Annual/Biennial Program Assessment Report

Academic Year Assessed: 2022-2023

College: College of Letters and Science

Department: Physics

Submitted by: John Neumeier

Undergraduate Assessment reports are to be submitted annually. The report deadline is October 15th .

Graduate Assessment reports are to be submitted biennially. The report deadline is October 15th .

Program(s) Assessed

List all majors (including each option), minors, and certificates that are included in this assessment:

B.S. in Physics, Professional Option

B.S. in Physics, Interdisciplinary Option

B.S. in Physics, Astronomy/Astrophysics Option

B.S. in Physics, Teaching Option

Physics Minor

1. **Past Assessment Summary.** A self-study/program review of the department was completed in Spring 2023. An external academic program review was also completed on May 2-3, 2023, and submitted to the Provost's office. The **external review** found the quality and rigor of the undergraduate program to be exemplary. The review team cited the advancing set of opportunities for undergraduate researcher due to the high research activity in the department. The **self-study** revealed a decrease in enrollment of majors from about 108 to 87 from 2019 to 2022. This is likely associated with the pandemic. The new Astronomy/Astrophysics option appears to be drawing students from the Professional and Interdisciplinary options. Based on the enrollment in the sophomore course PHSX301 of 23 students, which is a gateway course, we expect enrollment in upper division courses to improve. Furthermore, PHSX200, a course all majors take in Fall of their sophomore years, has an enrollment of 33 students in 2023. This suggests a healthy improvement in physics enrollment. Enrollment in the physics minor is low, currently at 10 students. We met with the Society of Physics Students at the end of F22 an S23 for a town-hall style meeting. This meeting provided some action items, as described in section 6.

2. **Action Research Question.** We sought responses from each instructor about their courses and what might be needed to improve them. In some cases, they provided input on whether students were meeting learning-outcome metrics; in the next assessment we will improve the response rate on this issue by providing instructors with a questionnaire. Enrollment numbers are noted above, in 1, and again noted below in 6. We developed a plan to offer PHSX444 once per year, in order to free the instructor to for a different class (described below in 6). This effort is still underway, but has received EFAC funds to increase the number of lab stations. We researched whether or not new undergraduate courses in Plasma Physics and Nuclear Physics might be of interest (described below in 6). We investigated improvements that can be made to advising (described below in 6). The PHSX224 lab manual needed updating, which was carried out through the summer of 2022 (described below in 6). The need to update the PHSX222 lab manual was cited, and is being addressed in Fall '23. We also investigated changes to the interdisciplinary option requirements, and implement those (described below in 6).

3. Assessment Plan, Schedule, and Data Source(s).

a) Multi-year assessment schedule

ASSESSMENT PLANNING SCHEDULE CHART					
PROGRAM LEARNING OUTCOME	**COURSES MAPPED TO PLOs**	**2021-2022**	**2022-2023**	**2023-2024**	**2024-2025**
1. Discipline specific knowledge				x	
2. Breadth of knowledge			x		x
3. Communication skills					
4. Problem-solving skills			x		
5. Experimental design skills					x
6. Option-specific outcomes				x	

b) Threshold values for which our program demonstrates student achievement.

Threshold Values		
PROGRAM LEARNING OUTCOME	**Threshold Value**	**Data Source(s)***
1) Discipline-Specific Knowledge: Graduates are expected to have in-depth knowledge in the following areas of fundamental physics: classical mechanics (including Newtonian, Lagrangian, and Hamiltonian approaches); electromagnetism (including statics, dynamics, and circuits); Quantum mechanics (including bound state problems, potential scattering, angular momentum, and perturbative methods); waves and oscillations.	The threshold value for this outcome is for 75% of assessed students to score above 2 on a 1-4 scoring rubric.	Exams and assignments assoc. w/ coursework in each course. Assessments responsibility of instructors of courses who grade student work.
2) Breadth of knowledge: Graduates are also expected to have knowledge at the introductory level and in the additional (elective) topics of physical and geometrical optics, laser physics, thermodynamics and statistical physics, astronomy, solid-state physics, special relativity, atomic physics, astrophysics, nuclear physics, approximation methods in quantum mechanics, and particle physics.	The threshold value for this outcome is for 75% of assessed students to score above 2 on a 1-4 scoring rubric.	Exams and assignments assoc. w/ coursework in each course. Assessments responsibility of instructors of courses who grade student work.
3) Communication skills: Graduates are expected to have the ability to present the results of their work in oral and written form, as well as the ability to communicate with members of scientific teams, supervisors, and clients.	The threshold value for this outcome is for 75% of assessed students to score above 2 on a 1-4 scoring rubric.	Student written work and participation in classroom discussions and presentations. Laboratory written reports. Assessments responsibility of instructors of courses who grade student work.
4) Problem-solving skills: Students are expected to be able to formulate and solve problems analytically and numerically. Their mathematical skills are expected to include working knowledge of calculus (including vector calculus), ordinary and partial differential equations, and linear algebra, as well as	The threshold value for this outcome is for 75% of assessed students to score	Homework sets and examinations in all courses. Assessments responsibility

