

developing community-based courses

projects and practices in physics

data lab

Demonstrate understanding of uncertainty in measurements

- Students should **determine/estimate the inherent uncertainty** in their measurement devices and **how those uncertainties affect their results**. This may progress through:
 - Developing **estimates of uncertainty in the devices**
 - Developing **rough predictions** for how the uncertainty in their device **propagates through the system**, assuming a linear proportionality
 - Developing **precise predictions** for how uncertainty contributed by measurement devices **propagates through the system**
- Students should be able to distinguish between sources of **systematic uncertainty and random error** and quantifiably determine the values of each

longer
investigatory
labs & science
communication

Projects & Practices in Physics
a community-based learning environment

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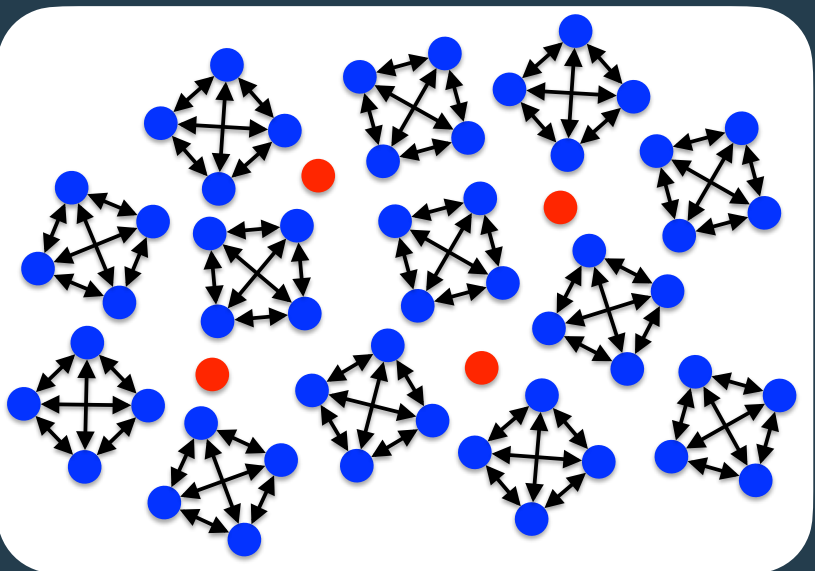
Project 3: Geosynchronous Orbit: Part A

The Carver Media Group is planning the launch of a new communications satellite. Elliot Carver (head of Carver Media Group) is concerned about the launch. This is a \$200,000,000 endeavor. In particular, he is worried about the orbital speed necessary to maintain the satellite's geosynchronous orbit (and if that depends on the launch mass). You were hired as an engineer on the launch team. Carver has asked that you allay his concerns.

Project 3: Geosynchronous Orbit: Part B

Carver is impressed with your work, but remains unconvinced by your predictions. He has asked you to write a simulation that models the orbit of the satellite. To truly convince Carver, the simulation should include representations of the net force acting on the spacecraft, which has a mass of 15×10^3 kg. Your simulation should be generalized enough to model other types of orbits including elliptical ones.

Codes for Project 3:
p3phys.py
PhysUI Module



```
# Objects
Earth = sphere(pos=vector(0,0,0), radius=6.4e6, material=materials.BlueMarble)
Satellite = sphere(pos=vector(7*Earth.radius, 0,0), radius=1e6, color=color.red, make_trail=True)

# More window setup
scene.range=12*Earth.radius

# Parameters and Initial conditions
mSatellite = 1
pSatellite = vector(0,5000,0)

# Time and time step
deltat = 1
t = 0
tf = 60*60*24

SatelliteMotionMap = MotionMap(Satellite, tf, 20, markerScale=2000, labelMarkerOrder=False)

#Calculation Loop
while t < tf:
    theta = (7.29e-5) * deltat # IGNORE THIS LINE
    Earth.rotate(angle=theta, axis=vector(0,0,1), origin=vector(0,0,0)) # IGNORE THIS
    rate(10000)

    Satellite.pos = Satellite.pos + pSatellite/mSatellite*deltat

    SatelliteMotionMap.update(t, pSatellite/mSatellite)

    t = t + deltat
```

