Unit A – Practical 1

Experimental determination of the acceleration of free fall

Safety

- There are no safety issues concerning this experiment.

Apparatus and materials

- ball
- metre rule (or tape measure)
- digital camera
- laptop

Introduction

In this practical, you will use height and time measurements to determine the acceleration of free fall, g. 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) ms^{-2}; there might a variation in the second decimal place of this value depending on the location.

To determine the value of g, you will use the following equation of motion:

$$s = ut + \frac{1}{2}at^2$$

where s: displacement, u = initial velocity, t = time and a =acceleration – in this case the acceleration of free fall, g. In free fall the displacement is equal to the height the object falls through, h, and the initial velocity is zero. Hence the equation becomes:

$$h = \frac{1}{2}gt^2$$

This indicates a linear relationship between h and t^2. This equation can be rearranged:

$$t^2 = \left(\frac{2}{g}\right)h$$

so that a linear graph of t^2 against h (independent variable on x-axis) can be plotted and the gradient of the line equal to $\frac{2}{g}$.
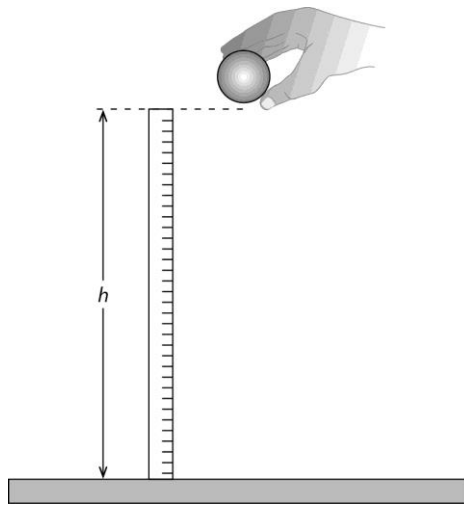
Procedure

1 Set the digital camera to record a video. A group member should be responsible for recording.

2 Another group member should be responsible for releasing the ball. Using a metre rule measure 30 cm above the ground or above the surface of a table. It is useful to keep the metre rule in the frame as reference.

3 Place the ball so that the lower surface of the ball is 30 cm above ground.

4 Start recording the video.

5 Release the ball. After the ball has reached the ground you can stop recording.

6 Repeat four more times for this height.

7 Repeat the process for initial heights of 50 cm, 70 cm, 90 cm and 110 cm.

8 Use the recorded videos to measure the time it takes for the lower surface of ball to reach the ground after it was released.

9 Record your measurements in a table with headings, units and values of the estimated uncertainty for each quantity.

Raw data table

Initial height, h / m ± . . .	Time / s ± . . .				
	#1	#2	#3	#4	#5

10 Complete a processed data table with your calculations of the average time, uncertainty of time from repeated measurements, square of time and uncertainty of square of time for each initial height.

Processed data table

Initial height, h / m ± . . .	Average time, t / s	Absolute uncertainty of t / s	t^2 / s^2	Absolute uncertainty of t^2 / s^2

11 Plot a graph of initial height, h, against the square of time, t^2. Use the values of uncertainty of t^2 to draw error bars.

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

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

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

Questions

1 What are the absolute uncertainties of your measurements introduced by your equipment?

2 Are there any reasons that these uncertainties are larger?

3 Compare your experimental value of g with the accepted value of 9.81 ms^{-2}. Does this value fall within the experimental region of values?

4 What might be sources of errors in this experiment?

5 Suggest ways of improving the accuracy of this experiment.