2018/2019 Physics Graduate Self-Assessment Report

This report is prepared on the basis of individual self-assessment reports from the instructors of the designated courses, as well as self-assessment forms completed following PhD proposals and defenses by the relevant committees.

The assessed courses were PHYS 601 (Fall), 602, 607, and 690 (all Spring). There were also 3 reports from PhD proposals and 3 from PhD defenses.

An executive summary of the various self-assessment reports is presented below, with Sec I summarizing the course reports and Sec II summarizing the proposal and defense reports. The course reports in their entirety are included in the Appendices, and the proposal and defense reports are in the files of the assessment committee chair, Dr. Georganopoulos.

I. Course reports:

PHYS 601:

Dr. Franson reports,

"The class performed well again this year. The overall success rate for the 6 learning goals was 96%, which is slightly better than last year"

Learning goal 3 (Heisenberg picture) performance dropped from 93% last year to 78% this year, but Dr. Franson notes that is likely due to being tested using a relatively difficult exam problem this year.

PHYS 602:

Most of the learning goals were achieved, but there was unusually poor performance (30%) with respect to goals 2e (BEC, superconductivity, etc.) and 4b (fluctuation theorems). Dr. Deffner notes,

"Like in previous years the students seemed to quite enjoy the course with regards to topics, depth and pacing. However, I was very surprised by the performance on the final exam."

He finds the root issue to be insufficient preparation by the majority of students, and suggests that we may have to foster a more serious attitude among them. He also notes this cohort seems less mathematically sound and suggests resuming the assignment of Jackson problems in 607.

<u>PHYS 607:</u>

This was Dr. Zhai's first year teaching this course, and he implemented an active Team Based Learning approach in this course for the first time. He continued the use of Zangwill as the primary textbook instead of Jackson as begun the previous year by Dr. Kestner in 607 and Dr. Pittman in 707.

For most of the learning goals, the proficiency levels this year show improvement compared to last year. Dr. Zhai summarizes,

"Most students showed satisfying performance on understanding the basic concepts and applying them in problems solving. Their understanding of the higher level materials, for example, the methods of the Green function and separation of variables was definitely less achieved. They were good at traditional electrostatic and magnetostatics problems which they had seen before, but less proficient in variations of those problems covering the same physics concepts."

Similar to Dr. Deffner, Dr. Zhai also noted motivation problems in this cohort:

"I had a hard time of convincing them the importance of reading the textbook before the class, which most of the class had not done enough."

He plans to assign pre-reading from an easier-to-understand book such as Griffiths next year to ease the task.

<u>PHYS 690:</u>

Dr. Hayden reports,

"This year, the class was outstanding in both their oral and written work. Many of them needed help improving their CV, but the technical assignments were all performed at an above average level, across the board. Truly the best class I've ever seen in PHYS 690."

<u>Summary of course reports:</u>

The learning goals of the PhD program are being achieved. Some departmental discussion may be warranted about establishing appropriate expectations among incoming grad students.

II. Proposal and defense reports:

This year there were 3 reports from PhD proposals and 3 from PhD defenses.

In all cases, all learning objective outcomes were reported as average or above.

Summary of proposal and defense reports:

The learning goals of the PhD program are being achieved successfully by the department.

Appendix A: PHYS 601 report by Dr. Franson

Results:

The student performance was considered to be satisfactory if it was at the level of B or above.

1. Utilize the postulates of quantum mechanics to describe quantum systems and determine their properties, including the results of measurements.
    a. Evaluated using homework problem 1 (lecture 5).
    b. Results: 9 satisfactory 0 unsatisfactory 100%

2. Use operator techniques to solve relevant problems.
    a. Evaluated using homework problem 5 (lecture 16)
    b. Results: 9 satisfactory 0 unsatisfactory 100%

3. Analyze the time dependence of quantum systems using the Heisenberg picture.
    a. Evaluated using final exam problem 2 .
    b. Results: 7 satisfactory 2 unsatisfactory 78%

4. Use the properties of angular momentum and spin to describe quantum systems such as the hydrogen atom and an electron in a magnetic field.
    a. Evaluated using homework problem 11.
    b. Results: 9 satisfactory 0 unsatisfactory 100%

