2018-2019 SELF-ASSESSMENT REPORT FOR THE LEARNING GOALS OF THE UNDERGRADUATE PHYSICS PROGRAM AT UMBC.

This document is based on the self–assessment reports by the instructors of courses PHYS 220, 303, 321, 330L, 407, 424. A summary for each course follows (focusing on the issues identified), along with a short overall evaluation of the Program in its entirety. The individual reports can be found as appendixes to this document.

PHYS 220, SPRING 2019. The instructor reports high mastery of the learning material from most of the students and agreement between direct and indirect assessment. No changes are proposed.

PHYS 303, FALL 2018. The instructor notices *that "there are extensive amounts of topics to be covered in one semester. For this reason, the pace of the course was generally high"*. The instructor would like to see higher learning goal mastering, especially in learning goals 3 (apply thermodynamic rules to and calculate thermodynamic parameters of engines and refrigerators) and 4 (understand and predict changes in thermodynamic variables during phase transformations). The instructor proposes targeted changes, such as *"Prepare study guides for exams including which topics we covered in the course and with specific emphasis on what I expect the students to know".*

PHYS 321, SPRING 2019. The students did well with most of the learning goals, the exceptions being goal # 5 (Develop an understanding of rigid body rotational motion and use it to solve related problems) and goal # 7 (Show an understanding of mechanics in non-inertial reference frames and use it to solve related problems). The overall assessment of the instructor is reflected in his agreement with the final comments made by Dr. Takacs from the Spring of 2018: *"The content of the course and the amount of time spent on each subject is about right. No change is recommended. The main difficulty is to convince students that active problem solving is the only way to learn how to apply advanced mathematics to physics problems. Tutoring, review sessions, remedial discussions on relevant mathematics might be useful, but nothing works, unless students are willing to invest time and energy into active learning, that is regular problem solving on their own."*

PHYS 330L, FALL 2018. As reported by the instructor, *"All of the students who completed PHYS 330L satisfactorily achieved all of the above learning outcomes."* Also, *"At the beginning, the students had a hard time communicating in clear, succinct phrases, but that improved over the course of the semester. At the end, every student could write a decent report in the format that we desired and with the kind of scientific analysis and rigor that met the learning objectives".* The instructor also notes *that "Those that went several weeks without turning in reports eventually dropped the course, for the most part. Those that completed the course, eventually were able to get things done on time, but some still could not, even at the end."* The instructor does not propose any changes.

PHYS 407, FALL 2018. This is a very interesting report. The instructor had time to cover the first five (out of seven) learning goals, and for those five the fraction of the students that did well was at about sixty five percent. The instructor raises the issue of the poor math preparation of a majority of the students and suggests as a remedy that we develop a sophomore math physics course in the department.

The instructor identifies an important issue: a group of students with numerous C, D, F, W's on their transcripts. He mentions that "*They seemed disenfranchised and not interested in being physics majors. I hope we can figure out a way to engage and teach them*". He then speculates that *"we may have somewhat of a perceived "caste system" of students who went to good high-schools and are bright and get A's, and others who aren't in that category and feel left out".*

PHYS 424, FALL 2018. The instructor mentions that the six learning goals have been satisfactorily met, except goal #1 (*Explain the breakdown of classical mechanics and the development of quantum mechanics*) and #5 (*Perform 3D calculations in Quantum Mechanics, using the example of the Hydrogen atom, with emphasis on the concepts of angular momentum and spin).* The instructor focuses on two important issues: *"problems with solutions on the internet were copied without thought"* and *"the homework solutions … were done by committee, and that several of the students did not understand what they had just copied."* Regarding the possibility to split the course in two semesters, he suggests *that "this would work as an elective course."*

COMMITTEE OVERALL EVALUATION

The committee finds that during this fourth year of implementing the learning goal self-assessment, no major deficiencies were identified. A question we should discuss is the uniformity of a C-grade for all courses throughout the curriculum and how does this relate to what we consider satisfactory learning for our learning goal self-assessment. We note that last year we agreed that all the learning goals of all courses used should be evaluated numerically by the instructors in terms of the percentage of the class that achieved a B or better level understanding of the corresponding material, as this is manifested by their performance of carefully selected problem(s) embedded in the exams and/or homework.

