Learning goal self-assessment for the Physics (UG) program at UMBC

Overall: *As in previous years, no major issues were identified. This is encouraging, indicating that the UG program has matured. It would be interesting to use this as a stepping stone to advance/make more relevant/modernize the curriculum. Similar considerations may be applied to the entire Physics program. We leave such a major issue to the department to decide if and how to proceed. We now very briefly discuss each course. The detailed report on each course has been produced by the course instructor and has been incorporated into this document.*

PHYS 220: *The instructor report In summary, considering their final scores, approximately 83% of students have mastered satisfactorily the main goals in this discipline (grades A and B: between 75-100%): "they are expected to be able to formulate Physical problems in the language of Python and to use mathematical and computational skills to solve physical problems". This is a similar outcome with recent years and the committee does not see anything substantial in need of change.*

PHYS 303**:** The instructor is satisfied, but he repeats in his report a particular issue: one of the learning goals (apply the Fermi and Bose-Einstein distributions to models electrons in solids and heat capacity of solids):
In previous years, I consider this an unrealistic learning goal. As 424 is not a pre-requisite, and thus the only exposure to quantum mechanics comes through 324. However, it is illusionary to believe that the students have already grasped concepts like degeneracy (if even covered in 324). Thus, neither the Fermi-Dirac nor the Bose-Einstein distribution can be derived in a comprehensive manner.

PHYS 330: The great majority of the students who completed PHYS 330L this semester satisfactorily achieved all the learning outcomes. Two out of 22 students showed extra struggle to complete the class with a B grade or above but, even these students presented some improvement in their participation in experiments, and on the comprehension and writing abilities throughout the semester. This assessment was based on reviews, analysis, and feedback given to them on their weekly lab reports and lab notebooks.

PHYS 407: A main point that the instructor makes is that we need to fix the class sequence, because the way currently is it allows for taking PHYS 407 too early, resulting in bad outcomes:

PHYS 424: The instructor comments that the students worked in groups and this was beneficial for everybody. One draw back was that each group had one student that used the group for their homework but did not use the group for understanding the material. The level of understanding of quantum mechanics for these students is acceptable.

PHYS 321. This is the only Mechanics course after the introductory courses. Beyond the very basics, it studies the Lagrange formalism, motion in non-inertial frames and the two body problem. The performance of the students is in most cases was above the bar (set here at 75%). A characteristic of this course is that the success rate decreases as we co from the first to the last chapter of the book (Taylor)`

APPENDIX: FULL REPORTS

Self-Assessment Report – Spring 2023

Introduction to Computational Physics – PHYS220

Adriana Rocha Lima – Department of Physics – UMBC – July 24th, 2023

1. Overview of PHYS220 - Spring 2023

A total of 30 students were enrolled in PHYS220. Two students withdraw by the end of the semester. Figure 1 shows the major programs of the students enrolled in PHYS220 during the Spring 2023 semester. Most of the students were not-seniors from Physics (33.3%), and seniors from Computer Engineering (26.7%). In summary, half of the students were seniors, and the other half were non-seniors (junior or sophomore).

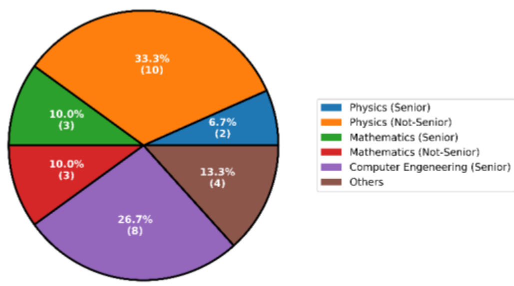

Figure 1. Profile of the students enrolled in PHYS220 in the Spring 2023.

2. Analyses of the Specific goals for PHYS220

2.1 "Use a software package (e.g., Mathematica or MATLAB) or high-level programming language (e.g., Python or IDL) to write modularized programs and plot simple figures, such as scatter plots, time series, histograms, and 2D contours".

As in previous years, on the first day of class, students completed a questionnaire about their proficiency level in Mathematica, MATLAB, and Python. The number of students that have never used Python has decreased from 8 to nearly 0 between 2020 and 2023. Figure 2 shows the normalized distribution of their responses. In 2023, we had an expressive number of students (around 70%) considering themselves at an "intermediate proficiency level" in Python at the beginning of the semester.

PHYS 303:

1. Derive the thermodynamics properties of a model system (e.g., two-state paramagnet, ideal gas) by determining its multiplicity.

   Most of the students did not appear to have any major difficulties with these tasks. Problems in the assignments and on the final exam were solved satisfactorily.

