¨Amplitude vs. Period in a Simple Pendulum¨

Grant Stilwell
Tualatin High School

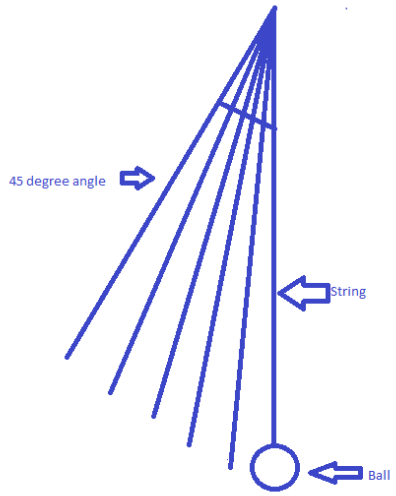
Table of Contents:

Introduction:

It is intriguing that, when dropped at low amplitudes, the period (or time it takes to return to the starting position) of a pendulum stays relatively the same. I have always wondered if this

principle applies to all amplitudes/displacements that a pendulum can be dropped from. It works this way because the equation for the restoring force in a simple pendulum is F=-mgsin(x) and the equation for simple harmonic motion is F=-mgx and, with angles under 15 degrees, the difference between sinx and x is negligible, therefore it is a simple harmonic oscillator(Khan Academy). In my investigation I hope to