Physics 2023-24 PIG DIP Report

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Main Narrative

What We Achieved

We produced all of the promised deliverables: a mission statement, a revised set of departmental learning goals, and a list of strategic priorities and concrete actions we plan to take over the next several years to address those priorities. These foundational items live in our attached "Foundational Document".

Additionally, through many hours of discussion and working on a mission statement and revised set of learning goals, we collaboratively clarified departmental values and a vision for departmental priorities over the next several years. As part of our process, we "mapped" where we currently address a larger set of (very) drafty goals. That map will remain a process document; a map based on our revised set of learning goals is in process. In our mapping processes thus far, among other things, we confirmed that computation and laboratory skills are presently under-scaffolded in our curriculum, and we came to better appreciate the large variety of mathematics that we address/use in the physics curriculum. (Re)teaching mathematics can be a huge time suck, and at least anecdotally mathematics acuity appears to be highly correlated with success in physics courses; the mathematics mapping exercise got us thinking about ways to amplify and resonate with what our students are getting in their mathematics courses and other physics courses.

We also met with the **astronomy department** (Andrea Dobson and Jessica Sutter) and settled on several ideas for cooperation:

- Scaffold very basic python programming in the 100- or 200-level physics sequence so that we all can rely on those skills (somewhat) at the 300 level.

- Coordinate on the senior capstone, including especially a senior seminar.
- Coordinate on advising goals for major advising and share related resources.
- Coordinate or at least share ideas around how to incorporate courses that satisfy the new General Studies writing requirement into our curricula.
- Maybe make general relativity a permanent course and cross-list with astronomy.

Similarly, we met with five members of the **mathematics and statistics department** (Barry Balof, Will Boyles, Doug Hundley, Marina Ptuhinka, and Albert Schueller). We learned more about what goes on in their calculus sequence—that the sequencing and content is fairly restricted by national norms to accommodate transfer credits—and about their use and thinking about computational tools throughout the curriculum. We also found several opportunities for potential productive cooperation. Those include,

- Coordinating on computational tools. Many of us are at least gravitating towards python-based tools.
- Coordinating on the senior capstone for mathematics-physics majors. Perhaps combined majors are required to take a senior seminar in math or physics; if in mathematics, a physics professor might serve as adviser.
- Consider cross-listing computational physics and/or GR with mathematics & statistics. Physics would need to reconsider the prerequisites for these courses to make the cross-listing useful for mathematics majors.
- Physics could share course level mathematics learning goals that could inform math's choices of what to cover (and maybe when and how) in courses that many physics students take. Likewise, if physics was more aware of when and where a given math topic is addressed in the math curriculum, we could help students to see and use the resonance between mathematics and physics knowledge.

Before our meeting with mathematics, we mapped our use of mathematics throughout the curriculum. After the meeting, to help us decide whether to pursue revision of mathematics course prerequisites and major requirements, we gathered some information from general physics and physics major students on their feelings about mathematics preparedness and the usefulness of mathematics courses. This information will help us to address several of our strategic priorities next year.

We also met with students graduating in 2024, and we designed and administered two surveys for our general physics students and for our major students (in 200-level courses and beyond). In our surveys and conversations with students, we focussed on (1) mathematics preparation as discussed above, (2) the effect of the spring start of our general physics sequence for students, and, additionally,

- (3) for general physics students:
    - what were students' motivations for taking the course (helps us better understand what populations General Physics is serving) and
    - who is accessing tutoring and similar resources;
- (4) for graduating students:
    - when/how they came to feel a sense of belonging in physics.

We have not yet spent much time discussing the results, but those results will inform our planning in the fall – especially around the general physics sequence.

Impact on Student Learning

We in physics are leaving this PIG DIP with a shared vision and set of priorities for student learning. Among other things, we are attempting to more intentionally and uniformly assess our learning goals. The hope is for an intentional assessment process to help us know whether our changes make a positive impact. Time will tell whether our strategic planning efforts pay off.

Sharing Project Results

We have specific plans to share resources with mathematics/statistics and astronomy, as described in paragraphs three and four above. And as mentioned above, our mission statement will be published on our webpage. Finally, should any other departments have interest in our planning process or curricular map(s)[1] (once it's finished), we would be happy to share.