computing



group-based

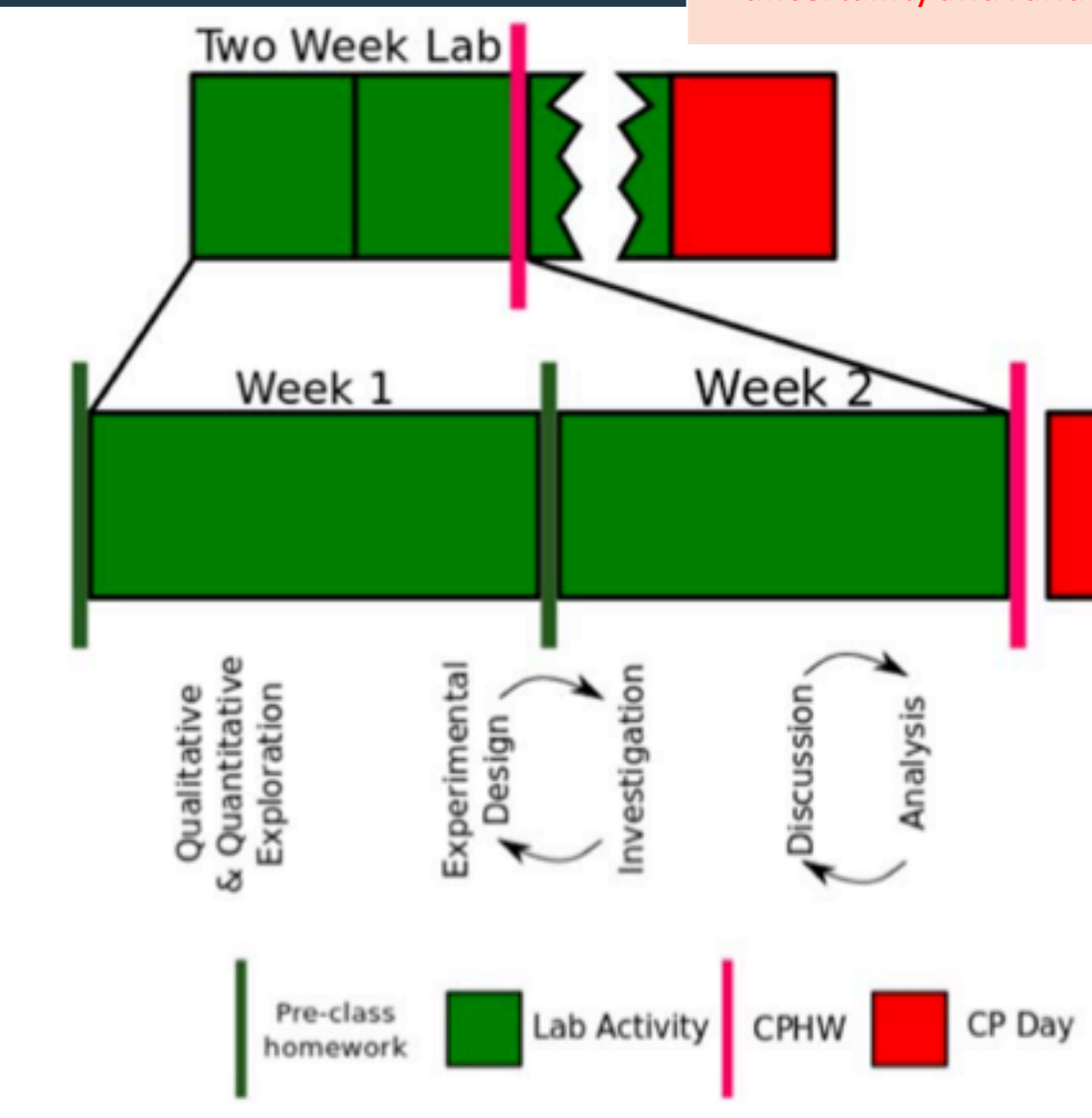
MICHIGAN STATE
UNIVERSITY



Irving, Obsniuk, & Caballero, EJP (2017)
Pawlak, Irving, & Caballero, Phys. Rev. PER (2020)
Irving, McPadden, & Caballero Phys. Rev. PER (2020)