The repeated proposal to create a pair of QM courses in the junior year, and to change PHYS 324, that currently has overlapping material with PHYS 424, to a capstone stone course with elements from the different disciplines is a major one and should be discussed in the context of restructuring our BSc curriculum.

The new proposal of developing a sophomore level math physics course to cover the needs of our undergraduates should also be seriously discussed.

LEARNING GOAL SELF ASSESSMENT COURSE REPORTS

Assessment Report for Introduction to Computation Physics (PHYS220) Spring 2019

1. Background:

Introduction to Computational Physics (PHYS 220) is a mandatory course for physics major students. Physics student usually take this course during their junior or senior years. As prerequisite for PHYS220, the students must have completed PHYS 122 or MATH 152 and CMSC 104 or CMSC 201 all with a grade of C or better.

PHYS220 is offered in the spring of 2019. A total of 38 students registered this course.

The learning goals specified in the assessment plan include:

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.
2. Use Monte Carlo methods to simulate and understand random walk problems, such as photon transport in isotropic-scattering medium.
3. Write programs to solve physics problems involving ordinary differential equations, such as projectile motion with drag and nonlinear oscillations.
4. Demonstrate a good mastery of basic data analysis methods, such as linear regression, uncertainty analysis, null hypothesis testing, and Fourier analysis.

2. Direct assessment

The scores for the midterm project are used for the direct assessment of the learning goals 1, 2 and 3. The scores for the final project are used for the direct assessment of the learning goals 1, 2 and 4. The results are shown in the plot below.

