

AS Physics Past Paper Questions

You may find the following useful for the uncertainty parts:

Absolute Uncertainty

If you only have one reading, or all repeat readings are the same, the absolute uncertainty is

\pm smallest increment

width of stick measured with ruler (precision 1mm): 25mm, 25mm, 25mm

width = 25 ± 1 mm

If the repeat readings are different, the absolute uncertainty is \pm (range / 2)

width of a stick measured with vernier caliper (precision 0.1mm): 25.1mm, 25.6mm, 25.3mm

width = 25.3 ± 0.25 mm

If two measurements are added or subtracted, the absolute uncertainties are added.

mass of rocket before launch = 420 ± 0.5 g

mass of rocket after launch = 106 ± 0.5 g

mass lost = $420 - 106 = 314 \pm 1$ g

Percentage Uncertainty

Multiplying or dividing by a constant number does not change the percentage uncertainty.

radius = $5\text{mm} \pm 10\%$

diameter = radius $\times 2 = 10\text{mm} \pm 10\%$

Unit conversions do not change percentage uncertainty.

diameter = $10\text{mm} \pm 10\%$

diameter = $1\text{cm} \pm 10\%$

diameter = $0.01\text{m} \pm 10\%$

When multiplying or dividing two measured quantities, the percentage uncertainties are added.

width = $25\text{mm} \pm 10\%$

length = $50\text{mm} \pm 5\%$

area = $25\text{mm} \times 50\text{mm} = 1250\text{mm}^2 \pm 15\%$

Raising a measurement to the power n multiplies the percentage uncertainty by n.

radius = $5\text{mm} \pm 10\%$

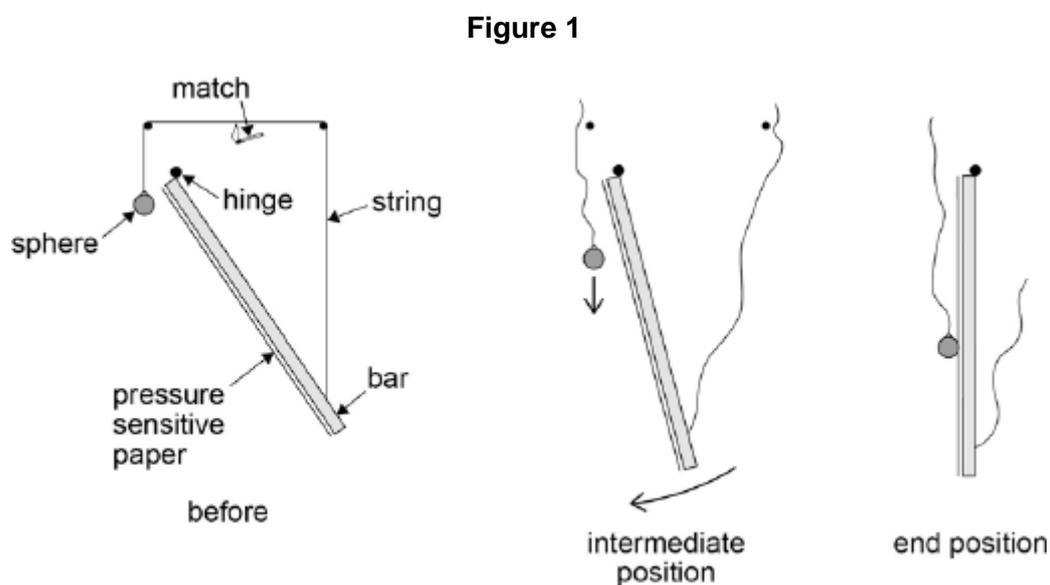
area = $3.14 \times \text{radius}^2$

area = $79\text{mm}^2 \pm 20\%$

Q1. This question is about measuring the acceleration of free fall g .

A student undertakes an experiment to measure the acceleration of free fall.

Figure 1 shows a steel sphere attached by a string to a steel bar. The bar is hinged at the top and acts as a pendulum. When the string is burnt through with a match, the sphere falls vertically from rest and the bar swings clockwise. As the bar reaches the vertical position, the sphere hits it and makes a mark on a sheet of pressure-sensitive paper that is attached to the bar.