advance mathematics skills obtained from math elective coursework.	above 2 on a 1-4 scoring rubric.	of instructors of courses who grade student work.
5) Experimental design skills: Students will participate in undergraduate research projects, laboratory courses, and may complete Capstone projects. These activities integrate their physics knowledge and problem-solving skills, including basic electronics, data acquisition, data analysis, and experimental design as appropriate to the research topic.	The threshold value for this outcome is for 75% of assessed students to score above 2 on a 1-4 scoring rubric.	Assessment of research and laboratory skills is through observation of lab procedures and written laboratory reports. Assessments responsibility of instructors of courses who grade student work.
6) Option-specific outcome: Graduates are expected to have additional knowledge and skills as appropriate to their selected option: Professional Option - additional elective Physics courses; Interdisciplinary Option - additional courses in selected discipline; Teaching Option – additional EDSI courses in education department.	The threshold value for this outcome is for 75% of assessed students to score above 2 on a 1-4 scoring rubric.	

4. What Was Done.

a) The completed assessment is consistent with the program's assessment plan.

b) The department head collected data from faculty teaching all courses, outside of introductory 200-level classes.

c) The rubric below demonstrates how the data are evaluated.

Indicators	**Beginning - 1**	**Developing- 2**	**Competent- 3**	**Accomplished- 4**
Analysis of Information, Ideas, or Concepts	Identifies problem types	Focuses on difficult problems with persistence	Understands complexity of a problem	Provides logical interpretations of data
Application of Information, Ideas, or Concepts	Uses standard solution methods	Provides a logical interpretation of the data	Employs creativity in search of a solution	Achieves clear, unambiguous conclusions from the data
Synthesis	Identifies intermediate steps required that connects previous material	Recognizes and values alternative problem solving methods	Connects ideas or develops solutions in a clear coherent order	Develops multiple solutions, positions, or perspectives
Evaluation	Check the solutions against the issue	Identifies what the final solution should determine	Recognizes hidden assumptions	Evaluates premises, relevance to a

			and implied premises	conclusion and adequacy of support for conclusion.

5. What Was Learned.

a) The majority of students appear to be exhibiting competency or accomplishment, with only less than 8% below in PHSX224 and 441. For PHSX444, 100% of the students assess at 3 or above. For PHSX305, a core class with students from various disciplines, 25% are below 3. For PHSX425 and 446, we are seeing only half of the students exhibiting competency or accomplishment. This needs to be better understood, but is probably associated with the mathematical difficulty of the courses. We plan to provide a better template to faculty in future evaluations.

b) We did an interim review of the Astronomy/Astrophysics Option, which is now in its 3rd year. Some of the new courses are falling below enrollment projections. We had hoped that addition of this option would increase enrollment in physics, but at the moment, this does not seem to be the case. The new option appears to be drawing students from the professional and interdisciplinary options. We are finding that many graduate students are taking some of the courses, such as ASTR475 and 476. Why is not clear, especially since PHSX560 is a more advanced version of ASTR476. As we continue to monitor this new option, more will be learned. The teaching option has only a few students enrolled; this is common. Our minor has very few students.

c) The quality and rigor of our undergraduate program was found to be exemplary by the external review committee.

d) The physics help center needs more space and more tutors who are undergraduates themselves.

e) Physics electives need to be better spread out through the semesters, particularly with more offerings in the fall semesters.

