AQA

Please write clearly in block capitals.

Centre number | 8 | 4 | 6 | 2 | 6 | Candidate number | 4 | 3 | 3 | 8 |

Surname Matheson

Forename(s) Lewis

Candidate signature

I declare this is my own work.

A-level PHYSICS

Paper 3
Section A

ALevelPhysicsOnline.com

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 70 minutes on this section.

Materials

For this paper you must have:
- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet
- a protractor.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 45.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

For Examiner's Use	
Question	Mark
1	
2	
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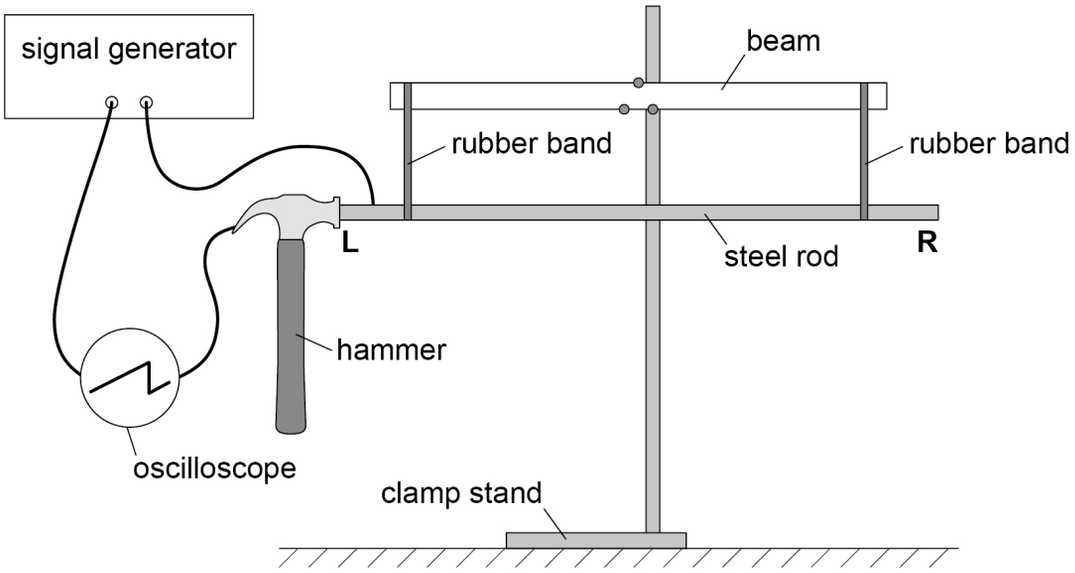
Section A

Answer **all** questions in this section.

0 1 **Figure 1** shows apparatus used to measure the speed of sound in a steel rod.

Figure 1



The steel rod is suspended from a beam using rubber bands.
When the hammer is in contact with the end **L** of the steel rod, a circuit is completed and the signal generator is connected to the oscilloscope.

Figure 2 shows the waveform then displayed on the oscilloscope.

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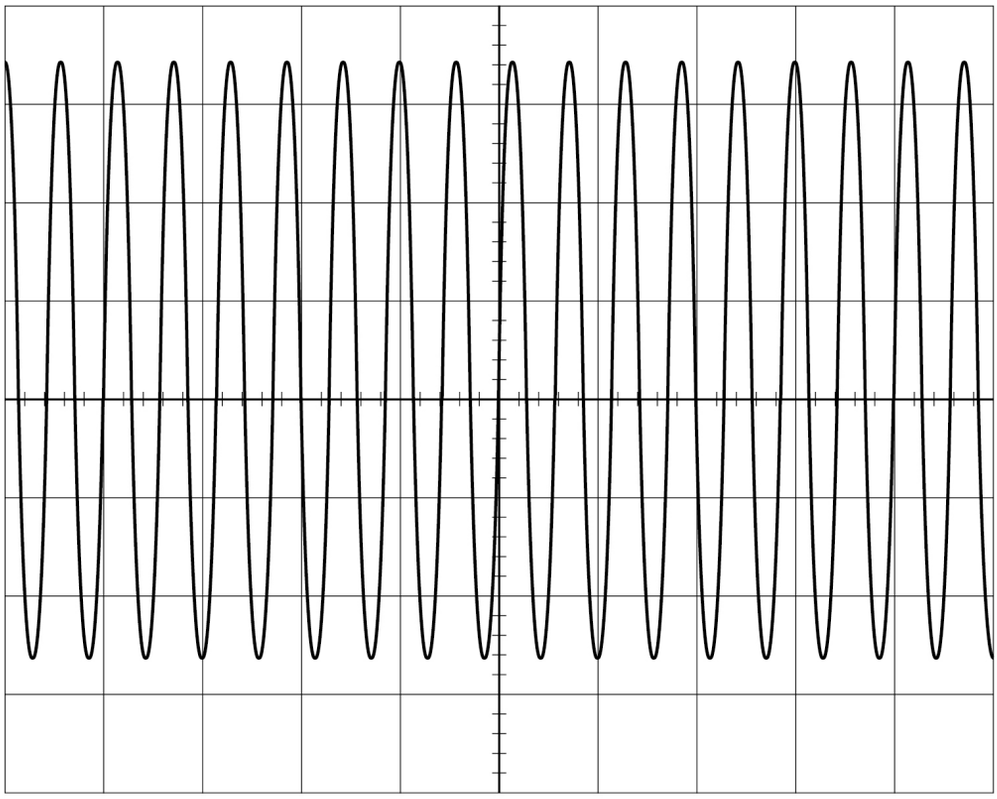
Figure 2



0 1 . 1 Which control on the oscilloscope should be used to centre the trace vertically on the screen?
Tick (✓) **one** box.