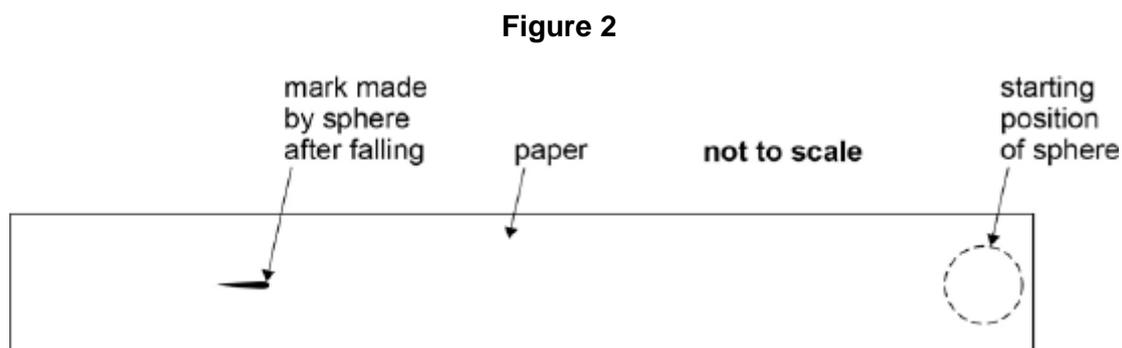
The student needs to measure the distance d fallen by the sphere in the time t taken for the bar to reach the vertical position.

To measure d the student marks the initial position of the sphere on the paper. The student then measures the distance between the initial mark and the mark made by the sphere after falling.

To measure t the student sets the bar swinging without the string attached and determines the time for the bar to swing through 10 small-angle oscillations.

- (a) **Figure 2** shows the strip of paper after it has been removed from the bar. The initial position of the sphere and the final mark are shown.

Mark on **Figure 2** the distance that the student should measure in order to determine d .



(b) The student repeats the procedure several times.

Data for the experiment is shown in the table below.

d / m
0.752
0.758
0.746
0.701
0.772
0.769

Time for bar to swing through 10 oscillations as measured by a stop clock = 15.7 s

Calculate the time for one oscillation and hence the time t for the bar to reach the vertical position.

time.....s

(1)

(c) Determine the percentage uncertainty in the time t suggested by the precision of the recorded data.

uncertainty =..... %

(2)

(d) Use the data from the table to calculate a value for d .

$d = \dots\dots\dots\text{m}$

(2)

(e) Calculate the absolute uncertainty in your value of d .

uncertainty = m

(1)

(f) Determine a value for g and the absolute uncertainty in g .

g = ms^{-2}

uncertainty = ms^{-2}

(3)

(g) Discuss **one** change that could be made to reduce the uncertainty in the experiment.

.....
.....
.....
.....

(2)

(h) The student modifies the experiment by progressively shortening the bar so that the time for an oscillation becomes shorter. The student collects data of distance fallen s and corresponding times t over a range of times.

Suggest, giving a clear explanation, how these data should be analysed to obtain a value for g .

.....
.....
.....
.....
.....
.....

(3)

(Total 15 marks)

(iv) Explain how you would calculate the Young modulus from your measurements.

.....

.....

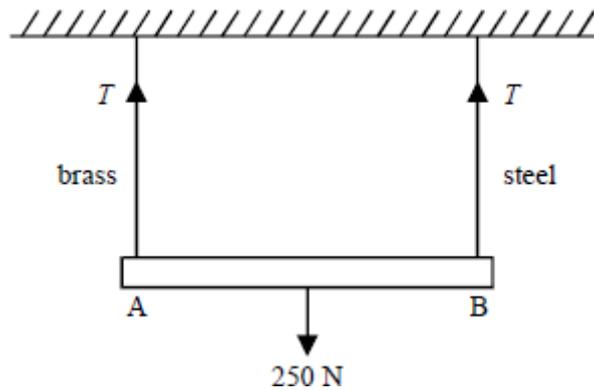
.....

.....

.....

(13)

(b) A uniform heavy metal bar of weight 250 N is suspended by two vertical wires, supported at their upper ends from a horizontal surface, as shown.



One wire is made of brass and the other of steel. The cross-sectional area of each wire is $2.5 \times 10^{-7} \text{ m}^2$ and the unstretched length of each wire is 2.0 m.

the Young modulus for brass = $1.0 \times 10^{11} \text{ Pa}$

the Young modulus for steel = $2.0 \times 10^{11} \text{ Pa}$

(i) If the tension, T , in each wire is 125 N, calculate the extension of the steel wire.

