1 August of the year of their first entry into the graduate program.
4. Students attempting but not passing an advancement exam are expected to take the corresponding graduate-level core course.
5. An attempt at a written advancement exam is a “free shot” at passing the Comprehensive Examination in Physics and does *not* count toward the two attempts students are given to pass the Comprehensive Examination.

2. ORAL ADVANCEMENT EXAMS FOR STUDENTS ENTERING WITH A M.S. DEGREE IN PHYSICS OR ASTRONOMY. New graduate students in the Physics Track, entering our program for the first time, that have earned a M.S. degree in physics or astronomy may be eligible to take an oral examination to earn exemption from the core courses in physics and pass the Comprehensive Examination. In order to be eligible for an oral test out exam, the student must have earned an M.S. degree in physics or astronomy at another institution. The oral exam is designed to streamline the transition into Ph.D. research for those students that have taken their M.S. coursework elsewhere.

The following rules shall apply to all oral advancement exams.

1. Only students with an M.S. degree may attempt an oral exam. In some cases, international students are admitted with a Bachelor's equivalency. This is typically a combination of a 3-year B.S. and a 2-year M.S. The Dietrich School does not recognize such degrees as M.S. degrees. A student with a Bachelor's equivalency is *not* eligible for the oral exam option.
2. Students intending to take an oral advancement exam must notify the Department (via email to the Director of Graduate Studies and the Graduate Administrator) of their intent to take an oral advancement exam prior to 1 August of the year of their first entry into the graduate program.
3. The oral exam will be administered by an ad hoc committee of three (3) faculty members who have taught one or more of the core subjects within the past ten years. Other faculty, not on the ad hoc committee, may sit in on the exam if desired. The exam will take place prior to the end of the second week of the fall semester, at a mutually agreeable time, and will not exceed two hours. Students will be expected to attend the respective course(s) until the results of the oral exam(s) are known.
4. The ad hoc oral exam committee may recommend that the student pass any, or all, of the core physics courses. Such a recommendation will exempt the student from the course(s) and constitutes passing of the Comprehensive Examination(s) (See Section E below) in the course(s).
5. The ad hoc oral exam committee may recommend that the student fail any, or all, of the core physics courses. Such a recommendation will require the student to enroll in the relevant course and to pass the Comprehensive Examination in that course during the first academic year in the program.
6. Oral advancement exam results are final and are not subject to appeal.
7. Students attempting but not passing an oral advancement exam are expected to take the corresponding graduate-level core course.
8. An attempt at an oral advancement exam will be a "free shot" at passing the Comprehensive Examination in Physics and will *not* count toward the two attempts that each student is given to pass the Comprehensive Examination.

C. QPA Requirement

Graduate students must maintain a GPA of at least 3.00 for all required core courses and for all graduate courses overall. PHYS 2341, 2370, 2371, and 2372 are considered to be substitute core courses for the purpose of GPA calculations and are acceptable for satisfying a portion

of the MS course requirement. (For GPA calculations letter grades are assigned the following values: D– = 0.75, D = 1.00, D+ = 1.25, C– = 1.75, C = 2.00, C+ = 2.25, B– = 2.75, B = 3.00, B+ = 3.25, A– = 3.75, A = 4.00, A^+ = 4.00.) The Graduate Bulletin describes the University's regulations regarding grades.

Students testing out of all core courses based on the provisions of Section 4.B above will not be subject to the core course GPA requirement but will still be subject to the overall GPA requirement.

Students in good academic standing can be supported by fellowships or teaching assistantships and take the comprehensive examination when appropriate. However, if the overall GPA is less than 3.0 such students may not be supported by teaching assistantships, fellowships or participate in the department's comprehensive examination according to the Arts & Sciences Graduate School policies. Instead, the student is automatically placed on academic probation. A student on academic probation must improve the GPA by taking graduate level coursework in the term during which the student is on academic probation.

D. Preliminary Evaluation

All graduate students must pass the "Preliminary Evaluation" at the end of their first academic year in the program. The decision whether or not a student has passed the Preliminary Evaluation is based on the student's performance in courses taken during the first two terms of study.

Physics Track: A graduate student is deemed to have passed the Preliminary Evaluation if the student has met the QPA requirement (QPA > 3.0) and has obtained grades of at least B in graduate-level (25xx-level) courses or at least B+ in preparatory courses (2341, 2370, 2371, and 2372) in each of the following core subject areas: Statistical Mechanics, Quantum Mechanics, and Electricity & Magnetism. A graduate student who passes the Preliminary Evaluation is also considered to have passed the Comprehensive Examination for the MS degree and may apply for that degree as soon as all other requirements for the MS have been satisfied.

Astrophysics Track: A graduate student is deemed to have passed the Preliminary Evaluation if the student has met the QPA requirement (QPA > 3.0) and has obtained a grade of at least B in four of the seven courses listed under "Astrophysics Track" in section 4.A.

Review process: The Graduate Committee meets at the end of the Fall term to evaluate the course performance of the first-year students during their initial semester. If the Committee finds that a student has failed to perform adequately, it will propose remedial steps to be taken during the second term. The Graduate Committee reviews the performance of all first-year graduate students again at the end of the Spring term to determine whether or not they have passed the Preliminary Evaluation and possibly also the Comprehensive Examination. In making its decision in the event of an inadequate final examination score the Committee may consider all aspects of a student's academic record including other measures of competence. If the Committee concludes that a student has not passed the Preliminary Evaluation at the end of the first year, the Committee may grant that student a time extension of no more than one additional year; in that

event the Committee will set specific conditions that the student must fulfill during that time. If the Committee determines that the student has not passed the preliminary evaluation and is not eligible to continue toward the M.S. or Ph.D. degrees, the student is entitled to appeal that decision. In order to appeal the decision, the student must submit a request in writing to the Graduate Committee to reconsider its evaluation within **two weeks** of receiving written notification of the decision of the Graduate Committee. The request must state specifically which decision is being appealed and give detailed reasons why the appeal should be considered. The Graduate Committee is **not** obligated to consider petitions received after this two-week period has expired and will consider such requests at its discretion.

E. Comprehensive Examination Requirement

All doctoral students must pass the Comprehensive Examination by the end of their second academic year. The decision whether or not a student has met the criteria for passing the Comprehensive Examination is based on the student's performance in the required graduate core courses listed in Section 4.A. As the Comprehensive Examination must be passed by the end of the second year, this means that each student gets two attempts to pass the Comprehensive Examination.

Physics Track: A graduate student is deemed to have passed the Comprehensive Examination if the student has met the QPA requirement (**QPA > 3.0** in all classes) **and** has obtained a grade of at least **B+** in each of the following core courses : Non-rel. QM I (PHYS 2565), Adv. E&M (PHYS 2555), Thrm. & Stat. Mech. (PHYS 2541), and either Dyn. Sys. (PHYS 2513) or Non-rel. QM II (PHYS 2566).

Astrophysics Track: A graduate student is deemed to have passed the Comprehensive Evaluation if the student has met the QPA requirement (QPA > 3.0) **and** has obtained a grade of at least **B+** in four of the seven courses listed under "Astrophysics Track" in section 4.A.

Review process: During its meeting at the end of every Spring term, the Graduate Committee reviews in particular the performance of all second-year students who have not yet have passed the Comprehensive Examination. In making its decision in the event of an inadequate course grade the Committee may consider all aspects of the student's academic record including other measures of competence. If the Graduate Committee concludes that a student has not passed the Comprehensive Examination by the two-year deadline, the Committee may grant that student a time extension of no more than one additional year; in that event the Committee may place the student on probation, and it will set specific conditions that the student must fulfill during that time. The Committee will review that student's performance again at the end of that time extension to determine whether or not he/she has passed the Comprehensive Examination. If the Committee determines that the student has not passed and must leave the Ph.D. program, the student is entitled to appeal that decision. In order to appeal the decision of the Graduate Committee, the student must submit a request in writing to the Graduate Committee to reconsider its evaluation within **two weeks** of receiving written notification of the Graduate Committee's decision. The request must state specifically which decision is being appealed and give de-

tailed reasons why the appeal should be considered. The Graduate Committee is **not** obligated to consider petitions received after this two-week period has expired and will consider such requests at its discretion.

