Pendulum lab

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Research question - How does the length of string holding the mass impact the frequency of a pendulum?

Aim - To investigate if the length of the string holding the mass affects the frequency of the pendulum.

Hypothesis - I believe that as the pendulum length decreases, the frequency of the pendulum will increase as the mass at the end of the pendulum will have to travel less distance so it should be faster

Independent variable - Length of pendulum (0.5m to 1.4m)
Dependent variable - Frequency of pendulum
Controlled variables:

Control variable	Why should it be controlled	How can it be controlled
Mass of the pendulum bob	Different masses could possibly change the length of time between oscillations	Using the same pendulum bob for all experiments and trials
Angle of release of the pendulum bob (15 degrees)	A different angle of release will affect the frequency of the oscillations, changing the results	Using the same release angle (15°) for all trials and measure with a protractor
Time that the number of complete swings is counted (30 seconds)	Using a different amount of time will change the amount of oscillations I count which will impact the frequency I get	Using a stop watch to measure out 30 seconds for when I'll count oscillations
General location and setup of the ring stand and the way the pendulum string is tied to the ring stand	Different locations could have different environmental conditions such as wind or being on a slop that could impact frequency	Conducting all my experiments in the same location
Same release procedure for the pendulum bob each time	Could impact the starting velocity which could impact frequency	Drop it the same way each time without giving any extra force

Materials:

- 1 ring stand
- Fishing line of 1.4 m length
- 1 pendulum bob mass of approximately 200 g
- 1 stopwatch
- 1 protractor
- 1 meter stick
- 1 electronic mass scale

Procedure:

1. Measure the mass of the pendulum bob and record the mass in kg
2. Construct the pendulum set-up using the ring stand, pendulum bob, and string
3. Measure the length of the string in meters using the meter stick. Measure from where the string connects to the ring stand to the center of the pendulum bob. Record this length in your data table
4. Use the protractor to set the angle of release at 15 degrees up from the pendulum bob's lowest position. Mark the release point so that the bob will be released from this point for each trial
5. One lab partner will operate the stopwatch and call out the starting and stopping time (each trial will run for 30 seconds). The other lab partner will release the pendulum bob and count out the number of complete swings in 30 seconds. Run your first trial and record your data.
6. Complete a total of three trials for each length and record your data in the data table.
7. Repeat the procedure (steps 3 to 6) for 9 additional shorter lengths of the string, in 0.1 meter increments.
8. Determine the frequency for each trial and record it in your data table. Frequency equals the number of complete swings in one second
9. Complete the processing of the data so that you are able to construct a graph that shows the relationship between the independent variable and the dependent variable.

Figure 1: Experiment setup

	Oscillations per 30 seconds		
Pendulum length (m)	Trial 1	Trial 2	Trial 3
1.4	12.5	12.25	12.5
1.3	13	13	13.25
1.2	13.75	13.5	13.5
1.1	14.5	14.25	14.5
1.0	15	15	15
0.9	15.75	15.5	16
0.8	16.5	16.75	16.5
0.7	18	18	18
0.6	19	19.25	19.25
0.5	21	20.5	21

Table 1: Table of pendulum oscillations in 30 seconds as length decreases

Raw data

Mass of weight - 0.0675kg

Calculations

To calculate the frequency of the pendulum (number of oscillations per second) we can take the number of oscillations in 30 seconds and divide it by the number of seconds (30). For example with my first trial from 1.4m:

$$Frequency = \frac{12.5}{30}$$
$$Frequency = 0.4167Hz$$

To get the average of my results, I simply need to add up the values I got for each of my trials and then divide by the number of trials. For example, with my results from 1.4m:

$$\begin{aligned} Average &= \frac{T_1 + T_2 + T_3}{3} \\ &= \frac{0.4167 + 0.4083 + 0.4167}{3} \\ &= \frac{1.2417}{3} \\ Average &= 0.4139Hz \end{aligned}$$

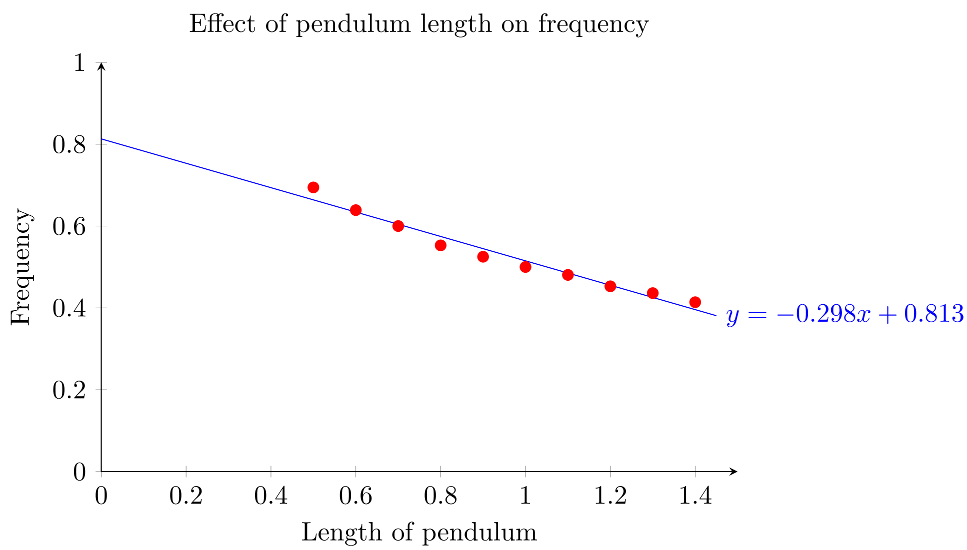
To calculate the uncertainty of my results, I simply need to take the average of the largest value I got and the smallest value I got for a specific pendulum length. For example, when my pendulum was 1.4 meters, I got the frequencies of 12.5, 12.25, and 12.5. To calculate the uncertainty, I would just have to do the following:

$$\begin{aligned} Uncertainty &= \frac{(Max + Min)}{2} \\ &= \frac{(0.4167 - 0.4083)}{2} \\ &= \frac{0.0084}{2} \\ Uncertainty &= 0.00417Hz \end{aligned}$$

Processed data

Pendulum length (m)	Average frequency (Hz)	Uncertainty (Hz)
1.4	0.4139	0.004167
1.3	0.4361	0.004167
1.2	0.4528	0.004167
1.1	0.4806	0.004167
1.0	0.50	0
0.9	0.5250	0.008333
0.8	0.5528	0.004167
0.7	0.60	0
0.6	0.6389	0.004167
0.5	0.6944	0.008333

Table 2: Frequency of pendulum with different lengths with calculated uncertainty



Evaluation

Weakness/Limitation	Impact on results	Suggested improvement
The use of only small angles during the experiment could possibly not give the complete picture of the results	Causes there to be a smaller dataset that might not give the complete picture of how length impacts frequency which could both increase or decrease the measured frequency	Use larger angles as well as small angles so that the data will be less affected by small angle approximations
The amount of string used to tie the pendulum bob was hard to control	Different amounts of string used to tie the pendulum made the length of the pendulum inaccurate, possibly increasing or decreasing the results	Using a different method of hanging the pendulum that is more adjustable so slight differences can be removed
It was hard to get an exact value for the number of oscillations in 30 seconds	Would lead to inaccurate results that would impact the measurement of the frequency as I'd have to approximate, either increasing or decreasing the measured frequency	Instead of doing number of oscillations in 30 seconds, measuring the amount of time it took for the pendulum to oscillate 30 times would be more accurate