LAs



HHMI
HOWARD HUGHES MEDICAL INSTITUTE

Polarization
Sydney Kerre
Catherine, Kate, Ryan,
Michigan State University, PHY 252, Spring 2016

Introduction

Polarization is an aspect of physics that is very common outside of a lab. It can be seen in sunglasses to reduce glare, or in photography to minimize reflections and lessen haze. Polarizers work by blocking out every direction that light waves point in from a source and only transmitting the waves that align with the polarizer. This phenomenon can be represented by Malus' Law, which states:

$$I = I_0 \cos^2 \theta$$

Methods

- Observed a light source through a single polarizer and then a second one.
- Measured Malus' Law by placing a detector at the end of both polarizers (Fig. 1.1) and quantitatively measuring the intensity of the light coming through (Fig. 1.2).
- Measured the intensity of only the first polarizer and determined how varying angles would change this.
- Created a model to account for the intensity of the light as it comes from the source, passes through the first polarizer, and passed through the second.

Conclusion

When initially making observations about the polarizers, we found that polarizers seemed to dim the light and reduce the intensity by about 50%. We found that this varied based on the angle of the polarizer. When the light seemed the least intense, it was blue.

Using the detector to quantitatively measure the angle and the resulting intensity, we found that the greater the angle, the less intense the resulting light appeared.

The model we synthesized is:
 $I = (I_0/2) \cos^2(\theta_2 - \theta_1)$ (uncertainty of ± 10)

We found that, when only measuring the intensity of one polarizer, changing the angle does not significantly impact the intensity.

For two polarizers, changing the angle greatly varies the intensity.

Uncertainty

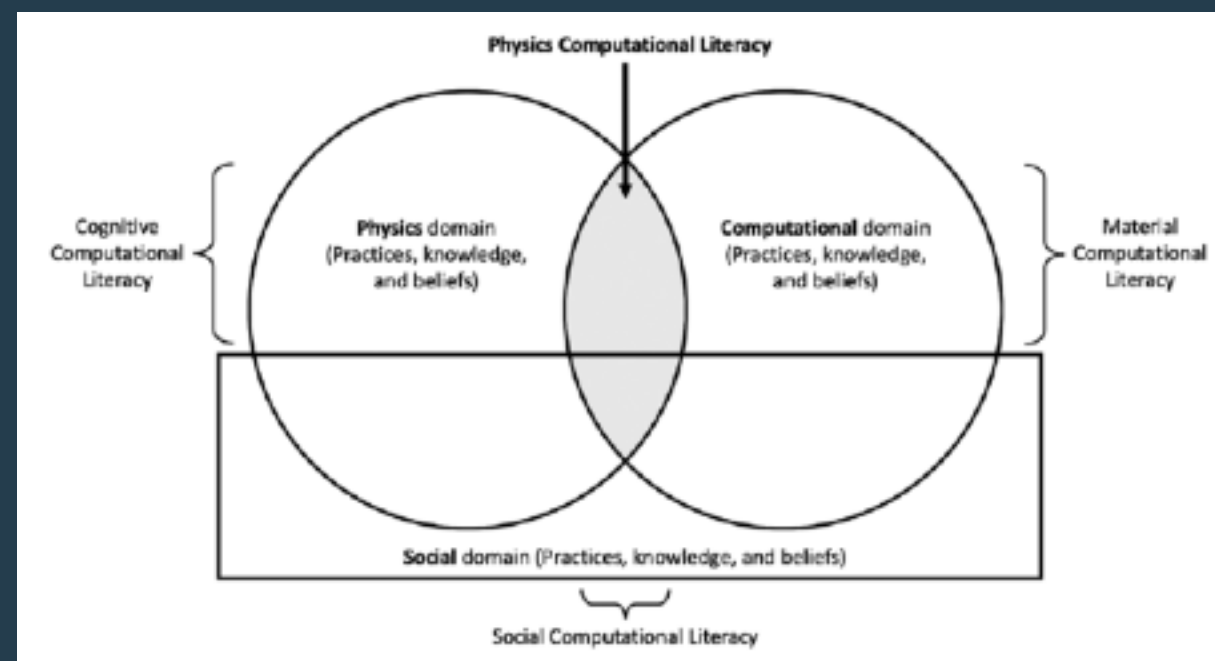
- When light passes through two polarizers, we should have seen no light, but we still saw some because the polarizers aren't manufactured perfectly.
- We assigned values of ± 1 or ± 0.1 to our values, depending on how much the numbers varied in the detector.
- Sources of uncertainty were: systematic error such as imperfect instruments, other light sources in the room.
- Movement of the light source from its initial position

