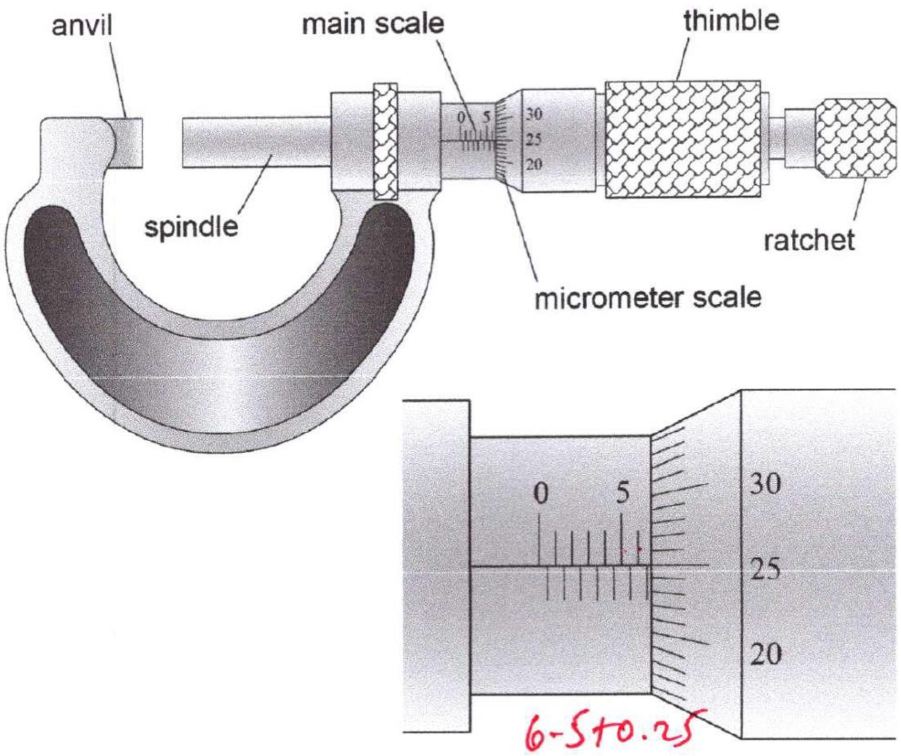
Measurements and their errors – AS Physics

1. No.1

0 1 . 1 **Figure 1** shows a micrometer screw gauge.

Figure 1



enlarged view of main scale and micrometer scale

= 6-75

What is the reading on the micrometer?

Tick (✓) **one** box.

[1 mark]

6.25	☐
6.75	☑
7.25	☐
8.25	☐

0 1 . 2 A metal wire of diameter d is held in the gap between the anvil and the spindle.
Just before the reading of d is taken, the gap is closed using the ratchet and not the thimble.

Explain why the gap is closed in this way.

[1 mark]

If ratched is not used, user could turn much and compress the wire resulting in measurements smaller than they should be

0 1 . 3 The mass per unit length μ of the metal wire is given by

$$\mu = \frac{\pi \rho d^2}{4}$$

where ρ is the density of the metal.

Values of d and μ are used to calculate ρ.

The percentage uncertainty in d is 1.2%.
The percentage uncertainty in μ is 2.0%.

Calculate the percentage uncertainty in the result for ρ.

[2 marks]

