What effect does the length of a pendulum's string have on the period of oscillation for that pendulum?

VCE Units 3&4 Physics – Lloyd King N4

Introduction

Aim: The purpose of this investigation is to determine the effect that a pendulum's string length has on that pendulum's period of oscillation. This research was of interest to me as I wanted to see the relationship between the length of the string and the period of that pendulum. I was able to look at this topic as it goes under the category of motion studied in VCE Units 3&4 Physics.

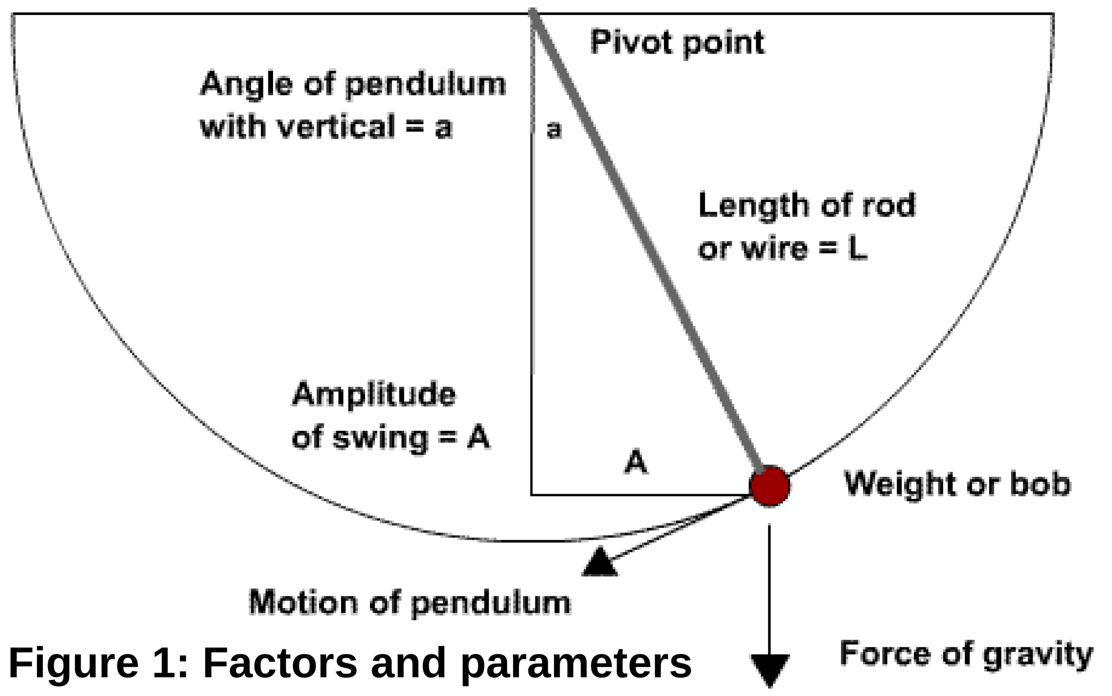

Figure 1: Factors and parameters in a simple pendulum.

Galileo experimented with pendulums and discovered that the remarkably regular period of the pendulum (the uniform time it took to make a full back-and-forth sweep) was proportional to the square root of the length of the pendulum.

$$T = (2\pi\sqrt{\frac{L}{g}}) = (2\pi\sqrt{L}\sqrt{\frac{1}{g}}) = (2\pi\sqrt{\frac{1}{g}}\sqrt{L}) =\therefore T\alpha\sqrt{L}$$

To calculate the period we can use the equation above or by timing the oscillations of the pendulum with a stopwatch. By rearranging the equation and taking out constants we can see that $T\alpha\sqrt{L}$

The equation above contains variable where:

- T is the period in seconds (s)
- π is the Greek letter pi and is approximately 3.14
- √ is the square root of what is included in the parentheses
- L is the length of the rod or wire in meters or feet
- g is the acceleration due to gravity (9.8 m/s² on Earth)

For my hypothesis I predicted that as the square root of the (length of string) is increased, the time for the period of the small mass would increase making them directly proportional.

Classification of variables:

Independent variables: The length of the string and the angle that the mass is being released from.

Dependent variable: The period of the pendulum.

Controlled variables: The mass of the object and the angle of the pendulum when changing the length.

Method

This investigation type: A practical investigation.