6. How We Responded.

a) Enrollment: We find enrollment of freshmen and sophomore students in courses at the level to be strong. Indicating we are rebounding from the pandemic era of weaker enrollment. We continue to monitor the enrollment in the Astronomy/Astrophysics Option and its influence on the other options.

b) The undergraduate curriculum committee assessed PHSX444, Advanced Physics Lab, and began a plan to offer it only one semester per year. To realize this, the number of lab stations must be increased. An EFAC request to fund this was submitted and funded. While this change is currently progressing, more space is required to accommodate the students. This is proving difficult, but we continue to seek solutions.

c) The undergraduate curriculum committee researched whether or not elective courses in Plasma Physics and Nuclear Physics might be of interest to the students. This was considered due to the small number of elective courses that are offered during some semesters. The response from our undergraduates was that 8-10 would be interested in such courses. This indicates that we could offer them once every two years. Instructors have been identified, but the timeline is not yet known. Such additionos could help with the imbalance of elective offerings between Spring and Fall semesters.

d) The Town-Hall Meeting with Society of Physics Students led to some recommendations that were acted on. We increased the number of peer (i.e. undergraduate) tutors in the Physics Help Center. We have made some changes to concentrate honors physics students into certain lab sections. Some recommendations were made regarding the Capstone (PHSX490) class, which will be implemented in S24.

e) We are currently reviewing the possibility of expanding the course selections available to the physics minor, with the aim of improving enrollment above the current number of 10 students. This would include adding some engineering courses and courses from other science disciplines.

f) We have instituted a yearly meeting of all undergraduate advisors, where the new (freshmen) advisor is onboarded. This also provides all advisors with the opportunity to share their experiences and practices. A handbook has been developed, which is a reference source for advisors.

g) Carla Riedel and Shane Mayer-Gawlik updated the PHSX224 lab manual and updated the equipment for some of the labs.

h) Student need for PHSX224 in the Spring semester was noted by advisors. We offered the class for the first time in S23. The enrollment was low, 9 students, compared to F22 enrollment, which was 56, almost at the cap of 60. F23 enrollment was 61. We communicated the addition of the Spring semester section to the electrical engineering department, since PHSX224 is a required course for their students. Our hope is that the Spring course will gradually enjoy higher enrollment, and reduce the strain on the Fall course.

i) A major change was implemented to the Interdisciplinary Option. The 16 credits for the declared area were replaced with the requirement that the student must choose any MSU minor. This assures that each Interdisciplinary student has completed a minor at MSU. It gives them a documented specific minor, mention of it on their diploma, and hopefully leaves them with a better education. To better incorporate this change, we removed the requirement of a 4-credit science elective in the freshman year, removed 3 credits of math electives, and removed 1 credit of physics electives.

7. Closing the Loop(s). Reflect on the program learning outcomes, how they were assessed in the previous cycle (refer to #1 of the report), and what was learned in this cycle. What action will be taken to improve student learning objectives going forward?

a) No changes were recommended at this time.

b) No, we have not been able to document the impact of changes implemented through prior program assessments.

Interim Review of Astronomy/Astrophysics Option

The new Physics Astronomy/Astrophysics option was implemented in Fall of 2021. The option has four required courses: ASTR 372 (Stars and the Milky Way), ASTR 373 (Extragalactic Astronomy), ASTR 475 (Observational Astronomy Techniques), and ASTR 476 (Theoretical Astrophysics). Enrollment in these courses is shown below:

	Fall 22	**Spring 23**	**Fall 23**	**Spring 24 (anticipated)**
ASTR 372		21; 9 option students		9; 5 option students
ASTR 373	3; 2 option students			
ASTR 475			21; 10 option students; 7 grads	
ASTR 476		not offered due to lack of enrollment		8; 2 option students; 5 grads

The enrollees comprise students in the option, physics majors and non-majors taking the courses as electives, and, for ASTR 475 and 476, physics graduate students. The enrollment numbers vary significantly, often falling short of the target minimum enrollment of 10 (shown in red). Enrollment in ASTR 475 includes juniors and seniors.

Interest in the option has been strong, as shown by the total enrollment numbers for the option of 25 in Fall of 2022 and 34 in Fall of 23. These students have not yet had time to complete the program, so it is too soon to assess the success rate. Meanwhile, the total number of physics majors has been decreasing in recent years: 115 in 2018, 105 in 2020, 89 in 2021, and 87 in 2022. The Astronomy/Astrophysics option was implemented with the hope that it would increase the enrollment numbers in Physics, but the option is not having this effect so far. Given that enrollment in the ASTR courses is often falling short of enrollment goals, it would be useful to consider if continuation of the Astronomy option justifies use of faculty and GTA resources, versus, for example, keeping these courses as electives that run less often.

It is unclear why so many graduate students are taking ASTR 476, given that the Physics Department offers a graduate version of the course (PHSX 560) which would be more appropriate.

Instructor Review of Individual Courses Taught in AY 2022-2023

Astronomy/Astrophysics Courses

Course Acronym: ASTR 371

Course Name: Solar System Astronomy

Enrollment: 28 students

2) Breadth of Knowledge

Please describe here how student breadth of knowledge was assessed in your class.