$$\mu = \frac{\pi \rho d^2}{4}$$

$$\rho = \frac{4\mu}{\pi d^2}$$

$\leftarrow 2\%$

$\uparrow$ $2 \times 1.2\%$

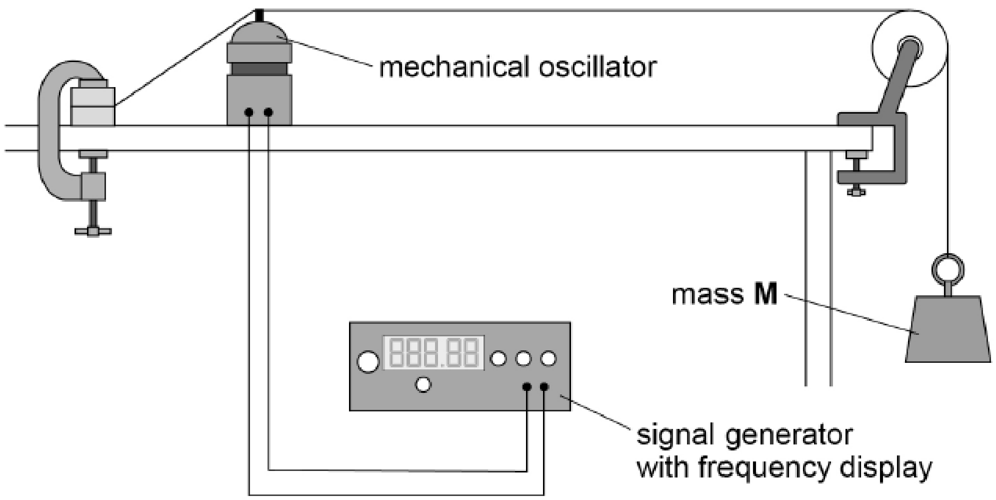
$= 2 + 2.4$

$= 4.4\%$

percentage uncertainty = 4.4 %

Figure 2 shows apparatus used to investigate how the frequency of stationary waves on a wire depends on its diameter d.

Figure 2



When the signal generator is switched on, the horizontal part of the wire oscillates.

A student changes the frequency until the first-harmonic stationary wave is produced. The student records the frequency f of the first harmonic and then turns off the signal generator.
She removes the wire and measures d using a micrometer.

She then repeats the experiment for wires of different diameter.

0 1 . 4 The wires used in the experiment are made of the same metal so that ρ is a control variable.

State **two** other control variables in the experiment.

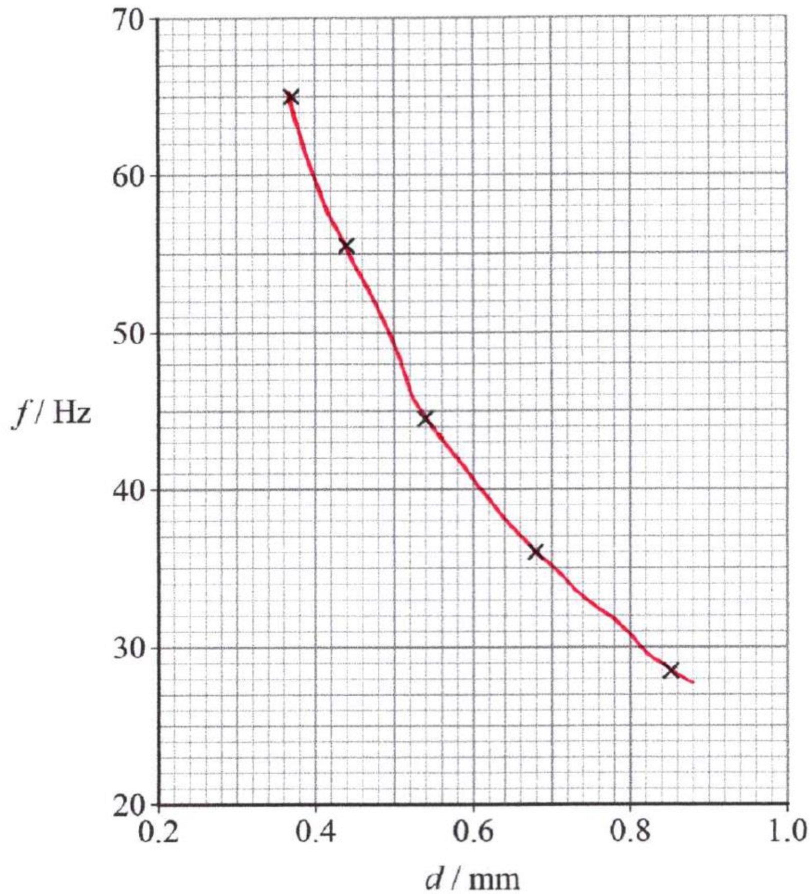
[2 marks]

1 Length of wire between oscillator and pulley

2 Mas of M_2

Figure 3 is a plot of the experimental data.

Figure 3



0 1 . 5 The student suggests that $f \propto \frac{1}{d}$.

Deduce, using data points from **Figure 3**, whether this suggestion is correct.

[2 marks]

$f \propto \frac{1}{d}$ $\therefore$ $fd = \text{Constant}$

$65 \times 0.37 = 24.05$

$28.5 \times 0.85 = 24.225$

They are very similar so true.

0 1 . 6 Another student repeats the experiment with the mass of **M** doubled.

Explain how this student's plotted data compare with **Figure 3**.

