2021/2022 Physics Graduate Self-Assessment Report

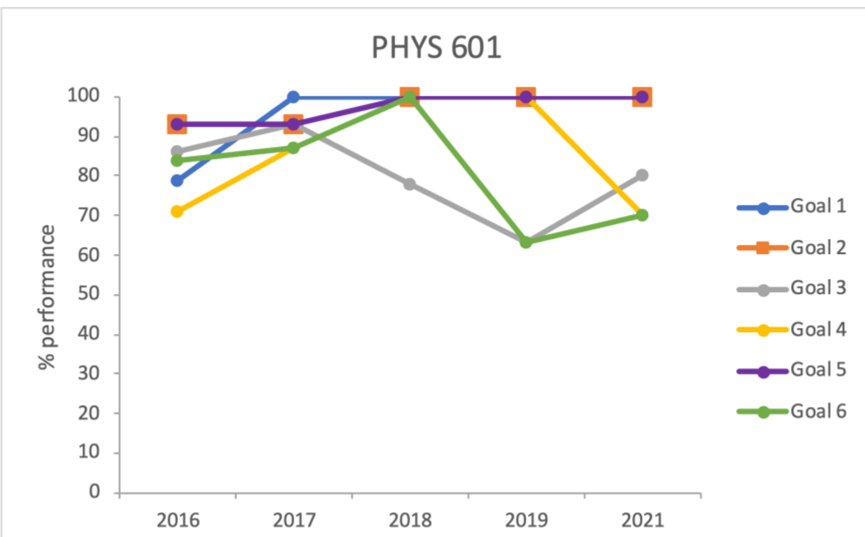
This report is prepared on the basis of individual self-assessment reports from the instructors of the designated courses, as well as self-assessment forms completed following PhD proposals and defenses by the relevant committees.

The assessed courses were PHYS 601 (Fall), 602, 607, and 690 (all Spring). There were also 9 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:

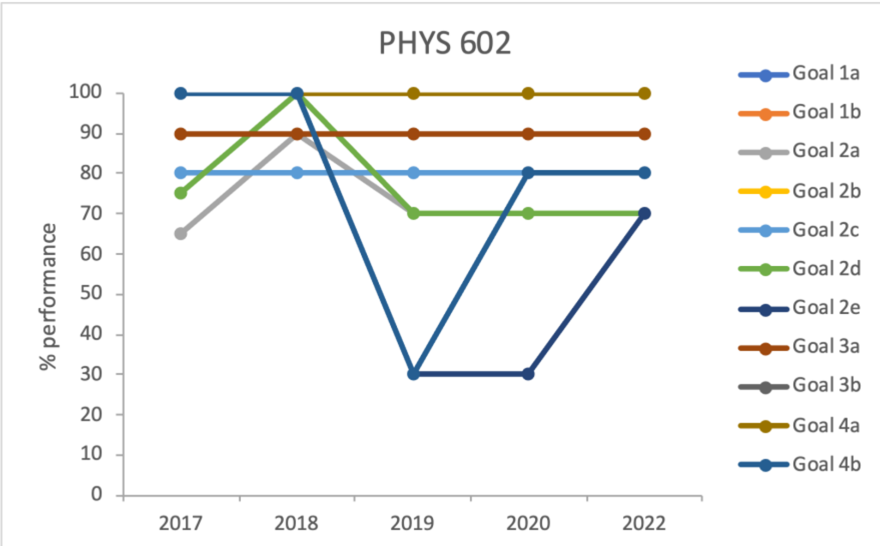
PHYS 601:



Dr. Franson reports,

"The overall success rate for the 6 learning goals was 87%, which is the same as last year. Two of the students did not seem to be prepared for graduate studies and received a C in the class. There was some indication of cheating on the final exam, although I can't prove it. Next semester all of the exams will be closed book with no computers or cell phones allowed."

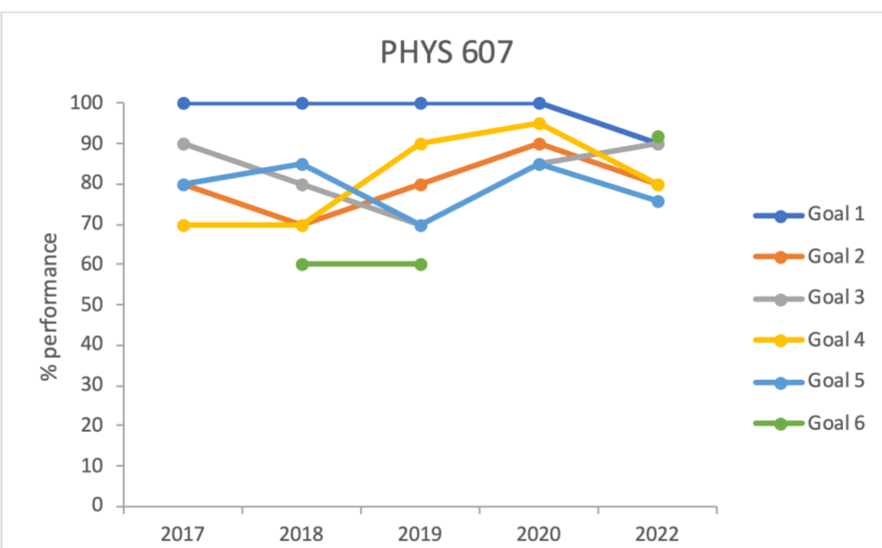
PHYS 602:



Dr. Deffner reports,

"To better assess the performance two exams were held: an extensive take-home exam (written) and an oral exam at the end of the semester… After two years of online instruction, I used the opportunity to implement further ideas and techniques from 'active learning.' In particular, I emphasized expressing concepts clearly and peer instruction... Overall, this worked remarkably well, and at least anecdotally I have evidence that this led to a deeper, conceptual understanding of the material."