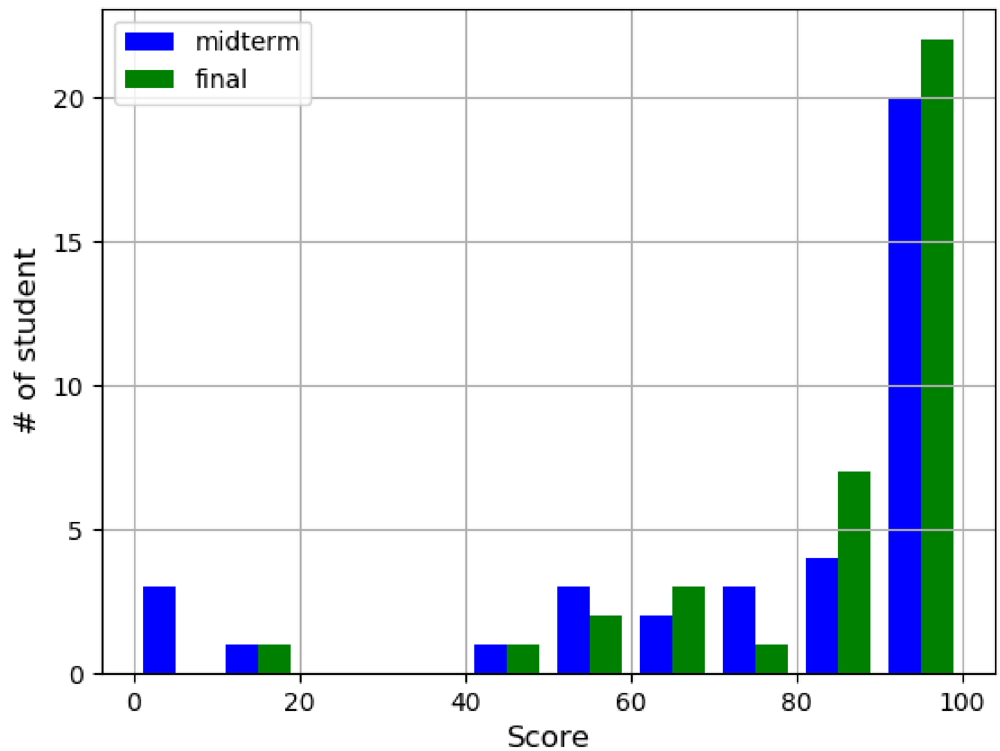
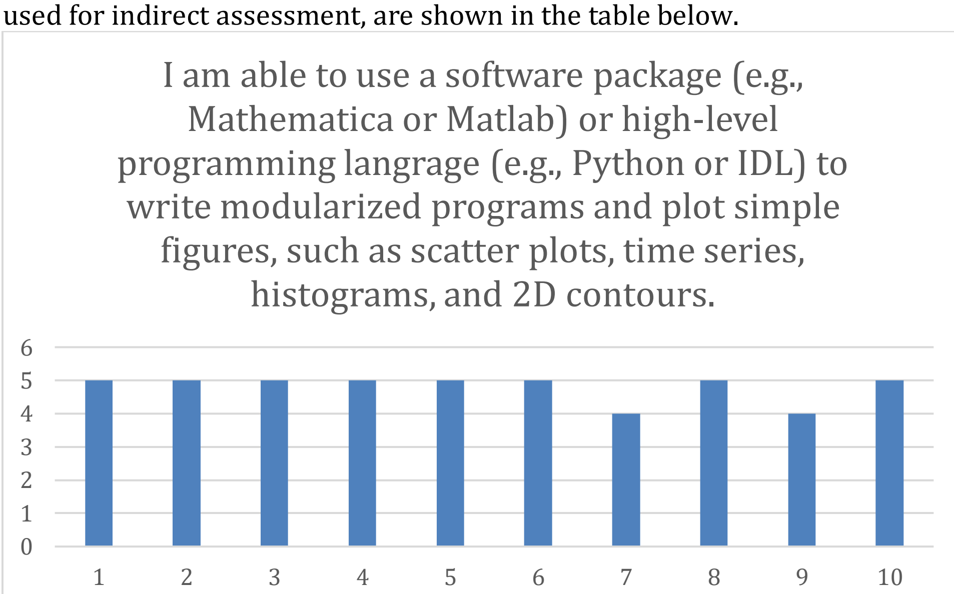
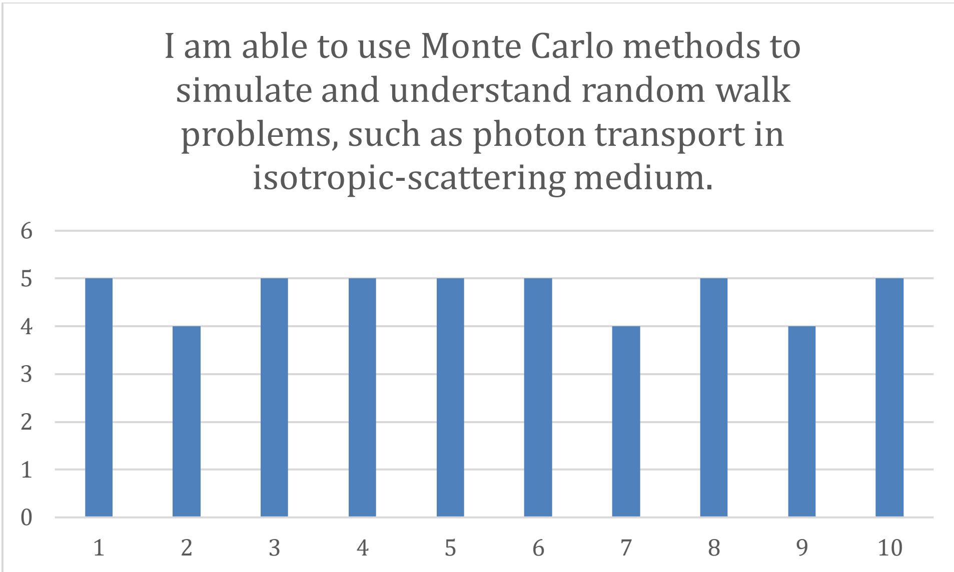


Figure 1 Distribution of the scores for the midterm and final project.