Individual Descriptions of Planned Changes in Courses

Kurt

One of the departmental learning goals focuses attention on the laboratory component of our curriculum and the need to provide all students with fundamental skills in experimental techniques. In addition, we are exploring ways to integrate computational methods across our curriculum. I will be implementing changes in the Phys267 course (Digital and Analog Electronics) that will place greater emphasis on experimental design, laboratory report writing, and computational analysis methods.

a. I will introduce more sophisticated measurement tools earlier in the semester and spend a bit less time on basic tools. This shift will give students more options for making measurements, which will create more choice when they are confronted with making decisions about how to measure a specific quantity.
b. I will shift the emphasis in some of the laboratory activities to computational analysis of collected data. This will likely make some of the experimental procedures more prescriptive to speed up data collection; however, in some cases the data analysis piece is more important than experimental design for data collection.
c. I will be changing the emphasis in laboratory write-ups to focus more on the interpretation of data and the connection of circuit behavior to fundamental theories describing circuit element behavior.

These changes should help prepare students better for the laboratory activities we are planning for the advanced laboratory course. In addition, it will arm students with a better understanding of data analysis outcomes such as statistical interpretation of fitting parameters and uncertainty.

[1] We found it very useful to have several Whitman examples to consider (sociology, chemistry, psychology) during our planning.

Crucially, students will have a chance to implement more computational methods for data analysis and coding in Python.

Doug

A key shift in our department mission and approach is greater emphasis on project and experiential learning while deemphasizing written solutions to traditional physics problems. While there will still be plenty of the latter, projects will be front and center for the senior assessment, and other forms of experiential learning will be built into both the formal curriculum and other co-curricular activities. In many cases, the project will involve the student bringing together different areas of physics to address a real-world problem of their interest, culminating in a written and oral presentation of their project.

As training for this senior assessment, I aim to incorporate skill building into my introductory and upper level courses, which will help prepare the students for constructing an effective project in the senior year.

1. In Physics 156, the students mainly do problem solving. I will broaden this approach by building in activities where the students must explain orally their solution to a problem. This may occur via recording a video, or presenting in class.

2. In Physics 350 (Soft Matter) the students read and present papers orally to the class. I will broaden this activity by offering the option of creating a demonstration of a principle of soft matter physics instead of presenting a paper.

Moira

Our new mission statement says that we in physics will help students “develop physics passion” and “cultivate [their] intellectual curiosity.” It also states that we will help students learn “ how physics knowledge and methodology can be applied in diverse real world contexts, and how physics connects to other branches of knowledge.”

In my Phys 156 course, I have the following ideas for boosting curiosity and helping students see and practice “how physics knowledge and methodology can be applied in diverse real world contexts.”

1. I plan to incorporate more demonstrations—many of those developed as part of Ashmeet’s last PIG.
2. For each week, I plan to recommend/assign at least one Veritassium, SmarterEveryDay or similar high-quality YouTube video on a real-world topic closely related to the week’s main physics content, and follow up with written or in-class reflections.
3. The last time I taught Phys 156, I assigned independent research presentations, where each student prepared and recorded a 4-6 minute presentation about a modern-day application of the physics concepts we covered in class. I aim to substantially revise this

project to be one that asks students to more explicitly apply physics concepts and physics-y ways of thinking (along the lines of ways demonstrated in Veritassium and SmarterEveryDay videos, for example) to better understand a real-world phenomenon or device they care about. I envision developing a few project topics to choose from, with an eye towards student interests which I'll first learn about through a survey at the beginning of the class. I'll bear in mind using the project deliverables to assess a few of our major learning goals and also have in mind using this project as a bit of scaffolding for a project-based senior capstone project. I aim to use this project as a pedagogical experiment that can inform our departmental work on our strategic priorities 1 and 2.