[1 mark]

X-shift ☐

Y-gain ☐

Y-shift ☑ ✓

This stretches the wave

Question 1 continues on the next page

When the hammer hits end **L**, a sound wave travels along the steel rod and is reflected at end **R**.
When the wave returns to **L** the rod bounces away from the hammer and the circuit is broken.

Figure 3 shows the waveform produced by the brief contact between the hammer and **L**.
Note that the waveform has now been centred vertically.

Figure 3

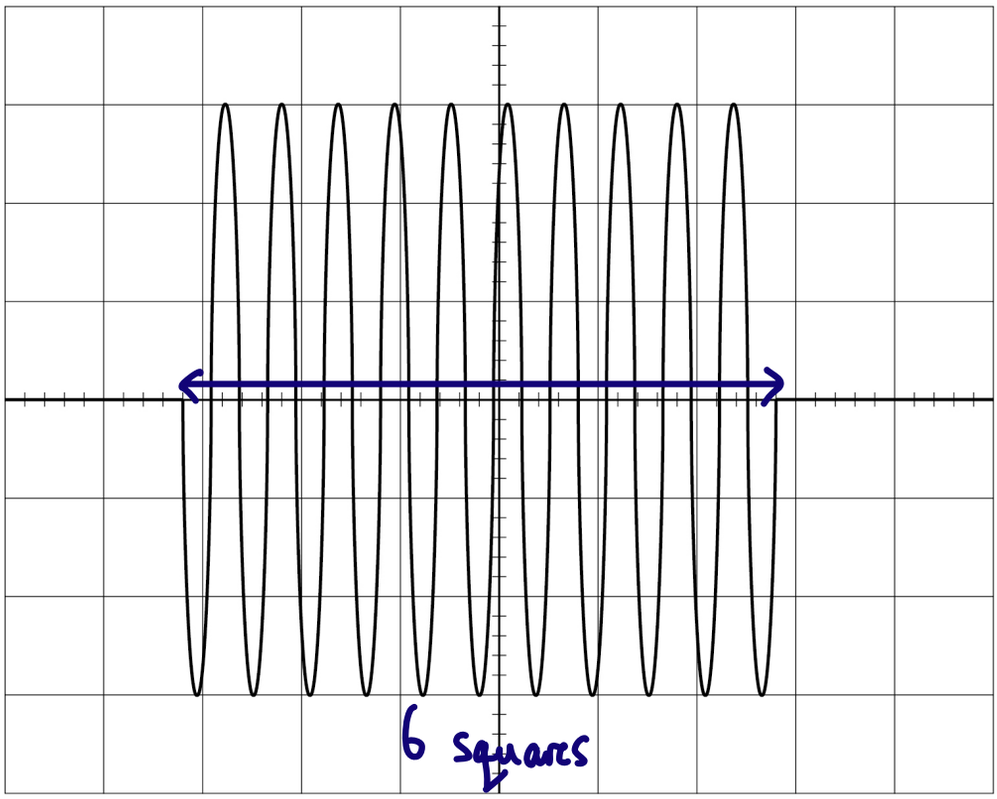
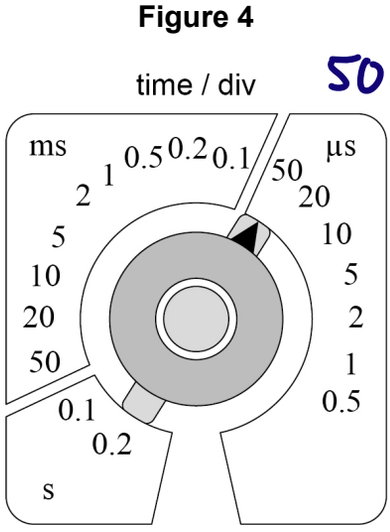


Figure 4 shows the time-base setting of the oscilloscope.

Figure 4



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0 1 . 2 The distance between **L** and **R** in **Figure 1** is $0.870\ \text{m}$.

Deduce the speed of sound in the steel rod.

[3 marks]

$v = \frac{s}{t}$

$s = 2 \times 0.870 = 1.740\ \text{m}$ ✓

$t = 6.0 \times 50 \times 10^{-6} = 3.0 \times 10^{-4}\ \text{s}$ ✓

$v = \frac{1.740}{3.0 \times 10^{-4}} = 5800$

speed of sound = 5.8×10^{3} ✓ m s^{-1}

0 1 . 3 A student repeats the experiment using a steel rod of twice the length.

Explain:

- how using the longer rod affects the waveform displayed
- any changes needed to get an accurate result for the speed.

You should include numerical detail.