3. Indirect assessment

A survey was sent out to get feedbacks from the students on the learning goals. The results, used for indirect assessment, are shown in the table below.




I am able to use Monte Carlo methods to simulate and understand random walk problems, such as photon transport in isotropic-scattering medium.
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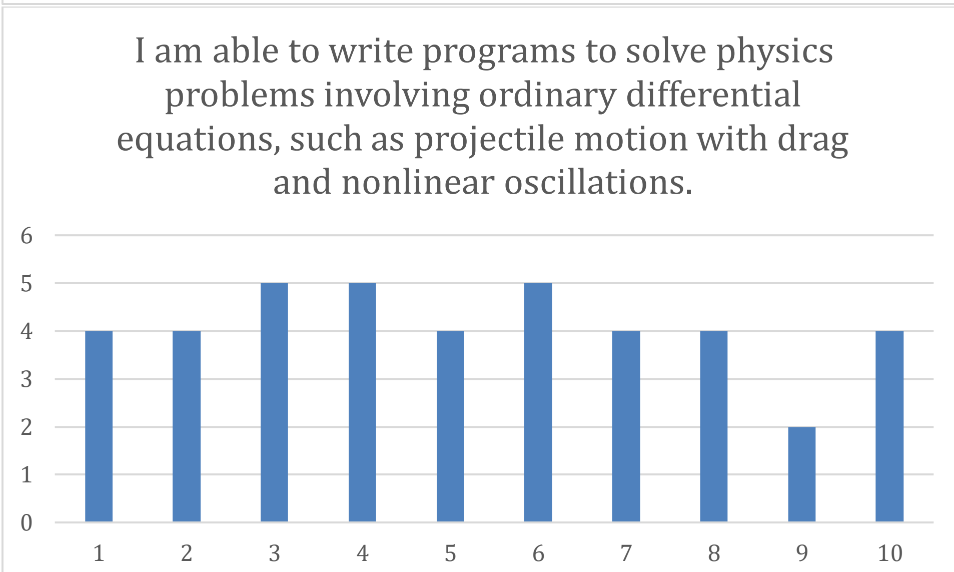
I am able to write programs to solve physics problems involving ordinary differential equations, such as projectile motion with drag and nonlinear oscillations.
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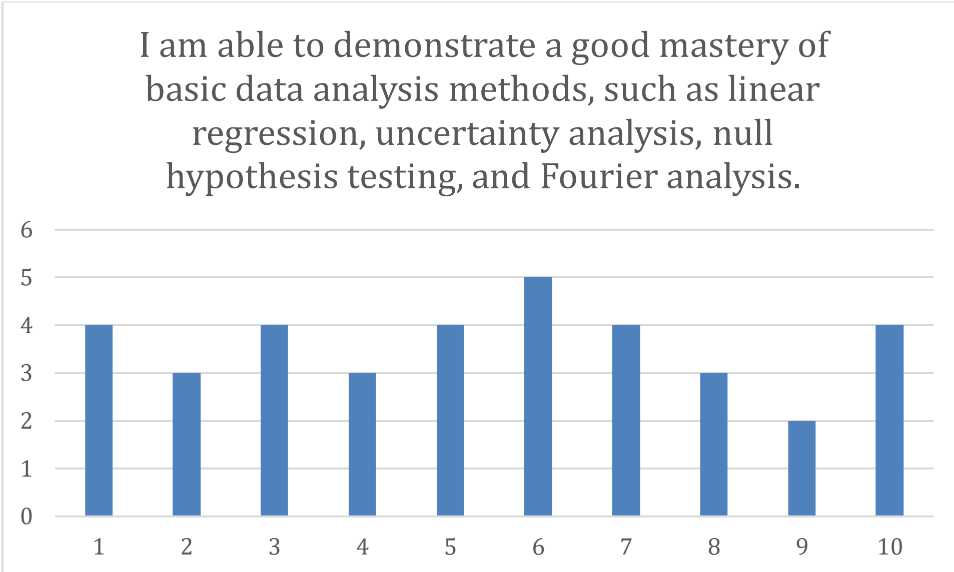
I am able to demonstrate a good mastery of basic data analysis methods, such as linear regression, uncertainty analysis, null hypothesis testing, and Fourier analysis.
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Self-Assessment of Learning Goals for PHYS 303 Fall 2018

