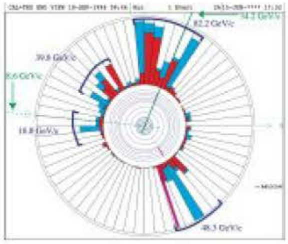
Implementation Plan Example: Catholic University Center July 2023		
AP Physics, Honors 11th grade Physics and On-level Physics		
Standard Learning Goals	Assessments	Lesson/unit ideas
• Understand energy on Macroscopic as well as Atomic scale • Analyze momentum conservation • Data analysis by collecting data and graphing it • Make real world connections with particle physics	• Students will do some sort of data analysis from CERN data (I have heard it's available) • Perform muon detector lab (Cosmic watch lab, demonstrated by Ken) • Have students explore the activities from the QuarkNet website. (showed by Ken)	These activities will be incorporated in units of energy, energy and momentum conservation, graphing and data analysis!! Show videos on Standard Model in particle physics Share the QuarkNet net experience, Jefferson lab presentation
If there's time … I would like to talk about the Mayan pyramids and how the secret chambers are detected via cosmic ray detectors to address CROSS-DISCIPLINARY SKILLS		Show videos, share presentations

Implementation Plan Example: Catholic University Center July 2023
12th grade - Research Practicum - Physical Sciences
Student learning Goals: - Develop an understanding of the Standard Model in general, Muons in the context of cosmic rays in particular (using video(s)) and of muon tomography (using pyramid example → annotated bibliography) - Be able to present data graphically (scatter plots, histograms) and interpret graph - Be able to describe and calculate the mean of a set of data - Be able to describe and calculate the measures of the spread of data (variance, standard deviation) - Be able to conduct and interpret hypothesis tests for two population means. Assessment: - Application to data collected during a Physics lab in the previous year - Ongoing

Group 2

- Physics
  - Muon Particle Detector will come back into use.
  - Probability of radioactivity decay.
- Chemistry
  - Examination of the Standard Model looking at the exotic particles.
  - Modeling quantum numbers
- All labs
  - Include error on predictions and measurements using bar graphs and bell curves
  - Virtual labs: Cosmic Ray Studies, Phydemo, Falstad, PhET
  - Use eV/c^2 as a dimensional analysis exercise



Group 3

What are you looking to do?

Data collection and analysis through Histograms (FWHM for uncertainty)

Dice Probability tied into Coin Probability. Exploring misconceptions of Probability between single and compound events

Using Fermilab data to measure momenta via vector addition in 2D to discover evidence of particles(momentum)

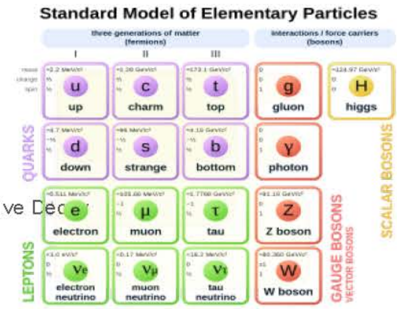
Introduction to Standard Model/Particle Physics (Shuffle the Deck Activity)

What class?

Physical Science, Chemistry, Physics

What unit?

Lab/Data Skills, Conservation of Momentum/Energy Units, Waves and Radioactive Dec



Group 4

Physics/ Chemistry/ Physical Science

- The "Dice, Histograms, and Probability" activity supports student data collection, graphing, and analysis skills. This can also be applied for radioactive decay.
- After introducing subatomic particles and quarks, the "Shuffling the Particle Deck" data activity is a great way to introduce the standard model.
- As a possible extension activity, students could be placed into groups and have them research different neutrino experiments such as ATLAS, NOvA, DUNE, MINERva, LHC, etc. being conducted around the world.
- For high school physics students, the "Case of the Missing Neutrino" activity is a great application of conservation laws to a more interesting situation than two carts on a track.

Table _

Exemplar of Coding Activity/Implementation Plan Development

<table>
<tr>
<th>Summary of Coding Activities: PNW Center[a]
(What happened during QN Workshop)</th>
<th>Four-Part Motion Lab: Coding Project</th>
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<td>
Day 1:
Motivating the use of computer programming and computational thinking in high school physics classes. Using interactive Jupyter coding notebooks, participants were able to model a projectile's motion in the earth's atmosphere; teachers progressively increased the model complexity to more accurately model effects such as air resistance, changing density with altitude, and changes in the force of gravity with altitude. The participants also completed a computational lab example. Participants used their smartphone accelerometer and the PhyPhox app to measure their acceleration as they walked; then utilized numerical integration techniques to calculate their velocity and position as they walked, using only acceleration data.

