2016/2017 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 2 reports from PhD proposals and 5 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,

"Class performance overall was better than average due to a talented pool of students this year. The overall success rate for the 6 learning goals was 84%."

The lowest performance score, 71%, was on learning goal 4 (angular momentum and spin), which Dr. Franson attributes to an unusually difficult final exam question used to assess the goal. Goals 2 (operator techniques) and 5 (interaction of EM fields with particles) had success rates above 90%, and 12 out of 14 students satisfactorily met the learning goals.

PHYS 602:

This was the first year of a renovated and modernized course structure implemented by Dr. Deffner. He reports,

"The students seemed to appreciate a more modern approach to the course. In particular, all students showed their interest in problems which are closely related to topics of active research. Several students have expressed their interest in a more advanced course on non-equilibrium statistical mechanics and quantum thermodynamics."

On the whole, the learning goals were successfully accomplished in the course. However, Dr. Deffner notes that students were not adequately prepared for learning goal 2a (fundamentals of thermodynamics) and recommends adding emphasis to partial derivatives and exact differential equations in PHYS 605. He also notes that learning goal 2d (quantum statistics) was hindered by students' inability to do non-trivial integrals.

<u>PHYS 607:</u>

Dr. Kestner reports that the biggest performance issue from last semester, goal 4 (dielectrics), was improved by increasing time spent on it at the cost of goal 6 (momentum and energy). Goal 2 (Green's function techniques) also showed improvement from 50% to 80% satisfactory. However, at an elementary level, he notes that

"Half of [the students] could consistently be tricked into misusing [the integral form of] Gauss's Law where there was no symmetry to exploit."

<u>PHYS 690:</u>

Dr. Hayden reports regarding the written communication skills, *"For the grant proposal and PhD proposal, where the topic was mostly technical, the students mostly got the point across while making occasional grammatical errors."* For the oral communication skills, *"The non-English speakers had the most difficulty not only in grammatical areas but also in their willingness to participate in class discussions. Several of these students would benefit from more opportunities to practice their speaking skills. I recommend that all faculty require their grad students to present weekly reports at their group meetings."*

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

The graduate self-assessment committee believes the learning goals of the program are being achieved. No programmatic shortcomings have been identified.

<u>II. Proposal and defense reports:</u>

This year there were 2 reports from PhD proposals and 5 from PhD defenses.

Both proposal reports rated all learning objective outcomes as above-average to excellent.

Of the 5 defense reports, 4 rated all learning objective outcomes as above-average to excellent, with 3 of those specifically commenting on the quality of the presentation. However, there was an outlying 5th report that reported below-average outcomes and gaps in basic education. In that case, the committee chair wrote an extensive report urging more rigor in the oral exam and the process of advancement to candidacy, and particularly, more caution in the case of PhD proposals with off-campus advisors.

<u>Summary of proposal and defense reports:</u>

The learning goals of the program are being achieved very successfully by the department. However, departmental discussion may be needed on the proper implementation PhD advising in cases where the responsibility is shared between on-campus and off-campus advisors.

Appendix A: PHYS 601 report by Dr. Franson

Results:

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: 11 satisfactory 3 unsatisfactory 79%

2. Use operator techniques to solve relevant problems.
   a. Evaluated using homework problem 5 (lecture 16)
   b. Results: 13 satisfactory 1 unsatisfactory 93%

3. Analyze the time dependence of quantum systems using the Heisenberg picture.
   a. Evaluated using midterm problem 2 .
   b. Results: 12 satisfactory 2 unsatisfactory 86%

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 final exam problem 1.
   b. Results: 10 satisfactory 4 unsatisfactory 71%

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: 13 satisfactory 1 unsatisfactory 93%

6. Use perturbation theory to find approximate solutions to more complex quantum- mechanical systems.
   a. Evaluated using final exam problem 4.
   b. Results: 11 satisfactory 3 unsatisfactory 84%

Comments:

Class performance overall was better than average due to a talented pool of students this year. The overall success rate for the 6 learning goals was 84%. Relatively low performance on goal 1 was obtained in homework 1, but this topic was covered again later in the class and the performance improved greatly. Relatively low performance was also obtained on goals 4 and 6, which is probably due to the fact that those final exam questions were more difficult than usual.