.....

.....

.....

(ii) Estimate how much lower the end A will be than the end B.

.....

.....

(3)
(Total 16 marks)

- M1.(a)** Clear identification of distance from centre of sphere to right hand end of mark, or to near r.h.end of mark ✓
1
- (b) 0.393 (s) ✓
Accept 0.39 (s)
1
- (c) For 10 oscillations percentage uncertainty = $\frac{0.1}{15.7} = 0.00637 \equiv 0.64\%$ ✓
same for the $\frac{1}{4}$ period ✓
2
- (d) Identifies anomaly [0.701] ✓ and calculates mean distance = 0.759 (m) ✓
Allow 1 max if anomaly included in calculation giving 0.750 (m)
2
- (e) Largest to smallest variation = 0.026 (m)
Absolute uncertainty = 0.013 (m) ✓
1
- (f) Use of $g = \frac{2d}{t^2}$ leading to
9.83 (m s⁻²) ✓
Allow 9.98 (m s⁻²) if 0.39 used
Ecf if anomaly included in mean in (d)
percentage uncertainty in distance = 1.7% ✓
Total percentage uncertainty =
1.7 + 2 x 0.64 = 3.0%
Absolute uncertainty = 0.30 (m s⁻²) ✓
[g = 10.0 ± 0.3 m s⁻²]
Expressed sf must be consistent with uncertainty calculations
3

(g) suggests one change ✓

Sensible comment about change or its impact on uncertainty ✓

eg

Use pointed mass not sphere

Because this will give better defined mark OR because the distance determination has most impact on uncertainty

OR

Time more swings / oscillations

As this reduces the percentage uncertainty in timing

OR

longer / heavier bar would take a greater time to swing to the vertical increasing t and s and reducing the percentage uncertainty in each

If data logger proposed, it must be clear what sensors are involved and how the data are used.

2

(h) $[s = \frac{g}{2}t^2]$

plot graph of s against t^2 or \sqrt{s} against t ✓

calculate the gradient ✓

the gradient is $g / 2$ or $\sqrt{g / 2}$ ✓

Accept: plot s against $t^2 / 2$ or plot $2s$ against t^2 :

calculate the gradient

in both cases gradient gives g

Allow 1 max for answer that evaluates g for each data point and averages

3

[15]

- M2.(a)** (i) diagram to show:
(long) wire fixed at one end **(1)**
mass / weight at other end **(1)**
measuring scale **(1)**
mark on wire, or means to measure extension **(1)**

max 3

[alternative for two vertical wires:

two wires fixed to rigid support **(1)**
 mass / weight at end of one wire **(1)**
 other wire kept taut **(1)**
 spirit level and micrometer or sliding vernier scale **(1)**

- (ii) measurements:
 length of the wire between clamp and mark **(1)**
 diameter of the wire **(1)**
 extension of the wire **(1)**
 for a known mass **(1)**

max 3

- (iii) length measured by metre rule **(1)**
 diameter measured by micrometer **(1)**
 at several positions and mean taken **(1)**
 (known) mass added and extension measured
 by noting movement of fixed mark against vernier scale
 (or any suitable alternative) **(1)**
 repeat readings for increasing (or decreasing) load **(1)**

max 5

- (iv) graph of mass added / force against extension **(1)**

gradient gives $\frac{F}{e}$ or $\frac{m}{e}$ **(1)**

correct use of data in $E = \frac{Fl}{eA}$ where A is cross-sectional area **(1)**

[if no graph drawn, then mean of readings
 and correct use of data to give 2_{\max}) **(1)**

max 2

(13)

The Quality of Written Communication marks are awarded for the quality of answers to this question.

- (b) (i) for steel (use of $E = \frac{Fl}{eA}$ gives) $e = \frac{FL}{EA}$ **(1)**

$$e = \frac{125 \times 2}{2.0 \times 10^{11} \times 2.5 \times 10^{-7}} \text{ (1)}$$

$$= 5.0 \times 10^{-3} \text{ m (1)}$$

- (ii) extension for brass would be 10×10^{-3} (m) (or twice that of steel) **(1)**
 end A is lower by 5 mm \checkmark (allow C.E. from (i))

max 3

[16]