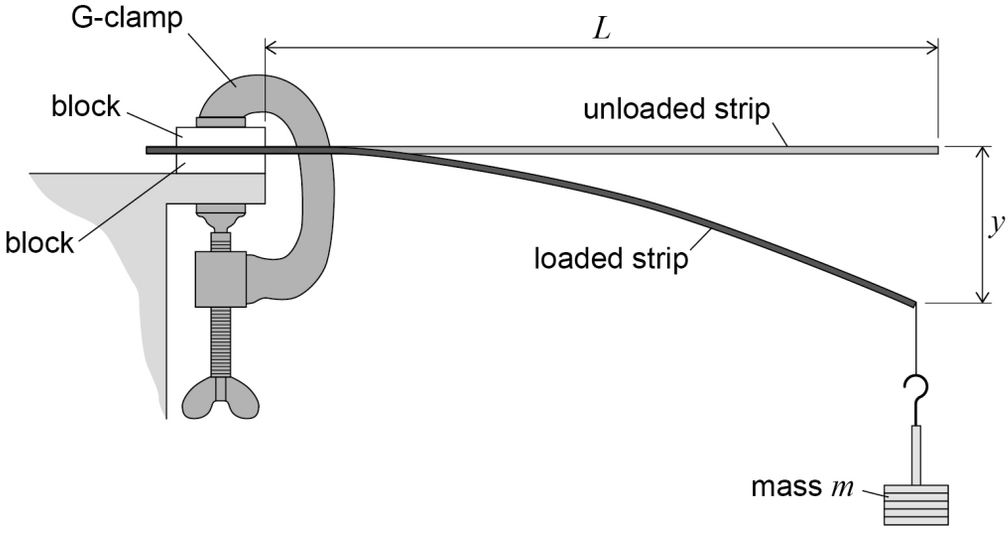
[4 marks]

Contact time is doubled ✓ (as it travels twice the distance) ∴ there are double the number of cycles ✓, requiring more (12) divisions than there are on the screen (10) so it would not all fit. The time-base ✓ would have to be adjusted to 0.1 ms div^{-1} ✓ so the complete waveform can fit on the screen.

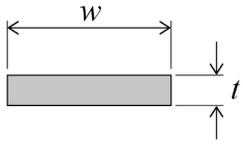
8

0 2 **Figure 5** shows a strip of steel of rectangular cross-section clamped at one end. The strip extends horizontally over the edge of a bench.

Figure 5



end view of unloaded steel strip



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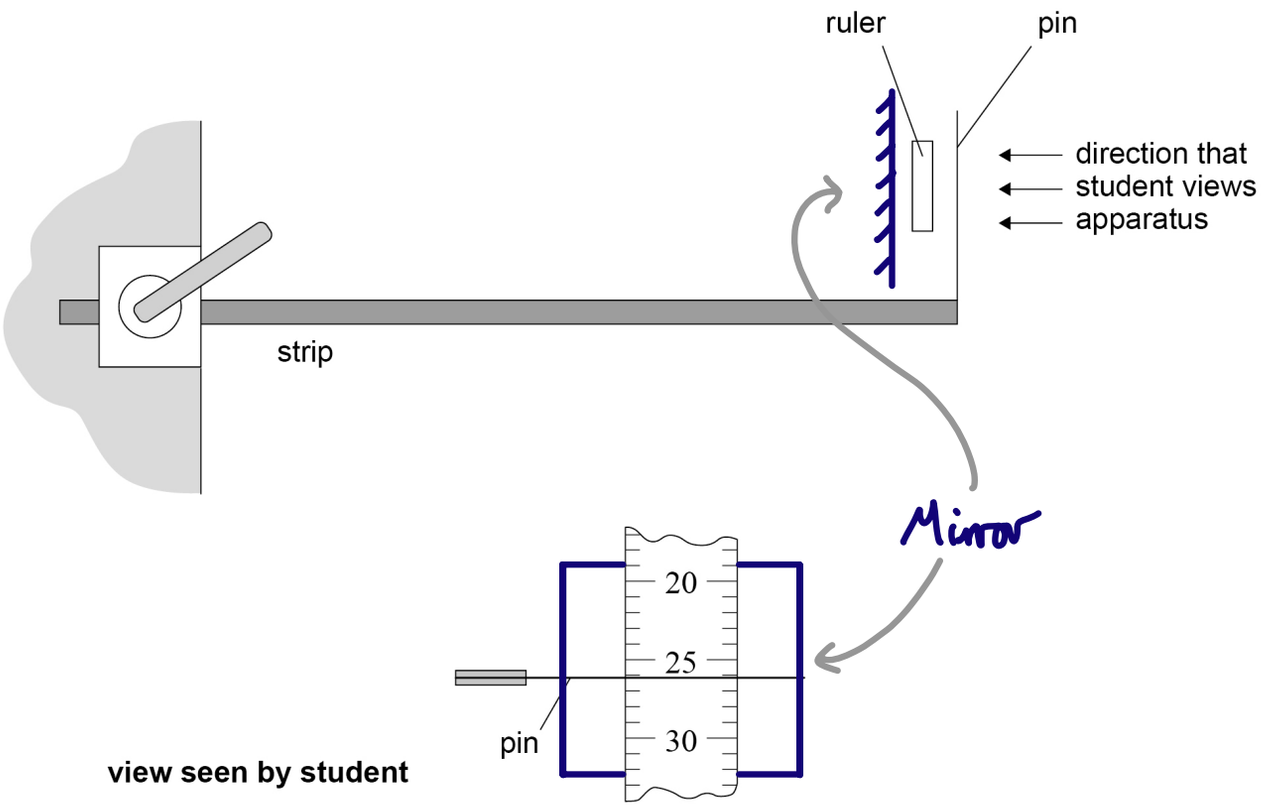
0 2 . 1 A mass m is suspended from the free end of the strip.
This produces a vertical displacement y.
A student intends to measure y with the aid of a horizontal pin fixed to the free end of the steel strip.
She positions a clamped vertical ruler behind the pin, as shown in **Figure 6**.

