Modifications to Physics Department Graduate Program

The current requirements to attain the advanced degrees of Ph.D. and M.S. in Physics at CMU are detailed in the Physics Department Graduate Program Handbook that is publicly available at

Modifications to these requirements have been proposed by the Graduate Program Working Group (co-chaired by Rachel Mandelbaum and Manfred Paulini) and were approved by the Physics Faculty on May 4, 2017. A detailed document outlining the findings of the Working Group can be found at
https://drive.google.com/file/d/0B8-nEOVAFkE3ZF80V29pZjltc3M/view?usp=sharing

while the motivations for the changes as well as the new program requirements and timeline are summarized here.

Motivation

The changes to the Graduate Program as proposed by the Physics Graduate Program Working Group are motivated by the following considerations:

- Our current graduate program requirements, while each serving a purpose, nevertheless do not map well to our program goals. Certain program goals are redundantly covered by many requirements, while others are not covered by any requirements at the time of qualification for Ph.D. candidacy (and are only seriously evaluated later in the program). The new requirements ensure more even coverage of our program goals.

- The students’ performance on the Written Qualifying Exam is highly correlated with their GPAs in our core courses, while preparing for the exam takes considerable student and faculty resources. In our cost/benefit analysis, these downsides outweigh its benefits. Also, the time spent studying for the Written Qualifying Exam during the first summer takes time from research in a way that disrupts the continuity of the program.

- Insufficient emphasis is placed on research in the early parts of the program. This results in inadequate standards imposed on research competency at the time of qualifying for Ph.D. candidacy, and is detrimental to the graduate recruitment process and the students’ education.

- It would be valuable to add more flexibility into the research part of the program in order to (a) accommodate student interests in different research areas, (b) balance the needs of the faculty towards meeting their research goals, (c) aid in...
student recruitment, and (d) enable an interdisciplinary focus earlier in the program.

Key Recommendations

The key recommendations of the Working Group as adopted by the faculty are:

(a) To replace the Written Qualifying Exam with an enhanced procedure for final exams in the core courses.
(b) To involve students earlier in research starting with the first semester, and include research readiness as part of the requirements for passing a student on to Ph.D. candidacy.
(c) To modify the Oral Qualifying Exam to serve as an oral exam emphasizing the assessment of the student’s research aptitude and readiness.
(d) To address in the near future other aspects of the graduate program such as the role of department requirements versus the individual advisor in satisfying certain program outcomes related to professional development.

Graduate Degree Requirements

The new graduate program requirements are summarized below. A detailed schedule and implementation are available in the Working Group Summary linked above.

Course Requirements

● **Research Project Courses:** Students are required to choose a research project advisor by the end of the second week of their first fall semester. They will work with this advisor in the form of “33775 Introduction to Research 1” on a 12 hour per week project for the entire semester. They will have an additional 12 hour per week project in the second semester, in the form of “Introduction to Research 2”, followed by an intensive full-time research experience covering the entire summer after the second semester. Some rotation between research groups will be encouraged, with students identifying their long-term thesis advisor ideally in the fall of their 2nd year, when they continue research in the form of “33997 Graduate Laboratory”.

● **Required Core Courses:** To enable students to engage in serious research projects of at least 12 hours per week in their first two semesters, the number of required introductory core courses is reduced from five to four: Quantum Mechanics 1 and Electrodynamics in the fall plus Quantum Mechanics 2 and Statistical Mechanics in the spring. Although Mathematical Physics is still offered
and encouraged for students with weaker undergraduate preparation (requiring extra background), the most important parts of Mathematical Physics are absorbed into the curriculum of Quantum Mechanics, Electrodynamics, and Statistical Mechanics.

- **Breadth Course Requirement:** By the end of the second year of graduate studies, students should complete the breadth requirement consisting of two courses out of a list of four courses. This requirement is unchanged.

**Examinations and Academic Performance**

- **Grade Requirements:** In place of the Written Qualifying Exam, a rigorous teaching and examination of the four required core courses is mandatory. Passing the four core courses requires at least a grade of B-.

- **Academic Performance:** Students cannot have a grade-point average (GPA) of less than 3.0 in each of two consecutive semesters. The requirement for students to maintain a satisfactory academic record is unchanged.