Ashmeet

Two of our departmental priorities for the next few years, one on "increasing opportunities for experiential learning," and the other on "strengthening our computational curriculum" resonate very closely with me. I have implemented aspects of these strategies in my classes and have received a good response from the students and seen a positive impact on their learning, and I plan to further strengthen them and make them an integral part of how my classes are structured. Particularly,

1. Phys300 ST: Computational Methods in Physics was introduced in Fall 2023 as a course to introduce students to computational techniques used by physicists. Our plan is to tentatively adapt this course to adapt in equal parts computational skills (in Python) and mathematical methods and make it a core course at the 200-level which can support the upper-level classes better. In the Fall 2024 iteration of PHYS300, I plan to strategically place discussion of more math methods intertwined with computational skills for students to see it more holistically. I also plan on making the project-aspect of the course more well defined and in resonance with our goals for the senior capstone project.

2. In PHYS347: Classical Mechanics and PHYS-245: Twentieth Century Physics, instead of traditional quizzes, I plan on introducing mini-projects where the students will have to merge aspects of experimental, analytical, and theoretical techniques to answer a real-world problem which can be understood by the techniques being taught in these classes. These will help better prepare our students for the senior capstone, but also allow them to appreciate and experience physics on a more first-hand basis, directly seeing applications of what they are learning to how the world works, in line with helping students "develop physics passion" and "cultivate [their] intellectual curiosity."

3. During Fall 2023, supported by a PIG grant, we developed many new in-class demonstrations for PHYS-156. These were focused on electromagnetism and waves/oscillations, and received strong positive feedback from students in their class evaluations. For PHYS-155 during Spring 2025, I will aim to lead a similar effort to develop and further strengthen our existing arsenal of demonstrations spanning mechanics. This will include creation of DIY-style experiments and projects (using everyday objects, phones as sensors, etc.) to aid with experiential learning.

Andrés

- One of the department's goals is that students know how to successfully communicate physics in different formats. Another goal is that students see the connection between physics and other branches of knowledge and society, and are able to find information that relates them.

Last spring semester I worked in Phys 155 with students to create a short YouTube video to explain a physics concept. In Phys 156 next autumn I will incorporate a component of written communication which will involve having the students research the connection that has physics and society. Students will investigate on a topic from electricity and magnetism with current or potential applications in society. Students will write an op-ed style essay outlining the advantages of investing in a technology related to that physics topic. The essay aims at justifying to a non-expert audience the relevance of science in society. This assignment will be scaffolded through the semester.

This aims at working on departmental goals 2 and 4, that focus on recognizing how physics can be applied to diverse contexts, and effectively communicating physics arguments in written form.

- In order to address some of the comments from alumni regarding Phys 339 (Adv. Lab.) I am designing new experiments that involve acquisition of large amounts of data that need to be processed using computer code in order to be analyzed and interpreted properly. One experiment will be directly related to my research in photonics and complexity, which will give students an overview of active fields of research.This will be a multisession experiment that will involve detailed hands-on work on the experimental setup, non-trivial data acquisition, thorough data processing, and interpretation of the data based on physics concepts new to the students.

Summary of Attached Materials

Foundational document, which includes

- A mission statement to be published on our department's web page after a final revision in the fall. (Feedback from those who read it along with this report is welcome.)
- A revised list of departmental learning goals to be published in the course catalog (to be submitted along with perhaps a few other changes to the major in the fall) and on our webpage. For the past 8 years or so, we had just three fairly generic goals. Our revisions can be summarized as follows:
    - We fleshed out our previous "problem-solving" goal to describe more specific methods and techniques we expect our students to employ.
    - We added a goal that explicitly addresses real-world application of physics knowledge and methodology.
    - We substantially revised our goal about physics experiment.
    - We fleshed out our previous "communication" goal. Now it explicitly addresses physics-style argumentation and "real-world" problems.
- A draft list of strategic priorities with rationale and a list of actions we intend to take to address the priorities. These strategic priorities will serve as a roadmap for the next 5 years, and we will revise them in the fall after
    - reviewing alumni feedback and data gathered as part of our External Review self-study,

    - student feedback collected this spring,
    - and informal discussions with faculty colleagues in astronomy and mathematics & statistics.

Process / very drafty **curricular maps**:

- Draft goals and mathematics maps, course by course
- Departmental learning goals and assessment plans map structure