2022/2023 Physics Graduate Self-Assessment Report

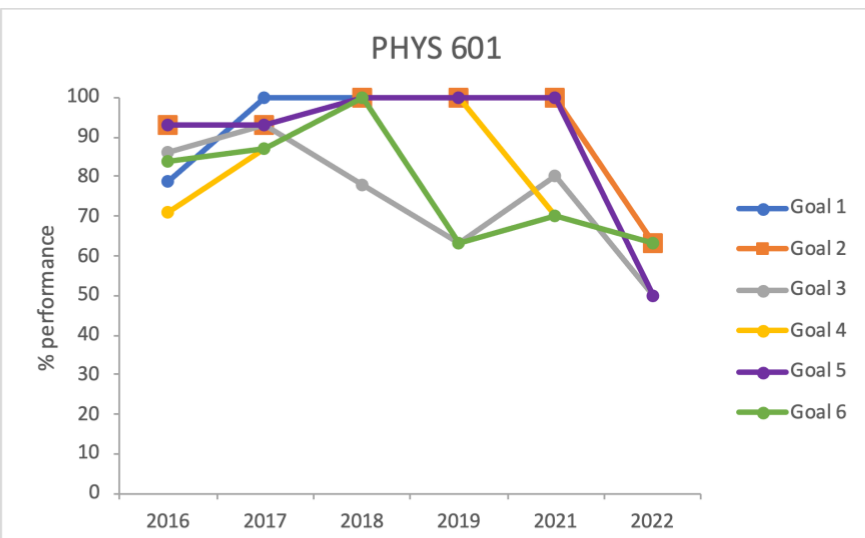
This report is prepared on the basis of individual self-assessment reports from the instructors of the designated courses, as well as self-assessment forms completed following PhD proposals and defenses by the relevant committees.

The assessed courses were PHYS 601 (Fall), 602, 607, and 690 (all Spring). There were also 5 reports from PhD defenses and 1 from a PhD proposal.

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:

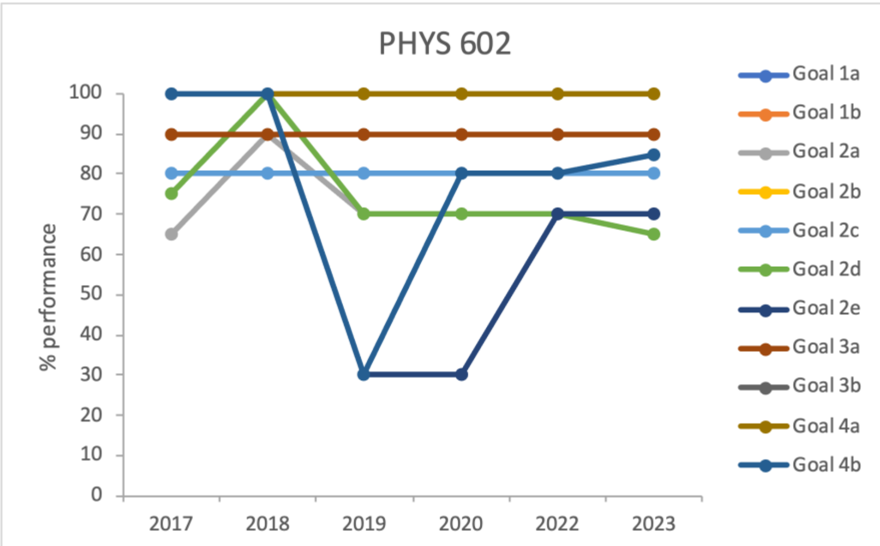


Dr. Franson reports,

"The overall success rate for the 6 learning goals was 59%, which is much lower than in previous years. There has been a steep decline in the quality and motivation of the graduate students over the past two years. This may be due in part to changes in the admission process, such as not requiring the GRE. This situation had a disruptive effect on the classes, which is not fair to the other students."

Also note that this semester the format of the 601 exams was changed to in-class, closed book, closed notes.