Student knowledge was assessed through regular homework assignments which connect closely to the lectures. Students learn the basics of astronomy including Newton's and Kepler's laws, how light behaves, and the orbits of the moon and the planets. Each solar system body is then described in more depth, including its origin and how it fits into context in the larger Solar System. Finally, planet formation theories and the discovery of exoplanets are taught. Two midterms and one final exam are given. Breadth of knowledge acquired through the class is assessed through homeworks and exams.

4) Problem-Solving Skills

Please describe here how student problem-solving skills were assessed in your class.

The regular homework assignments require the students to carry out calculations that use the equations and concepts taught in class. The exams assess how well the students have acquired and synthesized the necessary knowledge and problem-solving skills throughout the class.

Recommended Changes

The lab manual needs to be rewritten in the near future. This is currently being planned for the summer of 2024

This class has a mix of Physics/Astro majors and education students. Therefore, material is often easy for the majors, but difficult for the education students. Given these constraints, the current way the class is being taught maximizes the knowledge across all the students.

Course Acronym: ASTR 373

Course Name: Extragalactic Astronomy

Enrollment: 3 students

2) Breadth of Knowledge

Student breadth of knowledge was assessed through a combination of problem sets, concept checks, in-class activities, and exams.

A total of 7 problem sets were assigned as homework during the semester, each focusing on a distinct topic that was covered in lectures. The problem sets were quantitative in nature and primarily used to assess problem-solving skills. Concept checks were given as homework assignments throughout the semester and required the students to explain various concepts in their own words to demonstrate breadth of knowledge. Additionally, in-class activities/problems were incorporated into the lectures. Students first worked on their own, then discussed in groups, and finally shared/discussed as a class. This helped solidify knowledge and deeper understanding of the material. Students also read a number of Astrobites articles on current astrophysics research and had to answer questions relating to the article.Two in-class midterms and one Final exam were given during the semester. The exams were designed to assess application of fundamental concepts of extragalactic astronomy and solve problems in this area.

4) Problem-Solving Skills

Problem-solving skills were primarily assessed through problem sets, in-class activities and exams as described above.

Recommended Changes

No major changes planned at this time.

Physics Courses

Course Acronym: PHSX 224 (Fall 2022)

Course Name: Physics III

Total number of students 53, number of physics majors 16

2) Breadth of Knowledge

Please describe here how student breadth of knowledge was assessed in your class.

Learning outcomes: Introductory level laser physics, thermodynamics, solid-state physics, special relativity, atomic physics, particle physics

Assessment reports average homework scores using rubric: 93% were at level 3 or above, 97% were at level 2 or above

4: 28 students

3: 21 students

2: 2 students

1: 2 students

4) Problem-Solving Skills

Please describe here how student problem-solving skills were assessed in your class.

Learning outcomes: formulate and solve problems analytically and numerically.

Assessment reports average midterm scores using rubric: 81% were at level 3 or above, 98% were at level 2 or above

4: 12 students

3: 31 students

2: 9 students

1: 1 student

Recommended Changes

Be more methodical in instruction regarding experimental uncertainties. PHSX 220/222/240/242 could consistently emphasize measurement uncertainty.

Course Acronym: PHSX 261 (Fall 2022)

Course Name: Laboratory Electronics I

Enrollment: 21 students

2) Breadth of Knowledge

Physics 261 is a required lab-based course in the physics major. It is typically taken in the sophomore year. Knowledge covered begins with a review of introductory resistive circuits at a more complex level than the 222/242 level. Norton and Thevenin equivalent circuits and node voltage analysis are also developed. Semiconductor circuits including diodes, transistors, op-amps, comparators and Shmitt triggers. The course also introduces complex impedance and the use of imaginary numbers and Euler's formula to represent oscillatory inputs and outputs. High and low pass filters and resonant circuits are developed and phase and gain as a function of frequency are explored. The semester finishes with transient analysis of circuits. Each topic has at least one associated lab with it so that students see both the theoretical and practical side of the topics. Students become familiar with the use of test equipment found in common physics labs: power supplies, digital multimeters, current sources, function generators and oscilloscopes.

4) Problem-Solving Skills

Students in 261 complete weekly homework that covers a range of levels. For new material basic questions are asked to increase familiarity but each week includes higher level problems to challenge students. Two midterms and a final exam are also used to evaluate knowledge and problem-solving skills. Lab sessions consist of up to 3 hours experimental time each week allowing for significant exploration of the lab materials. This allows for students to do labs that are not simply following a recipe as more open-ended problems can be investigated. Students are asked to include error analysis in lab reports and more writing is required in lab notebooks than was previously expected in introductory courses. Lab work typically requires substantial trouble shooting of circuits as students learn how to work with breadboards and components that are more complex than a two terminal device.