- **Oral Research Exam:** To test for research readiness we replace the Special Oral Qualifying Exam with an Oral Research Exam taken before the start of the spring semester of the student’s 2nd year. Students will give a presentation about their research from the 1st to 3rd semester and will be asked questions related to their research as well as basic physics concepts relevant to the presented research topic. Students can fail the Oral Research Exam and are allowed a second chance immediately after the spring semester in their 2nd year.

**Program Schedule**

To allow flexibility for students to take non-core courses in their first year, two options for the timing of course choices are possible (see table on the next page). Option A students complete all 4 core courses in year 1, while Option B students postpone one core course until year 2 in order to take an advanced topic course or Mathematical Physics in year 1. The table also shows other important program milestones, allowing the full context of courses and research to be seen.
Current schedule (black). New schedule, option A (red). New schedule, option B (blue).

<table>
<thead>
<tr>
<th>Yr</th>
<th>Fall</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 core courses; No research</td>
<td>2 core courses; 1st research project</td>
<td>Continue research or 2nd research project; Written Qual (Aug)</td>
</tr>
<tr>
<td>1</td>
<td>2 core courses; Research project</td>
<td>2 core courses; Research project</td>
<td>Research project</td>
</tr>
<tr>
<td>1</td>
<td>1 core course; 1 breadth / subject course or Mathematical Physics; Research project</td>
<td>2 core courses; Research project</td>
<td>Research project</td>
</tr>
<tr>
<td>2</td>
<td>Breadth or subject courses; Research project</td>
<td>Oral Qual (Jan); Ph.D. candidacy (Jan); Research project</td>
<td>Thesis research</td>
</tr>
<tr>
<td>2</td>
<td>Breadth or subject courses; Research project</td>
<td>Oral Research Exam (Jan); Ph.D. candidacy (Jan); Thesis research</td>
<td>Thesis research</td>
</tr>
<tr>
<td>2</td>
<td>1 core course; 1 breadth or subject course; Research project</td>
<td>Oral Research Exam (Jan); Ph.D. candidacy (Jan); Thesis research; breadth course for students who took Mathematical Physics in year 1 fall semester.</td>
<td>Thesis research</td>
</tr>
<tr>
<td>3</td>
<td>Thesis research</td>
<td>1st annual review</td>
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As shown, both schedules A and B enable students to complete important program milestones on a similar time-scale (i.e. pass on to Ph.D. candidacy after 3 semesters as is currently the case), while providing some flexibility for an entry into advanced courses in the first year for those who find this advantageous.

Ph.D. Candidacy and Annual Research Reviews

- **Ph.D. Candidacy**: Passing on to Ph.D. candidacy will require passing the 4 core courses with at least a B- grade and achieving at least a B average in the 4 core
courses, as well as passing the Oral Research Exam. In addition, passing two breadth courses with at least a B- remains among the requirements for Ph.D. candidacy.

- **Annual Reviews:** Students will be encouraged to find their long-term thesis advisor in the fall of their 2nd year and are required to have chosen a thesis advisor by the end of their second year. Starting no later than one year after being passed to Ph.D. candidacy, a student must hold a first annual research review and continue to hold such an annual review until graduation. The annual review requirement is unchanged.

Teaching Requirement

All graduate students are required to perform classroom or laboratory teaching for at least one semester before receiving a Ph.D. in Physics. This requirement is unchanged.

Thesis Committee and Thesis Defense

The purpose of a doctoral thesis committee is to judge the validity, originality, significance, and proper presentation of the candidate's doctoral thesis. The rules to form a thesis committee and hold a thesis defense follow the MCS guidelines and are unchanged.

Topics Deferred for Later

The changes described here address the key concerns about the current graduate program, and hence we would like approval to implement this plan starting in the Fall 2017 semester. There are a few small but potentially tricky issues that were deferred for later. Our goal is to complete the following points (that are easily disentangled from other program components) during fall 2017: fine-tuning the role of the department vs. the individual advisor in certain program outcomes such as communication skills; the question of whether the list of four courses in the core should be adjusted; and metrics for evaluation of the new program requirements, to be used once enough time has passed.

Transition to New Program Rules for Current Students

Assuming an approval by College Council before the end of the Spring 2017 semester, all new students entering the Graduate Program in the Fall 2017 semester would be subject to the new program rules. They will be informed about the new rules, and in particular the need to choose a research project advisor at the beginning of the fall semester, at the beginning of the summer. Current CMU graduate students who have
not yet been passed on to Ph.D. candidacy are able to choose whether they want to continue following the graduate program rules that were in place when they entered the program or take advantage of the new rules.