5. Understand the interaction of the electromagnetic field with charged quantum-mechanical particles and solve related problems such as the rate of absorption and emission of light.
    a. Evaluated using homework problem 8 (lecture 22).
    b. Results: 9 satisfactory 0 unsatisfactory 100%

6. Use perturbation theory to find approximate solutions to more complex quantum-mechanical systems.
    a. Evaluated using final exam problem 4.
    b. Results: 9 satisfactory 0 unsatisfactory 100%

Comments:

The class performed well again this year. The overall success rate for the 6 learning goals was 96%, which is slightly better than last year. The performance on goal 3 appeared to be lower than last year, but that is probably due to the fact that it was tested using a relatively difficult problem on the final exam this year. In the same way, the performance on goal 4 appears to be better, but that is probably because it was tested on a take-home exam. There do not appear to be any areas in need of significant improvement. All all of the students completed the course at the graduate level.

Appendix B: PHYS 602 report by Dr. Deffner

1. **Methods of Statistical Physics:** Be familiar with the following mathematical tools and apply methods in standard problems

   a) Probability theory and distributions

   Concepts and technical skills were tested in homework, midterm and final exams. Initially the conceptual understanding of abstract probability distribution appeared vague (unfortunately like in previous years), but by the end of the class all students correctly solved the problem on the final exam. Also the transformation between distributions for different random variables worked fine.

   b) Evolution in phase and probability space (Liouville's equation, diffusion, Fokker-Planck equations, and Langevin equation)

   The students developed a good and deep understanding of the different notions. In homework, midterm and final exams they proved their technical skills by solving Fokker-Planck and Langevin equations. In the final exam it was further tested whether students are able to describe the physical significance of the models, and all students succeeded.

2. **Systems in thermal equilibrium:** Understand the following concepts and solve problems in "real-life" applications

   a) Fundamentals of thermodynamics (laws of thermodynamics, quasistatic processes, equilibrium response functions, equations of state for ideal and non-ideal gases, Maxwell relations)

   This was basically a review of the undergraduate curriculum. The performance of the students was adequate. However, it did show that many of the students were only insufficiently prepared by the undergraduate courses, which might also explain why some even chose to forgo the first attempt of the qualifying exam.

   b) Statistical approach (random walks, ergodic hypothesis, statistical ensemble, Maxwell-Boltzmann distribution and thermodynamic ensembles)

   These were completely new topics for the students, but they studied well. Problems in the exams were solve to full satisfaction.

   c) Equilibrium phase transitions (phase equilibrium, mean-field theory, critical exponents)

   Also a completely new topic, which was tested on the final exam. Generally the students performed well. As in previous years the students had general misconceptions about how to classify the order of phase transition. Most undergraduate courses seem to be brief or even incorrect on this topic.

d) Quantum statistics (Fermi-Dirac and Bose-Einstein distribution)

Generally, students performed as expected.

e) Quantum states of matter (Bose-Einstein condensation, superfluidity, superconductors)
Qualitative problems on the exams were solved to full satisfaction by only a handful of problems. However, the issue seems to be a general lack of seriousness in their preparation (see general remarks below).

3. **Systems close to thermal equilibrium:** Be familiar with the following concepts and solve simple problems close to experimental systems

   a) Linear response and Onsager relations

   A qualitative question on the final exam was solved to full satisfaction and the students demonstrated adequate understanding.

   b) Transport phenomena

   The students exhibited good physical understanding and creative thinking in solving the problems on the homework and midterm exam.

4. **Systems far from thermal equilibrium:** Be familiar with the following concepts and be able to explain the main gist

   a) Maxwell's demon

   Homework problems and reading assignments were performed to full satisfaction.

   b) Fluctuation theorem and Jarzynski equality

   Qualitative problems in the homework and midterm exams and qualitative problems on the final exam were solved to full satisfaction by only three students (see general remarks below).

General remarks:

Like in previous years the students seemed to quite enjoy the course with regards to topics, depth and pacing. However, I was very surprised by the performance on the final exam. The average scores on the homework and the (take-home) midterm were high, and the scores on the final exam were only as expected in three cases (Touil, Thorsteinsson, and Roy). When investigating what could have happened, I found my suspicion confirmed: most of the students took (strong) inspiration from the submissions of the well-performing students in homeworks and midterm, and thus were only insufficiently prepared for the final. Given that this included all students that did not even attempt the qualifying exam in January, I wonder whether we are doing a poor job in communicating to our students that graduate school is hard and that it will require dedication and commitment.