Recommended Changes

None at this time.

Course Acronym: 262 (Spring 2023)

Course Name: Laboratory Electronics

Enrollment: 17 students

2) Breadth of Knowledge

Much of the class was preparing the students for the final project. This required them to have some kind of analog input, build a circuit that interprets the inputs and outputs a signal, and a hookup to some device that interprets the output and performs an action. Students required knowledge of the components of their circuit and how they interact, as well as converting signals between digital and analog.

4) Problem-Solving Skills

None of the students' projects worked correctly immediately. Part of their grade was documenting the process, including identifying issues and solving them. If they were able to achieve this, I would consider the project successful.

Recommended Changes

Slowing down the pace compared to some previous instructors appeared to help the students towards the start of the semester. Using the previous notes, each lecture moved forward at too fast a pace for many students to ask questions and properly understand the material. Combined with the dense textbook, this often led to students having to relearn the material during lab time, instead of being armed with the information prior to lab.

Also, lectures seems to cease later in the semester while the students focused on the project. While the project was certainly the focus of the course, I created additional lectures for those interested in furthering their learning. It seemed odd to abandon the lecture before the end. Many of the components in the lab room turned out to be faulty. Purchasing some new ones could help.

Course Acronym: PHSX 301 (Spring 2023)

Course Name: Mathematical Methods in the Physical Sciences

Enrollment: 23 students

2) Breadth of Knowledge

The course PHSX 301 ``Mathematical Methods in the Physical Sciences" discusses the most important mathematical skills needed for intermediate and advanced Physics classes. Although some of these techniques are also covered in some of the math requirements, they are not discussed in sufficient detail. In the class the students tackle problems based on their existing Physics knowledge with more advanced mathematical techniques. This allows them to both expand their knowledge as well as solidify their existing Physics and Math competencies.

4) Problem-Solving Skills

The students learn to hone their mathematical problem solving skills through ungraded practice problems (solutions provided) and in-class examples. Their skills were then assessed through five 50-min in-classes quizzes, each covering a different part of the course material. In each of the quizzes the students were asked to solve several math and physics problems.

Closing the Loop

a) Please provide any changes you plan to implement for the course to improve outcomes.

I plan to provide more resources to student's who come into the class with gaps in their knowledge. The grading structure will be modified to encourage revision of prior concepts more as strong foundation is crucial.

b) Please provide recommendations that could be made to the physics program to improve outcomes in your course.

It would be beneficial if some concepts discussed in the class were introduced to the students earlier in their studies. For example, many of vector concepts such as i,j,k notation could already been introduced in Freshman Mechanics (PHSX 240). These earlier classes progress much slower and students would have an opportunity to slowly become familiar with vectors and vector notation.

Course Acronym: PHSX305RN (Spring 2023)

Course Name: The Art and Science of Holography (R, N – core designations)

Enrollment: 12 Students

2) Breadth of Knowledge

The course is laboratory-based, but in a unique way. Students go through a tutorial-style lab with the instructor or TA to learn the general process for making six different types of holograms. The students then independently meet with their lab partners to make holograms on their own without the presence of instructors. This requires and helps build a much better understanding of the details necessary to produce high-quality holograms. Failure to implement any one of a number of important details will lead to a failed hologram attempt. Therefore, there is a strong component of hands-on breadth of knowledge that is assessed by each of the six mandatory holograms that each lab group turns in.

Students also turn in individual lab write-ups of each of their holograms. This requires them to identify things that were important to their success (or failure) in making their holograms. Typically, this requires that students think about the influence of various practical factors at work in a real laser lab setting when working with optical components that require extreme stability for success. In the course, students learn about laser stability, coherence lengths, object coherence, and various aspects required to understand in the making of successful holograms.

From a theoretical knowledge standpoint, the in-class exam shows that roughly 95% or more of students score a 2 or higher on the breadth of knowledge rubric, with roughly 75% scoring a 3 or higher from a theoretical knowledge standpoint.

4) Problem-Solving Skills

Often, students will fail to successfully make a hologram on the first attempt and must evaluate what factors may have contributed to that failure. Sometimes failures are due to the presence of a deleterious effect, and sometimes failures are due to the absence of a required, but subtle component. One of the nice features of making holograms is that everything must work correctly to make a successful hologram, and any one of dozens of factors can lead to a failed or inferior hologram, so problem solving is inherently necessary to success when making holograms. In many cases, students are able to figure out what went wrong on their own, but the instructor and TA can provide further guidance for students who cannot figure out what went wrong.