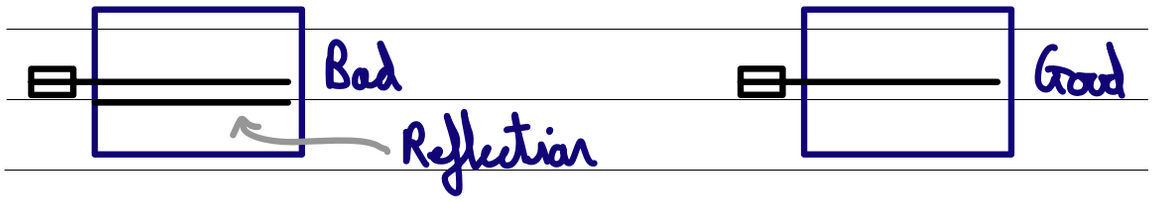
Figure 6



Explain a procedure to avoid parallax error when judging the reading indicated by the position of the pin on the ruler.
You may add detail to **Figure 6** to illustrate your answer.

[2 marks]

Place a mirror behind the ruler ✓ and adjust your eye position until the pin is lined up with it's reflection. ✓



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0 2 . 2 It can be shown that

$$y = \frac{4mgL^3}{Ewt^3}$$

where:

L is the distance between the free end of the **unloaded** strip and the blocks
w is the width of the strip and is approximately $1\ \text{cm}$
t is the thickness of the strip and is approximately $1\ \text{mm}$
E is the Young modulus of the steel.

A student is asked to determine E using the arrangement shown in **Figure 5** with the following restrictions:

- only one steel strip of approximate length $30\ \text{cm}$ is available
- m must be made using a $50\ \text{g}$ mass hanger and up to four additional $50\ \text{g}$ slotted masses
- the experimental procedure must involve only **one** independent variable
- a graphical method must be used to get the result for E.

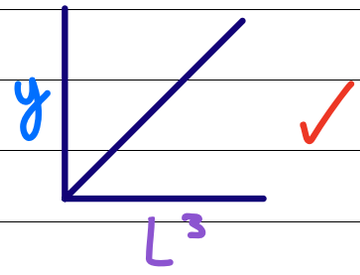
Explain what the student must do to determine E.

[5 marks]

Can either have L or m as the independent, I choose L ✓ ∴ m must be the control variable ✓ along with w and t, y is the dependent.
Measure L with a ruler, w with vernier callipers and t with a micrometer. ✓

$y = \frac{4mg}{Ewt^3} \cdot L^3$

$y = mx + c$



✓

Plot y against L^3, gradient = $4mg/Ewt^3$

∴ $E = 4mg/\text{gradient} \times wt^3$ ✓

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Turn over for the next question

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0 3 Conductive putty can easily be formed into different shapes to investigate the effect of shape on electrical resistance.

0 3 . 1 A student uses vernier callipers to measure the diameter d of a uniform cylinder made of the putty.

Suggest **one** problem with using callipers to make this measurement.

[1 mark]

They may reduce the diameter of the putty. ✓

0 3 . 2 **Table 1** shows the calliper measurements made by a student.

Table 1

d_1 / mm	d_2 / mm	d_3 / mm	d_4 / mm	d_5 / mm
34.5	34.2	32.9	33.4	34.0

Show that the percentage uncertainty in d is about 2.4%.
Assume that all the data are valid.

[2 marks]

$$\bar{d} = \frac{34.5 + 34.2 + 32.9 + 33.4 + 34.0}{5} = 33.8 \text{ mm}$$ ✓

Abs uncertainty = ½ range = ½ (34.5 − 32.9) = 0.8 mm

$$\% \text{ uncertainty} = \frac{\text{Abs uncertainty}}{\text{mean}} \times 100$$

$$= \frac{0.8}{33.8} \times 100 = 2.37\% \checkmark \approx 2.4\%$$

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0 3 . 3 The length of the cylinder is 71 ± 2 mm.

Determine the uncertainty, in mm^3, in the volume of the cylinder.

[4 marks]

$V = \frac{\pi d^2}{4} \cdot L = \frac{\pi \times 33.8^2}{4} \times 71 = 63706.2\ mm^3$ ✓

$\%d = 2.367\%$ $\quad \%L = \frac{2}{71} \times 100 = 2.817\%$ ✓

$\%V = (2 \times \%d) + \%L = 7.55\%$ ✓

$\text{Absolute} = \%V \times V = 0.0755 \times 63706.2$

$= 4814\ mm^3$

uncertainty = 4.8×10^3 ✓ mm^3

Question 3 continues on the next page

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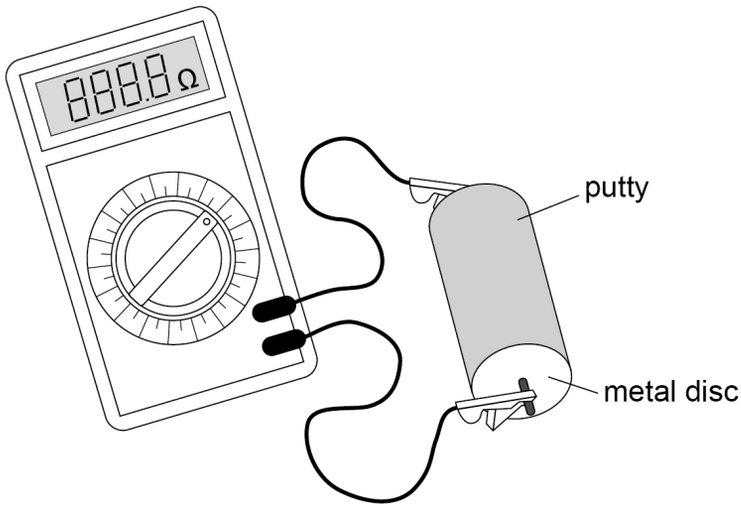
0 3 . 4 A student is given some putty to form into cylinders.