determine the relationship between the amplitude of a pendulum, and the time it takes for it to return to the starting position (or as close to it as it is going to get). In my experiment, amplitude is defined as the level of offset from rest that the pendulum has in degrees. Period is defined as the amount of time it takes for the pendulum to complete one full cycle, all the way there, all the way back. Some of the variables that were controlled in my experiment include, the length of the string, the mass of the pendulum, and the person timing each trial. I believe that if I increase the amplitude of the pendulum, then the period will increase as well because sinx will no longer be equivalent to x.

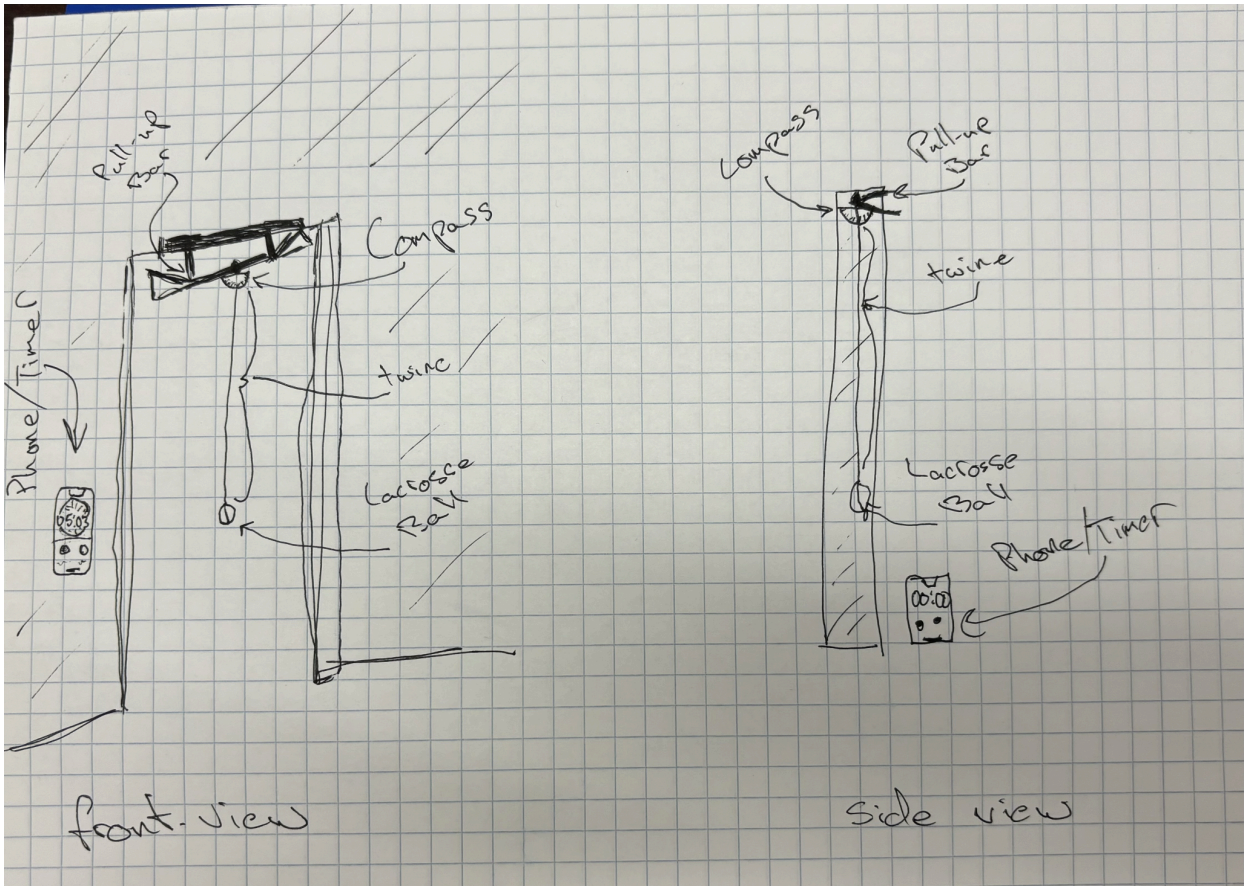
Diagram:



