Topic 4 – Practical 3

Experimental determination of the acceleration of gravity using a simple pendulum

Safety

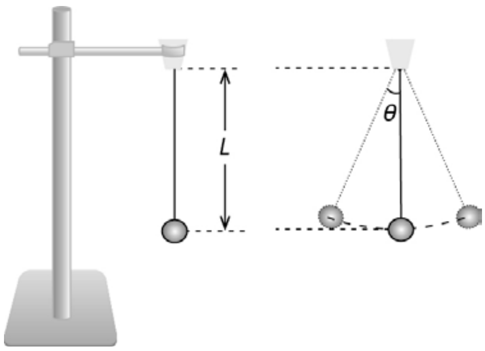
Wear safety glasses/goggles.

Apparatus and materials

- stand and clamp
- cotton thread (~ 1.1 m)
- rubber stopper with hole to fit the thread
- small brass or lead pendulum bob
- stopwatch
- metre rule
- protractor
- fiducial mark

Introduction

In this practical, you will use a simple pendulum to determine the value of acceleration of gravity g (or acceleration of free fall). This is the acceleration of a falling object when only the gravitational pull of the Earth acts on it. The value of g is 9.8(1) m s^{-2}; there might a variation in the second decimal place of this value depending on the location.



A simple pendulum is one with small point mass suspended by a weightless string. If it is displaced from its equilibrium position for a small angle θ ($\theta < 10°$) then the pendulum will perform simple harmonic motion (SHM). The period of this motion is given by:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

where T = period of the SHM, L = length of the pendulum and g = the acceleration of gravity. You are going to measure the time period of the pendulum for various lengths of string then use a graphical method to find g.

The equation above can be written as:

$$T^2 = \frac{4\pi^2}{g}L$$

so that the gradient of a T^2 vs L graph is equal to:

$$\frac{4\pi^2}{g}$$

Procedure

1 Pass the cotton thread through the hole of the rubber stopper. The length of the pendulum L is measured from the point where the thread comes out of the rubber stopper up to the centre of the pendulum bob.

2 Secure the rubber stopper with the clamp and position the pendulum so that it is overhanging the bench.

3 Adjust the length of the pendulum by drawing the thread through the stopper so that L is 1 m.

4 Give a small displacement to the pendulum. You can use a protractor to ensure that the angular displacement, θ, is less than 10°.

5 Measure the time it takes for the pendulum to complete 20 full oscillations.
(Note: the time it takes the pendulum bob from the equilibrium position to the next equilibrium position is half a period. One full period is the time it takes the bob to return to the equilibrium position **from the same side**. Use of a fiducial mark can help you identify and narrow down the time the bob passes through the equilibrium position.)

6 Repeat four more times for this pendulum length.

7 Record your measurements in an appropriate table.

Raw data table

Pendulum length, L / m ± . . .	Time for 20 full oscillations / s ± . . .				
	#1	#2	#3	#4	#5

8 Repeat the process (steps **4**–**7**) for pendulum lengths 0.90 m, 0.80 m, 0.70 m and 0.60 m.

9 For each pendulum length calculate:

a the average time for 20 oscillations and the uncertainty of repeated measurements

b the period of one oscillation and the relevant uncertainty

c the square of the period and the relevant uncertainty.

Record these calculations in a separate table.

Processed data table

Pendulum length, L / m ± . . .	Average time for 20 oscillations / s	Uncertainty from repeated measurements of t / s	Period, T / s	Uncertainty of T / s^2	T^2 / s^2	Uncertainty of T^2 / s^2

10 Plot a graph of the square of the period, T^2, against pendulum length, L. Use the values of uncertainty of T^2 to draw error bars.

11 Draw best-fit line for your points and calculate its gradient.

12 From the value of the gradient, calculate the experimental value of g (= 2 × gradient).

13 Determine the gradient uncertainty and use it to calculate the uncertainty of the experimental value of g.

Questions

1 Is there another way of plotting your data in a linear graph so you could determine the value of g from the gradient? In what other way could you rearrange the equation $T = 2\pi\sqrt{\frac{L}{g}}$ to allow you to do this?

2 How would performing this experiment on the Moon affect your measurements and results?