This assessment is based on the questions of three in-class midterms, two take-home midterm-extensions, three quizzes and the final exam. Specific learning goals were reported in the syllabus and the scores were compiled according to exam/homework performance.

There are extensive amounts of topics to be covered in one semester. For this reason, the pace of the course was generally high. Compared with last year's course, I skipped few subjects in the course which were taking time, such as detailed explanation of phase diagrams. In order to make sure that the students learned/understood the topics, they were assigned weekly homeworks (a total of 13 homework) with multiple questions to practice the topics with real world examples. During office hours, based on students' requests and needs, I both restated the topic of that week and went over students' individual questions. Students who attended these office hours regularly scored better in the homeworks and exams than others. Not limited to office hours, I allowed students to come to my office and ask/discuss whatever they wanted whenever we both were available. I also answered any questions asked via e-mail within a day.

I was flexible with the deadlines and accepted all homeworks submitted before I posted the solution manual (generally 3-5 days after the deadline). Some students complained about getting back their homeworks/grades late, but this was a predicted consequence of flexible deadline homework submissions. The top ten highest graded homeworks were counted towards the grading and the average of homeworks was 92/100 which is really high. There are even few students who submitted more than 10 homeworks (I told them that I am going to grade top 10 homeworks)

I conducted three exams during the semester. In each 50-minute exam, there were three questions. One of them was directly from homework questions. The second was a modified version of a question that I solved in class. Third question was generally a challenging question. My aim with these challenging questions was to foster the synthesis ability of the students where they would need to use their overall knowledge from the course and creativity in order to solve the question. Solving the question would also teach them new things. This question generally had several parts, so that the students could earn partial credits. All of the exams also contained at least 25 bonus points. The class average for in-class exams was ~47/100 (2nd midterm average was 35, which is extremely low). In order for them to increase their grades, the students were provided additional take-home questions for every midterm exam. The grading was done by taking the average of in-class and take-home exams for the final grade. Without the examination stress and more time, take-home exams had an average of >95/100 although they included challenging questions as well.

Improvements can be made to examinations such as:

- Make in-class exams shorter by decreasing the number of parts in the multiple part questions and instead of asking for derivations, I will request short answers stating which equations/physical phenomena/mathematical approach they will use to solve the issue in hand, which would still require an in-depth understanding of the course material.

-Prepare study guides for exams including which topics we covered in the course and with specific emphasis on what I expect the students to know.

Assessment of specific learning goals follows:

1. Derive thermodynamic properties of a model system (work done, internal energy, heat capacities, enthalpy, ...)

This was very similar to one of the first midterm questions. Out of 22 students, 11 of them scored perfectly. This indicates that the majority of the students learned the concept well, although there is room for improvement.

2. Understand how thermodynamic properties differ in interacting systems.

One of the quizzes was focusing on this subject together with 4 homeworks. All of the averages of homeworks were greater than %90 and the quiz averaged and 18 over 25. Only one of them scored less than %50 and one didn't attend. This indicates that the majority of the students mastered the concept.