In April, students write a proposal for an independent project of their own creation based upon the knowledge they gained earlier in the course. Students learn a bit about writing a proposal, and then learn a lot about implementing their proposal through their efforts at executing their final project. Ultimately, they must overcome many obstacles in order to achieve a successful final project. In addition to showing the project to all of the other students in the course as well as the instructor and TA, the students write-up the details about their project and what might have been done better or differently, as well as lessons they learned while making their final project hologram.

Students will be unable to produce a successful hologram if their knowledge level isn't somewhere between a 2 and 3 in terms of the provided rubric. In my experience of teaching the course, at least 95% of students achieved this.

Recommended Changes

a) Although the course outcomes are already fairly good for students of all majors (both STEM and non-STEM majors) with a long track record in that regard, a recent EFAC proposal was approved. With that funding, work is underway to update the course to allow the production of color holograms, as well as the purchase of a holographic printer.

b) Continued support at providing the space and TA assignment to support the course is vital to the continued success of the course. Once the supply chain for buying film has stabilized, department support of offering the course for both Fall and Spring semesters will help the course's ability to reach more students across campus. Currently the course is typically only offered in the spring semester which limits access to students who have busy spring semesters.

Course Acronym: PHSX 320 (Fall 2022)

Course Name: Classical Mechanics

Enrollment: 12 students

2) Breadth of Knowledge

The course PHSX 320 ``Classical Mechanics" covers the physics of mechanics at an intermediate level. This course provides the necessary foundations for more specialized physics topics such as astronomy, and thermodynamics and statistical mechanics.

4) Problem-Solving Skills

PHSX 320 is one of the key classes for students to learn how to formulate Physics problems with advanced mathematical techniques. With PHSX 320 in the fall semester just following the development of these high level skills in PHSX 301 in the spring semester. Students were able to practice their problem skills in weekly problem solving sets, following this their skills were assessed in five checkpoint tests, each covering an important topic in classical mechanics.

Recommended Changes

More focus on the key foundations, leaving out more specialized topics for future study. The students could be encouraged to read the textbook and study earlier before exams.

Course Acronym: PHSX 343 (Fall 2022)

Course Name: Modern Physics 1

Enrollment: 11 students

2) Breadth of Knowledge

Classic formula of points gained from a combination of homework, labs, and exams. This is a standard physics course.

4) Problem-Solving Skills

Problem-solving skills were primarily tested during the labs. Concepts were introduced, and twisted to test students' abilities to think about the material in a way not discussed in lecture.

Recommended Changes

The course seemed appropriate for its level. It's difficult to think of ways to improve because this was the first course that I taught. Frankly, I was entirely concerned with becoming a competent teacher, and wasn't analyzing how I could improve on the past notes. Again, I wasn't thinking about this. If there were any issues with the lab equipment, that could be addressed. Nothing stuck out to me as lacking.

Course Acronym: PHSX 425 (Fall 2022)

Course Name: Electricity & Magnetism II

Enrollment: 10 students, number of physics majors 8 (two physics grad students)

2) Breadth of Knowledge

Please describe here how student breadth of knowledge was assessed in your class.

Learning outcomes: none among the list, as this course is a specialized upper-division course

4) Problem-Solving Skills

Please describe here how student problem-solving skills were assessed in your class.

Learning outcomes: formulate and solve problems analytically and numerically, calculus, differential equations.

Assessment reports average midterm scores using rubric: 30% were at level 3 or above, 80% were at level 2 or above

4: 1 student

3: 2 students

2: 5 students

1: 1 student

0: 1 student

425: Assessment reports average homework scores using rubric: 60% were at level 3 or above, 80% were at level 2 or above
4: 5 students
3: 1 students
2: 2 students
1: 1 student
0: 1 students

Recommended Changes

Engage aggressively earlier in the semester with struggling students. Students who fail pre-req courses should be removed from rosters. Too many physics majors register for next-semester courses before current semester course grades are known.

Course Acronym: **PHSX 437**

Course Name: Laser Applications

Enrollment: 14 students

2) Breadth of Knowledge

1. Each student had to complete weekly homework assignments (10 in total). Each assignment comprised 2 to 4 separate problems, each problem addressing a distinct topic or section from the textbook that was previously discussed in class. Student's solution for each problem was evaluated (with written commentary where appropriate) and graded, and running average was calculated. The graded homework was returned within about one week, along with the grades, comments and a copy of instructor's solutions.