To find the resistance of a cylinder, metal discs are placed in contact with the ends of the cylinder and connected to a resistance meter.

Figure 7 shows the apparatus.

Figure 7



The student forms the putty into cylinders of different lengths, each of volume $5.83 \times 10^{-5}\ \text{m}^3$.
The length L and resistance R are measured for each cylinder.

It can be shown that $R = \dfrac{\rho L^2}{5.83 \times 10^{-5}}$ where ρ is the resistivity of the conductive putty.

The student plots the graph shown in **Figure 8**.

Determine ρ.
State an appropriate SI unit for your answer.

[4 marks]

$\frac{R}{L^2}$ = gradient = $\frac{\rho}{5.83 \times 10^{-5}}$

ρ = gradient $\times 5.83 \times 10^{-5} = 650 \times 5.83 \times 10^{-5}$

$= 3.79$

$\rho =$ 3.8 * ✓ unit = Ωm ✓

* I gave this to 2sf, as I calculated the gradient to 2sf

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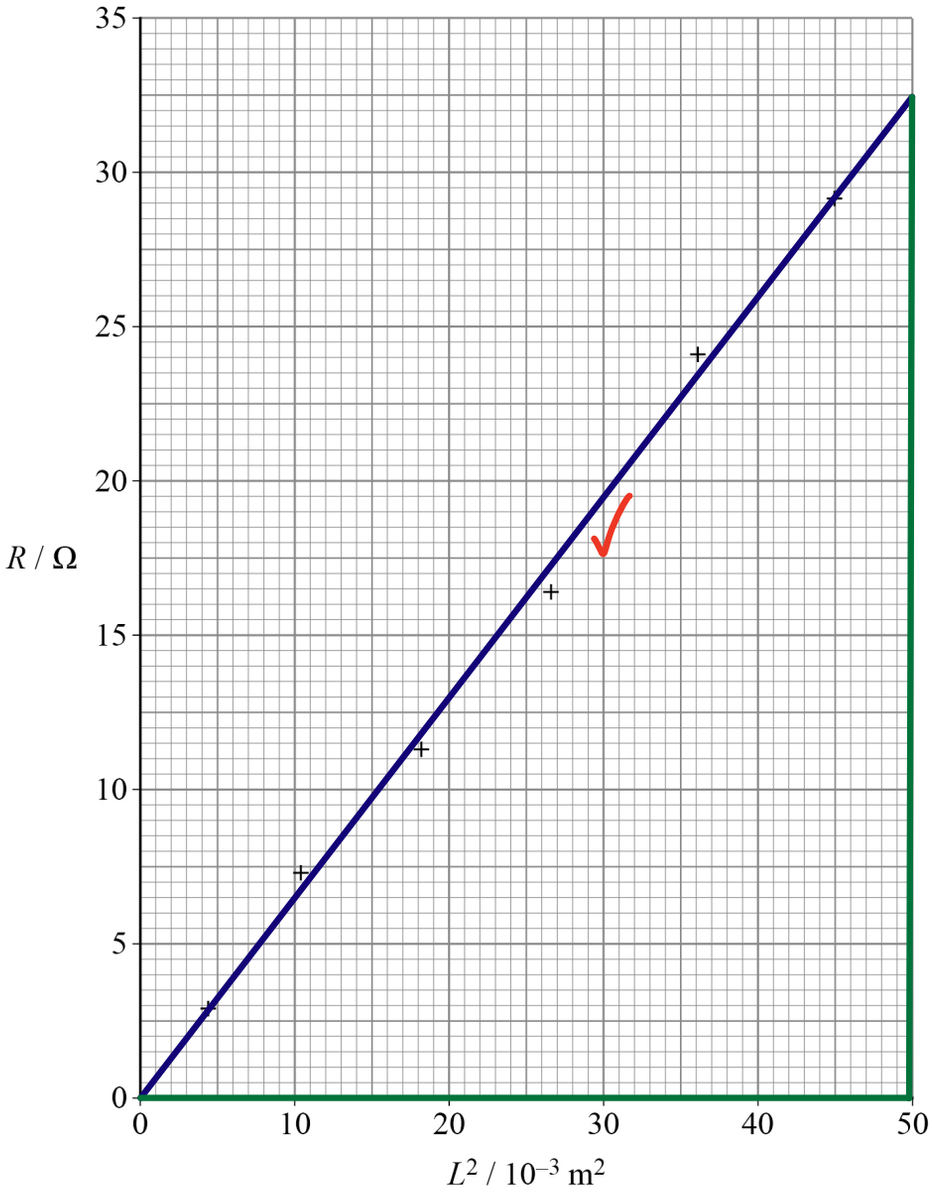
Figure 8