3. Apply thermodynamic rules to and calculate thermodynamic parameters of engines and refrigerators.

Half of the 2nd and 3rd midterm questions were on this subject. Students had many examples solved on this subject (including in-class quizzes, questions and homeworks). However 2nd midterms average was very low. After grading the exam, I spent 2 courses on the subjects that the students were failing. These efforts increased the average grade in the 3rd midterm.

4. Understand and predict changes in thermodynamic variables during phase transformations.

This was one of the hardest topics covered in the class. Last year students had difficult time understanding this subject. In some universities, there is a dedicated course specifically design for this subject. I just introduced them the subject, but didn't go into details.

5. Apply the Fermi distribution and Bose-Einstein distributions to model real life problems/examples.

Homeworks 13-14 and the final exam (including the takehome part) were covering these topics. The averages of the take-home exam and the homeworks were greater than %92, but in-class final-exam average which consisted of difficult questions was %60. This indicates that the learning goal was accomplished, but it can be improved, such as spending more time during lecturing. I spent last 3 weeks on these subjects.

Self-Assessment of Learning Goals for PHYS 321 Fall 2019

The class in the spring of 2019 had 38 students, with a number of these repeating the class. Of these students, 3 did virtually no work (handed in less than 25% of the homework) and either dropped the course or failed the course. Easily 1/3 of the class did very well and demonstrated very good understanding of the material. Of the others approximately 1/3 had difficult with the linear algebra and differential equations needed for the course. Several students came to office hours regularly, but these were not students who desperately needed the help.

The Assessment Plan specifically requires evaluation of seven subject areas. They were assessed by a specific problem on the final exam. The subject areas are as follows:

1. Use Newton's laws to set up and solve a range of physical problems.

> The first exam contained two problems that required good knowledge of free-body diagrams and application of Newton's second law. In general the students did well with the simpler of the problems, and 3/4 of the students were able to do the physics of the second problem.

2. Exhibit an understanding of energy conservation, potential energy, conservative and central forces, conservation of momentum and angular momentum, and use it to solve a range of physical problems.

> Several problems on exams addressed this and students did well on most of these. Many of the homework problems specifically addressed these areas, and so the practice seemed to pay off.

3. Set up and solve problems related to driven and damped oscillations, along with coupled oscillators and normal modes of oscillation.

> The final exam contained a standard normal modes problem and was completed well by the majority of the students.

4. Use the Lagrange formalism to find and solve the equations of motion for mechanical systems.

> Again, this was test on the final. Students seem to enjoy doing the Lagrangians of various systems and this showed as good scores on this problem.

5. Develop an understanding of rigid body rotational motion and use it to solve related problems.

> This was covered on the final exam. It showed that for simple situations students could struggle through the solution; however a second section of the problem showed that they had only a basic understanding of the physics behind the equations.

6. Understand and solve problems related to the two-body central force problem.

> This was covered on the second exam. Basic understand was demonstrated by most students (3/4).

7. Show an understanding of mechanics in non-inertial reference frames and use it to solve related problems.

This was covered on the final exam, and was the area that students did the worst. Only the top ¼ of students could do adequately on this topic.

I agree with the final comments made by Dr. Takacs from the Spring of 2018:
The content of the course and the amount of time spent on each subject is about right. No change is recommended. The main difficulty is to convince students that active problem solving is the only way to learn how to apply advanced mathematics to physics problems. Tutoring, review sessions, remedial discussions on relevant mathematics might be useful, but nothing works, unless students are willing to invest time and energy into active learning, that is regular problem solving on their own.

Self-Assessment of Learning Goals for PHYS 330L Fall 2018

Dear Graduate Program Assessment Committee,

PHYS 330L is supposed to assess following educational objectives for bachelor's degree graduates of the Department of Physics:

- The ability to communicate scientific information effectively, both verbally and in writing.
- Demonstrated ability to design and carry out experiments using modern equipment and analyze and interpret experimental data.