F. Advanced Course Requirements

Physics Track: All students must take a certain number of 3000-level courses offered in our Department to earn the PhD degree. Students taking five of the core courses listed above must take at least four additional 3000-level courses, whereas students taking only four of the core courses must take at least five additional 3000-level courses. It is expected that the majority of students will take all of these courses in the Department of Physics and Astronomy. In some instances, graduate courses taught by other departments may align better with the research of a student and may be substituted for a course in the Department of Physics and Astronomy. Students may take courses outside of the Department of Physics and Astronomy to satisfy their requirement for advanced courses subject to the following regulations.

1. Students are expected to take all advanced courses in Physics and Astronomy that are directly relevant to their research. Relevance will be determined in consultation with the thesis advisor and the thesis committee. The thesis committee will report on the appropriateness of the coursework of the student.
2. Students must take a minimum of 2 advanced courses taught by the Department of Physics and Astronomy.
3. Students may substitute an advanced graduate course taught outside the Department of Physics and Astronomy for an advanced course with approval of the Graduate Curriculum Committee or if the course is among those courses listed for standing approval by the Graduate Curriculum Committee. The approved list is below.
4. Faculty and/or students may petition the Graduate Curriculum Committee to add courses to the standing list of approved courses. In order to do so, the Graduate Curriculum Committee must be provided with, minimally, a course syllabus, a justification for the course in the student's field of specialty, a textbook (if used), and a statement from a recent instructor of record addressing the general level (M.S. or Ph.D.) of the course and the degree of commitment required by the course.

The 3000-level courses currently being offered are listed below; there will be additions, substitutions, and special courses over time. The choice of courses should be made in consultation with the student's research advisor who may recommend or require additional courses. Curriculum recommendations may be found in Appendix II.

3000-Level Courses

PHYS 3274	Computational Methods
PHYS 3542	Advanced Statistical Mechanics
ASTRON 3580	Galactic and Extragalactic Astronomy
ASTRON 3705	Astronomical Techniques

PHYS 3707	Intro to Many Body Physics
PHYS 3715	Solid State Physics
PHYS 3716	Advanced Solid State Physics
PHYS 3717	Particle Physics
PHYS 3718	Advanced Particle Physics
PHYS 3725	General Relativity I
PHYS 3726	General Relativity II
PHYS 3730	Introduction to Biophysics
ASTRON 3750	Stellar Structure
PHYS 3765	Field Theory 1
PHYS 3766	Field Theory 2
PHYS 3770	Topics in Quantum Physics
ASTRON 3785	Cosmology
PHYS 3790	Particle Astrophysics
ASTRON 3101	Special Topics: Introduction to Astronomy
PHYS 3101	Special Topics in (Bio)Physics

Courses Outside of Physics and Astronomy Approved for 3000-level Advanced Course Credit

CS 2750	Machine Learning
ECE 2233	Focused Ion Beam Scanning and Electromicroscopy
ECE 2262	Low-dimensional Nanoelectronics Devices
PSYCH 2090	Structural Equation Modeling
PSYCH 2476	Topics in Cognitive Psychology[1]
PSYCH 2477	Design of Educational Systems
PSYED 2030	Experimental Design
PSYED 3408	Hierarchical Linear Modeling
PSYED 3472	Causal Inference in Educational Research
MATH 2301	Analysis I
MATH 2302	Analysis II
MATH 2921	Ordinary Differential Equations II
MATH 3380	Mathematical Biology
CMPBIO 2041	Cellular and Systems Modeling

1 *The detailed content of this course can change from year to year; students need to consult with their advisor to ensure that the version offered in a given year is relevant to their research area.*

A **Directed-Study** (PHYS or ASTRON 3902) or **Directed-Research** (PHYS or ASTRON 3907) plan must be supervised by a faculty member. Registering for unsupervised **Independent Study** will be interpreted as registering to study for formal exams. Independent Study credits don't count towards the required course credit.

Students supported with departmental Teaching, Research or Fellowship funds are expected to complete the core course requirements before taking optional or elective courses in other departments. Requests to register for courses outside of the department must be approved by the student's academic advisor in addition to satisfying the regulations stipulated above. Students supported by Research funds while completing degree requirements must also receive written approval from their research advisor in order to register for courses outside of the department. A copy of this approval must be provided to the graduate administrator for the students' records.

Astrophysics Track: All students that aim to earn the Ph.D. in physics on the astrophysics track must earn a grade of B or better in all of the following courses:

- PHYS 2513 Dynamical Systems
- ASTRON 3101 Introduction to Astronomy
- ASTRON 3550 Stellar Structure
- ASTRON 3580 Galactic and Extragalactic Astronomy
- ASTRON 3705 Astronomical Techniques
- ASTRON 3785 Cosmology

Up to four of these courses may be taken as part of the Comprehensive Examination.

A **Directed-Study** (ASTRON 3902) or **Directed-Research** (ASTRON 3907) plan must be supervised by a faculty member. Registering for unsupervised **Independent Study** will be interpreted as registering to study for formal exams. Independent Study credits don't count towards the required course credit.

G. Research Agreement

Within **six months** after receiving written notification of having passed the Comprehensive Examination each graduate student must file a completed Research Agreement which indicates that he/she has been accepted as a dissertation student by a research advisor. This form must be filed with the graduate administrator in accordance with the procedures detailed in Appendix I. The research advisor and the student are jointly responsible for following these procedures. Only graduate students who have a current executed Research Agreement on file may register for PHYS/ASTRON 3000 (dissertation research), or for FTDB 3999 (full-time dissertation study) if the student has accumulated 72 credits. Until then, students enroll in PHYS 3907 (directed research) with an "interim" research advisor.

It may take time to find a faculty member in this Department who does research in an area that is of interest to a particular graduate student, is willing to serve as that student's research advisor, and is able to support the student. Therefore all Ph.D. students are urged to begin this search within the first or second month after their arrival.

In an effort to assist students in finding a research advisor and become affiliated with research groups, several things occur. New graduate students are encouraged to visit or participate

in research group meetings of interest to them. The graduate administrator arranges for the faculty to give research talks to the new graduate students. This occurs most Fridays in the spring term. In addition, APAGS and the department hold a Graduate Student Research Mixer, typically in February. This event often proves to be useful in providing information and in introducing new students to advanced graduate students. The faculty research pages often list their current graduate students. Students are urged to contact fellow students to talk about their research and laboratory experiences with the faculty member(s) whom you are considering.

The decision to work together on a significant research project represents a long-term commitment for both the faculty member and the graduate student and therefore should not be taken lightly. Thus it is standard practice for the faculty member to "try out" the student by assigning some kind of experimental or theoretical project. This trial period will also give the student the opportunity to discover what it is like to work with that faculty member in that specialty area. All graduate students who complete the first two semesters in good standing should use the summer months following their first year as their first opportunity for working in a research group on a trial basis. If necessary, they should continue to search actively for a research advisor during the early part of the fall term of their second year.

Since most of our graduate students are supported by the Department through the first two academic years, mostly as Teaching Assistants (TAs), the faculty members can "try out" the students who are interested in working with them for a term without having to support them financially. But all graduate students are expected to be supported as a Graduate Student Researcher (GSR) by their research advisor beginning with the summer that follows their fourth semester in our program. Therefore, any student who has not found a research advisor by that time is in danger of being without financial support.

Once it has been executed, the Research Agreement should be regarded as binding on both parties. Should unforeseen circumstances arise subsequently that preclude a continuation of productive collaborative research work, the Research Agreement must be formally terminated using the lower section of Part A of the student's Post-Comps Progress Form; a reason must be given, and all parties must sign. When a research advisor concludes that a Research Agreement needs to be terminated, it is very important that the affected graduate student be notified in writing as early as possible, especially if the student will lose financial support.

Although most students finish their Ph.D.s in the group that they originally join it can happen that a student wishes to reconsider his/her choice. It is recommended that students seek the advice of the Director of Graduate Studies if this is the case. A student who does decide to change groups must be accepted into another group in order to remain in the program. Moreover, since dissertation research is largely nontransferable and changing research focus may involve additional coursework, switching groups will almost always result in additional time in the program. Expectations of funding from the new group will need to be clearly defined. The "primary" research advisor takes primary responsibility for the financial support of the student.