Apparatus: 1 Fishing line (approx. 2m in length), 1 tape measure, 1 lead fishing sinker (sphere shape) (mass = 25 grams = 0.025kg), a kitchen scale to measure the mass of the sinker (to be done beforehand), a fixed position to attach the pendulum, a pair of scissors, 1 large protractor and you may need a teammate to help you whilst you are collecting data.

1. Feed the fishing line through the sinker, then tie a knot at the bottom and attach the other end of the fishing line to a fixed position. (Find a safe place where the pendulums range of motion will not injure anyone).
2. Place the protractor next to the line and make sure you pull the mass out to a 45˚ angle (ensuring no slack). Use stopwatch to time 5 oscillations, and repeat this 3 times.
3. Then change the length of the string by cutting it using the scissors. Once cut then repeat step 5 until you have recorded 5 different lengths. I chose to do (180.2, 83, 67, 51 and 22) cm.

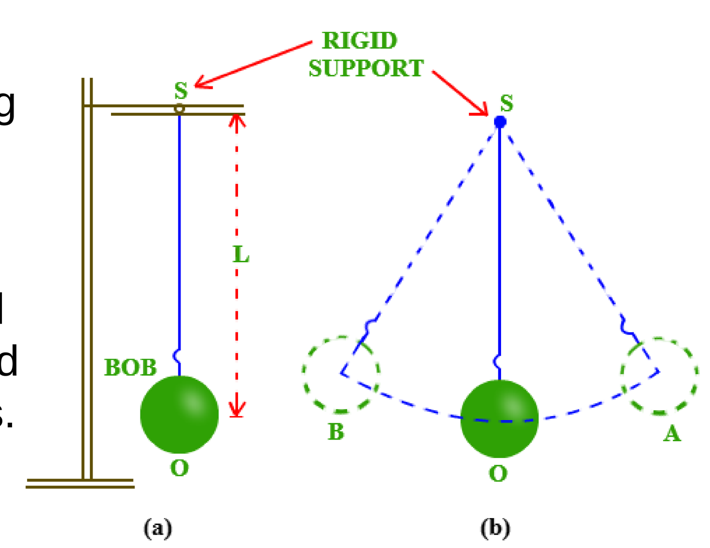

Figure 2: Displays the setup of the prac however the mass (bob) is not to the right scale.
(a) Mass (bob) at rest in mean position O.
(b) Mass (bob) in swinging motion between extreme position A and B.

Results

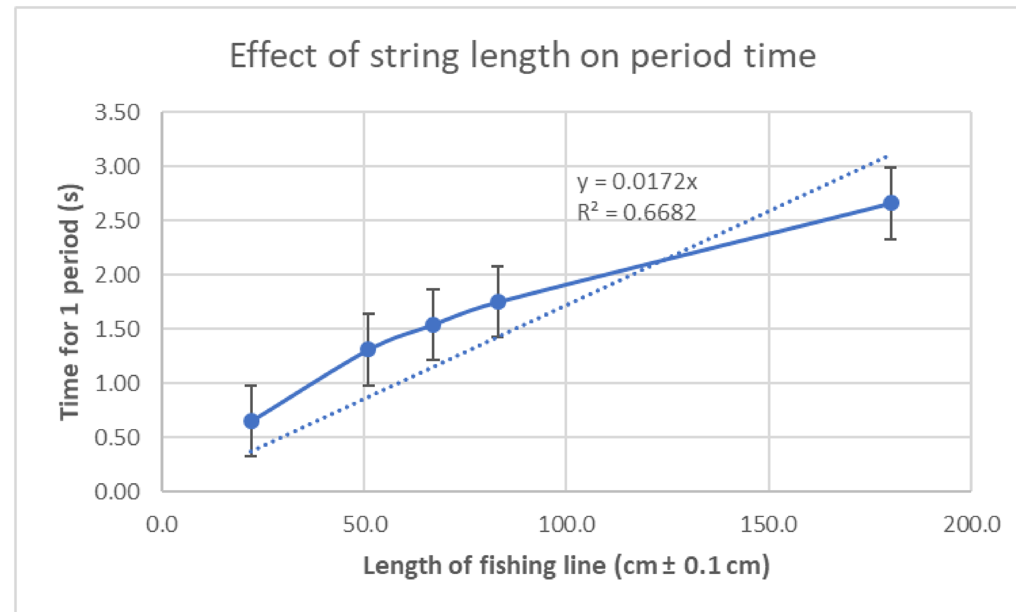

Figure 3: The effect of string length on the period time.

