# Topic 4 – Practical 3

## *Experimental determination of the acceleration of gravity using a simple pendulum*

### Safety

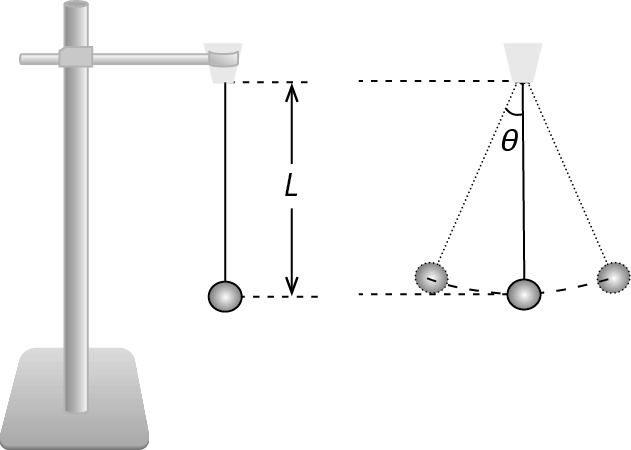
Wear safety glasses/goggles.

### 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* (*θ* < 10°) then the pendulum will perform simple harmonic motion (SHM). The period of this motion is given by:

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:

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

### 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 |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

1. Repeat the process (steps **4**–**7**) for pendulum lengths 0.90 m, 0.80 m, 0.70 m and 0.60 m.
2. For each pendulum length calculate:
   * 1. the average time for 20 oscillations and the uncertainty of repeated measurements
     2. the period of one oscillation and the relevant uncertainty
     3. 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 / s2 | Uncertainty of *T*2 / s2 |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

1. 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.
2. Draw best-fit line for your points and calculate its gradient.
3. From the value of the gradient, calculate the experimental value of *g* (= 2 × gradient).
4. 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 to allow you to do this?
2. How would performing this experiment on the Moon affect your measurements and results?