TITLE: SIMPLE PENDULUM

AIM: To investigate;

(i) *The relationship between the length of a simple and its period of oscillation,*

(ii) *If the period of oscillation depends upon the mass of the bob, and*

(iii) *If the period of oscillation depends upon the amplitude of the oscillation.*

APPARATUS

Length of string, masses to act as bobs, stopwatch, meter rule, protractor, stand and clamp.

THEORY

If the mass of the pendulum is concentrated into a size which is much smaller than the distance from the mass to the support, and if the supporting string is light, then the pendulum is referred to as a *simple pendulum.*

SIMPLE PENDULUN

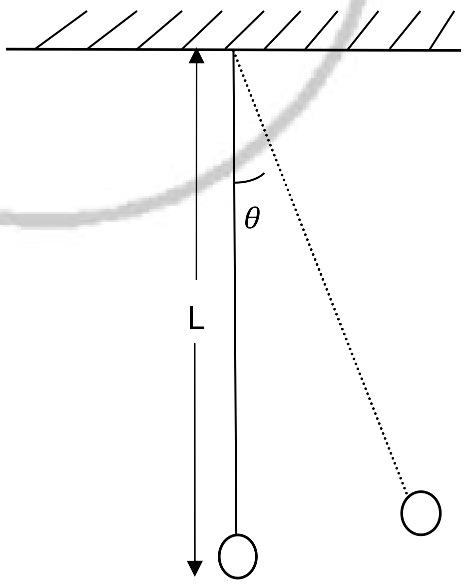

Figure 11.1

The angular distance of the pendulum from the equilibrium position i.e. string vertical is known as the displacement, and the maximum displacement is called the amplitude of the oscillation. For minute amplitudes (say less than or equal to 5°), the period (time for one complete oscillation) is given by:

$$\mathrm{T} = 2\pi\sqrt{(\mathrm{L}/\mathrm{g})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11.1)$$

Where T is the period in seconds, L is the length in meters and g is the acceleration of gravity in ms^{-2}. Therefore, the theory predicts three properties of the simple pendulum which is to be investigated in this experiment.

1. The period, T is directly proportional to $\sqrt{L}$. Squaring both sides;

   $$T^2 = 4\pi^2\left(\frac{L}{g}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11.2)$$

   This shows that, T^2 is proportional to L.

2. The mass of the bob does not appear in the equation, equation (i), hence the prediction that the period is independent of the mass of the bob.
3. It is necessary to assume that the amplitude of oscillation is small in the equation derivation. Equation (11.1) then prediction that the period T does not depend on the amplitude of oscillation.

In part A, when investigating the variation of period with length it is necessary to keep the angular amplitude small and the mass constant throughout the experiment, so that any variations due to mass or amplitude does not interfere with the investigation of period with length. Similarly, to investigate the variation of period with mass, the length is to be kept constant, the amplitude being small (< 5 degrees).

PROCEDURE

(A) Period and Length

1. Maked L as large as possible and tied the bob at its end. Tied the string to the clamp and set the pendulum into oscillations, the amplitude being small ($\theta < 10°$).
2. Measured the time t for 20 complete oscillations.
3. Repeated the measurement. Then noted down the two values in the table for this L.These timings agreed within a reasonable amount.
4. Calculated the mean value of t, determined it for five values of L decreasing the value at regular intervals from largest to the smallest, so that the smallest value of the readings is at least 30cm.

(B) Period and Mass

1. Selected a fixed L and determined the period T for three different masses of the bob.
2. Followed the same procedure as in part A

(C) Period and Amplitude

1. With the mass of the bob fixed and the length of the pendulum fixed at 1.0m, measured the period for several widely different amplitudes of 10, 20, 40, 60 and 70 degrees.