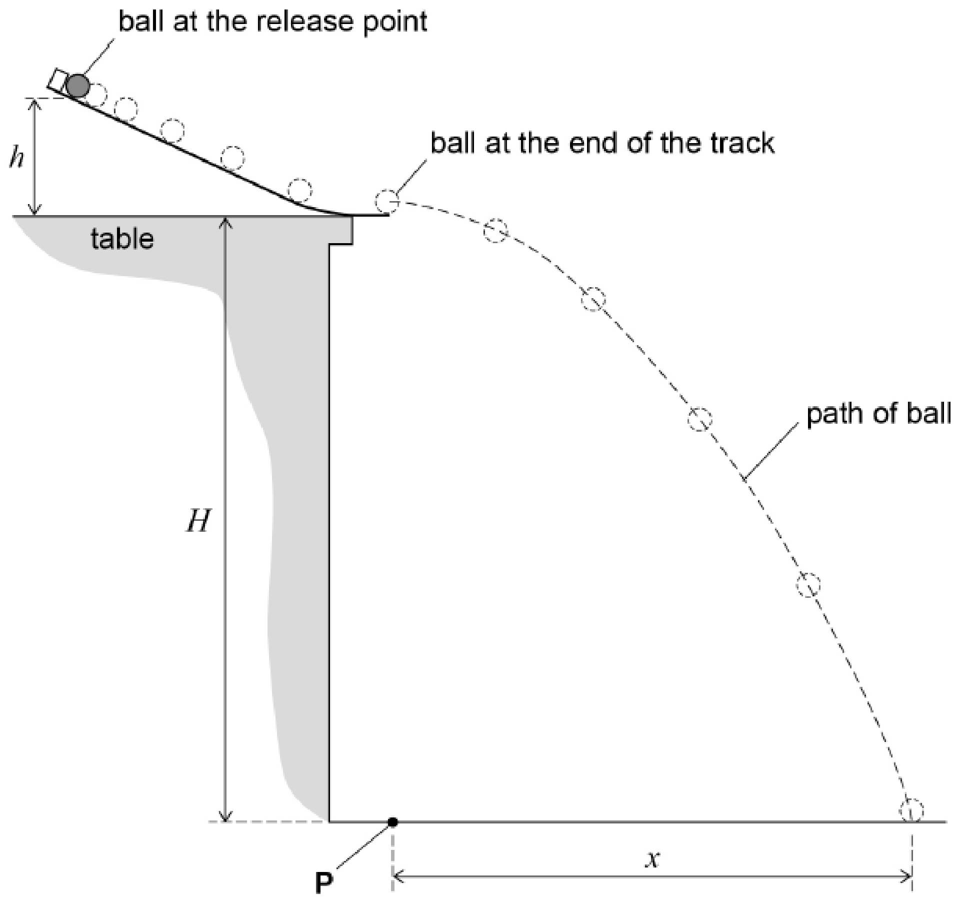
[2 marks]

$f = \frac{1}{2L}\sqrt{\frac{T \times 2}{\mu}}$ so every value of f will increase by $\sqrt{2}$

2. No.2

0 2 **Figure 4** shows an arrangement used to investigate projectile motion of a ball.

Figure 4



The ball is placed on the track at the release point.
The ball is released from rest from a vertical distance h above the table.

When the ball reaches the end of the track, it is a vertical distance H above the horizontal floor.
The ball leaves the track horizontally and lands on the floor at a horizontal distance x from the end of the track.

0 2 . 1 To measure x a student must locate a point **P** on the floor vertically below the end of the track.

Describe a procedure to locate **P**.
You may add detail to **Figure 4** to illustrate your answer.

[1 mark]

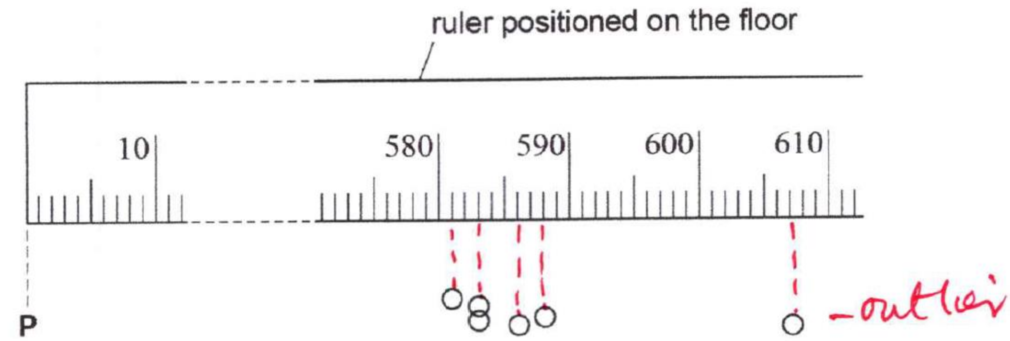
Use a plumb line and hang it from the edge of track.

