Core Practical Resources

The core practicals for the IAL specification are the same as for the GCE AL specification and a resource pack is available which includes a technician sheet, a student sheet and a teacher sheet. Below are the three sheets for Core practical 1.

Core practical 1: Determine the acceleration of a freely-falling object

Objectives	
• To measure the acceleration due to gravity *g* of an object falling freely and consider the following alternative methods: (a) object falling through a trap door (b) object falling through a light gate	
Equipment per student/group	**Notes on equipment**
metre ruler or tape measure with millimetre resolution	
(a) steel sphere	5–10 mm diameter
(a) electronic timer	Standard timer
(a) electromagnet to retain steel sphere	Connect the electromagnet to the timer so that switching off the current starts the timer.
(a) trap door	Connect the trap door so that the timer stops when the trap door opens.
(b) falling object, such as a 2 cm dowel, 10 cm long	
(b) means to guide dowel through light gate	Two pieces of curtain track, held a distance apart, or a length of 30 mm diameter acrylic tube would work well.
(b) light gate and data logger	

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  - (a) object falling through a trap door
  - (b) object falling through a light gate

Safety

- Ensure that any apparatus that might topple over is secure.
- Be aware of falling objects.

All the maths you need

- Use ratios, fractions and percentages.

  $$\text{Percentage uncertainty (\%U)} = \frac{\text{uncertainty}}{\text{mean value}} \times 100\%$$

  $$\text{Percentage difference (\%D)} = \frac{(k-g)}{g} \times 100\%$$

  (k is the measurement students make)
- Find arithmetic means.

  $$\text{The mean of a range of data} = \frac{\text{sum of readings}}{\text{number of readings}}$$
- Translate information between graphical, numerical and algebraic forms.
- Plot two variables from experimental or other data.
- Understand that $y = mx + c$ represents a linear relationship.
- Determine the slope and intercept of a linear graph.

Equipment

- metre rule or tape measure with millimetre resolution

For (a):

- steel sphere
- electronic timer
- electromagnet to retain steel sphere
- trap door

For (b):

- falling object, such as a 2 cm dowel, 10 cm long
- means to guide dowel through light gate
- light gate and data logger

Procedure

1. Drop the object from rest and record the time taken t for:
   (a) the sphere to fall to the trap door
   (b) the dowel to pass through the light gate.
2. Repeat the measurement for (a) and (b) twice more and work out the mean value.
3. Measure and record the height h fallen by the object.
4. Repeat the timing of the drop as you vary the height; you should take at least 6 readings.

5. Use half the range in your readings for t as the uncertainty in t. Calculate the percentage uncertainty in t.
6. For method (b) you should measure the length of the dowel.

Analysis of results

1. Plot a graph of t^2 (y-axis) against h (x-axis) and work out the gradient m of the line of best fit.
2. Calculate a value for g where $g = \frac{2}{m}$.
3. Use your value for the length of the dowel to calculate the mean speed v of the dowel as it passes through the light gate.
4. Plot a graph of v^2 against h and work out the gradient m of the line of best fit.
5. Calculate a value for g, where $g = \frac{m}{2}$.
6. The percentage uncertainty (%U) in t^2 is twice that in t. Use this to draw on your plot's error bars – in the y direction only. You can use a typical mid-range value for calculating uncertainties and need not work out a separate error bar for each value. Draw further lines of fit to calculate the %U in your value for g.
7. Calculate the percentage difference (%D) between your value and the accepted value of 9.81 ms^{-2} and comment on the accuracy of your method.

Learning tips

- Ensure that points plotted on a graph take up more than half of the available space on both scales. You do not always need the origin on a graph.
- Keep scales simple, one big square as 5, 10 or 20 is ideal. One big square as 3 or 7 is very difficult to plot on and often leads to errors.
- Always consider whether or not the graph line should go through the origin. Straight lines should be drawn with aid of a ruler – one long enough to cover the full length of the line.
- Since the object is falling at constant acceleration, use the appropriate SUVAT equation.

  a) $s = ut + \frac{1}{2}at^2$ where $u = 0$, $a = g$, and $s = h$

  $t^2 = \frac{2h}{g}$ and comparison with $y = mx + c$ shows that plotting t^2 against h should be a straight line passing through the origin with gradient $\frac{2}{g}$.

  b) $v^2 = u^2 + 2as$ where $u = 0$, $a = g$, and s is h.

  $v^2 = 2gh$ and comparison with $y = mx + c$ shows that plotting v^2 against h should be a straight line passing through the origin with gradient $2g$.

Questions

1. Describe any advantage in using light gates in this experiment.
2. Discuss the effect of air resistance on your value for g.
3. Explain why the graph should be a straight line.

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Safety

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- Be aware of falling objects.

Specification links

- Core practical 1
- Practical techniques 1; 4; 2 or 11 dependent on method
- CPAC statements 2a; 2b; 2d; 4b

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   (b) the dowel to pass through the light gate.
2. Repeat the measurement for (a) and (b) twice more and take the mean value.
3. Measure and record the height *h* fallen by the object.
4. Repeat the timing of the drop as you vary the height; you should take at least 6 readings.
5. Use half the range in your readings for *t* as the uncertainty in *t*. Calculate the percentage uncertainty in *t*.
6. For method (b) you should measure the length of the dowel.

Notes on procedure

- It may be interesting to have two groups of students using the two methods separately to see if different results are produced.
- This would be a good experiment to practise handling the uncertainties, especially in the square of a quantity. Offering students a choice of methods will start their path towards mastery of practical physics, and use of investigative techniques (CPAC statement 2).

Answers to questions

1. There should be less uncertainty in the measurement of time but this will be of interest particularly if the class have used both methods.
2. Students' value for *g* will have been reduced by air resistance. They should use the %D in their remarks.
3. A straight line has a constant gradient. The line should be straight because the gradient depends only on *g*, which is constant.