2. Derive the thermodynamics properties of a model system (e.g., paramagnet, ideal gas) using Boltzmann factors and the partition function.

   Typically, this is a rather simple task and the students performed generally well.

3. Calculate the entropy change during a thermodynamic process (e.g., heating under constant pressure or constant volume, phase change).

   Like in most problems in thermodynamics the students did very well.

4. Determine relationships between state variables for a thermodynamic process (e.g. adiabatic or isothermal compression, Joule-Thomson expansion).

   Like in most problems in thermodynamics the students did very well

5. Determine the efficiency of a heat engine (e.g., Carnot cycle).

   Like in most problems in thermodynamics the students did very well

6. Apply the Fermi distribution and Bose-Einstein distributions to model problems (e.g., electrons in solids, heat capacity of solids, blackbody radiation).

   As I have pointed out in previous years, I consider this an unrealistic learning goal. As a 300-level class 424 is not a pre-requisite, and thus the only exposure to quantum mechanics comes through 324. However, it is illusionary to believe that the students have already grasped concepts like degeneracy (if even covered in 324). Thus, neither the Fermi-Dirac nor the Bose-Einstein distribution can be derived in a comprehensive manner.

   To work around this issue, I discussed analogous classical problems which eventually do lead to the same distributions. However, I am convinced that maybe only one or two students really made the connection to quantum statistics.

General remarks:

We have fully returned to “normal” operations, and even the mask mandate fell over the course of the semester. Student engagement and learning, as well as the final grades all seem to have returned to “normal”.

Quantitative assessment (success in %):

1) 90%
2) 90%
3) 95%
4) 95%
5) 90%
6) 70%

<u>PHYS 330:</u> The great majority of the students who completed PHYS 330L this semester satisfactorily achieved all the learning outcomes. Two out of 22 students showed extra struggle to complete the class with a B grade or

above but, even these students presented some improvement in their participation in experiments, and on the comprehension and writing abilities throughout the semester. This assessment was based on reviews, analysis, and feedback given to them on their weekly lab reports and lab notebooks.

A particularity of this year, following the two previous years of the COVID pandemic, has been the increase of students missing classes and requiring make-up classes or other special arrangements. This is partially reflecting an over-cautioned response from students showing any sign of illnesses but, it also leads to potential increase in abuses by others. This issue has been somewhat disruptive for the class, forcing group activities to be re-arranged and students to take longer in performing their experiments.

As in the previous years, I continued the policy to motivate students to turn in all lab reports on time and to be well prepared for each experiment. This policy includes:

- Students were required to submit a pre-lab report prior to each experiment, which had to be approved by the instructor before the beginning of each experiment

- In order to pass the class, students were required to submit all the reports

- Late reports carried a penalty in points

These policies clearly improve class participation, and the completion and delivery of all required reports. These rules have successfully improved student behavior in the class.

My final evaluation is that all the students who completed the class were successful in achieving the learning outcomes proposed by this course.

Prof. Vanderlei Martins

7.19.23 Learning Outcomes Assessment Report

Spring 2023 PHYS 407 Electromagnetic Theory

Instructor: Todd Pittman

Some relevant info for this report:

- This year's class had 15 students. The final course grade distribution was:
  - A or B: 10 students (67%)
  - C: 2 students (13%)
  - DFW: 3 students (20%)

- In my 2022 LOA Report for PHYS 407, I noted that the majority of students who DFW'd were taking 407 out of sequence (ie. before 321 and 424) and I wrote with an urgent plea to the undergraduate curriculum cmte. to examine why so many students were getting off track in this way.
  - Unfortunately, the undergrad curriculum cmte. did not meet, nor make any changes to the pre-req's, but at least I was able to remind Academic Advisors (at a Faculty mtg, and by email) to urge their advisees to stay in sequence (unless they are "straight-A superstars"). This seemed to help a bit this year.

- Nonetheless, I note that 100% of the DFW's this year (3 students) were taking 407 out of sequence. Perhaps they received bad advising, or had some weird circumstances?
- **Again – I urge the ugrad curriculum cmte. to look into this, and arrange the pre-req's as needed.**

- The syllabus included the 7 specific Learning Outcomes Objectives (LOO's).

- Grading of the course was based on:
  - 3 regular Exams: These were 55 min, closed-book exams.
  - 10 HW assignments
  - A cumulative Final Exam: This was a 2 hour open-book online exam.

- My assessment of each of the 7 learning outcomes objectives is based on:
  - Quantitative evaluation of the results of specific HW and exam problems.
  - Subjective evaluation based on classroom participation and discussions.