$\frac{\Delta y}{\Delta x} = \frac{32.5 - 0}{50 - 0} = 650\ \Omega m^2$ ✓

11

Turn over for the next question

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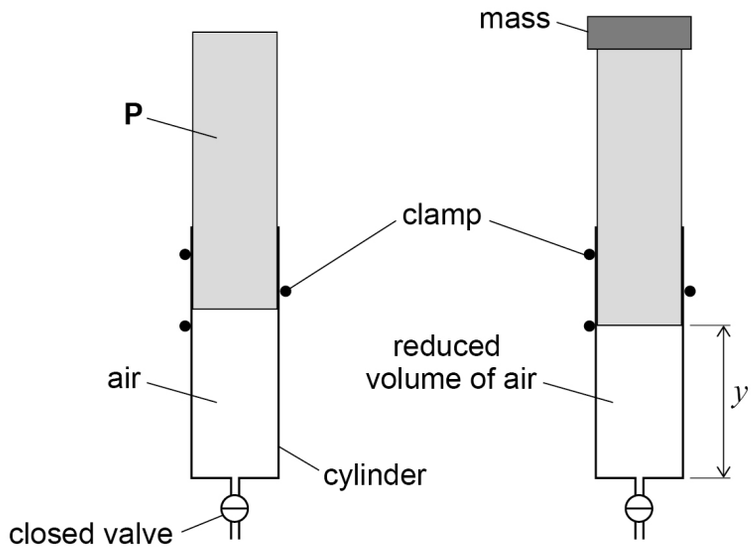
0 4 **Figure 9** shows air trapped in a vertical cylinder by a valve and a piston **P**.
The valve remains closed throughout the experiment.

A mass is placed on top of **P**.
P moves downwards and the volume of the trapped air decreases.
There are no air leaks and there is no friction between the cylinder and **P**.

Figure 9



The vertical distance y between the end of **P** and the closed end of the cylinder is measured.
Additional masses are used to find out how y depends on the total mass M placed on top of **P**.
Figure 10 shows a graph of these data.

0 4 . 1 Show that y is **not** inversely proportional to M.
Use data points from **Figure 10**.

[2 marks]

If $y \propto \frac{1}{M}$ $y = \frac{k}{M}$ $yM = k$ ✓

From graph $89 \times 0.5 = 44.5$
$71 \times 2.0 = 142$ ✓
$\therefore$ Not a constant

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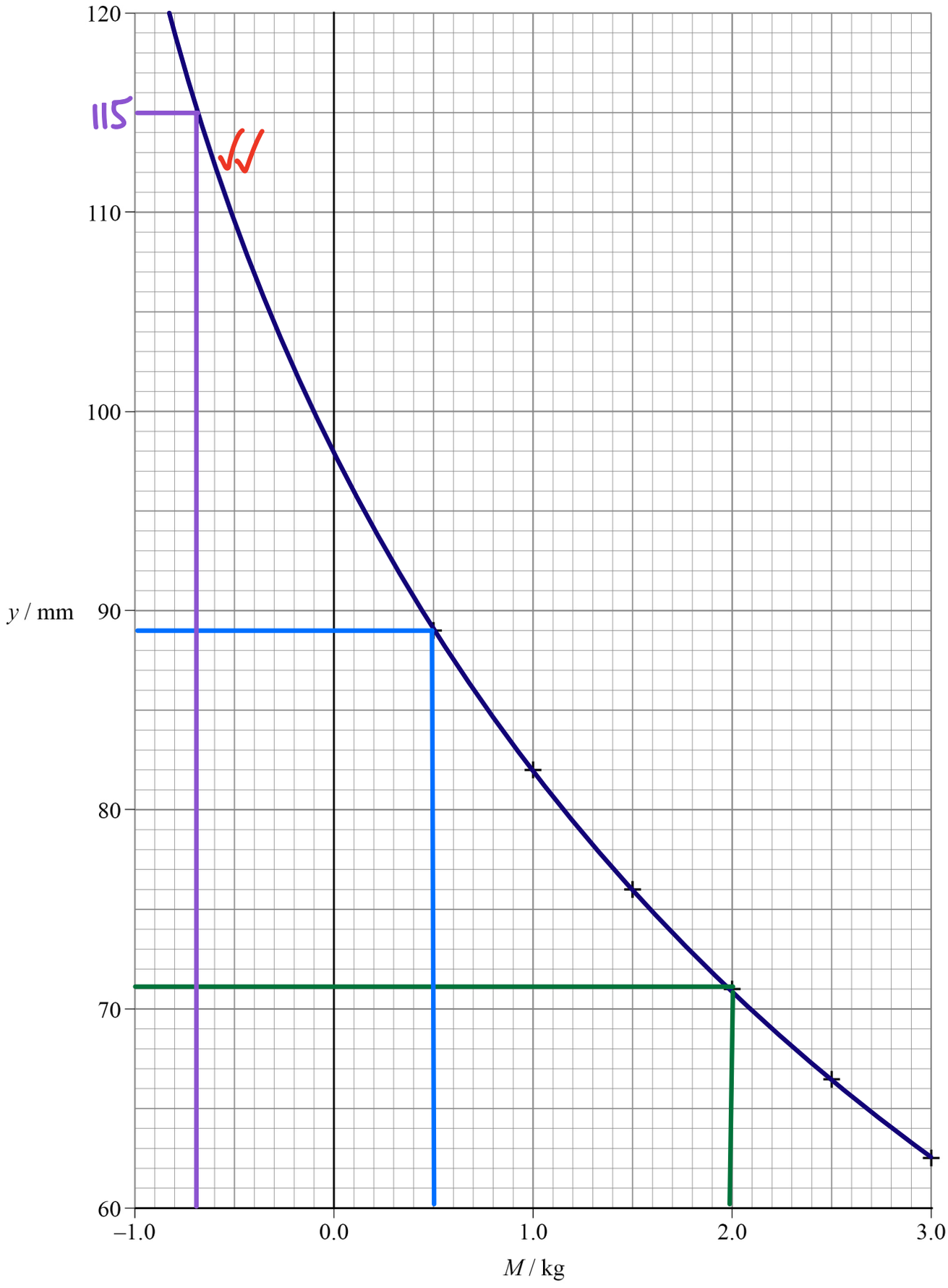
Figure 10