These objectives are evaluated by assessing the achievement of the four learning outcomes described below. By the end of the course, students should be able to:

1. Follow a general laboratory guide and develop specific strategies for accomplishing prescribed measurement goals using available lab materials and equipment.

2. Write a mature laboratory report which includes the most common elements and organization of scientific papers published in journals today.

3. Replicate the key experiments demonstrating the nature of light and optical systems, such as: measuring the speed of light, measuring the wavelength of a laser using a Michelson interferometer, measuring the thickness of an object using thin-film interference, characterizing single and double slits using a laser, and measuring Brewster's angle.

4. Demonstrate an understanding of the concepts behind modern optics technology, such as laser gyros, holographic films, and fiber optic cables.

Fall 2018 instructor's report:
All of the students who completed PHYS 330L satisfactorily achieved all of the above learning outcomes. This assessment was based on reviews, analysis, and feedback given to them on their weekly lab reports and lab notebooks. Each week they were required to write a lab report that took the form of a manuscript submitted to Applied Physics Letters or Optics Letters. At the beginning, the students had a hard time communicating in clear, succinct phrases, but that improved over the course of the semester. At the end, every student could write a decent report in the format that we desired and with the kind of scientific analysis and rigor that met the learning objectives. This is the "Writing in the Discipline" course for our department, so there was a heavy emphasis on the writing. The amount of scientific learning that occurs in this course is not terribly high. The students are basically reproducing fundamental experiments in optics and as such they learn as they go along, but the retention is not great.

Initially, a large fraction of students failed to turn in their lab reports on time, or at all. Those that went several weeks without turning in reports eventually dropped the course, for the most part. Those that completed the course, eventually were able to get things done on time, but some still could not, even at the end.

Self-Assessment of Learning Goals for PHYS 407 Spring 2019

Some relevant info for this report:

- This year's class had 17 students. The final course grade distribution was 6 A's, 2 B's, 3 C's, 4 D's, 2 F's.
    - 9 worked hard and did well, one worked hard and didn't do well, and 6 put in very little effort and did poorly.
- This was my first time teaching 407 and I misjudged the pace of the course and ran out of time. I only covered 5 of the 7 learning outcome objectives. This was entirely my fault. I apologize and will do better next time.
- The syllabus included the specific learning outcomes objectives.
- Grading of the course was based on:
    - 3 regular Exams (closed book, in class, 55 minutes)
    - 11 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. *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: 11 of 17 students (65%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 3/4 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: 11 of 17 students (65%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 2/3 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 17 students (65%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly 2/3 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: 11 of 17 students (65%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly half 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: 10 of 17 students (59%) mastered this objective.
    b. My assessment based on participation and discussion: Roughly half 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. I did not leave enough time to adequately present this material. I'm unable to assess. This is my failure.

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.

Comparison with Student Survey from Jen:

- I didn't get any Survey's this year. Did I miss those?

Comments, suggestions, and wrap-up notes:

- Having 6 of 17 students in the category of "didn't put in any effort and did poorly" is very discouraging. That number is way too high. I was unable to motivate these students and felt like a failure. Some comments on this group include:
    - Most of these 6 have numerous C, D, F, W's on their transcripts. They seemed disenfranchised and not interested in being physics majors. I hope we can figure out a way to engage and teach them. I'm worried we may have somewhat of a perceived "caste system" of students who went to good high-schools and are bright and get A's, and others who aren't in that category and feel left out.