To satisfy specific research goals or interests, a student may request permission to perform PhD research under the primary guidance of a faculty member outside the Department of Physics and Astronomy. The chairperson of the Department of Physics and Astronomy will consider such requests on a case-by-case basis in consultation with the Director of Graduate Studies and others. If the chosen research advisor is from another department within the University, a

graduate faculty member of the Department of Physics and Astronomy must serve as the co-advisor. See Appendix III for details.

H. Admission to Candidacy

A student who has passed the Comprehensive Examination, has satisfied the required teaching courses, has submitted a completed Research Agreement (Part A and B), and has held the first meeting of the student's dissertation committee should, in consultation with his or her research advisor, file an application for admission to candidacy for the Doctor of Philosophy (PhD) degree. All students **must** be admitted to candidacy at least eight months before the defense of their dissertation.

I. The Dissertation Committee

Once the Research Agreement has been executed, the research advisor and the graduate student should discuss the membership of the student's Dissertation Committee, which must be finalized within **eight months** after the graduate student has received written notification of having passed the Comprehensive Examination. Collectively the members of a Dissertation Committee have two principal responsibilities: (1) they serve as a broadly knowledgeable review and advisory board for the purpose of assisting the dissertation research project to progress at a reasonable pace from its beginning stage all the way through to its completion; and (2) they help maintain departmental quality standards in the level of dissertation research.

The composition of the Dissertation Committee must be as follows:

1. It consists of at least four members, all four of whom must be members of the Graduate Faculty.
2. Three of the Dissertation Committee members must hold a primary, joint, or secondary faculty appointment in the Department of Physics and Astronomy. This departmental core group must include the student's research advisor (or co-advisor, see Appendix III), who serves as Committee Chair.
3. The committee must include at least one member who is a theorist and another member who is an experimentalist.
4. One member of the Dissertation Committee must be a faculty member with science expertise whose primary appointment is in a department other than Physics and Astronomy. If this member is from outside the University of Pittsburgh, the proposed individual must be approved in advance by the Department Chair and the Associate Dean for Graduate Studies. Check with the Graduate Administrator if the external member is already on the approved list. If not, the Assistant Dean requests a current CV and a letter from the student's research advisor explaining the reason for proposing this individual. This proposed individual must have publications, supervised graduate student(s), and taught graduate course(s), essentially the equivalent of our Graduate Faculty.
5. In order to comply with the Graduate Program Assessment Matrix, the Committee completes an evaluation form at each doctoral committee meeting.

The first meeting of the Dissertation Committee must be held within **twelve months** of the student receiving written notification of having passed the Comprehensive Examination. The University requires that the Committee meets with the student at least once every twelve months after that to assess progress toward the Ph.D. The Committee has the authority to recommend or deny any extension of the statute of limitations, to require supplementary research, or the rewriting of any portion or all of the dissertation, among other actions, and shall conduct the final oral examination (dissertation defense). (Refer to Appendix I for further details regarding the function of Dissertation Committees.)

The Dietrich School of Arts and Sciences (DSAS) has additional regulations regarding Dissertation Committee membership and procedures. Please see the DSAS Doctoral Dissertation Committee Policy online: https://www.asgraduate.pitt.edu/dsas-doctoral-dissertation-committee-policy. In particular, the DSAS policy defines details for external PhD committee members, committee members whose institution has changed, and retired committee members. It also defines rules for remote attendance of committee members for first committee meeting and the defense.

Soon after the Research Agreement has been executed, the research advisor and the graduate student should begin to discuss the membership of the student's Dissertation Committee. When all members of the Dissertation Committee have been identified and contacted, and have indicated their willingness to serve, Part B of the graduate student's Post-Comps Progress form must be completed and submitted (form on the website https://www.physicsandastronomy.pitt.edu/graduate/useful-forms-and-policies), along with any required supporting documentation, to the Department Chair for review and approval. The graduate student is responsible for filing her/his PCP Form with Part B completed and approved with the departmental Graduate Administrator within eight (8) months after receiving written notification of having passed the Comprehensive Examination.

If it becomes necessary subsequently to change the membership of a Dissertation Committee, a Change in Dissertation Committee form (form link: https://www.physicsandastronomy.pitt.edu/sites/default/files/REQUEST%20FOR%20A%20CHANGE%20IN%20DOCTORAL%20DISSERTATION%20COMMITTEE_1_0.pdf.pdf) must be filled out and submitted by the graduate student to the Graduate Administrator for processing immediately upon change or at least two weeks prior to the doctoral defense.

J. Teaching and the Teaching Requirement

Teaching is an essential element of graduate education. As such, all graduate students are required to serve as Teaching Assistants for either two regular academic terms or one regular term plus one six-week summer session. Qualified teaching activities must include contact with students, such as teaching in a laboratory course or as recitation instructor. In order to satisfy the teaching requirement, the teaching assistant must have student contact hours for at least one semester. The teaching requirement cannot be satisfied under any circumstances through teaching responsibilities that consist entirely of grading (e.g., homework/exam/lab grading). In some cases, when the teaching requirement does not align with the career plans of a student, the stu-

dent can be exempted from the requirement upon the request of both the student and the research advisor. Students should familiarize themselves with the University's Teaching Support (available through University Center for Teaching and Learning (UCTL). The Department maintains several documents to aid in teaching which may be found at the Department's web site under Graduate Program; titles include "Responsibilities of Teaching Assistants and Teaching Fellows," "Guidelines for Proctoring Exams," "Resource Room Guidelines," "Guidelines of Financial Support," and "Contractual Obligations."

Students will be graded on their teaching performance. A committee comprised of the Chair of the Department, the Chair of the Graduate Admissions Committee, and the Director of Graduate Studies will determine teaching grades. Teaching grades will be based upon the recommendations of the professor/instructor in charge of the course(s) in which the teaching assistants are employed **and** the student reviews of TA performance. Credit toward fulfillment of the teaching requirement of the Department of Physics and Astronomy will only be awarded to teaching assistants that receive a teaching grade of **B or better** for the semester or summer session. Repeated, unexcused failure to show up for classes prepared and on time **alone** suffices for teaching assistants to earn a grade below the **B** threshold without regard to any other considerations of teaching performance. Failure to receive a grade of B or better suffices for the Graduate Committee to find the student to not be in good academic standing. The consequences of being in poor academic standing include forfeiture of any funding guarantees, especially through teaching support, made to the student as part of their admissions offer and, possibly, not being permitted to continue in the graduate program in the Department of Physics and Astronomy at the University of Pittsburgh. The Graduate Committee will review such cases individually to render a final decision on the academic status of any student that has not performed teaching duties at an acceptable level. All aspects of the academic record of the student, especially past teaching performance, will be considered during the deliberations of the Graduate Committee. Teaching Assistants are notified and encouraged to review the results of the Teaching Evaluations at the end of the term.

Students that have exhibited exceptional teaching performance, as determined by the TA Grading Committee discussed in the previous paragraph, may be deemed, by the TA Grading Committee, to have satisfied their teaching requirement after only a single semester of teaching. In these cases, teaching assistant must have had considerable contact with students and cannot fulfill the teaching requirement if their responsibilities were exclusively grading activities. The decisions of the TA Grading Committee are final and are not subject to appeal.

K. Dissertation Submission

Dissertations must be prepared and submitted in specific formats. Information about preparing the dissertation may be found on the Graduate Studies webpage at https://etd.pitt.edu/.

L. Statute of Limitations

All requirements for the PhD degree must be completed within a period of ten years from the student's initial registration if entering the program with a Bachelor's degree and 8 years if entering with a Master's degree. (Official approved leaves may extend the statute of limitations,

See section N below.) In addition, the Doctoral Comprehensive exam has a strictly enforced statue of seven years.

Under exceptional circumstances a candidate may apply for an extension of the statute of limitations for the PhD degree. The request form must be approved by the Graduate Committee and submitted to the Graduate Administrator for processing to the Dean for final action. Requests for an extension must be accompanied by a departmental assessment of the work still required of the student to complete the degree as well as documented evidence of the extenuating circumstances leading to the request for an extension. Students who request an extension of the statute of limitations must demonstrate proper preparation for the completion of all current degree requirements. Arts & Sciences does not extend the statute of limitations of the Comprehensive Examination (seven years for the Ph.D.) under any circumstances.

