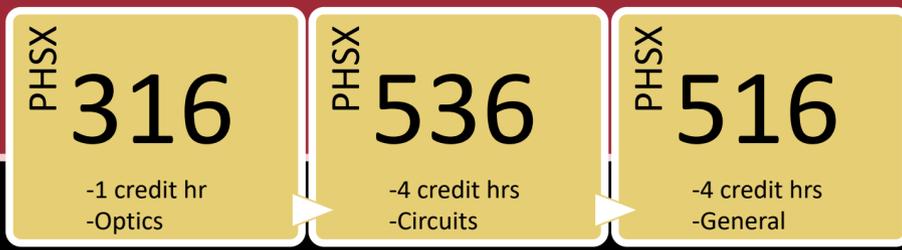


Deep Thought: Aligning Advanced Laboratory Curricular Goals for Deeper Engagement and Understanding of Experimental Physics

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Physics and Astronomy

Background

The intermediate physics lab, PHSX 316, and upper division physics labs, PHSX 536 and PHSX 516, are the bulk of the experimental coursework that Physics and Astronomy majors take. Whereas most of the undergraduate curriculum for majors in our department is focused on learning theory, only the 9 credit hours total from 316-516 and the 2 total credit hours in the lower division labs prepare students for experimental physics as they head into graduate school or into the workforce. We hope to improve student engagement in the content of these labs.



Issues to address

Many different computational and mathematical skills were used across the three labs. This required students to learn multiple new types of software.

PHSX 316 had no design labs, and little opportunity to self manage time. Both PHSX 536 and 516 heavily rely on students **designing something and independently managing a project** to be successful. This was a large jump in expectations between 316 and 536/516.

Old	Physics Content	Computational Skills	Lab Skills
316	Optics	Excel, word	Uncertainty
536	Circuits	Pspice, LaTeX, various data fitting software in various languages	Simulations vs Experiment, Design
516	General Physics	LaTeX, various data fitting software in various languages	Uncertainty, Ethics, Planning
Need	Catch-up Prep	Streamlining	Catch-up Prep and Streamlining

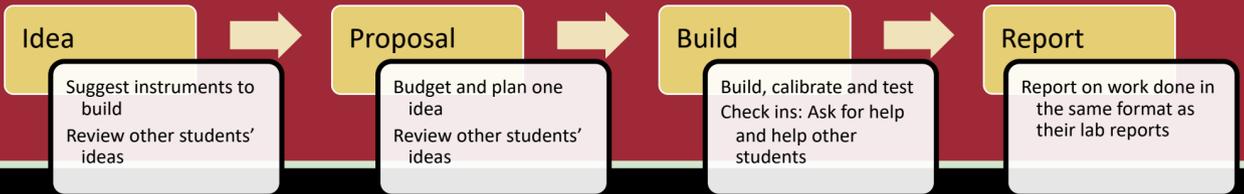
Implementation

Standardize and review computational skills

- LaTeX**
 - Module made with tutorials and exercises
 - Now used for reports in all labs
- Python**
 - Module made with tutorials and exercises
 - Now use for fitting in 516 and 536
- LTSpice**
 - Module made with tutorials and exercises
 - Has a Python interface and provides realistic simulations of complex circuits

Plan	Physics Content	Computational Skills	Lab Skills
316	Optics	LaTeX, Python	Uncertainty, Planning and Design
536	Circuits	Pspice, LaTeX	Simulations vs Experiment, Design
516	General Physics	LaTeX, Python	Uncertainty, Ethics, Planning
Method	Make modules for background content	Use LaTeX, Python and PSpice	Create Instrument Project = design and planning skills

Time management and design: Instrument Project for 316 to better match work in 536/516



Student Feedback and Learning

316 First lab & LaTeX

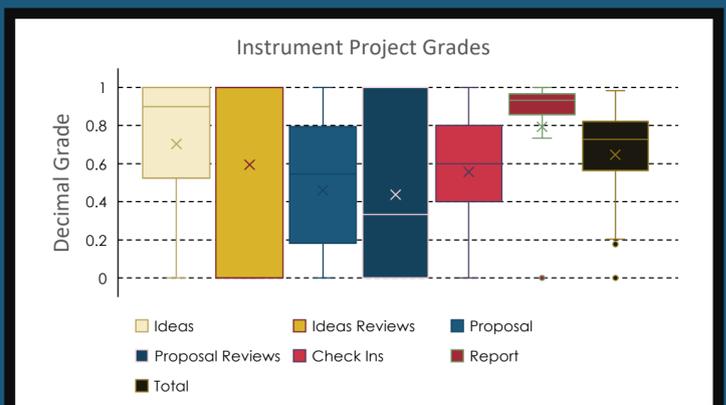
"Today, I finished my lab report and learned a lot for doing [a] LaTeX document. It was a huge jump for me and [it] also caused(sic) me a lot of time. Hope I can finish it sooner in [the] next lab."
"I did all calculations necessary for the lab report today, and also learned a lot of new things about Latex. I'd never actually written something to submit [in] Latex, so this was a new experience for me and took some time."

316 Last lab & LaTeX

"...I definitely think I'm getting the hang of Latex."
"...I had to look up some instruction on performing some Latex functions such as placing a table in a double column report."
"Since this was the third lab report that [was] being wrote(sic) [in] LaTeX[,] I am feeling the efficiency is much better than [in the] first experiment ... LaTeX is a powerful tool to use."

316 Instrument Project

"The instrument project was the most fun lab. Being able to create something you want and figure out how it works makes the whole semester worth it."
"Instrument project was really fun to do, liked how open-ended it was ... although, there were some downsides to it[.]"



Reflections

The Good: Standardizing LaTeX and Python for the labs and building greater review support for these and LTSpice has had a positive effect on student attitudes and use of these tools.

Needs improvement: The instrument project was well received by many students, but also poorly preformed by some. Greater scaffolding for the idea and proposal stage is necessary. Some additional scaffolding for Latex may also help. In addition, we need surveys for feedback from 536 and 516 that are better suited to the smaller number of students in those labs.

Timeline:

Data collection		Initial data collection		Data collection	Data collection	Development of better surveys for 516 and 536	Data collected	Data collected	
Modules	Content	Planning	Optics content modules made	Data collection	Planning Summer Work	Content modules and uncertainty modules improved	Data collected	Data collected	
	Computational skills		Pspice lectures made			Create circuit content modules			
	Laboratory Skills		Latex and Python Tutorials made, 316 Instrument Project Designed			Improvements to Latex module and Instrument Project			
Timeline		Fall 2019	Spring 2020	Summer 2020	Fall 2020	Spring 2021	Summer 2021	Fall 2021	Spring 2021