2. Two Midterm Exams and one Final exam were administered. The exams were designed to provide detailed assessment of student breadth of knowledge in each key topic are covered in the class. Midterm exams were returned to the student with the grades, commentary and instructor's solutions within about a week after the exam.

3. The instructor created laboratory demonstration sessions (typically 30 min each) as well as shorter in-class illustrative demos e.g. using laser pointer etc. Computer simulations and animations (using Wolfram Mathematica) were often used in class to illustrate theoretical concepts. During these sessions student participation was encouraged to chime in with their own observations and comments. These commentaries provided still another good way to assess students' breadth of knowledge.

Problem-Solving Skills

Students' problem-solving skill were assessed using homework assignments and exams as described in the previous section. In addition, the Laser Application course has some specific aspects, which consisted mainly in closer than average relation between practical skills and underlying theory of

quantum mechanics and electromagnetism. For this purpose, the course incorporated numerous computer-modelling templates that students used to advance their problem-solving skills.

Recommended Changes

No changes are planned at this time. This course lacks facilities for carrying out laboratory demonstrations. Currently I am using for this purpose a very tight space that have been able to temporarily free up in my research lab. But this is by far not adequate for a class of more than 5 students.

Course Acronym: PHSX441 (Spring 2023)

Course Name: Solid State Physics

Student Numbers: 9 students: 6 Physics, one Physics Graduate student, and two EE.

2) Breadth of Knowledge

PHSX441 is an elective course. The subject matter regularly establishes connections to topical matter from PHSX220, 222, and 224, allowing students to synthesize their knowledge of physics, and to apply basic physics to a more advanced topic. Quantum mechanics as applied to solid state physics is emphasized, which builds extensively on PHSX224. Students are required to read a paper that was published in a professional journal, such as Physical Review Letters, provide a 15-minute presentation to the class, and submit a two-page written report on the paper. Breadth of knowledge acquired through the course is assessed through weekly homework, attendance, presentation grade, and the written report. The assignments connected closely to lectures. Student reading is assigned prior to each lecture.

4) Problem-Solving Skills

The weekly homework assignments require students to carry out calculations that synthesize knowledge learned in class with knowledge from PHSX220, 222, 224, M171, 172, 273, and 274. The assignments also require independent research about various aspects of lecture topics. Problem-solving skills are assessed through homework grades, presentation grade, and the written report.

Assessment reports based on overall performance using defined rubric 100% were at level 3 or above.

4: 5 students

3: 4 students

2: 0 students

1: 0 students

Recommended Changes

No changes at this time. Student preparation seems to be very good, based on student work on the homework assignments. These indicate that students are developing good knowledge from prior

courses and are able to strengthen their knowledge of quantum physics and other areas of physics by taking this course.

Course Acronym: PHSX 444 (Fall 2022 and Spring 2023)

Course Name: Advanced Physics Lab

Student Numbers: 5 (graduate students, not included here, are taught simultaneously but register to take PHSX 516).

2) Breadth of Knowledge

PHSX 444 is a required course for professional option physics majors and an elective for other physics options, typically taken in a student's senior year. The experiments span a broad range of physics topics, making heavier use of optics, electromagnetism, and basic electronics. Students are required to submit detailed lab reports (and lab notebooks) after completing each experiment. The lab reports are to be written in the style of a scientific paper, with detailed diagrams, explanations, plots, and tables. Proper error propagation is required. The course has no exams.

Student breadth of knowledge was assessed by the scores on their lab reports, in particular the description of the experiments, results, data analysis (including plots with fits and/or tables) and conclusions drawn from their work.

100% of undergraduate students were assessed at level 3 or above.

4) Problem-Solving Skills

Each lab also includes a number of questions or problems with the lab handout. Student's responses are integrated into the lab report and typically include some extended analysis or theoretical modeling of data. Their scores are included as part of their lab report scores.

100% of undergraduate students were assessed at level 3 or above.

Recommended Changes

a) Please provide any changes you plan to implement for the course to improve outcomes:

Experiments should be reviewed to ensure they are spanning an appropriate range of topics. Preferably, students will be able to choose between experiments to do those that match their interests. This will require some restructuring of the course and possibly a larger space.

b) Please provide recommendations that could be made to the physics program to improve outcomes in your course:
Some time is spent at the beginning of the course teaching basic data analysis and presentation in Python. This is necessary due to the inconsistent preparation and programming skills of students, which ranges from highly skilled to fairly inexperienced. More numerical instruction which includes basic

programming skills and practice could be helpful both to gain more time for experiments in this course and to allow for more advanced analysis or additional experiments.