References

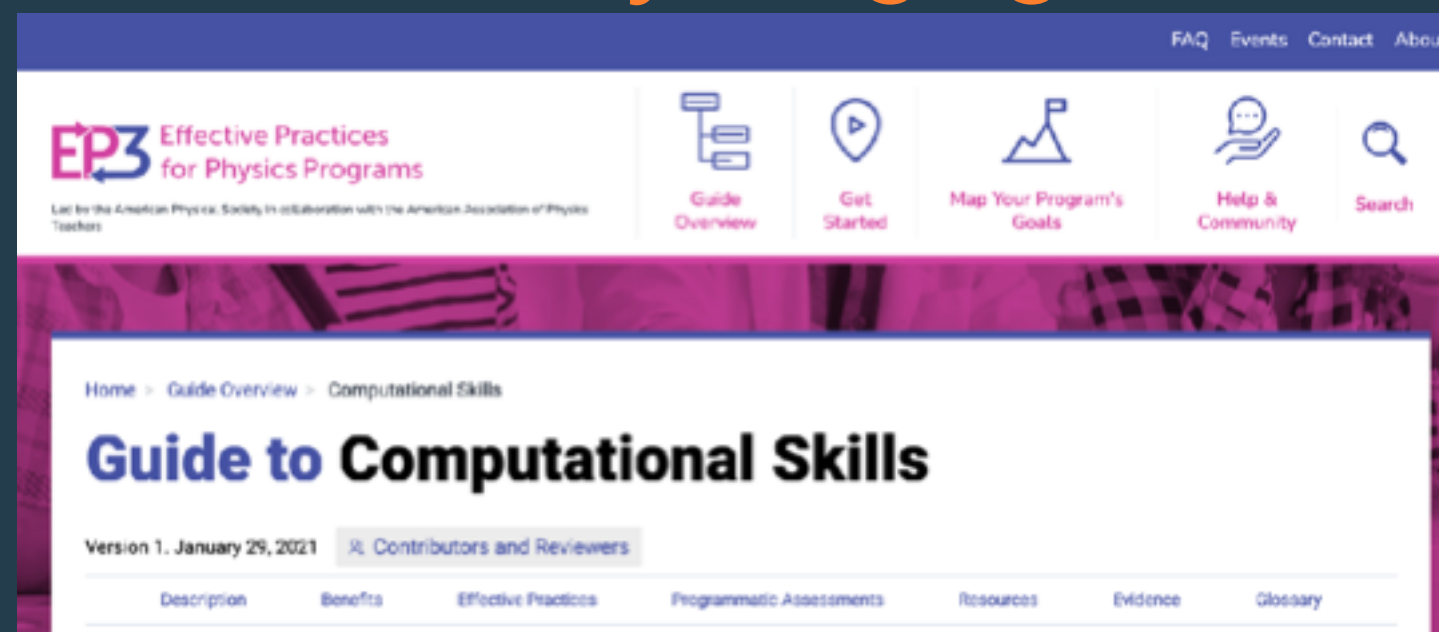
Funding Source: Michigan State University; Dr. William Martinez and Kelsey Funkhouser

Funkhouser, Kelsey, et al. EJP 40.6 (2019): 065701.
Henderson, Funkhouser, & Caballero 2019 PERC Proc.