DATA COLLECTION/ANALYSIS

(A) Period and Length

Length, L Cm	Time for 20 Oscillations		Mean time $\left(\frac{t_1+t_2}{2}\right)$ sec	Period, T sec	T^2 sec^2
	t_1 sec	t_2 sec			
30	22.02	22.55	22.29	1.11	1.23
40	24.58	24.97	24.78	1.24	1.55
50	27.66	28.14	27.90	1.40	1.94
60	30.83	30.45	30.64	1.53	2.34
70	32.87	33.32	33.10	1.66	2.76

Value for the acceleration of gravity, g

From equation 11.3 $\mathrm{g} = 4\pi^2 \times \mathrm{gradient}$

$$\mathrm{gradient} = \frac{L_2 - L_1}{T_2^2 - T_1^2}$$

$$= \frac{0.7 - 0.4}{2.76 - 1.55}$$

$$= \frac{0.3}{1.21}$$

$$= 0.247933$$

$$\therefore \mathrm{g} = 4\pi^2 \times 0.25$$

= 9.869604

=9.9m/s^2

Percentage error in g

$$\%error = \frac{\bar{x}-x}{x} \times 100\%$$

$$= \frac{9.9-9.8}{9.8} \times 100\%$$

$$= \frac{0.1}{9.8} \times 100\%$$

$$= 1.020408\%$$

= 1%

(B) Period and Mass

Mass, M G	Time for 20 Oscillations		Mean time $\left(\frac{t_1+t_2}{2}\right)$ sec	Period, T sec	T^2 sec^2
	t_1 sec	t_2 sec			
20	36.35	36.47	36.41	1.82	3.31
40	36.49	36.34	36.42	1.82	3.31
60	36.59	36.68	36.64	1.83	3.35

The period of the pendulum remains virtually the same as its mass changes. The periods obtained were almost the same with very minute differences in magnitudes.

They could have been the same but due to experimental errors they are not the same.This agrees with the prediction that the period is independent of the mass.

(C) Period and Amplitude

Amplitude $\theta°$	Time for 20 Oscillations t_1 sec	t_2 sec	Mean time $\left(\frac{t_1+t_2}{2}\right)$ sec	Period, T Sec	T^2 sec^2
10	40.72	40.34	40.53	2.03	4.12
20	41.30	40.55	40.93	2.05	4.19
40	41.89	42.13	42,01	2.10	4.41
60	42.64	43.04	42.84	2.14	4.59
70	43.74	43.79	43.77	2.19	4.79

The period of the pendulum remains virtually the same as its amplitude changes .The periods obtained were almost the same with very minute differences in magnitudes. They could have been the same but due to experimental errors they are not the same. This suggests that the period is not affected by the change in amplitude.

DISCUSSION

In Part A, to investigate the relationship between the period and its length, the mass and the amplitude were constant, several lengths were taken and the period increased with increase in lengths. A graph of length against period squared gave an acceleration due to gravity of 9.9m/s^2 with a percentage error of 1%.

In Part B, When a fixed length and amplitude were selected, for different masses the period did not change. A period is the time taken to complete one oscillation. From this definition. From this definition, the period was found by dividing the time taken to complete 20 oscillation by 20,the number of oscillations.

In Part C, with the mass of the bob and length fixed, the period of the pendulum remained the same with change in amplitude. The period was found by dividing the time taken to complete 20 oscillations by 20,the number of oscillations. The formula $T = \frac{t}{20}$ is used instead of $\mathrm{T} = 2\pi\sqrt{(\mathrm{L}/\mathrm{g})}$,because we are investigating whether the period of the pendulum is independent of the mass and amplitude.

All experiments are subjected to errors, the major source of error was damping due to friction at the point of suspension, and also due to air. Due to this friction, the total energy of the bob does not remain exactly constant. Hence, the time period changes from oscillation to oscillation. Extraneous sources, such as air currents can also cause random errors. Errors are also caused by the least count of the stop watch and the metre scale. The project may be improved by using a more sophisticated theoretical model which takes damping into account. A better quality string, and a stop watch with a smaller least count would be useful.

CONCLUSION

The relationship between the length of the pendulum and period of oscillations:

The period of the pendulum increased with increase in length. Thus, the period of the pendulum is affected by length.

The relationship between the mass of the bob and the period of oscillation:

The period of the pendulum remained virtually the same as its mass changed. This showed that the period of oscillation is independent of mass of bob,

The relationship between the amplitude of the pendulum and period of oscillations:

The period does not change with change in amplitudes. Therefore, the period is not affected by the amplitude of the pendulum.

Finally, the period of a simple pendulum depends only by the length of the string and the acceleration due to gravity, giving an equation for T as $T = 2\pi\sqrt{(L/g)}$.

REFERENCES

P. C. Simpemba, J. Simfukwe & M. Chengo, *PH110 Laboratory manual,* (2016), Department of Physical Sciences, School of Mathematics and Natural Sciences, Copperbelt University, Kitwe, Zambia.