M. Language

There is no foreign language requirement, but an international student must demonstrate English language proficiency in compliance with university policy as described in the University's Graduate Studies Catalog.

The University is required by the English Fluency in Higher Education Act of the Commonwealth of Pennsylvania to determine that all individuals who teach possess adequate English language fluency for effective communication with students. The English Language Institute (ELI) administers the English Comprehensibility Test to newly international appointed TAs who are non-native English speakers before classes begin in the fall. The test is scored 1 (poor) – 5 (very good). A score of 3 is required for laboratory teaching assistants, while a score of 4 is required for recitation instructors. A special ITA class in speaking English, is required of students receiving scores of 1 or 2. Tutoring is required of students who get a score of 1,2, or 3. In both cases, a satisfactory grade in the course/tutoring must be earned, and the student's score must increase by at least one (e.g., from 2 to 3 or from 3 to 4) at the next testing as approved by the DGS. The inability to attain adequate performance is grounds for nonrenewal of financial aid (TA, TF, GSR, GSA). Failure to improve (via tutoring and retesting) at the end of your first term (2nd term with approval of the Director of Graduate Studies), could result in loss of TA funding.

N. Leaves of Absence

Under special conditions, such a illness or personal concerns, graduate students may be granted one leave of absence. A maximum leave of two years may be granted to doctoral students. The length (in increments of semesters) and rationale for the leave of absence must be stated in advance, requested to the dean by the student, and approved by the dean. If the leave of absence has been approved, the statute of limitations for the degree is extended by the amount of semesters of the leave. However, the 7-year limit on the Ph.D. comprehensive exam will not be extended. Readmission following an approved leave of absence may be requested, if leave exceeds beyond the official request. More information can be found on this webpage. Please contact the Graduate Administrator for the leave of absence form.

O. Petition Procedure

The Graduate Student Annual Review Committee consists of the academic advisors, the core course instructors, the admissions committee, the director of graduate studies, and the department chair. It, or an appropriate subcommittee, is empowered to make reasonable modifications to these requirements on a case-by-case basis in response to a petition by a graduate student. A committee meets to consider proposals for directed study, to receive petitions to modify or set aside rules, and to redress grievances.

5. REQUIREMENTS FOR THE M.S. DEGREE

A minimum of 30 credits and a 3.0 GPA is required at the graduate level for the MS for both thesis and non-thesis options. The student must be in compliance with all of the University's degree requirements. At least four courses must be graduate core courses (PHYS 2373, 2513, 2541, 2555, 2565, 2566), each with a grade of B or better. A 3000-level course can be substituted for one of these, but only with the Academic Advisor's approval. No more than six credits of graduate work completed at another institution may be accepted by the Graduate Committee toward the completion of the residence requirement. Credits earned for PHYS 2997 and PHYS 2998 may not be used to satisfy this requirement. No more than two non-physics graduate-level courses, *approved in advance by the Director of Graduate Studies*, will be considered for credit for the MS degree.

A. Courses

There are three ways to earn an MS degree:

(1) Submit no thesis and complete at least eight courses. Courses and directed study/research credit must be accrued to reach the minimum 30 credit hours. Four courses must be graduate core courses as listed above, each with a grade of B or better. Courses needed to accrue the necessary credit hours may include any number of 3000-level advanced graduate courses.

(2) Submit no thesis and complete at least six courses from among 2373, 25XX or beyond. Four courses must be graduate core courses as listed above, each with a grade of B or better. In order to accrue the requisite 30 credits for graduation, the student may engage in Directed Study, Directed Research, or take additional, approved courses at the 3000-level.

(3) Submit a thesis and complete at least six courses. Four courses must be graduate core courses as listed above, each with a grade of B or better. Courses and directed study/research credit must be accrued to reach the minimum 30 credit hours. Courses may include any number of 3000-level advanced graduate courses.

Applicants interested in pursuing the thesis option are required to reach out to potential advisors before applying and to name in their application narrative the faculty member who has agreed to serve as their thesis advisor.

B. Grades

The candidate must maintain a GPA of at least 3.00 for all courses overall.

C. Comprehensive Exam

The Comprehensive Examination for MS students is equivalent of the Preliminary Evaluation for PhD students. Refer to Section 4.D, Preliminary Evaluation.

D. Thesis and Oral Examination

A thesis for the MS degree must represent either an original research project or a significant survey of some topic of current interest in physics. A student should find it possible, while carrying some course work, to complete the MS thesis in one term. A copy of the final draft of the thesis must be submitted to the department chair, and copies of the thesis must be distributed to the members of the Master's Committee, a group of at least three members of the graduate faculty recommended by the professor guiding the student's research and approved by the department chair.

Information about preparing the thesis may be found on the Graduate Studies webpage at https://etd.pitt.edu/.

A final oral thesis examination to determine the ability of the student to comprehend and to organize the materials of his or her field will be conducted by the Master's Committee. In addition to the content of the thesis, the examination may cover the subject matter of the courses taken.

E. Statute of Limitations

All requirements for the MS must be completed within a period of four calendar years from the student's initial registration for graduate study. The MS Comprehensive exam must not exceed the strictly enforced statue of four years and will not be extended for any reason.

F. Language

There is no foreign language requirement, but the student must demonstrate English language proficiency in compliance with University policy https://www.asgraduate.pitt.edu/admissions/international-students.

G. Leaves of Absence

Under special conditions, such a illness or personal concerns, graduate students may be granted one leave of absence. A maximum leave of one year may be granted to master's students. The length (in increments of semesters) and rationale for the leave of absence must be stated in advance, requested to the dean by the student, and approved by the dean. If the leave of absence has been approved, the statute of limitations for the degree is extended by the amount of semesters of the leave. However, the 4-year limit on the MS comprehensive exam will not be extended. Please contact the Graduate Administrator for the leave of absence form.

H. Petition Procedure

The Graduate Student Annual Review Committee consists of the academic advisors, the core course instructors, the admissions committee, the director of graduate studies, and the department chair. It, or an appropriate subcommittee, is empowered to make reasonable modifications to these requirements on a case-by-case basis in response to a petition by a graduate student. The Graduate Committee also meets to consider proposals for directed study, to receive petitions to modify or set aside rules, and to redress grievances.

APPENDIX I

NORMAL PROGRESSION BEYOND THE COMPREHENSIVE EXAMINATION

(Revised Version Approved by the Graduate Committee on Aug. 28, 2007)
(PK/DT clarifications Jan. 2009, PK/AL/DT clarifications July 2009)
(Revised intermediate committee meeting guidelines, and AF clarifications October 2021)

The majority of the students admitted to our PhD program satisfy all of the requirements for passing the Comprehensive Examination by the end of their first year. All of them must do so by the end of their second year. This Appendix describes in detail the benchmarks that our PhD students must achieve after passing the Comprehensive Examination and the time scale they are expected to adhere to in order to make satisfactory progress towards the completion of their degree objective.

1. Finding a Research Advisor:

It will generally take time to find a faculty member in the Department who does research in an area that is of interest to a particular graduate student, is willing to serve as that student's research advisor, and is able to support the student. Therefore, all PhD students are urged to begin this search as soon as possible and certainly within the first or second month after their arrival. (If you want to request permission to perform your PhD research under the primary guidance of a faculty member outside the Department of Physics and Astronomy, please see Appendix III.)

The decision to work together on a significant research project represents a long-term commitment for both the faculty member and the graduate student and therefore should not be taken lightly. Thus, it is standard practice for the faculty member to "try out" the student by assigning some kind of experimental or theoretical project. This trial period will also give the student the opportunity to discover what it is like to work with that faculty member in that specialty area. Graduate students are encouraged to begin research **as soon as possible** after arriving on campus, so long as this work does not compromise performance in the core graduate courses and the Comprehensive Examination. At minimum, all graduate students who complete the first two semesters in good standing should use the summer months following their first year as an opportunity for working in a research group on a trial basis. If necessary, they should continue to search actively for a research advisor during the early part of the fall term of their second year.