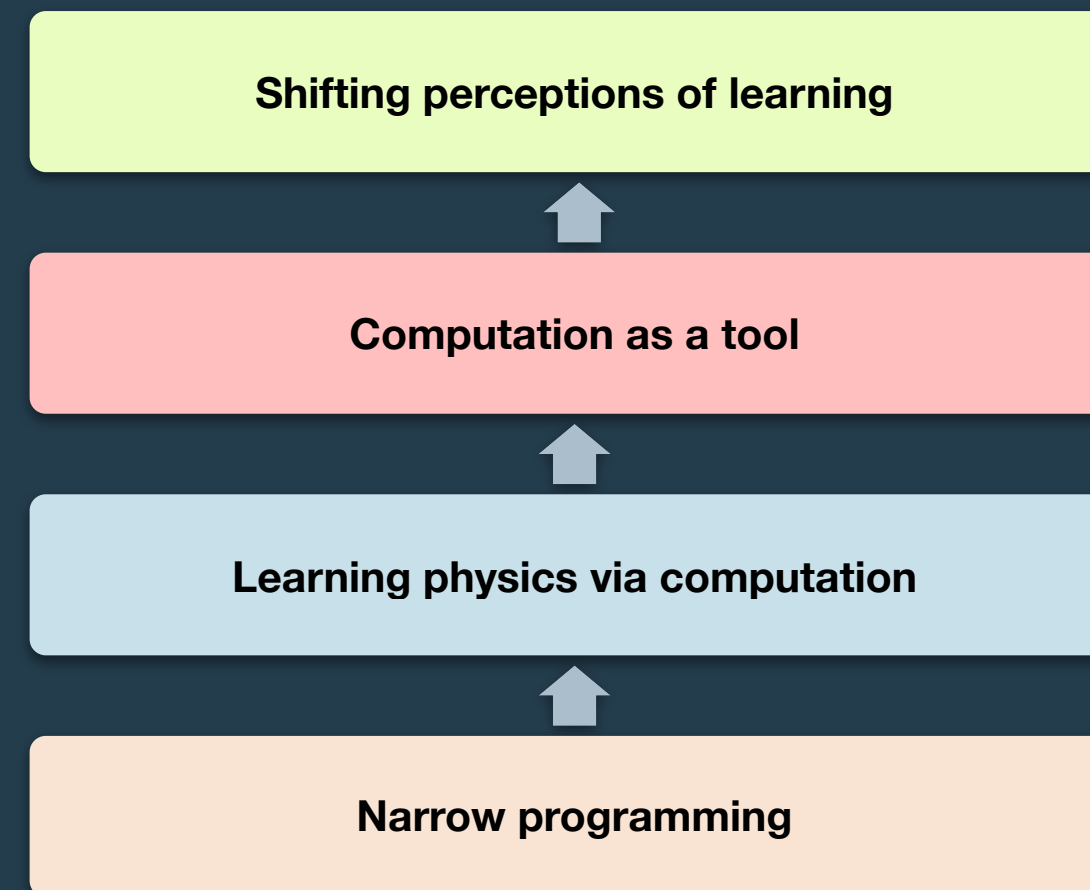
research



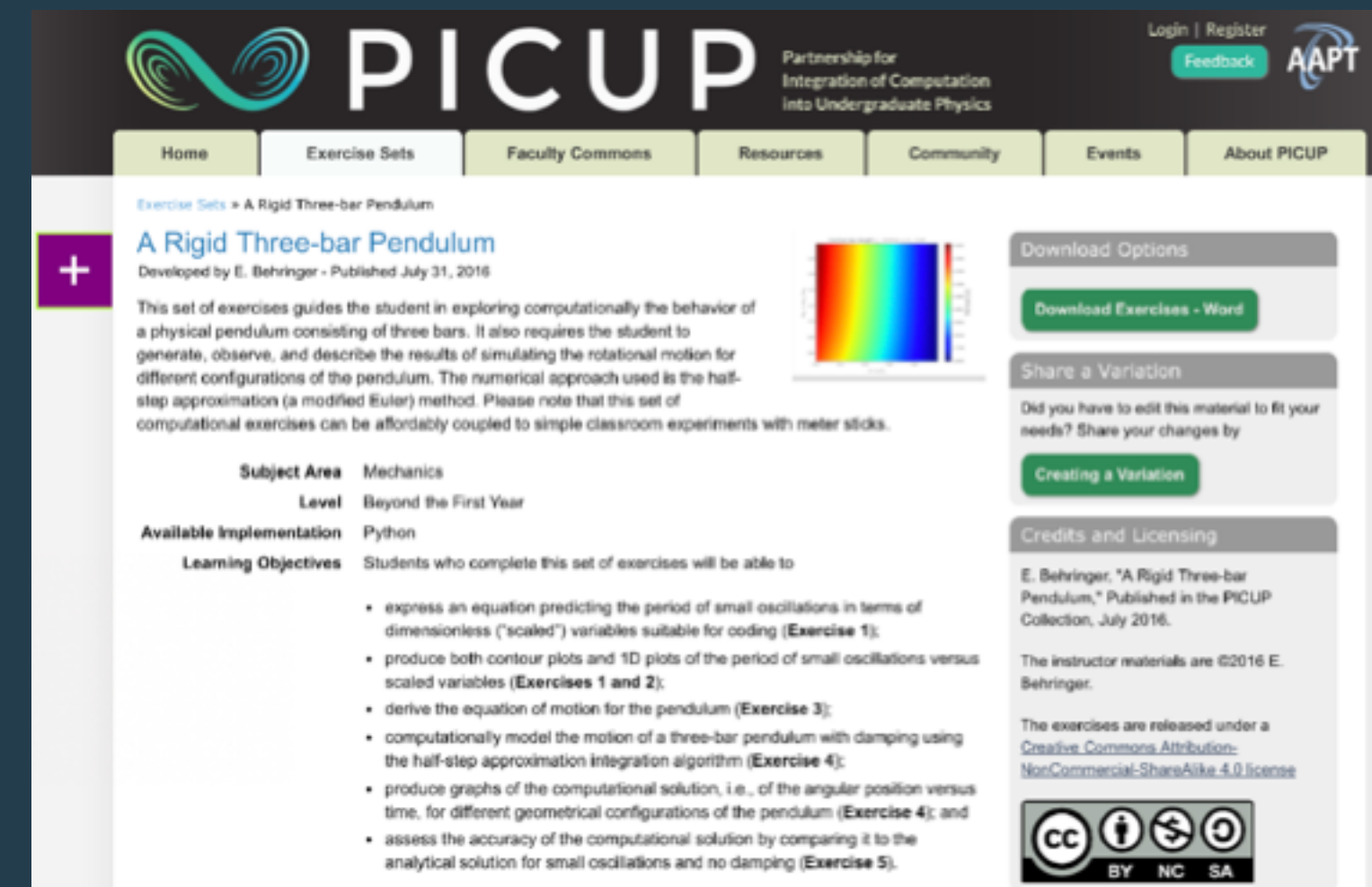
community engagement



faculty learning community



Obsniuk, Irving, Caballero, PERC 2015
Pawlak, Irving, & Caballero, Phys. Rev. PER, 2020
Odden, Lockwood, Caballero, Phys. Rev. PER, 2019



Caballero, et al. TPT 57.6 (2019): 397-399.
gopicup.org

department-wide efforts

Caballero & Hjorth-Jensen, 2018

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