- The linear equation is stated as y = 0.0172x or rather: The effect of string length on the period time is = 0.0172 x length of the fishing line (cm).
- From the data I am able to see the length of the string is proportional to the period. This is shown from the graph as when the fishing line length is decreased so is the time taken for 1 period of oscillation.

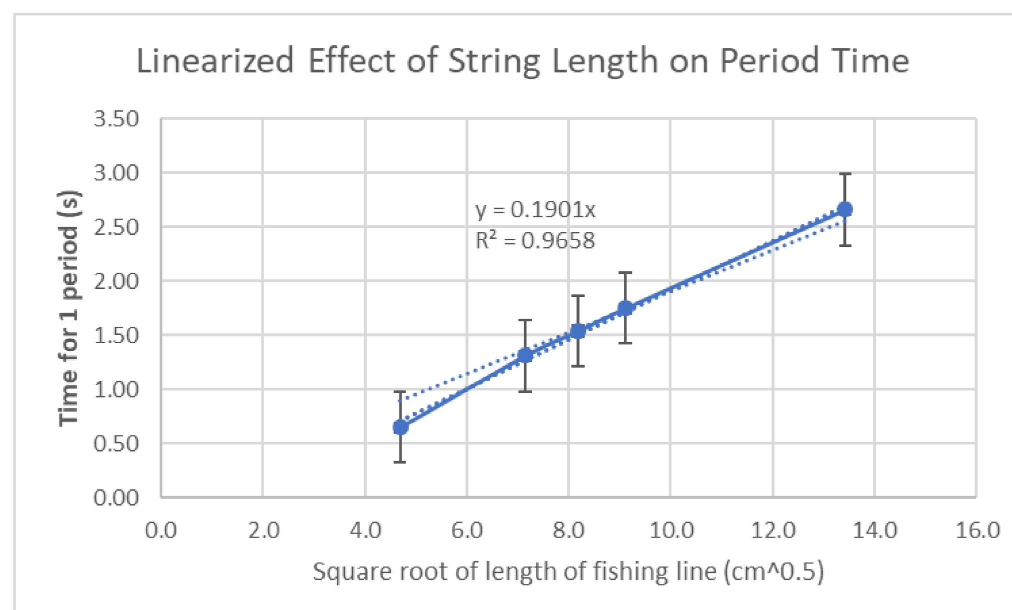

Figure 4: The effect of string length on the period time.

- The coefficient of determination (R^2) is a very high 0.9568 indicating a strong linear association between the two variables.
- This is also shown by how the line of best fit passes through every region of uncertainty. Whereas in figure 1, the best fit line does not even touch some of the uncertainty lines.

Discussion

Figure 4 supports my hypothesis as on the x-axis I have the Square root of length of fishing line (cm^0.5) and on the y-axis I have the time for 1 period (s) of oscillation. Figure 4 supports my hypothesis by showing how when the square root of the (length of string) is increased, the time for the period of the small mass would increase making them directly proportional.

Limitations & Improvements: A limitation that could have caused these outliers on figure 3 could be due to the lack of accuracy through the use of a stopwatch app on my phone. As I was releasing the sinker I might have had a slight pause before I pressed the start button on the timer which might have affected my results. To improve this limitation I would record the experiment with my phone and use a computer program called tracker to analyse the motion of my pendulum.

Conclusion

It was hypothesized that as the square root of the fishing line length was increased, the time for the period of the small mass would also increase, making them directly proportional. By analysing my results the hypothesis was proven true.

The actual results were different to the expected results due to the uncertainties and difficulties that were encountered such as the large impact that the stopwatch had on the results.

Real life example: People who are building swings for children to ride on may find this topic of some interest.

Acknowledgements

Juddy.com.au – Physics notes 4.3.1-4.3.4

Figure 1:Equations for a Simple Pendulum. (n.d.). Retrieved September 25, 2017, from http://www.school-for-champions.com/science/pendulum_equations.htm#.WcioM8gjHIU

Figure 2: Laws of Simple Pendulum. (n.d.). Retrieved September 25, 2017, from http://www.tutorvista.com/physics/laws-of-simple-pendulum