0 2 . 2 A ruler, graduated in mm, is used to determine x.
The student places the ruler on the floor with the zero graduation aligned with **P**.

The student determines x when the ball is released six times at a particular value of h.
He makes marks on the floor where the ball lands.

Figure 5 shows circles that indicate these marks.

Figure 5



Determine x for this value of h.

[3 marks]

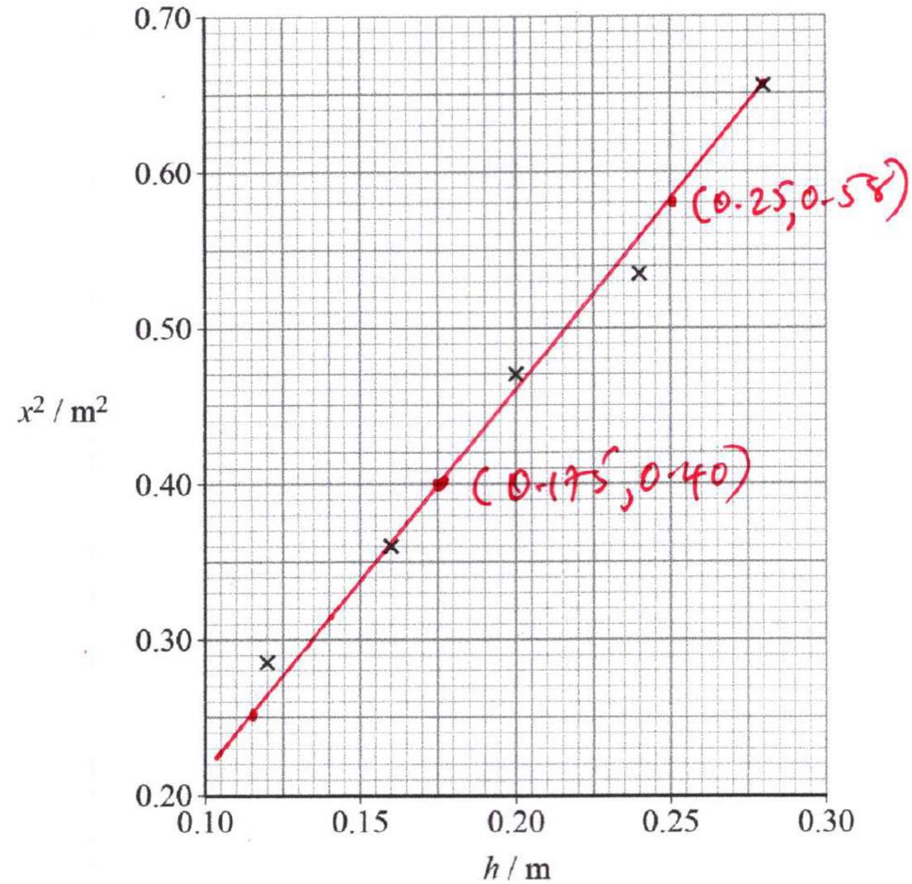
$$\bar{x} = \frac{581+583+583+586+588}{5}$$

$$= 584\text{mm}$$

$x =$ 584 mm

0 2 . 3 The student obtains values of x corresponding to other values of h.
Figure 6 shows his results.

Figure 6



It can be shown that $\frac{x^2}{H} = \frac{20}{7}h$

$x^2 = \left(\frac{20}{7}H\right)h$

Determine H.

$y = mx + c$

[3 marks]

$\text{Gradient} = \frac{20}{7}H \Rightarrow H = \frac{\text{Grad} \times 7}{20}$

$G = \frac{0.58 - 0.4}{0.25 - 0.175}$

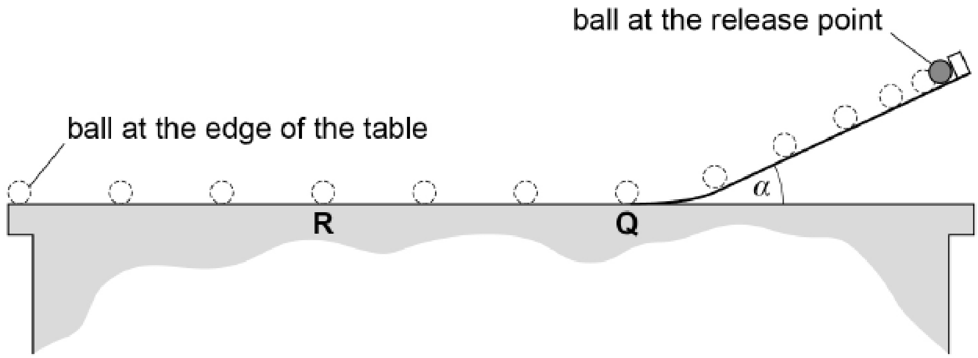
$= 2.4$

$H = \frac{2.4 \times 7}{20} = 0.84$

$H =$ 0.84 m

In a different arrangement, the ball is released from rest and then continues to roll at a constant velocity across a horizontal table, as shown in **Figure 7**.