Method:

The materials that I used for this experiment were as follows: one regulation size lacrosse ball, approximately 150 cm of twine, a compass (the one used to find angles), my Iphone 15 (for a timer), and a pull up bar hanging from a door frame.

Diagram of lab setup:



**Protractor not a compass

I began this experiment by tying the twine around the lacrosse ball and to the pullup bar so that there would be exactly 105cm of twine separating the two. Then, with the ball hanging straight down, not swinging at all, I put the protractor up to the pull up bar so that it read 0 degrees. I did this to ensure that I was not holding the protractor at a slight angle which would have skewed the results. I then had my assistant pull the ball at a perpendicular angle to the pull up bar, while I observed the angle using the protractor. Once the desired angle was reached I would inform my assistant and they wouldn't move the ball any further. I then removed the protractor, and my assistant dropped the ball and started the timer at the same time. They then waited for the ball to return to its original position and then stopped the timer. I repeated this process for 18 data points with 5 trials for each data point.

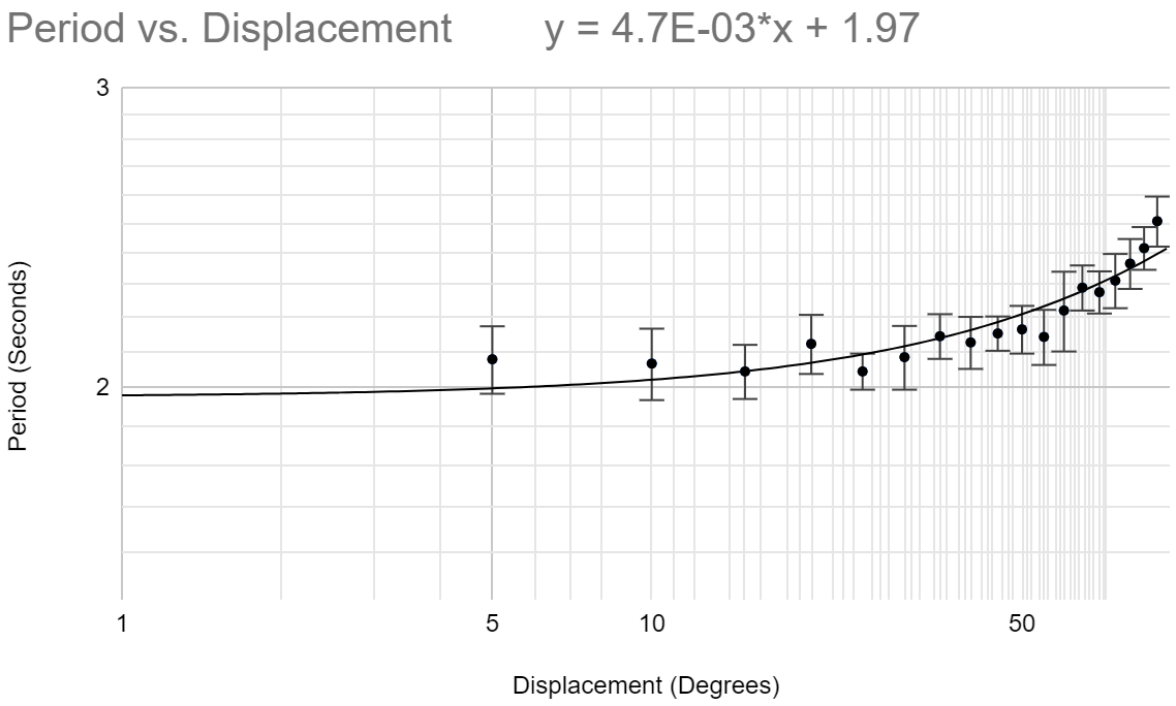
Results:

Amplitude vs. Period

Angle in Degrees	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average	Uncertainty
5	2.09	2.14	1.99	2.18	1.99	2.078	0.095
10	2.16	1.98	1.96	2.09	2.14	2.066	0.1
15	2.06	2.04	1.94	2.09	2.09	2.044	0.075
20	2.18	2.03	2.16	2.04	2.2	2.122	0.085
25	2.03	2.03	2.08	2.09	1.99	2.044	0.05
30	2.08	2.16	2.14	2.06	1.98	2.084	0.09
35	2.18	2.14	2.08	2.21	2.11	2.144	0.065
40	2.08	2.16	2.19	2.04	2.16	2.126	0.075
45	2.19	2.09	2.18	2.16	2.14	2.152	0.05
50	2.18	2.19	2.09	2.23	2.13	2.164	0.07
55	2.14	2.09	2.16	2.24	2.08	2.142	0.08
60	2.26	2.18	2.24	2.33	2.09	2.22	0.12
65	2.24	2.38	2.26	2.31	2.26	2.29	0.07
70	2.28	2.2	2.29	2.28	2.33	2.276	0.065
75	2.36	2.24	2.26	2.41	2.29	2.312	0.085
80	2.28	2.39	2.44	2.41	2.31	2.366	0.08
85	2.48	2.44	2.34	2.44	2.38	2.416	0.07
90	2.48	2.58	2.53	2.53	2.41	2.506	0.085

The method I have chosen to use to process my data is the use of a “log log” graph. I did this because it helps to show the relationship that takes place between amplitude and period.