Many of our graduate students are supported by the Department through the first two academic years, typically as Teaching Assistants (TAs), enabling the faculty members to "try out" the students who are interested in working with them for a term without having to support them financially. But all graduate students are expected to be supported as a Graduate Student Researcher (GSR) by their research advisor beginning with the summer that follows their fourth semester in our program. Therefore, any student who has not found a research advisor by that time is in danger of being **without financial support**.

2. Executing a Research Agreement:

As soon as a faculty member and a graduate student have reached a mutual agreement to work together as research advisor and dissertation student, this understanding must be formalized by the execution of a Research Agreement (Part A of the Post-Comps Progress Form which is available from the Department's graduate administrator). The upper section of Part A must be completed and signed by both the research advisor and the graduate student. **The graduate student is responsible for filing the completed Research Agreement with the graduate administrator within six (6) months after receiving written notification of having passed the Comprehensive Examination. Only graduate students who have a current executed Research Agreement on file may register for PHYS 3000 (dissertation research).**

Once it has been executed, the Research Agreement should be regarded as binding on both parties. Should unforeseen circumstances arise subsequently that preclude a continuation of productive collaborative research work, the

Research Agreement must be formally terminated using the lower section of Part A of the student's Post-Comps Progress Form; a reason must be given, and all parties must sign. When a research advisor concludes that a Research Agreement needs to be terminated, it is very important that the affected graduate student be notified in writing as early as possible, especially if the student will lose financial support.

3. Forming a Dissertation Committee:

Soon after the Research Agreement has been executed, the research advisor and the graduate student should begin to discuss the membership of the student's Dissertation Committee. (See Section 4.I of the **Graduate Student Handbook** for rules regarding the composition of Dissertation Committees.) When all members of the Dissertation Committee have been identified and contacted, and have indicated their willingness to serve, Part B of the graduate student's Post-Comps Progress (PCP) form must be completed and submitted, along with any required supporting documentation, to the Department Chairperson for review and approval. **The graduate student is responsible for filing her/his PCP Form with Part B completed and approved with the departmental graduate administrator within eight (8) months after receiving written notification of having passed the Comprehensive Examination.**

If it becomes necessary subsequently to change the membership of a Dissertation Committee, a Change in Dissertation Committee form (available from the graduate administrator) must be filled out and submitted by the graduate student.

4. Dissertation Committee Meetings:

Collectively the members of a Dissertation Committee have two principal responsibilities: (1) they serve as a broadly knowledgeable review and advisory board for the purpose of assisting the dissertation research project to progress at a reasonable pace from its beginning stage all the way through to its completion; and (2) they help maintain departmental quality standards in the level of dissertation research. Particular attention must be paid to the Dietrich School's remote attendance policy (see https://www.asgraduate.pitt.edu/dsas-doctoral-dissertation-committee-policy) for committee members.

5. First (Prospectus) Meeting:

The first meeting of a graduate student's Dissertation Committee must be held within twelve (12) months after the student received written notification of having passed the Comprehensive Examination. The graduate student is responsible for seeing to it that this is done. The research advisor must remind the student of this responsibility. At the first meeting of the Dissertation Committee the graduate student is expected to make a presentation which demonstrates that he/she has acquired an appropriate level of understanding of the physics concepts and the current state of knowledge in the specific research specialty area of the dissertation and, in that context, of the significance of the question that the dissertation research is setting out to answer. (The material presented by the student at this meeting could later be part of the introductory chapter of the dissertation.) **The graduate student will also be expected to present a well-thought-out proposal of how the dissertation research is to be carried out. The proposal should include time estimates for achieving a series of clearly defined milestones that can be used in subsequent meetings to monitor the progress of the project.** (The above scenario assumes that the student's dissertation research consists of a single extended project. In dissertations where this is not the case, the graduate student's presentation should be appropriately changed to reflect this difference.) At least one week prior to the meeting the graduate student must furnish each member of her/his Dissertation Committee with a brief written document (3-5 pages of text, not in power point "bullet" format) that summarizes the proposed research project, explains its significance, and provides milestones and time estimates for carrying it out; a copy of this document must also be given to the graduate administrator at that time for inclusion in the graduate student's file.

The committee will evaluate the quality of the student's research plan, written and oral communication skills, and relevant background knowledge. The committee's feedback will be provided through an online form, the results of which are confidential but will be shared with the student, committee members, and graduate administrator. **Only one form submission per meeting is expected. The committee is encouraged to complete this form jointly during the meeting or shortly thereafter.** The student should have a follow-up meeting with the committee chair to discuss any possible actions in response to the committee's recommendations.

The research advisor is responsible for completing the appropriate section of the student's PCP form for this and all subsequent dissertation committee meetings. (The PCP form and the online feedback form will be placed in the student's file; data is compiled for future statistical analysis by the Graduate Program Assessment Committee.) The graduate student is responsible for filing an application for Admission to Candidacy for the PhD degree with the Department's graduate administrator at that time.

6. Annual Committee Meetings:

The University of Pittsburgh requires that the dissertation committee meets with the student at least once every 12 months. The graduate student is responsible for seeing to it that this is done. The research advisor must remind the student of this responsibility.

At each of these meetings the graduate student is expected to summarize the work that he/she has accomplished since the previous meeting, discuss any significant unanticipated difficulties that have been encountered, review the rate of progress in terms of milestones met and unmet, and identify goals and milestones for the year ahead. In contrast to the prospectus meeting, the dissertation committee may elect to waive an extensive research presentation by the student during subsequent annual meetings. In such cases, there is no need for the committee meeting to last longer than ~20-30 minutes. Meetings must include a meeting of the student will all members of the committee. Meetings must include an opportunity for the student to consult with the committee without the PhD supervisor. Prior to the meeting, students must provide the committee with a brief, written self-evaluation report and written feedback from any previous committee meetings. [See below for practical suggestions for the organization of the self-evaluation report and the meeting agenda.]

The committee will provide the student with written feedback subsequent to the meeting, *using the online form as described above*, and the research advisor will have a follow-up meeting with the student *as described above*.

Suggestions for the annual self-evaluation report:

The student will submit to the thesis committee and the graduate administrator a written self-evaluation report one (1) week prior to the meeting. This report will begin with a brief summary of the thesis topic. The remainder of the document will address the following items, either in written prose or in simple bullet-point format as appropriate.

- The student will provide a copy of the most recent Meeting Summary and Feedback from the previous meetings.
- A summary of progress since the last committee meeting. This can be a simple bulleted list of tasks accomplished and/or achievement of milestones.
- A response to any questions and/or concerns from previous committee meetings.
- A brief discussion (a bulleted list will suffice) of research plans for the coming year, including potential significant obstacles to these plans, if any.
- A description of plans to apply for internal or external fellowships or other research funding including acquisition of computational/experimental/observational resources.
- A list of papers, including pre-prints, and a list of papers in advanced stages of preparation.
- A list of talks and/or presentations given.
- An anticipated timeline towards graduation.
- A description of post-graduation aspirations.
- Any other items that the student would like the thesis committee to know in order to enable the committee to best support the student's research and career goals.

Suggestions for the meeting format:

As mentioned above, for intermediate committee meetings (i.e. besides the prospectus and defense meetings), the thesis committee may elect to waive the lecture-style review of the student's research. The format and length of the meeting may be left to the discretion of the committee, subject to the following minimum guidance:

- The thesis committee will meet with the student to review the student's self-evaluation report, the student's research progress, the student's progress toward degree, and the student's professional goals.
- To enable the student and/or committee to discuss any issues that they may prefer to address without the advisor being present, the student will meet briefly with the committee while the thesis ad-

visor is not present.
The committee will also meet with the advisor while the student is not present.

- By default, the entire committee should meet together for the annual meeting. If this is not possible, the student must arrange to meet separately with all committee members that were not present at the primary committee meeting.
- In cases in which the student is making adequate progress toward degree and career goals, the entire meeting need not last longer than approximately 20-30 minutes in total.
- In cases in which the thesis committee identifies sufficiently serious concerns about research progress, progress toward degree, and/or progress toward career goals, the student may be required to convene a longer committee meeting that will include a detailed review of the student's research work (see below).