For comparison, 2 students received a grade of B minus and their overall performance was unsatisfactory; that corresponds to a success rate of 86%. Those two students appeared to be either unprepared or unmotivated. The remaining 12 students met the learning goals.

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, 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. Generally, the students did well. However, (at least in the beginning) they also exhibited an unsatisfactory lack of familiarity with partial derivatives and exact differential equations. It might be worthwhile to consider adding these topics to Mathematical Methods.

   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. However, there seems to be a general misconception 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 well with the exception of the students will the poor final grades. The overall understanding was demonstrated, however some of the students lack the sufficient technical and mathematical skills to correctly compute the non-trivial integrals.

e) Quantum states of matter (Bose-Einstein condensation, superfluidity, superconductors)

Qualitative problems on the exams were solved to full satisfaction.

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. However, several students had either not fully digested, or simply forgotten about the importance of assuming "local equilibrium". The upper half, however, demonstrated deep understanding.

   b) Transport phenomena

   A problem on the first midterm was solved surprisingly well. The students exhibited good physical understanding and creative thinking in solving the problem.

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.

General comments:

The students seemed to appreciate a more modern approach to the course. In particular, all students showed their interest in problems which are closely related to topics of active research. Several students have expressed their interest in a more advanced course on non-equilibrium statistical mechanics and quantum thermodynamics.

Quantitative assessment (success in %):

1a)	90%
1b)	100%
2a)	65%
2b)	100%
2c)	80%
2d)	75%
2e)	100%
3a)	90%
3b)	100%
4a)	100%
4b)	100%

Appendix C: PHYS 607 report by Dr. Kestner

This year all students had basic proficiency in Gauss's Law, etc. (goal 1), though half of them could consistently be tricked into misusing Gauss's Law where there was no symmetry to exploit.

Last year, the students seemed to be competent at solving Laplace's equation already (goal 3) from their prior experience in PHYS 605, so this year I spent less time on solving Laplace's equation and more time on Green's function techniques and method of images (goal 2). I consider this to have been successful at increasing their understanding, particularly of Green's functions. About 80% of the students showed a basic level of proficiency with Green's functions (goal 2), compared to probably 50% last year, without a reduction in proficiency with Laplace's equation (~90%). An added foray into conformal mapping, however, produced confusion across the board.

The biggest issue last semester was in understanding dielectrics (goal 4). I spent more time on it this semester and that seemed to fix most of the problem, with about 70% showing satisfactory understanding. I also spent more time on magnetostatics (goal 5), with slight improvement up to 80% proficiency. As a result, though, I ran out of time to carefully cover learning goal 6 (momentum and energy), breezing through it in one lecture, so I cannot assess proficiency there, but I am confident in predicting it is unsatisfactory.

Learning goals:

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

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

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

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

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

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

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) a simple written explanation of an everyday phenomenon understandable by a freshman econ major
b) writing an outline for their MS/PhD proposal
c) written critique and commentary of a famous research article
d) CV preparation
e) 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

In general, the student's performance varied depending on the written assignment. For the grant proposal and PhD proposal, where the topic was mostly technical, the students mostly got the point across while making occasional grammatical errors.

The non-English speakers had the most difficulty not only in grammatical areas but also in their willingness to participate in class discussions. Several of these students would benefit from more opportunities to practice their speaking skills. I recommend that all faculty require their grad students to present weekly reports at their group meetings.

The oral presentations were fairly good given that they had little of their own research to talk about. I think attendance at the weekly departmental seminars tends to help this.

I believe the learning outcomes of the Graduate Programs in the area of oral and written communications are being achieved successfully, as evidenced by the assessments we make in this course.

Mike Hayden
PHYS 690