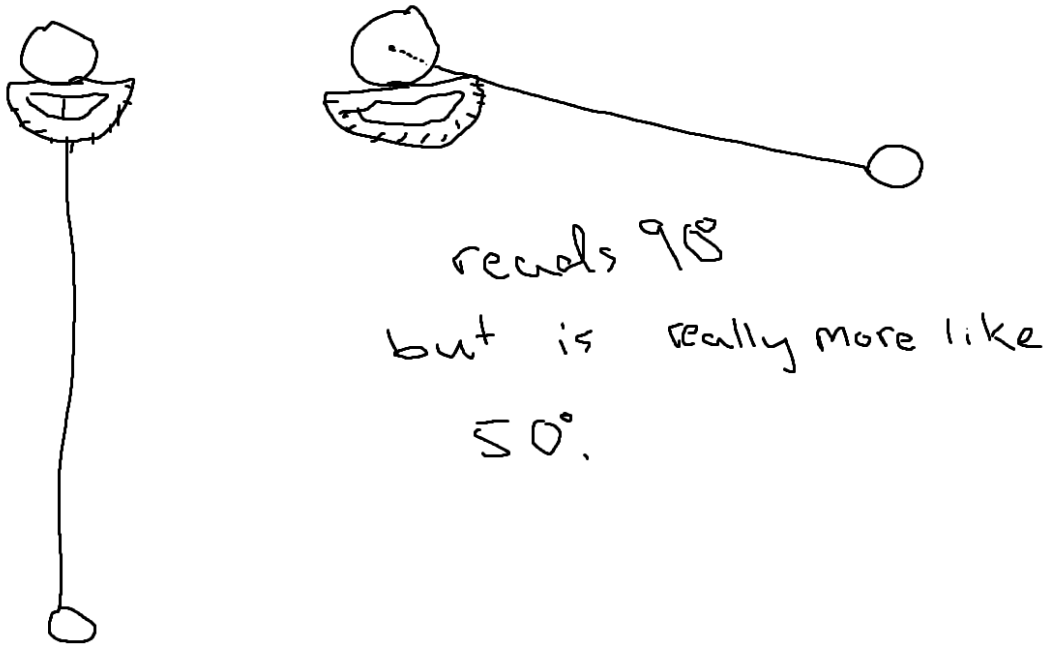
Data File:


Period vs. Displacement
y = 4.7E-03*x + 1.97
Period (Seconds)
3
2
1
5
10
50
Displacement (Degrees)

Conclusion:

In conclusion, there is a positive experimental relationship between amplitude and period. My data supports this conclusion because we can see an increasing upwards slope as the amplitude increases. This conclusion supports my hypothesis that, as the amplitude increases, the period will as well.

One limitation of this experiment was that, when I was observing the protractor for the angle the ball was dropped at each time, I neglected the fact that the ball was really swinging at a distance of the length of the string plus the radius of the pull up bar. This led me to misidentifying the angle that the ball was dropped at. However, the results of my experiment should still be valid considering the angle of displacement/amplitude was still steadily increasing from data point to data point, it just may have been marked incorrectly. See diagram below.



An improvement that could be made to this experiment is modifying the pendulum mechanism so that it is possible to read the angle properly.

Relate links:

- https://homework.study.com/explanation/how-does-amplitude-affect-the-period-of-a-pendulum.html#:~:text=The%20amplitude%20of%20a%20pendulum,especially%20when%20creating%20small%20swings. Provided definitions for different parts of the experiment. Such as the pendulum and period.
- https://www.khanacademy.org/science/in-in-class11th-physics/in-in-11th-physics-oscillations/in-in-simple-pendulums/a/simple-pendulum-ap1 Shows and supports the math behind the pendulum. Also says that the period doesn't depend on the mass.
- Is there any instance in which the amplitude can change the period of a pendulum? : r/askscience Many people that provide good arguments about the period and wether or not it was effected by the mass.
- https://physics.stackexchange.com/questions/346683/intuition-why-does-the-period-not-depend-on-the-amplitude-in-a-pendulum Mentions that if the mass doesnt effect the period something else has to. Determined that the length of the pendulum does change the period.
- https://galileo.phys.virginia.edu/classes/152.mf1i.spring02/Pendulum.htm EDU link that supports my claims of period not being effected by mass.

Bibliography:

- "Simple Pendulum Review." *Kahn Academy*, www.khanacademy.org/science/in-in-class11th-physics/in-in-11th-physics-oscillations/in-in-simple-pendulums/a/simple-pendulum-ap1#:~:text=Increasing%20the%20amplitude%20means%20that,has%20no%20effect%20on%20period. Accessed 10 Jan. 2024.