Prior to scheduling the Committee Meeting, the student must be informed as to which meeting format will be used. The choice of the long format (with a seminar-style presentation) or short format is at the discretion of the Committee. It is the responsibility of the research advisor to make a recommendation to the committee and solicit its consent to a short-form meeting The advisor will inform the student of the committee's choice of long or short format **at least four weeks** prior to the committee meeting. Please note that should the committee elect a short-format meeting, the committee may subsequently require a long format meeting should noteworthy deficiencies be identified in the student's annual self-evaluation report and/or the short-format Committee meeting.

7. Final Meeting (Thesis Defense):

At the final meeting of the Dissertation Committee the graduate students report on the completed dissertation project and are examined on the details of their work. In contrast to all of the preceding meetings, notification of the date, time, and place of the dissertation defense must be sent to the Graduate Administrator a month in advance, publicly posted in advance, shared with Dietrich School Graduate Student Services office and the meeting is open publicly until the Dissertation Committee begins its final deliberation.

No written progress report needs to be prepared prior to the final meeting of the Dissertation Committee, but the graduate student must strictly adhere to the rule that **each member of the Dissertation Committee must be provided with a PDF copy of the dissertation (complete with all indexes, chapters, figures, tables, equations, and appendixes) at least four (4) weeks in advance of the meeting date. A committee member may request a hard copy if that is their preference.**

During the thesis defense meeting, the student will give a ~30 min. presentation, followed by first an open-session Q&A period, where anybody in the audience can ask questions, and subsequently a closed-session Q&A period with only the student and the dissertation committee members present.

APPENDIX II

RECOMMENDED NON-CORE GRADUATE COURSES FOR DEPARTMENT SPECIALTY AREAS

1 Areas of Research Specialization in the Department of Physics and Astronomy

1. Astronomy / Observational Astrophysics.
2. Cosmology.
3. Elementary Particle Experiment.
4. Elementary Particle Theory.
5. Condensed Matter Experiment
6. Biophysics.
7. Condensed Matter Theory.
8. Physics Education.

2 Standard Post-Core 3000-level Courses in Physics and Astronomy

For a graduate degree in physics, students are required to complete those 2000-level courses designated as core courses. Also, the Physics & Astronomy Colloquium Course (Phys 2999) has been added to the schedules of first-year graduate students to facilitate students' decisions about their future research specialty. Two terms of Teaching Practicum (Phys 2998 and/or Astron 2998) are required for graduation. In the second year, Computational Methods (Phys 3274) and Research Internship (Phys 2900) are usually recommended. In addition to the 2000-level courses, the following 3000-level courses will be offered with regularity. Some will be offered yearly, and others will be offered every other year. Some of the courses are shared with CMU, but decisions on which department will teach a course in a given year are usually only made in the year before courses are offered. Various subsets of the 3000-level courses are recommended to students, depending on their desired areas of research specializations. Special Topics courses are also occasionally offered. Advanced students may take Directed Study (Phys 3900 or Astron 3900), Research & Dissertation (Phys 3000), and/or FTDS (Full-time dissertation study).

1. Astron 3550: Stellar Structure (every other year)
2. Astron 3580: Galactic & Extragalactic Astronomy (every other year)
3. Astron 3705: Astronomical Techniques (every other year)
4. Astron 3785: Cosmology (every other year)
5. Phys 3101: Special Topics in Biophysics (every other year)
6. Phys 3102: Quantum Optics and Quantum Information (at least every other year)
7. Phys 3274: Computational Methods (every year)
8. Phys 3373: Advanced Math Methods (irregular)
9. Phys 3542: Advanced Statistical Physics (every other year)
10. Phys 3707: Introduction to Many-Body Physics (every year)
11. Phys 3715: Solid State Physics (every year)
12. Phys 3716: Advanced Solid State Physics (every other year)
13. Phys 3717: Particle Physics (every year)
14. Phys 3718: Advanced Particle Physics (every year)
15. Phys 3725: Introduction to General Relativity (every other year)
16. Phys 3726: General Relativity 2 (every other year)
17. Phys 3730: Introduction to Biophysics (at least every other year)
18. Phys 3765: Field Theory 1 (every year)
19. Phys 3766: Field Theory 2 (every year)
20. Phys 3770: Topics in Quantum Physics (irregular)
21. Phys 3790: Particle Astrophysics (every other year)

In addition, in two specialty areas (Biophysics and Physics Education) we recommend courses outside of the department. These courses are not on the above list.

3 Recommendations for Individual Research Areas

3.1 Astronomy / Observational Astrophysics

1. Phys 2513 (Dynamical Systems)

and three or more of the following courses:

2. Astron 3550 (Stellar Structure)
3. Astron 3580 (Galactic & Extragalactic Astronomy)
4. Astron 3705 (Astronomical Techniques)
5. Astron 3785 (Cosmology)

3.2 Cosmology

1. Phys 2513 (Dynamical Systems)
2. Phys 2566 (Non-rel. Quantum Mechanics II)
3. Astron 3785 (Cosmology)
4. Phys 3725 (Introduction to General Relativity)
5. Phys 3790 (Particle Astrophysics)

Students specializing in early universe/dark matter studies should additionally take:

6. Phys 3726 (General Relativity II)
7. Phys 3765 (Field Theory I)
8. Phys 3766 (Field Theory II)
9. Phys 3717 (Particle Physics)
10. Phys 3718 (Advanced Particle Physics)

Students specializing in contemporary universe/dark energy studies should additionally take:

6. Astron 3550 (Stellar Structure)
7. Astron 3580 (Galactic & Extragalactic Astronomy)
8. Astron 3705 (Astronomical Techniques)

3.3 Elementary Particle Experiment

1. Phys 2513 (Dynamical Systems)
2. Phys 2566 (Non-rel. Quantum Mechanics II)
3. Phys 3274 (Computational Physics)
4. Phys 3717 (Particle Physics)
5. Phys 3718 (Advanced Particle Physics)
6. Phys 3765 (Field Theory I)
7. Phys 3766 (Field Theory II)

Students should consider taking advantage of the other following advanced courses:

1. Phys 3725 (Introduction to General Relativity)
2. Phys 3726 (General Relativity II)
3. Phys 3785 (Cosmology)
4. Phys 3790 (Particle Astrophysics)

3.4 Elementary Particle Theory

1. Phys 3717 (Particle Physics)
2. Phys 3718 (Advanced Particle Physics)
3. Phys 3725 (Introduction to General Relativity)
4. Phys 3726 (General Relativity 2)
5. Phys 3765 (Field Theory 1)
6. Phys 3766 (Field Theory 2)
7. Phys 3785 (Cosmology)
8. Phys 3790 (Particle Astrophysics)

3.5 Condensed Matter Experiment

At least three of the following courses:

1. Phys 3542 (Advanced Statistical Physics)

2. Phys 3707 (Introduction to Many-Body Physics)
3. Phys 3715 (Solid State Physics)
4. Phys 3102 (Quantum Optics and Quantum Information)

and at least one of the following courses:

1. Phys 3274 (Computational Methods)
2. Phys 3540 (Introduction to Astrophysics & Cosmology)
3. Phys 3716 (Advanced Solid State Physics)
4. Phys 3717 (Particle Physics)
5. Phys 3725 (Introduction to General Relativity)

3.6 Biophysics

1. Phys 3542 (Advanced Statistical Physics)
2. Phys 3707 (Introduction to Many-Body Physics)
3. Phys 3715 (Solid State Physics)
4. Phys 3730 (Introduction to Biophysics)

and two of the following courses:

1. Biosc 1470 (Biological Chemistry) – usually offered in the spring
2. Biosc 1540 (Computational Biology) – usually offered in the fall
3. Phys 3101 (Special Topics in Biophysics) – usually offered every other year
4. CmpBio 2041 (Cellular and Systems Modeling) – usually offered in the spring
5. Math 2921 (Ordinary Differential Equations II) – usually offered in the spring
6. Math 3380 (Mathematical Biology) – usually offered in the spring

3.7 Condensed Matter Theory

1. Phys 2566 (Non-rel. Quantum Mechanics II)
2. Phys 3542 (Advanced Statistical Physics)
3. Phys 3707 (Introduction to Many-Body Physics)

4. Phys 3715 (Solid State Physics)
5. Phys 3716 (Advanced Solid State Physics)
6. Phys 3765 (Field Theory 1)

and two of the following four courses:

1. Phys 3540 (Introduction to Astrophysics & Cosmology)
2. Phys 3717 (Particle Physics)
3. Phys 3725 (Introduction to General Relativity)
4. Phys 3730 (Introduction to Biophysics)
5. Phys 3766 (Field Theory 2)
6. Phys 3770 (Topics in Quantum Physics) – offered irregularly

3.8 Physics Education

Three of the following courses:

1. Phys 3542 (Advanced Statistical Physics)
2. Phys 3715 (Solid State Physics)
3. Phys 3717 (Particle Physics)
4. Phys 3730 (Introduction to Biophysics)

and two of the following three courses:

1. PsyEd 2019 (Stat2: Analysis of Variance)
2. PsyEd 2030 (Experimental Design)
3. Psy 2476 (Seminar in Cognitive Psychology)

Short Course Descriptions for Regularly Offered 3000-level Graduate Courses

The courses below generally have the department's core courses, or the equivalent, as a pre-requirement. If you are interested in taking a 3000-level course, but have not yet finished all the core courses, please contact the course instructor for permission.

