<u>2017/2018 Physics Graduate Self-Assessment Report</u>

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 6 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.

<u>**I. Course reports:**</u>

<u>PHYS 601:</u>

Dr. Franson reports,

"Class performance overall was relatively good again this year due to a talented pool of students. The overall success rate for the 6 learning goals was 92%."

Learning goal 4 (angular momentum and spin) improved from 71% last year to 87% this year.

<u>PHYS 602:</u>

This was the second year of a renovated and modernized course structure implemented by Dr. Deffner. Students did very well on all of the learning goals. Dr. Deffner notes,

"…It is striking how much stronger this cohort is in comparison to previous year's students."

<u>PHYS 607:</u>

This was the first year using Zangwill as the primary textbook instead of Jackson. While most students showed excellent understanding of the learning goals, Dr. Kestner remarks, *"The students' performance was bimodal to an unusual extent this year… The existence of a solutions manual (which I allowed students to consult since there is no way to prevent it) may explain some students' sudden realization during the exam that they didn't know how to solve the problems on their own."*

<u>PHYS 690:</u>

Dr. Hayden reports,

"This year, in particular, the international students' writing was very marginal and suffered from not only grammatical errors but also difficulties in organization and logical development… I would also say that this particular class seemed mostly uninterested in engaging in the class beyond the barest minimum."

He raises the question of whether the class is still of high value to the program in view of the growing research culture of the department, where some of the original goals are likely being accomplished in research group meetings.

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

The learning goals of the PhD program are being achieved. This year's cohort appears to be an unusual one, both in strength of talent and in inconsistent study habits.

II. Proposal and defense reports:

This year there were 6 reports from PhD proposals and 3 from PhD defenses.

On the defense reports, learning objective outcomes were mostly above average to excellent, with nothing reported as below average.

The proposal reports were also nearly universally average and above, with only a couple of boxes checked as below average, and no worrying trends were evident. Two of the reports commented on the importance of classroom development of communication skills and the attendant feedback.

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

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: 14 satisfactory 0 unsatisfactory 100%

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: 13 satisfactory 1 unsatisfactory 93%

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: 12 satisfactory 2 unsatisfactory 87%

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: 12 satisfactory 2 unsatisfactory 87%

Comments:

Class performance overall was relatively good again this year due to a talented pool of students. The overall success rate for the 6 learning goals was 92%. The performance on goal 4 was improved relative to last year, but could still be improved further. Improvement is also needed in the area of the radial Schrodinger's equation based on the qualifying exam results. Essentially all of the students except one 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, 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 very well.

   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 the previous year 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 very well. This is particularly noteworthy as the previous cohort really struggled with this part of the material.

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 and the students 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.

In addition, it is striking how much stronger this cohort is in comparison to previous year’s students.

Quantitative assessment (success in %):

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

Appendix C: PHYS 607 report by Dr. Kestner

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: 70%

3) Solve boundary-value problems in electrostatics using separation of variables in cartesian, spherical, and cylindrical coordinates. Proficiency: 80%

4) Use the concept of electric displacement to solve electrostatics problems in macroscopic media. Proficiency: 70%

5) Use elementary concepts of Ampere's law, the vector potential, and magnetic scalar potential to treat magnetostatics problems. Proficiency: 85%

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

The students' performance was bimodal to an unusual extent this year. Most students showed excellent understanding of the learning goals on the exams, but there were always 3 or 4 out of 13 students who were totally confused (and not always the same ones!). Part of the reason may be that this year, for the first time, I used Zangwill as the primary textbook instead of Jackson. While I am happy with it and will continue using it, the existence of a solutions manual (which I allowed students to consult since there is no way to prevent it) may explain some students' sudden realization during the exam that they didn't know how to solve the problems on their own.

I continued my experiment with providing less class time to separation of variables since it is covered extensively in PHYS 605, but this year I may have gone too far in this as proficiency noticeably declined. The other main difference from last year is an improvement in proficiency on goal 6 (momentum and energy), though clearly more time still needs to be spent on this topic.

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

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. This year, in particular, the international students' writing was very marginal and suffered from not only grammatical errors but also difficulties in organization and logical development. I recommended to them and their advisors that they seek the assistance of the writing assistant available via the GSA.

Most of the 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.

For some reason, this year the students uniformly did a poor job of preparing for and leading the ethics case studies. I would also say that this particular class seemed mostly uninterested in engaging in the class beyond the barest minimum.

This makes me wonder if this class is really of that much value to the graduate program anymore. Historically, this class was the first exposure for the students to the research "setting" in the sense that they had to think, for the first time, about how to identify a research topic, start a literature search, organize their thinking in order to write an outline of the research, and to write a short summary of that research (in the form of a proposal). In addition, they had to make a short oral presentation of their proposal. In the past, I have had them make a poster presentation as well. I no longer require the poster presentation as no one in recent years has had any difficulty with that assignment. As the research culture in our department has evolved over the past ten years into one where research groups are holding regular group meetings and students are actively engaged in research groups as early as the first summer, many of the original goals of PHYS 690 are possibly getting accomplished in that setting. In PHYS 690, we also spend time working on the student's CVs and talking about career progressions (academia, industry, gov't) and discussing research misconduct. These topics are probably not being covered that much in regular group meetings.

Mike Hayden
PHYS 690