Day 2:
Participants completed a mini-bootcamp in coding with Python. Using interactive coding notebooks, the teachers were able to both edit and run the code while also completing small learning assignments throughout the notebooks. Many teachers went from having no experience with Python to being able to import data and make a plot with Python.

Day 3:
QuarkNet coding fellow Tracie Schroeder joined virtually and led the group to complete multiple QuarkNet coding activities using real data (muon mass, periodic table of elements, sunspot, and solar position).

Day 4:
Participants were tasked by Tracie to develop a teaching lab and an associated coding notebook for analyzing any collected data. Using pair programming techniques, the participants developed a four-part motion lab for high school students utilizing Jupyter Notebooks. (In conversation with Tracie during a debriefing meeting held with coding fellows on August 27, 2023, the small group of five participating teacher made this approach possible.)

Day 5:
Machine Learning. Our goal was to provide a foundational understanding of machine learning concepts so that teachers could answer questions about machine learning in the classroom. To this end, Dr. Dolen walked the workshop participants through two interactive learning notebooks. Using open cosmic ray data from the Major Atmospheric Gamma Imaging Cherenkov Telescopes (MAGIC), the notebooks introduced multiple concepts involved in machine learning classification tasks. Initially, the participants were tasked with identifying gamma-ray cosmic ray events while rejecting hadron initiated cosmic rays. Participants identified data-based observables that could be used to separate gamma-ray and hadron events. They applied thresholds to these observables, measured signal efficiency and background reject rates, and developed Receiver Operating Characteristic (ROC) curves based on their choices. Participants were then exposed to decision tree and ensemble method machine learning tools. These machine learning methods were chosen because they are both powerful and easy to understand.
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Velocity and Acceleration Lab

Part A - Setup
Part B - Measuring Constant Velocity
Part C: Measuring Constant Acceleration
Part D - Using Python to Calculate Acceleration of a Cart Rolling Down a Ramp

Excerpt of Coding:

Velocity and Acceleration Lab

Part A - Setup

Today, we're going to
• Determine the velocity of the constant velocity car
• Confirm that the velocity is constant
• Measure the constant acceleration of an object falling under the influence of gravity
• Measure the constant acceleration of an object rolling down a ramp

First, we need to import the required libaries so our code can work. Click play below to import them.
+ Code + Text
<pre>
# this cell only needs to be run once, but re-exectuing it doesn't hurt anything either
# imports software packages (not too exciting)
import pandas as pd
import numpy as np
%matplotlib inline
import matplotlib as mpl
import matplotlib.pyplot as plt
</pre>
Part B - Measuring Constant Velocity

Now, we are going to determine the velocity of the car by measuring the time it takes the car to travel 2 meters. We will take two times, the first from the starting line to 1 meter and then from 1 meter to the finish line.

Using python to verify acceleration = 0

This is where you come in, input your data for the times from 0 (starting line) to 1 meter and from 1 meter to 2 meters and run the code.
<pre>
#Take out the first hashtag (#) of the line and put in your data.
t_a = [.6,.61,.54,.59]
t_a = sum(t_a)/len(t_a) #calculates the average time by summing your time measurements and dividing by the number of trials

#Now, repeat to input the times from 1 meter to 2 meters
t_b = [.6,.61,.54,.59]
t_b = sum(t_b)/len(t_b) #calculates the average time by summing your time measurements and dividing by the number of trials

t0 = (t_a + t_b)/2 #averages t_a and t_b from both t_a and t_b
v0 = 1/t0 #calculates velocity by taking average distance of 1m and dividing by the average of t_a and t_b
print("The average time of your car is: ",t0, "s")
print("The average velocity of your car is: ",'{:0.3g}'.format(v0), "m/s")
</pre>
The full coding project/activity is available here:
https://colab.research.google.com/drive/1jk6cgg4TfXs5V3v74i_jr65fAO-efXWc?usp=sharing
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[a]Excerpts from Annual Report submitted by James Dolen; https:/quarknet.org/content/pnw-quarknet-center-2023-workshop-annual-report.