To a certain degree I also noticed in the student's performance that the course in E&M was somewhat less mathematical and formal than in the past. Solving Jackson problems definitely hones mathematical skills that the students then also take to work on topics in other courses.

Quantitative assessment (success in %):

1a)	90%
1b)	100%
2a)	70%
2b)	100%
2c)	80%
2d)	70%
2e)	30%
3a)	90%
3b)	100%
4a)	100%
4b)	30%

Appendix C: PHYS 607 report by Dr. Zhai

This is the first time I teach PHYS 607. The textbook is Modern Electrodynamics, Zangwill, which was used previously by Dr. Jason Kestner and also consistent with PHYS 707, Advanced Electromagnetic Theory, for which the same textbook is used but covering the latter half.

Motivated by Physics Education Research (PER) and other evidence based teaching researches, I decided to use the Team Based Learning for this course, which have many advantages, including a student-oriented class and more efficient learning environment. I divided the class into groups with three to four members in each group. I laid out learning goals and listed the reading materials for students to finish before each class. In each class I briefed the subjects and then distributed a set of group working problems which cover the subject. They worked on the problems in group. I went around the classroom overseeing the discussion and providing my comments when necessary.

The percentage of students who were able to demonstrate proficiency in each learning goal in an exam setting is reported below:

1) Use elementary concepts of the electric potential, the integral form of Gauss's Law, and electrostatic potential energy to treat electrostatics problems. Proficiency: 100%

2) Solve boundary-value problems in electrostatics using method of images and Green's function techniques. Proficiency: 80%

3) Solve boundary-value problems in electrostatics using separation of variables in cartesian, spherical, and cylindrical coordinates. Proficiency: 70%

4) Use the concept of electric displacement to solve electrostatics problems in macroscopic media. Proficiency: 90%

5) Use elementary concepts of Ampere's law, the vector potential, and magnetic scalar potential to treat magnetostatics problems. Proficiency: 70%

6) Apply Poynting's theorem and conservation of momentum and energy to electromagnetic fields. Proficiency: 60%

Most students showed satisfying performance on understanding the basic concepts and applying them in problems solving. Their understanding of the higher level materials, for example, the methods of the Green function and separation of variables was definitely less achieved. They were good at traditional electrostatic and magnetostatics problems which they had seen before, but less proficient in variations of those problems covering the same physics concepts. Overall the international students performed better than domestic students, at least in this cohort, primarily because of students' background and academic preparation, not necessarily how hard they worked in this class. I had a hard time of convincing them the importance of reading the textbook before the class, which most of the class had not done enough. Part of the reason was that the textbook is not easy to understand given their academic levels, as electromagnetic theory is a difficult subject to teach. In the future, I will adjust the time of lecturing and group working in classes to achieve better outcome. More importantly, I will assign an easier textbook, for example, Introduction to electrodynamics by Griffiths for the pre-class reading to ease up this task. I will provide more feedback on their homework and urge them focusing more on critical thinking and problem solving of the physics and mathematical concepts.

Appendix D: PHYS 690 report by Dr. Hayden

Dear Graduate Program Assessment Committee,

PHYS 690 is supposed to assess the oral and written communication skills as required for professional presentations and publications.

The writing learning outcome was assessed through evaluation of the student's writing in several assignments:

a) writing an outline for their PhD proposal
b) writing a critique and commentary of a famous research article
c) preparing a detailed CV
d) writing an abridged NSF grant proposal, (3 page technical, budget, budget justification, CV, refs)

The oral skills learning outcome was assessed through evaluation of the student's presentations and discussions in class, including:
a) an oral presentation typical of a 15 minute conference presentation
b) leading a group discussion for a specific ethics case study

This year, the class was outstanding in both their oral and written work. Many of them needed help improving their CV, but the technical assignments were all performed at an above average level, across the board. Truly the best class I've ever seen in PHYS 690.

Mike Hayden
PHYS 690