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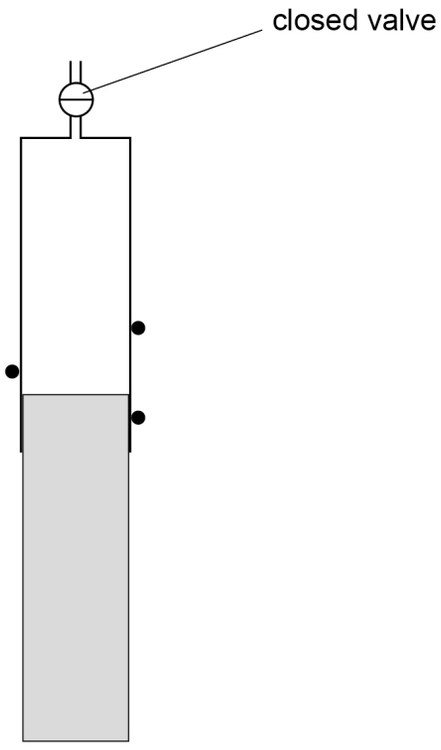
0 4 . 2 The masses are removed and the cylinder is inverted.
P moves downwards without friction before coming to rest, as shown in **Figure 11**.

Figure 11



Explain why **P** does not fall out of the cylinder unless the valve is opened.

[3 marks]

As P slides down, the volume of trapped air increases, decreasing the pressure. ✓
Atmospheric pressure acting on P greater than the inside pressure ✓ ∴ an upwards force acts on P that is equal to the weight of P. If valve is opened, the pressure inside is equal to atmospheric pressure ∴ resultant force on P is its weight so it falls. ✓

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0 4 . 3 The mass of **P** is $0.350\ \text{kg}$.

Deduce y when the cylinder is in the inverted position shown in **Figure 11**.

Draw a line of best fit on **Figure 10** to arrive at your answer.

[4 marks]

Initially $M = 0.35$ kg acting downwards on the air inside. Once removed $M = -0.35$.

Then inverted, force equivalent to $M = 0.35$ acts downwards.

$\therefore M = -0.70$ kg ✓

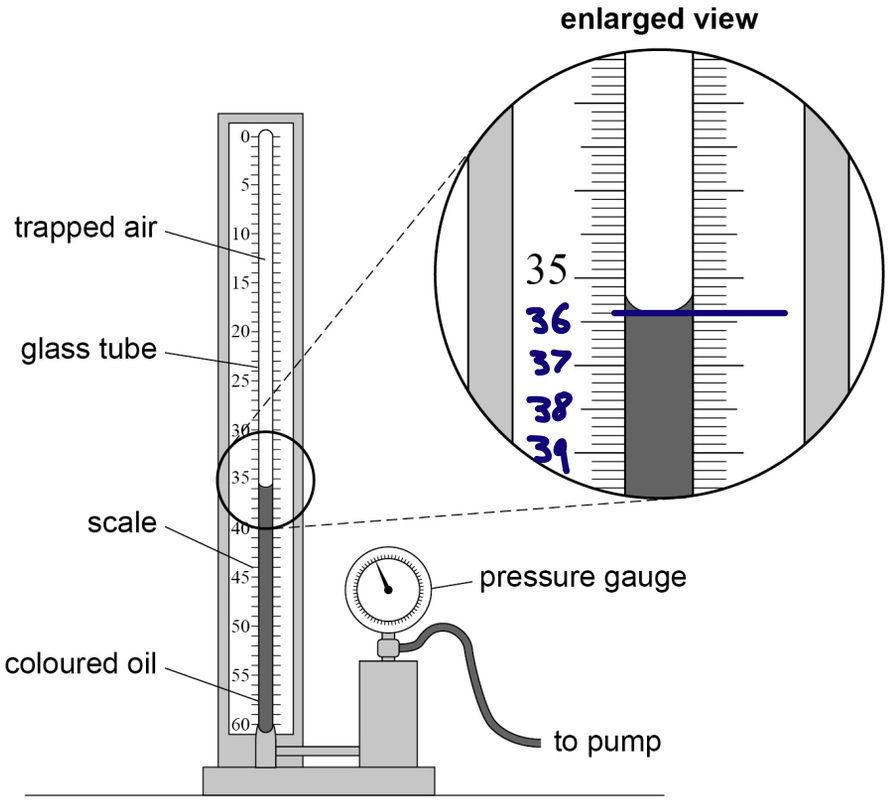
From graph, $y = 115$

$y =$ 115 ✓ mm

Question 4 continues on the next page

Figure 12 shows apparatus used in schools to investigate Boyle's law.

Figure 12



A fixed mass of air is trapped above some coloured oil inside a glass tube, closed at the top.
A pump applies pressure to the oil and the air.
The trapped air is compressed and its pressure p is read from the pressure gauge.

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0 4 . 4 A scale, marked in $0.2\ \text{cm}^3$ intervals, is used to measure the volume V of the air.
A student says that the reading for V shown in **Figure 12** is $35.4\ \text{cm}^3$.