        - For example, it would be interesting to study the GPA vs. "undergraduate research opportunities" to see if we are offering the same educational experience to all of our students.
    - 4 of the 6 (and the 1 who tried hard and did poorly---so 5 of 7) transferred in classes from Community College. I don't know much about that situation, but one conclusion could be that freshman physics and math courses at the Community Colleges do not prepare students (for our upper level physics classes) as well as freshman physics and math courses at UMBC. This is a serious issue. As a parent in a local neighborhood, I've heard several of my peers say, "My kid will go to HCC then transfer into UMBC…it's a great deal and you take the same courses for much cheaper". I feel uncomfortable when this topic comes up.

- I share the frustration/confusion of previous 407 instructors about the math background for this course (Vector analysis, vector algebra, differential calculus, integral calculus….ie. Chapter 1 of Griffiths). The advice I got was along the lines of, "they don't know it…you have to spend a lot of time on it". I also found this to be true and spent way too much time on it.
    - I need to better understand where/when our students learn this. I messed up and didn't ask my colleagues and I still don't know.
    - I've heard from a few students (this is just unofficial hearsay) that they learn it in math courses at UMBC, but "..those classes are a
    - disaster". If that's the case, should we tell our students to boycott those classes and should we offer our own? Perhaps Math Physics, but in sophomore year?
- *Repeated comment from 2016 and 2017 and 2018:* I found that every single HW and Exam problem was related to one of the 5 learning goals I assessed. I just chose an arbitrary subset to do my assessment. Is that the idea? I guess I'm a little confused on the methodology we should use. Also, when I said a student "mastered" a problem, I used "C+'ish" or above type of work. Is that OK, or do you need a further breakdown?

Self-Assessment of Learning Goals for PHYS 424 Fall 2018

Some relevant info for this report:

- This year's class had 15 students. One student did very little work and never showed up for class, except the semester exams.
- The final course grade distribution was 4 A's, 2 B's, 2 C's, 5 D's, 2 F's.
- The syllabus included the specific learning outcomes objectives.
- Grading of the course was based on:
    - 3 regular Exams (closed book, in class, 55 minutes)
    - 15 HW assignments
    - A cumulative Final Exam (closed book, in class, 2 hours).

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 the first homework assignment and part of the second homework assignment.
      Based on the scores there was a very weak understanding of the development of quantum mechanics. Students did not understand blackboady radiation at all, and had no real knowledge of basic atomic physics experiments that defined quantum mechanics.

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: 3/4 of the class had a good understanding of this.

3. *Solve the Schrodinger equation for various 1D potentials.*
    - My assessment based on specific HW and Exam problems: 1/2 of the students had a good understanding of this, while others were only able to parrot simple problems that they had seen.

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: The students were good on understanding the ideas of Dirac notation and, but when faced with applying these ideas to problems they struggled when they were not guided through the analysis. Approximately half of the students performed satisfactorily.

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: This was the worst area for the students. In particular, their understanding of the quantum mechanics of angular momentum and spin was lacking. Only 1/3 of the class had adequate understanding of these topics.

6. *Analyze systems of identical particles and the concepts of fermion and boson statistics.*
    - My assessment based on specific HW and Exam problems: Approximately ½ of the students did very well with this topic, and the other half struggled. This matched with students who had completed PHYS303 prior to taking this course.

Comments, suggestions, and wrap-up notes:

- Students who came to class seemed genuinely interested in the material, but they did not spend enough time working on the homework problems. It was obvious that problems with solutions on the internet were copied without thought. I spent an enormous amount of time "inventing" problems that could not be searched. In many instances, I could see that the homework solutions for these problems were done by committee, and that several of the students did not understand what they had just copied. Even after many attempts to have students abandon this approach and come to my office for help, I could not overcome the homework by committee approach.

- Comments on the previous desire to split the course. Personally I do not see a need to do this as a required course. It would be nice to do additional work on the more advanced applications, but I believe that this would work as an elective course. I would recommend that students be advised to not take this course in their junior year, and complete PHYS303 before this course if possible. Also, I would have a bit more emphasis placed on the underpinnings of quantum mechanics in the modern physics class, with less work on topics such as the hydrogen atom.