<u>PHYS 602:</u>

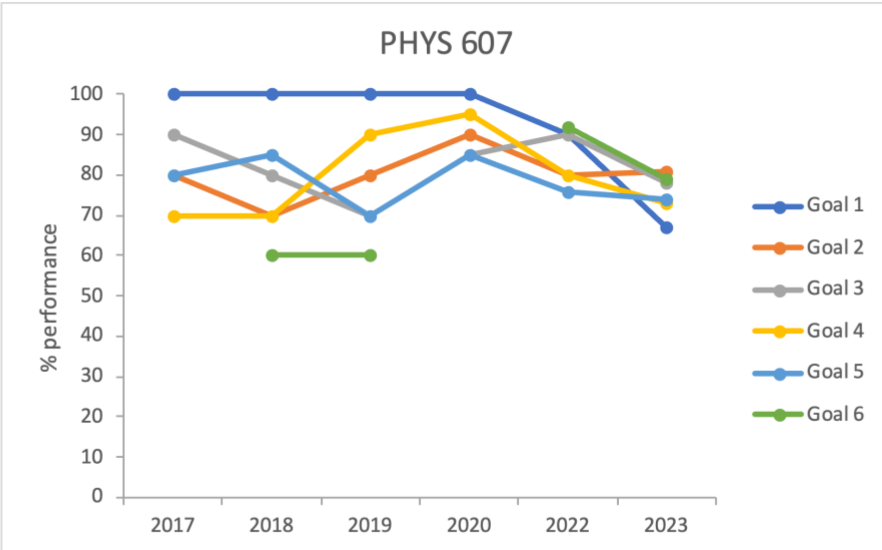


Dr. Deffner reports,

"In Spring 2023 I had only 7 students. Of these, 2 were already considered on academic probation, and another 3 had been facing significant academic challenges in Fall 2022. This composition of students significantly impacted the learning environment and made for an extremely tense atmosphere in the classroom.

After teaching this course for 6 years, I decided to gently revamp and change the textbook… Overall, my new version of PHYS602 is a much better course that provides a deeper, more comprehensive discussion of modern Statistical Physics… I believe this would have worked fine with a "normal" cohort of graduate students."

<u>PHYS 607:</u>



Dr. Zhai reports,

"In this semester (Spring 2023) I have used a traditional lecture style to teach PHYS 607, as this is the most preferred way from students… The student's struggles can be attributed to a lack of foundational knowledge and skills necessary for success in their current coursework… Moving forward, addressing and rectifying the gaps in their academic background will be crucial to improve their future performance and facilitate a more successful educational journey.

<u>PHYS 690:</u>

Dr. Hayden reports,

"I feel that the learning outcomes were achieved by all students this semester. Each year the students are improving in their performance of the assessments in this course, particularly in the oral presentations and the leading of the ethics case studies. Their written work has been static over the past several years. I urge the faculty to ask their research students to write more often and to do so earlier in their careers so that when they get to their dissertation, it is not such a chore."

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

The learning goals of the PhD program are being achieved.

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

This year there was 1 PhD proposal and 5 PhD defense reports. 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

Learning outcome assessment results for QM I (PHYS 601) - Fall 2022

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 final exam.
    b. Results: 5 satisfactory 3 unsatisfactory 63%

2. Use operator techniques to solve relevant problems.
    a. Evaluated using homework problem 5 (lecture 16)
    b. Results: 5 satisfactory 3 unsatisfactory 63%

3. Analyze the time dependence of quantum systems using the Heisenberg picture.
    a. Evaluated using the midterm .
    b. Results: 4 satisfactory 4 unsatisfactory 50%

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.
    b. Results: 5 satisfactory 3 unsatisfactory 63%

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 11 (lecture 22).
    b. Results: 4 satisfactory 4 unsatisfactory 50%

6. Use perturbation theory to find approximate solutions to more complex quantum-mechanical systems.
    a. Evaluated using problem 10.
    b. Results: 5 satisfactory 3 unsatisfactory 63%

Comments:
The overall success rate for the 6 learning goals was 59%, which is much lower than in previous years. There has been a steep decline in the quality and motivation of the graduate students over the past two years. This may be due in part to changes in the admission process, such as not requiring the GRE. This situation had a disruptive effect on the classes, which is not fair to the other students.

Appendix B: PHYS 602 report by Dr. Deffner

Remarks: In Spring 2023 I had only 7 students. Of these, 2 were already considered on academic probation, and another 3 had been facing significant academic challenges in Fall 2022. This composition of students significantly impacted the learning environment and made for an extremely tense atmosphere in the classroom.

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, written and oral exams. Curiously, this particular cohort seems better prepared with regards to abstract notions of probability theory. However, based on my experience from previous years I also spend significantly more time introducing the mathematical tool kits.

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 fact, I spend several weeks building a better understanding of phase space and its dynamics, In homework, written and oral exams they proved their technical skills by solving Fokker-Planck and Langevin equations.

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.

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 solved to full satisfaction.

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

Generally, the students performed adequately. 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)

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 quantitative problem on the homework 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 the written 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 the oral exam were solved to full satisfaction.