Figure 7



The bottom of the track is fixed to the table at point **Q**.
The angle between the straight part of the track and the table is α.
A marker is placed at **R**, a point midway between **Q** and the edge of the table.

The student uses a stopwatch to measure the time t for the ball to roll from **Q** to **R**.

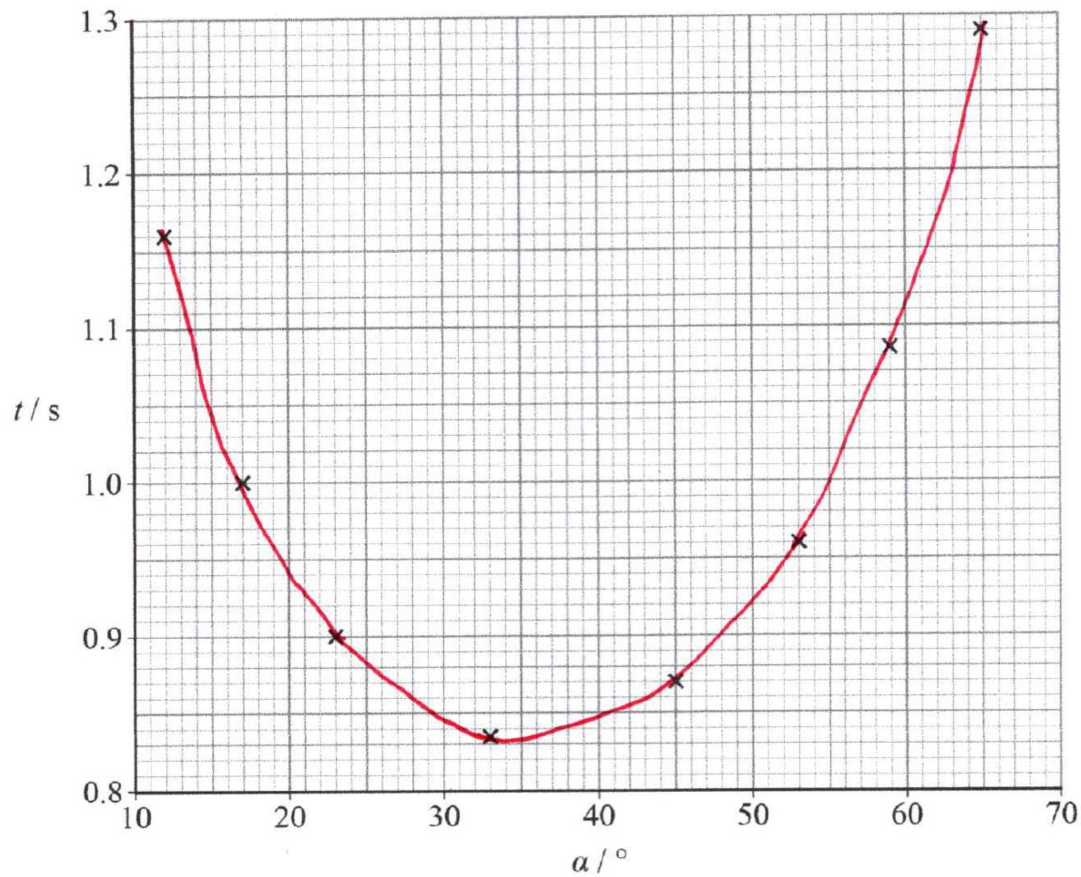
0 2 . 4 Explain why increasing the distance **QR** will reduce the percentage uncertainty in t.

[1 mark]

Larger distances so takes longer time and therefore larger values of t but same resolution and therefore smaller percentage uncertainty.

0 2 . 5 **Figure 8** shows values of t for different values of α.

Figure 8



At a particular value of α the ball rolls from **Q** to **R** at its maximum velocity.

Explain how the student should use **Figure 8** to determine this value of α.
Go on to suggest what further readings should be taken to reduce the uncertainty in this value of α.

[2 marks]

- Measure length of ramp, then measure horizontal distance to edge of ramp using set square and ruler.
- Draw curve of best fit
- Max v when t is min.
- Read off the graph.