Course Acronym: PHSX 446 (Spring 2023)

Course Name: Thermodynamics & Statistical Mechanics

Enrollment: 7 students, 6 physics majors, 1 EE grad student

2) Breadth of Knowledge

Please describe here how student breadth of knowledge was assessed in your class.

Learning outcomes: none among the list, as this course is a specialized upper-division course

4) Problem-Solving Skills

Learning outcomes: formulate and solve problems analytically and numerically, calculus, differential equations.

Assessment reports average midterm scores using rubric: 57% were at level 3 or above, 71% were at level 2 or above

4: 1 student

3: 3 students

2: 1 student

1: 2 students

446: Assessment reports average homework scores using rubric: 57% were at level 3 or above, 86% were at level 2 or above
4: 4 students
3: 0 students
2: 2 students
1: 1 student

Recommended Changes

Engage aggressively earlier in the semester with struggling students. Students who fail pre-req courses should be removed from rosters. Too many physics majors register for next-semester courses before current semester course grades are known.

Course Acronym: PHSX 451

Course Name: Elementary Particle Physics

Enrollment: 5 students

2) Breadth of Knowledge

As for learning outcomes, PHSX 451 included content over special relativity, nuclear physics, and particle physics. Knowledge was assessed with discussion posts over reading assignments, weekly assignments over traditional textbook problems where students were required to submit written solutions and give an in-class oral presentation on a randomly chosen problem, and there was a final project which had a written paper and an oral presentation. I would say that more than 75% of the students were 3 or above in this criterion.

4) Problem-Solving Skills

Problem-solving skills were most needed in the weekly assignments. These skills were assessed in grading the written solutions and during the oral presentations. The amount of mathematical skill varied across problems, ranging from mostly conceptual to over a page of computation. I would say that more than 75% of the students were 3 or above in this criterion.

Recommended Changes

The course went very well, so I wouldn't plan to make any major changes if I had the opportunity to teach it again. All of my students were at the senior or graduate level, but most of them said it was the first time they were writing a paper or giving a presentation for a physics course. Some really struggled with these communication skills, so it would be beneficial to incorporate similar assignments in other physics courses.

Course Acronym: PHSX461 (Fall 2022)

Course Name: Quantum Mechanics I

Enrollment: 14 students

2) Breadth of Knowledge

Application of the fundamental concepts of quantum mechanics is assessed with two midterms, a final exam, and weekly homework assignments. The exams test the rapid application of fundamental concepts of quantum mechanics with carefully curated sequential problems that build to a meaningful solution of a physical system. The homework assignments include exercises that reinforce the development of the mastery of the fundamental skills and require students to adapt/integrate quantum mechanical concepts to other physical systems and concepts from other subjects to demonstrate the synergy between the core subjects of physics. The homework assignments are graded and contribute up to 30% of the final grade of the student. The exams count for 60% of the final grade.

4) Problem-Solving Skills

The exams and homework require application and continued development of fundamental calculus, linear algebra, and statistics skills. Assessment of the homework and exams incorporates the mastery of these fundamental math skills and their application for solving problems in quantum mechanics.

Recommended Changes

Significant changes are not planned at this time. Consideration of a new textbook that present a more modern treatment of quantum mechanics and its application to quantum information science and engineering technologies should be encouraged and supported.

Course Acronym: PHSX462 (Spring 2023)

Course Name: Quantum Mechanics II

Enrollment: 12 students

2) Breadth of Knowledge

Application of the fundamental concepts of quantum mechanics and approximation methods for the analysis of systems without analytical is assessed with two midterms, a final exam, and weekly homework assignments. The exams test the rapid application of fundamental concepts of quantum mechanics and approximation methods with carefully curated sequential problems that build to a meaningful solution of a physical system. The homework assignments include exercises that reinforce the development of the mastery of the fundamental skills and require students to adapt/integrate quantum mechanical concepts and approximation methods to other physical systems and concepts from other subjects to demonstrate the synergy between the core subjects of physics. The homework assignments are graded and contribute up to 30% of the final grade of the student. The exams count for 60% of the final grade.

4) Problem-Solving Skills

The exams and homework require application and continued development of fundamental calculus, linear algebra, statistics, approximation methods, and differential equation skills. Assessment of the homework and exams incorporates the mastery of these fundamental math skills and their application for solving problems in quantum mechanics.

Recommended Changes

Significant changes are not planned at this time. Consideration of a new textbook that present a more modern treatment of quantum mechanics and its application to quantum information science and engineering technologies should be encouraged and supported.