Astron 3550/Phys 3550: Stellar Structure (every other year)
Stars are the most common astrophysical objects. They create most of the atomic elements and most of the observable optical light in the sky. This class provides an overview of the physics of stars and the interstellar medium. Topics will include hydrostatic equilibrium, nuclear processes, radiative transfer, metallicity and opacity, convection, stellar evolution, stellar explosions, properties of the interstellar medium, and energy feedback from stars.

Preparation: Some prior knowledge of astronomy/astrophysics will be useful. For students without this prior knowledge, this could be obtained by serving as an astronomy TA (Astron 2998: Teaching Practicum), or concurrently taking Phys 3540: Introduction to Astrophysics & Cosmology.

Astron 3580/Phys 3580: Galactic and Extra-galactic Astronomy (every other year)
Galaxies are the fundamental building blocks of the present Universe. This class will give an overview of galaxies, their properties, and their formation and evolution with an emphasis on current research areas. Topics will include observational properties (morphology, masses, colors, concentrations), scaling relations, evolution with redshift, stellar populations, gas and dust, dynamics and dark matter, evolution and mergers, and active galaxies.

Preparation: Some prior knowledge of astronomy/astrophysics will be useful. For students without this prior knowledge, this could be obtained by serving as an astronomy TA (Astron 2998: Teaching Practicum), or concurrently taking Phys 3540: Introduction to Astrophysics & Cosmology.

Astron 3705: Astronomical Techniques (every other year)
This class will expose students to the basics of astronomical data analysis, with an emphasis on statistical techniques and the development of practical programming skills. Topics may include the nature of random and systematic errors, fitting and likelihood techniques, hypothesis testing, astronomical instrumentation and data reduction, and the use of large survey data sets.

Astron 3785/Phys 3785: Cosmology (every other year)
This class will give an overview of the standard cosmological model and the wide range of observational tests. Topics include the expansion history of the Universe, thermodynamic history, nucleosynthesis, recombination, inflation, perturbations and the microwave background, structure formation, evidence for dark matter and dark energy, and future probes of dark energy.

Preparation: Some prior knowledge of astronomy/astrophysics will be useful. For students without this prior knowledge, this could be obtained by serving as an astronomy TA (taking Astron 2998: Teaching Practicum), or concurrently taking Phys 3540: Introduction to Astrophysics & Cosmology.

Phys 3101: Special Topics in Biophysics (every other year)
This course will give a broad overview of topological phases. Many of these phases are realized in solid state materials and exhibit remarkable bulk and surface properties. Topics covered will include recently discovered topological insulators, quantum Hall phases, concepts such as anyons and charge fractionalization, topological superconductors, Majorana excitations and their use as qubits, and quantum error corrections with surface code. This course will focus on both the theorectical aspects of topological phases, as well as experimental results used to identify such phases.

Phys 3102: Quantum Optics and Quantum Information (at least every other year)
Quantum optics describes the manipulation and coupling of quantum systems to their environment, and is key to understanding quantum computation, precision measurements, fundamentals of QM like entanglement and decoher-

ence. Fundamental concepts and applications in a wide range of systems such as atoms, ions, photons, spin qubits, superconducting qubits, condensates, and optical lattices will be considered.

Phys 3274: Computational Methods (every year)
In this course learn how to connect a variety of numerical and computational techniques to problems arising in classical mechanics, classical chaos, quantum mechanics, and statistical mechanics. Numerical techniques include numerical integration, Monte Carlo methods, simulation, data modeling, numerical linear algebra, and solution of different equations. Computational topics include an introduction to the linux operating system, use of class libraries, object-oriented programming, templates and elementary graphics. Students should be familiar with the C programming at an elementary level.

Phys 3373: Advanced Math Methods (irregular)
This course will focus on a subset of the following topics: group theory, statistics and data analysis, tensor algebra, differential geometry, as well as applications in quantum mechanics, particle physics and general relativity.

Phys 3542: Advanced Statistical Physics (every other year)
This course is aimed at a wide audience of primarily second year (and more senior) graduate students with interests in experimental or theoretical physics and astrophysics/cosmology. The aim is to provide a broad perspective of the concepts and techniques of statistical physics, which cut across many areas of active research. Depending on the composition and areas of interest of a particular class, an attempt will be made to include some examples from different disciplines. For example, potential topics to be covered include white dwarf stars; fluctuations and response; phase transitions and critical phenomena; mean field theories; Landau theory; order parameters; scaling, fluctuations, response, universality; broken symmetry; renormalization group; interacting systems; weakly interacting Bose gas; excitation spectrum; superfluidity; BCS as a mean field theory; and nonequilibrium stochastic processes.

Phys 3707: Introduction to Many-Body Physics (every year)
This is a one-term nuts-and-bolts introduction to the quantum physics of interacting, many-particle systems. The course includes second quantization, many body physics, and a brief introduction to relativistic quantum mechanics and the Dirac equation. Throughout there will be discussion of applications of the techniques and concepts in various subfields of physics. The approach will generally be intuitive and hands-on. The course typically will begin with second quantization for fermionic and bosonic systems, with examples typically involving electrons, phonons and photons, arising from the quantization of the electromagnetic field. Applications will typically include the interacting electron gas and plasmons; the interaction of the radiation field and matter; electron-phonon interactions; and dressed electrons and the polaron problem. There will typically be some discussion of condensation phenomena and superfluidity (typically Bogoliubov theory, broken symmetry and Goldstone bosons) and superconductivity (pairing, BCS and Landau-Ginzburg theories). There will generally be some exposure to Greens functions and Feynman diagrams.

Phys 3715: Solid State Physics (every year)
This is a one-term course on solid-state physics, which emphasizes the special ways one must think about crystalline materials. The course will allow students emphasizing this area to enhance their own research efforts, and it will permit other students to have an appreciation for an extremely large part of current research activity in physics. Roughly speaking, there will be three parts to the course. Some variation on emphasis can be expected depending on the instructor and on the interests of the class. (i) Phonons: Crystal lattices; diffraction and scattering; reciprocal lattice; lattice vibrations, quantization; thermal properties. (ii) Electrons: Free electron model; density of states; thermal properties; Bloch's theorem, electron states and energy bands; semiconductor statistics; quasi-classical electron dynamics; Boltzmann equation and transport. (iii) Additional topics: Electron-electron and electron-phonon interactions; Hall effect; Landau levels; superconductivity; electromagnetic response.

Phys 3716: Advanced Solid State Physics (every other year)
This is a second, graduate-level solid state physics course. The topics will be adjustable given the cross section of students taking the course and topical developments in the field. Topics suitable for this course include: a brief exposure to "practical" group theory; optics and spectroscopy relevant to the solid state including linear and non-linear response and complex dielectric constant; coherence and correlation including the density matrix Bloch equations, and optics; introduction to NMR; superconductivity beyond the Ginsburgh-Landau theory; advanced topics in magnetism; advanced topics in transport theory.