General remarks:

After teaching this course for 6 years, I decided to gently revamp and change the textbook. This was motivated by (i) the experience that I have gained as an instructor, and (ii) by the regular complaints of the students about the number of typos in the previous book. Overall, my new version of PHYS602 is a much better course that provides a deeper, more comprehensive discussion of modern Statistical Physics. To meet the time-constraints, I dropped a few topics that anyways should have been covered in courses on Classical Mechanics, Quantum Mechanics, and undergraduate Thermal Physics. I believe this would have worked fine with a “normal” cohort of graduate students.

Unfortunately, this cohort had a unique set of issues, which were almost impossible to work around. To give just a few examples, (i) one student seems to have been suffering from a sleeping disorder, and in fact feel asleep in every single class, (ii) a particularly poorly performing student with a colorful personality was constantly disruptive and essentially never stopped talking, and (iii) one student suffered from extreme anxiety, which did not allow them to participate in any classroom discussion.

All of this made effective teaching extremely challenging. Regrettably, the most vocal students located these challenges entirely with the instructors (not just me), and in fact I received the lowest SCEQ scores since I started teaching. In the direct instructor feedback I received nonsensical remarks such as (slightly paraphrased) “the take-home exams are too hard, since non-standard problems are tested for which no solutions can be found online”, “the instructor’s reputation is truly intimidating, which is why the student couldn’t enjoy the first few weeks; only after the student got to know the instructor, the student started learning”, and finally “this course is too hard, since it covers too many topics that the students have not seen previously”.

As a department we are well-aware of the numerous issues that this particular cohort caused, and I am very much looking forward to more academically inclined students that will take my course in the future.

Quantitative assessment (success in %):

1a) 90%
1b) 100%
2a) 70%
2b) 100%
2c) 80%
2d) 65%

2e) 70%
3a) 90%
3b) 100%
4a) 100%
4b) 85%

Appendix C: PHYS 607 report by Dr. Zhai

PHYS 607 covers the advanced topics on electromagnetism. The textbook is Modern Electrodynamics by Zangwill, which is also used in PHYS 707, Advanced Electromagnetic Theory, covering the latter half.

I first taught this course in 2019, and this is the fifth time I teach PHYS 607. I have tried different strategies in teaching this class, including Team Based Learning (TBL), a hybrid of in person and online classes (primarily driven by the COVID-19 pandemic), traditional lecture based class, etc.

In this semester (Spring 2023) I have used a traditional lecture style to teach PHYS 607, as this is the most preferred way from students. I encourage students taking notes and use the office hour effectively. I graded all homework and left detailed comments on how to approach each problems. In addition, I added quizzes to evaluate student performance, which is based on the homework due on the same day.

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: 67.2%

2) Solve boundary-value problems in electrostatics using method of images and Green's function techniques. Proficiency: 81%

3) Solve boundary-value problems in electrostatics using separation of variables in cartesian, spherical, and cylindrical coordinates. Proficiency: 77.5%

4) Use the concept of electric displacement to solve electrostatics problems in macroscopic media. Proficiency: 73%

5) Use elementary concepts of Ampere's law, the vector potential, and magnetic scalar potential to treat magnetostatics problems. Proficiency: 74%

6) Apply Poynting's theorem and conservation of momentum and energy to electromagnetic fields. Proficiency: 79%.

In the recent semester, the student's academic performance exhibited a decline compared to the last four years. The student's struggles can be attributed to a lack of foundational knowledge and skills necessary for success in their current coursework. This deficiency in their academic foundation proved to be a significant hindrance, as it impeded their ability to comprehend and engage with the advanced concepts and material presented throughout the semester. Consequently, the student's overall performance suffered, and they faced challenges in meeting the academic expectations. Moving forward, addressing and rectifying the gaps in their academic background will be crucial to improve their future performance and facilitate a more successful educational journey.

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, we returned to in person classes and all evaluations were done in person. This year's class did an exceptional job in presenting the ethics case studies and in their oral presentations. I credit their high level of oral skills to the culture being developed in each faculty member's research group where students are regularly exposed to listening to and giving oral presentations.

The level of skills in the written component of the class varied somewhat. All the students need help in writing clearly. The non-native English speakers also need some additional training in grammar, but not significantly, mostly minor issues like articles.

I feel that the learning outcomes were achieved by all students this semester. Each year the students are improving in their performance of the assessments in this course, particularly in the oral presentations and the leading of the ethics case studies. Their written work has been static over the past several years. I urge the faculty to ask their research students to write more often and to do so earlier in their careers so that when they get to their dissertation, it is not such a chore.

Mike Hayden
PHYS 690