- For my quantitative evaluation, I'm using "C+" performance, or better, as "mastered".

Assessment of the 7 Learning outcomes objectives:

1. *Have a working understanding of vector analysis, of the physical meaning of differential operators such as the div and curl, and of related theorems such as the divergence, Gauss's and Stokes' theorems.*
    a. My assessment based on specific HW and Exam problems: 12 of 15 students (80%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 80% of the students mastered this objective.

2. *Solve problems in electrostatics that manifest an understanding of the divergence of electrostatic fields, the electric potential, and work and energy in electrostatics.*
    a. My assessment based on specific HW and Exam problems: 12 of 15 students (80%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 60% of the students mastered this objective.

3. *Demonstrate an ability to solve problems in electrostatics by solving Laplace's equation, and by using the method of images, or of separation of variables.*
    a. My assessment based on specific HW and Exam problems: 11 of 15 students (73%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 60% of the students mastered this objective.

4. *Understand electric fields in matter, through being able to solve problems involving the field of a polarized object, the electric displacement, and dielectrics.*

    a. My assessment based on specific HW and Exam problems: 10 of 15 students (67%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 50% of the students mastered this objective.

5. *Demonstrate an understanding of magnetostatics, through the ability to solve problems involving the Lorentz force and the Biot-Savart Law, as well as the divergence and curl of the magnetic field and vector potential of the magnetic field*.
    a. My assessment based on specific HW and Exam problems: 12 of 15 students (80%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 60% of the students mastered this objective.

6. *Understand magnetic fields in matter, through solving problems involving magnetization, the field of a magnetized object, the auxiliary field H, magnetic susceptibility and permeability and ferromagnetism.*
    a. My assessment based on specific HW and Exam problems: 10 of 15 students (67%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 60% of the students mastered this objective.

7. *Demonstrate an understanding of the electromotive force, the electromagnetic induction, and Maxwell's equations.*
    a. I did not leave enough time to adequately present this material. I'm unable to assess. This is my failure.

PHYS 407

Some relevant info for this report

- This year's class had 15 students. The final course grade distribution was:
    - cvvA or B: 10 students (67%)
    - C: 2 students (13%)
    - DFW: 3 students (20%)

- In my 2022 LOA Report for PHYS 407, I noted that the majority of students who DFW'd were taking 407 out of sequence (ie. before 321 and 424) and I wrote with an urgent plea to the undergraduate curriculum cmte. to examine why so many students were getting off track in this way.
    - Unfortunately, the undergrad curriculum cmte. did not meet, nor make any changes to the pre-req's, but at least I was able to remind Academic Advisors (at a Faculty mtg, and by email) to urge their advisees to stay in sequence (unless they are "straight-A superstars"). This seemed to help a bit this year.
    - Nonetheless, I note that 100% of the DFW's this year (3 students) were taking 407 out of sequence. Perhaps they received bad advising, or had some weird circumstances?
    - **Again – I urge the ugrad curriculum cmte. to look into this, and arrange the pre-req's as needed.**

- The syllabus included the 7 specific Learning Outcomes Objectives (LOO's).

- Grading of the course was based on:
    - 3 regular Exams: These were 55 min, closed-book exams.
    - 10 HW assignments

  - A cumulative Final Exam: This was a 2 hour open-book online exam.

- My assessment of each of the 7 learning outcomes objectives is based on:
  - Quantitative evaluation of the results of specific HW and exam problems.
  - Subjective evaluation based on classroom participation and discussions.

- For my quantitative evaluation, I’m using “C+” performance, or better, as “mastered”.

Assessment of the 7 Learning outcomes objectives:

8. *Have a working understanding of vector analysis, of the physical meaning of differential operators such as the div and curl, and of related theorems such as the divergence, Gauss's and Stokes' theorems.*
    a. My assessment based on specific HW and Exam problems: 12 of 15 students (80%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 80% of the students mastered this objective.

9. *Solve problems in electrostatics that manifest an understanding of the divergence of electrostatic fields, the electric potential, and work and energy in electrostatics.*
    a. My assessment based on specific HW and Exam problems: 12 of 15 students (80%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 60% of the students mastered this objective.

10. *Demonstrate an ability to solve problems in electrostatics by solving Laplace's equation, and by using the method of images, or of separation of variables.*
    a. My assessment based on specific HW and Exam problems: 11 of 15 students (73%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 60% of the students mastered this objective.