PHYS 607:



Dr. Zhai reports,

"I first taught this course in 2019, and this is the fourth 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 2022) I have used a traditional lecture style to teach PHYS 607."

Of note is the huge improvement on goal 6 (Poynting's theorem, momentum and energy), which in many previous years has been hurried or altogether skipped for lack of time.

<u>PHYS 690:</u>

Dr. Hayden reports,

"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...

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.

II. Proposal and defense reports:

This year there were 9 reports from PhD proposals and 5 from PhD defenses.

Of the 9 PhD proposals, 1 reported below-average oral communication skills and 2 reported below-average written communication skills.

For the 5 PhD defenses, all learning objective outcomes were reported as average or above.

<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

Learning outcome assessment results for QM I (PHYS 601) - Fall 2021

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: 10 satisfactory 0 unsatisfactory 100%

2. Use operator techniques to solve relevant problems.
   a. Evaluated using homework problem 5 (lecture 16)
   b. Results: 10 satisfactory 0 unsatisfactory 100%

3. Analyze the time dependence of quantum systems using the Heisenberg picture.
   a. Evaluated using the midterm.
   b. Results: 8 satisfactory 2 unsatisfactory 80%

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: 7 satisfactory 3 unsatisfactory 70%

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: 10 satisfactory 0 unsatisfactory 100%

6. Use perturbation theory to find approximate solutions to more complex quantum-mechanical systems.
   a. Evaluated using final exam.
   b. Results: 7 satisfactory 3 unsatisfactory 70%

Comments:

The overall success rate for the 6 learning goals was 87%, which is the same as last year. Two of the students did not seem to be prepared for graduate studies and received a C in the class. There was some indication of cheating on the final exam, although I can't prove it. Next semester all of the exams will be closed book with no computers or cell phones allowed.

Appendix B: PHYS 602 report by Dr. Deffner

Remark: This year's cohort consisted of 8 students, and after two years we returned to f2f instruction. To better assess the performance two exams were held: an extensive take-home exam (written) and an oral exam at the end of the semester.

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. 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 everything to my satisfaction. 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, 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)

Also a completely new topic. Generally, the students performed adequate. 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. In addition, this was a main topic in the written and oral exams. Some students developed quite remarkable insight, whereas other seemed totally lost.

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:
Like in previous years the students seemed to quite enjoy the course with regards to topics, depth and pacing. After two years of online instruction, I used the opportunity to implement further ideas and techniques from “active learning”. In particular, I emphasized expressing concepts clearly and peer instruction. To this end, I used “the circle”, a method that I have been experimenting with in my group meetings. In this set-up, one student is chosen to be the “center of attention” and one-by-one the other students have to ask a question about the topic that was covered in the preceding class. Obviously, this is something that can only be done in the second half of the semester, after the students have gained some comfort and familiarity. Overall, this worked remarkably well, and at least anecdotally I have evidence that this led to a deeper, conceptual understanding of the material. During the oral exams, similar questions were asked, and the results are encouraging enough to repeat the same testing next year.

Quantitative assessment (success in %):

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

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 fourth 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 2022) I have used a traditional lecture style to teach PHYS 607. I distribute lecture slides a week before the class so that students have time to prepare for it. Because of the pre-lecture materials, during the classes I used more time focusing on the key arguments, skipped some lengthy math derivations, but still preserved the integrity of the theoretical developments. Homework have been rewritten so that students would have less institutional memory to follow. Overall, students' performance is satisfactory, though I see some fluctuation among different topics (see below).

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: 90%

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: 90%

4) Use the concept of electric displacement to solve electrostatics problems in macroscopic media. Proficiency: 80%

5) Use elementary concepts of Ampere's law, the vector potential, and magnetic scalar potential to treat magnetostatics problems. Proficiency: 76%

6) Apply Poynting's theorem and conservation of momentum and energy to electromagnetic fields. Proficiency: 92%.

Overall students performed well. On the other hand, it was surprising to me that some students could not properly apply Gauss's law for the electric displacement vector to properly solve electrostatic problems. A common mistake is they did not differentiate the different permittivity in different regions. As this is quite a simple concept, I would tend to believe this is due to an unintended negligence in a stressful test environment. Another key area is in the magnetostatics, where almost all students know the condition for applying the scalar potential theory for magnetic field (current density is zero), though they did not realize the solution to Laplace's equation is zero if no charge is present in free space boundary conditions. I hypothesize that it was due to the relative complicated setting of the problem which confused them so they did not realize it is a free space problem.

If I were to teach PHYS 607 again, I will continue to adjust my teaching strategy, i.e. to adjust the ratio of in-class work and lectures; use more tutorial materials or group works to promote active learning.

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