Pre-requirement: Phys 3715, Solid State Physics

Phys 3717: Particle Physics (every year)
This is the first term of a two-term sequence exposing the student to basic methods and recent developments in high energy physics. The first term of the sequence is suitable as a one-term course for students not specializing in high-energy physics. Particle physics involves completely relativistic phenomena and requires the generalization of non-relativistic quantum concepts to the relativistic regime in order to develop the phenomenological and calculational methods suitable for relativistic processes in which the number and type of particles can change. The course examines experimental and phenomenological foundations of particle physics. The known particles and fundamental interactions are investigated. Modern experimental techniques of particle physics are discussed (including basic properties of particle interactions with matter). General features of electromagnetic, weak, and strong interactions, and their associated symmetries, are explored.

Phys 3718: Advanced Particle Physics (every year)
This is the conclusion of the 2-term sequence Phys 3717/3718, which should be taken in order. This course covers the Standard Model in detail and includes: the phenomenology of weak interactions; group theory and the quark model; the parton model for deep inelastic scattering and other high energy processes; an introduction to gauge theories of electroweak and strong interactions. Various topics of current interest in particle physics beyond the Standard Model will also be discussed.

Pre-requirement: Phys 3717, Particle Physics

Phys 3725: Introduction to General Relativity (every other year)
This course covers the basic conceptual foundations of general relativity starting from the special theory, with applications, calculational techniques and discussions of current observational probes. Topics include the equivalence principle, geodesic deviation, tidal forces, the description of gravitation as geometry, Schwarschild space time. Also covered are: solar system tests and post-Newtonian parameters; gravitational lensing; micro and macrolensing as probes of dark matter; observations; vacuum Einstein's Equations and Schwarschild solution.

Phys 3726: Advanced General Relativity (every even year)
The advanced course begins with a derivation of Einstein's equations and energy momentum tensors. The following are studied: stellar evolution, gravitational collapse, compact stars and black holes; gravitational radiation sources and detection; cosmology; the Friedmann-Robertson-Walker metric; the Standard Big Bang; successes and problems; inflation; dark energy and observations; cosmic microwave background and observations.

Pre-requirement: Phys 3725, Introduction to General Relativity

Phys 3730: Introduction to Biophysics (at least every other year)
In this course we will review useful physical ideas and techniques that have contributed significantly to recent developments in biophysical research. This includes: the use of statistical approaches for understanding gene regulation and signal transduction in biological and chemical networks; nonlinear dynamics for understanding biological pattern formation, ecology, and population dynamics; hydrodynamics for understanding cell motility and taxis; and information theory for signal processing in neuronal networks. The course will also introduce basic concepts in biology that range from molecular to cellular biology. Specific topics to be covered include: introduction to biology; microscopy techniques; basics of cell biology; genetics (the genetic code, gene replication, gene expression, genetic networks); molecular biology techniques; energy in biological systems and the statistical view of biological dynamics; entropy and free energy in biology; two-state models in biology and neurobiology.

Phys 3765: Field Theory 1 (every year)
This is the first semester of a graduate course in Quantum Field Theory. The course develops the perturbative approach to relativistic field theory. The topics covered will be: Lorentz and Poincare groups; method of second quantization; free scalar field theory; free spin-1/2 field theory; field quantization; symmetries and conservation laws; interacting scalar field theories, Yukawa theory; perturbation theory and Feynman rules; elementary renormalization theory; quantum electrodynamics.

Phys 3766: Field Theory 2 (every year)
This is the second semester of a graduate course in Quantum Field Theory. It builds on the material covered in Phys 3765 (Field Theory 1), which is a prerequisite. The course further develops the techniques of relativistic quantum field theory, covering the path integral approach to field theory, additional topics in quantum electrodynamics, symmetry breaking, non-abelian gauge theories, and the Standard Model. In more detail, the topics covered will be: Green's functions, asymptotic scattering theory, and the LSZ formalism; functional integration and the path integral; quantization of abelian (QED) and non-abelian (Yang-Mills) fields; the renomalization group; spontaneous symmetry breaking of global and local symmetries; the Standard Model.

Pre-requirement: Phys 3765, Field Theory 1

Phys 3770: Topics in Quantum Physics (irregular)
This course will serve as an introduction to the field of Quantum Information and Quantum Computing, beginning with basic concepts such as entanglement and state teleportation and building towards applications such as Shor's algorithm, quantum cryptography, and quantum search. Key topics including quantum bits, circuits, and algorithms will be covered, as well as decoherence, quantum errors and correction schemes, and quantum measurement and noise. The courses will focus especially on different physical implementations of quantum computing systems (ex. trapped ions and superconducting circuits), their challenges and advantages, and survey recent developments in the field.

Phys 3790: Particle Astrophysics (every other year)
Particle physics plays an increasingly important role in astrophysics. This class will cover areas of common interest between these fields. Topics may include dark matter (particle abundances, particle candidates, direct and indirect detection), neutrino masses and oscillations, high energy cosmic rays and detection schemes, high density matter in neutron stars, models for inflation, baryogenesis, cosmological phase transitions, and models for dark energy.

APPENDIX III

TO: Faculty and Graduate Students

FROM: David Jasnow, Chairperson, Department of Physics and Astronomy

DATE: June 4, 2004

SUBJECT: PhD research conducted outside the department

This document replaces the previous statement on this subject published in December 2002.

The Department of Physics and Astronomy has faculty engaged in internationally recognized programs of research in a wide range of fields. Research activities are described in our brochure, on the departmental web site and through links to material maintained by our individual faculty members and/or groups. Graduate students can also learn about current research activities through the "research talks" which take place during the academic year.

Students entering our program, after completing their "core" education requirements, are expected to find a research advisor within the department and to form a graduate committee to guide their PhD research. The graduate advisor has prime responsibility for mentoring the student and supervising the research. The chairperson of the department as well as the Associate Dean for Graduate Studies must both approve the selection of all graduate thesis committees.

In rare occasions a student, to satisfy specific research goals or interests, may request permission to perform PhD research under the primary guidance of a faculty member outside the Department of Physics and Astronomy. The chairperson of the Department of Physics and Astronomy will consider such requests on a case-by-case basis in consultation with the Director of the department's graduate program and others. Below are some guidelines the chairperson may use in deciding whether or not to approve the formation of a particular thesis committee when the primary research advisor is not in the Department of Physics and Astronomy.

GUIDELINES

- The "primary" research advisor from another department or school within the University will serve as co-chair of the thesis committee. He or she must be a member of the graduate faculty, must have substantial training in graduate-level physics or astronomy, and must have a record of physics or astronomy related research activities.

- A member of the graduate faculty within the Department of Physics and Astronomy must agree to serve as co-chair of the thesis committee.

- It is essential that the departmental co-chair of the thesis committee takes an active interest and commits to active participation and, ideally, collaboration in the research project.

- Thesis committees will not be approved if the departmental co-chair acts merely as a "formal" advisor without active involvement.

- The department chairperson may limit the number of students working outside the department if, in his or her judgment, a further increase is inconsistent with the research goals of the department.

- The "primary" research advisor takes primary responsibility for the financial support of the student. Any GSR contract should conform to university policies described at https://www.gradstudies.pitt.edu/sites/default/files/assets/GSRAcademicRegs6-1-22.pdf. Before signing, it is the student's responsibility to bring a copy to the graduate administrator in the Department of Physics and Astronomy to initiate the appropriate review.

PROCEDURES

- A graduate student wishing to conduct his or her PhD research under the supervision of a primary advisor outside the department should inform the Graduate Secretary as soon as possible of intentions. After discussions with the respective faculty members, the student should identify the proposed primary advisor from outside the department and the proposed co-advisor from within the Department of Physics and Astronomy. The student will be informed in writing if there are potential problems based on the guidelines above.

- In consultation with the primary advisor and the departmental co-chair, the student must submit a written proposal describing the nature of his or her anticipated PhD research as soon as possible, but no later than 4 months after the beginning of an arrangement for joint supervision. A provisional thesis committee must approve the proposed research as suitable for a PhD issuing from the Department of Physics and Astronomy. The primary advisor may be requested to submit a CV and list of publications.

- It will be expected that the primary advisor and the departmental co-chair submit a brief statement outlining the plan for advising and mentoring the student and the nature of the anticipated research collaboration.

(original document Dec., 2002)