11. *Understand electric fields in matter, through being able to solve problems involving the field of a polarized object, the electric displacement, and dielectrics.*

    a. My assessment based on specific HW and Exam problems: 10 of 15 students (67%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 50% of the students mastered this objective.

12. *Demonstrate an understanding of magnetostatics, through the ability to solve problems involving the Lorentz force and the Biot-Savart Law, as well as the divergence and curl of the magnetic field and vector potential of the magnetic field*.
    a. My assessment based on specific HW and Exam problems: 12 of 15 students (80%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 60% of the students mastered this objective.

13. *Understand magnetic fields in matter, through solving problems involving magnetization, the field of a magnetized object, the auxiliary field H, magnetic susceptibility and permeability and ferromagnetism.*
    a. My assessment based on specific HW and Exam problems: 10 of 15 students (67%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 60% of the students mastered this objective.

14. *Demonstrate an understanding of the electromotive force, the electromagnetic induction, and Maxwell's equations.*
    a. I did not leave enough time to adequately present this material. I'm unable to assess. This is my failure.

Fall 2022 PHYS 424 "Introduction to Quantum Mechanics"

Some relevant info for this report:

- This year's class had 26 students, the same number as in the fall of 2021.
- My perception was that, on average, this was an interested group, however they seemed a bit less motivated than students in the past.
- The final course grade distribution was 10 A's, 4 B's, 5 C's, 4 D's, 1 F, 1 I, and 1 drop.
- The syllabus included the specific learning outcomes objectives.
- Grading of the course was based on:
    - 3 regular Exams (closed book, in class, 55 minutes)
    - 12 HW assignments
    - A cumulative Final Exam (closed book, in class, 2 hours).
- My assessment of each of the 6 learning outcomes objectives is based on:
    - Quantitative evaluation of the results of specific HW and exam problems.
    - Subjective evaluation based on classroom participation and discussions.

Assessment of the 6 Learning outcomes objectives:

1. *Explain the breakdown of classical mechanics and the development of quantum mechanics.*
    - My assessment based on specific HW and Exam problems: 80% mastered this objective.

- My assessment based on participation and discussion: Roughly three quarters of the students mastered this objective.

2. *Utilize the concept of the wavefunction (and quantum states) to describe quantum systems, with emphasis on using the statistical interpretation and predicting the outcomes of measurements.*
    - My assessment based on specific HW and Exam problems: 70% mastered this objective.
    - My assessment based on participation and discussion: Roughly three quarters of the students mastered this objective.

3. *Solve the Schrodinger equation for various 1D potentials.*
    - My assessment based on specific HW and Exam problems: 65% mastered this objective.
    - My assessment based on participation and discussion: Roughly 75% of students mastered this objective.

4. *Work with Dirac notation and the formalism of QM including the concepts of Hilbert space, operators, commutators, eigenfunctions and eigenvalues, and the uncertainty principle.*
    - My assessment based on specific HW and Exam problems: 75% mastered this objective.
    - My assessment based on participation and discussion: Half of the students mastered this objective.

5. *Perform 3D calculations in Quantum Mechanics, using the example of the Hydrogen atom, with emphasis on the concepts of angular momentum and spin.*
    - My assessment based on specific HW and Exam problems: (50%) mastered this objective.
    - My assessment based on participation and discussion: Roughly half of the students mastered this objective.

6. *Analyze systems of identical particles and the concepts of fermion and boson statistics.*
    - My assessment based on specific HW and Exam problems: 50% mastered this objective.
    - My assessment based on participation and discussion: Less than half of the students mastered this objective.

PHYS 424

Comments, suggestions, and wrap-up notes:

- This class had several groups of students who worked together regularly. This really helped them with their homework solutions. One draw back was that each group had one student that used the group for their homework but did not use the group for understanding the material. This is the situation every year for this course. Usually, this is a student that is trying to just get through the course to graduate. I believe that this is an acceptable outcome, as these students do make it through (many times with a D) and they are not going to go on to graduate school. The level of understanding of quantum mechanics for these students is acceptable.
- *Repeated comment from previous semesters:* I found that every single HW and Exam problem was related to one of the 6 learning goals. I just chose an arbitrary subset to do my assessment.

PHYS 321

This is the only Mechanics course after the introductory courses. Beyond the very basics, it studies the Lagrange formalism, motion in non-inertial frames and the two body problem. The performance of the students is in most cases above the bar (set here at 75%). The performance was estimated from class participation, problem solving in the class, and ability to answer challenging questions. A characteristic of this course is that the success rate decreases as we co from the first to the last66666x vvbbb hv v
\ chapter of the book (Taylor)`, as expecte\\\\\\\d