State:

- the error the student has made
- the correct reading, in cm^3, of the volume.

[2 marks]

Reading has been taken at top of meniscus. ✓

volume = 35.8 ✓ cm^3

Question 4 continues on the next page

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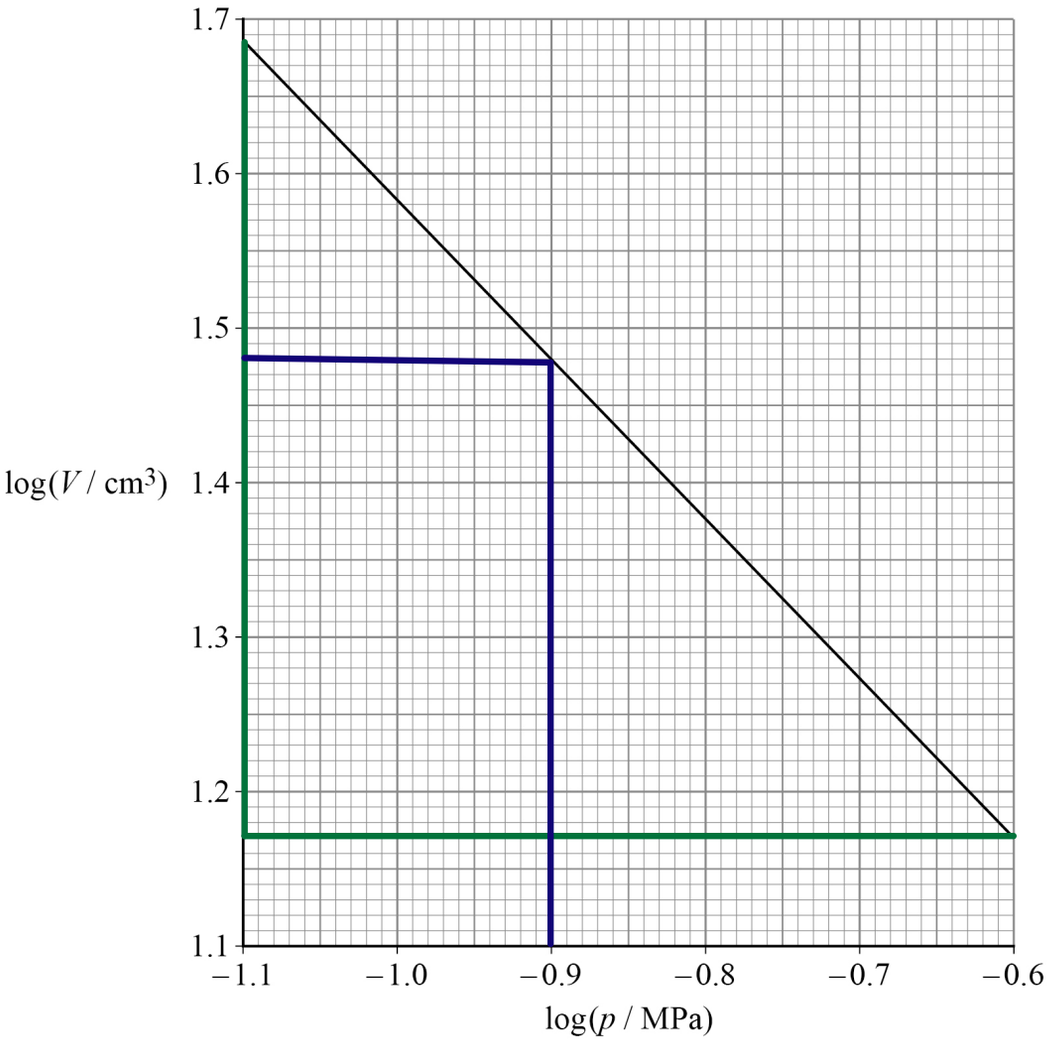
0 4 . 5 **Figure 13** shows data obtained using the apparatus in **Figure 12**.

Figure 13



Explain why the gradient of the graph in **Figure 13** confirms that the air obeys Boyle's law.

[3 marks]

$V \propto \frac{1}{P}$ $V = \frac{k}{P}$ $\log V = \log k - \log P$

$\log V = -\log P + \log k$ ✓

$y = mx + c$

$\therefore$ gradient should equal -1 ✓

$\frac{\Delta y}{\Delta x} = \frac{1.17 - 1.685}{-0.60 - (-)1.10} = -1.03$ ✓ ≈ 1

$\therefore$ obeys Boyle's law

0.34 MPa

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0 4 . 6 The largest pressure that can be read from the pressure gauge is 3.4×10^5 Pa.

Determine, using **Figure 13**, the volume V corresponding to this pressure.

[3 marks]

$\log p = -0.90$ $\log V = 1.48$ $m = -1.03$

Values from the graph

$\log V = -\log P + \log k$ ✓

$\log k = \log V - 1.03 \log P$

$\log k = 1.48 - (1.03 \times -0.90) = 0.553$

$\log V = -\log P + \log k = (-1.03 \times \log 0.34) + 0.553$ ✓

$\log V = 1.0356$

$V = 10^{1.0356} = 10.85$

$V =$ 10.9 ✓ cm^3

0 4 . 7 State **one** property of the air that must not change during the experiment.
Go on to suggest how this can be achieved.

[2 marks]

Temperature ✓ must remain constant, by changing the pressure of the gas slowly. ✓

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END OF QUESTIONS

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