Overview

- Suppose we attach sensors to a swinging pendulum, and record acceleration in 3 directions while the pendulum is in motion
- How can we derive an accurate value for gravity based on this time-series data?
- **Solution**: Fitting with a model
- **Model**: A model lets us predict patterns in data. If we can implement a pendulum model that is accurate and obeys most, if not all, laws of physics, then the solution it spits out should be quite accurate as well

Overview

Research Question	How can gravity be measured with high precision in a classroom setting?
Experimental Approach	Collect 3D acceleration data from many oscillations of swinging pendulum
Analysis	Fit large periodic data sets with a model

Final_anaysis.py: Objective

- Building an accurate model
  - Lengthy data (~10000+) and noisy
- Utilize Python's built in lib: curve_fit to tweak our model based on the goal of minimizing error
  - Suppose we have a pendulum solution of the form:
    - Acceleration_z = ***Amplitude*** * (cos(***frequency****t)) + ***vertical shift***
    - Python's curve_fitter conveniently picks the best values for these variables **(Amp, freq, shift)**, such that the output of our model will fit nicely against the actual data
    - This is the essence of fitting! Picking/creating a model -> Optimizing it by reducing error.

Input/Output

Input/Output

Input:

- An integer for experiment # to fit and analyze

```
MacBook-Air-4:scripts kenneth$ python3 final_analysis.py
Input the number corresponding to the experiment you wish to analyze: (6 or 7):
```

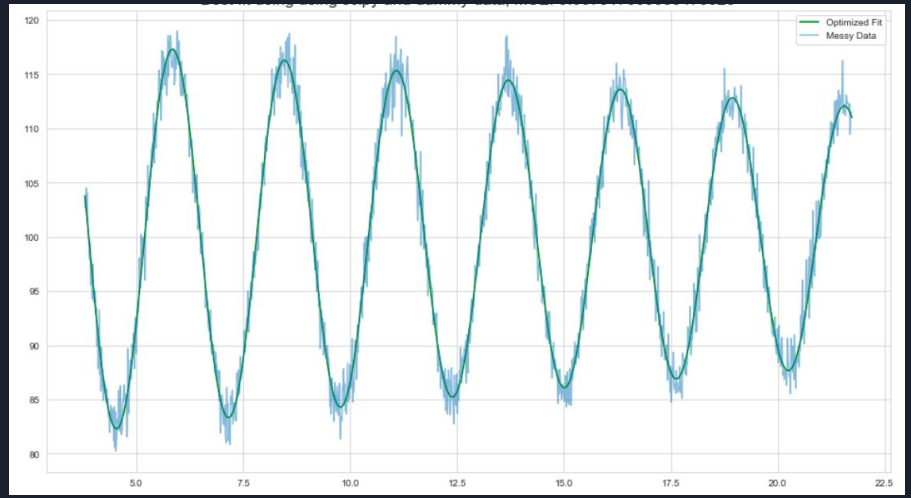
- The integer corresponds to a dataset that looks something like this:

	TOF time	d	DOF time	acc_x	acc_y	acc_z	magn_x	m
20539	266.323982	40.0	200.008528	1.859223	-2.019542	9.913464	-52.9	
20540	266.337726	40.0	200.018205	1.856830	-2.031506	9.927821	-52.4	
20541	266.351372	42.0	200.027889	1.856830	-2.033899	9.932607	-51.9	
20542	266.365081	40.0	200.037560	1.856830	-2.033899	9.932607	-52.3	
20543	266.378767	42.0	200.047236	1.844866	-2.050649	9.903893	-51.5	

Output:

- Optimal values for model parameters “g” and “b”.
- A plot of the model that uses these optimal parameters, fitted over the experimental data
- MSE/ChiSq: Error metric and goodness of fit metric
  - Tells us how accurate the model fit is

Example of what plot output might look like:



Visual Outputs: Raw Data -> Fit

The result, in orange, fits very nicely:

- Each peak is aligned well (this is important since pendulum undergoes periodic motion, this needs to be accurate)
- G and b are returned as single value parameters which have been optimized by the fit for the data set