AQA

Please write clearly in block capitals.

Centre number | | | | | |

Candidate number | | | | |

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________
I declare this is my own work.

A-level
PHYSICS

Paper 3
Section A

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	
3	
4	
TOTAL	

J U N 2 2 7 4 0 8 3 A 0 1

IB/M/Jun22/E8

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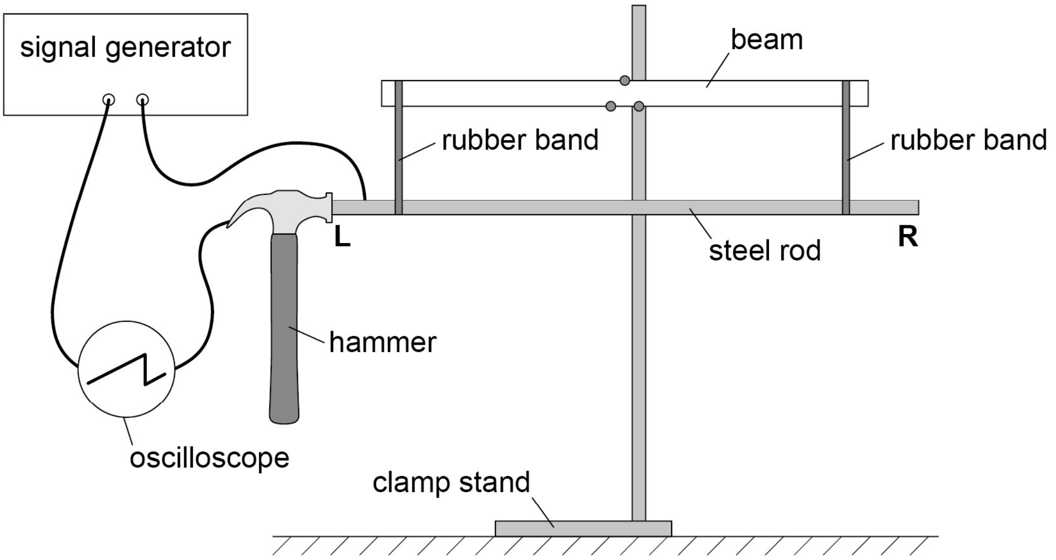
Section A

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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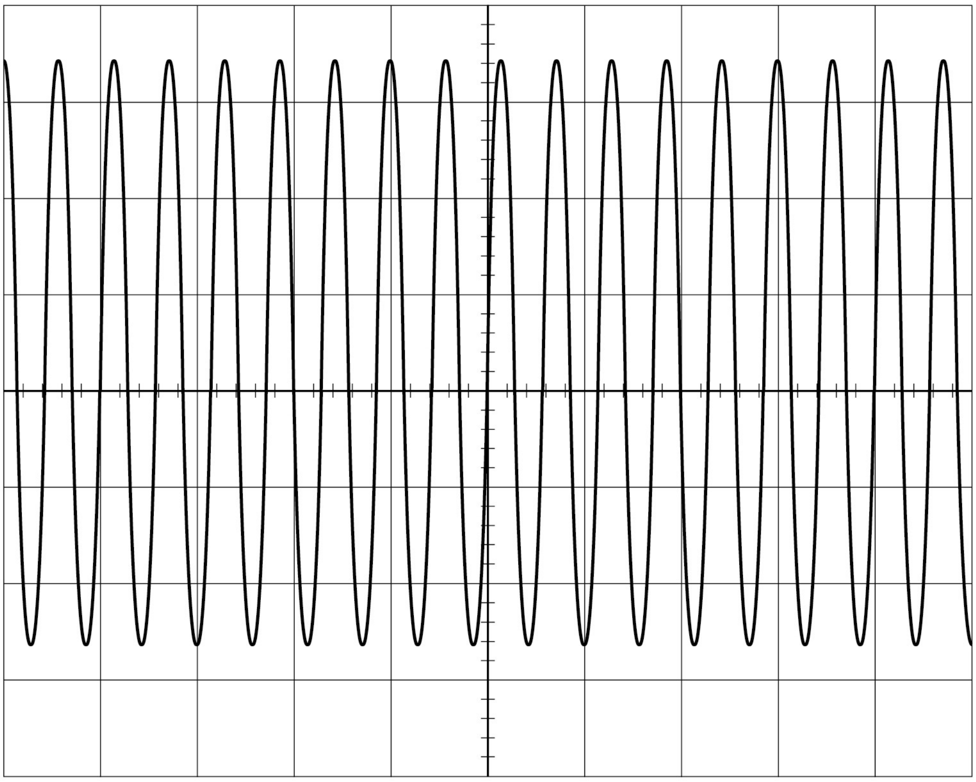
Figure 2



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 ☐

Question 1 continues on the next page

Turn over ►

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

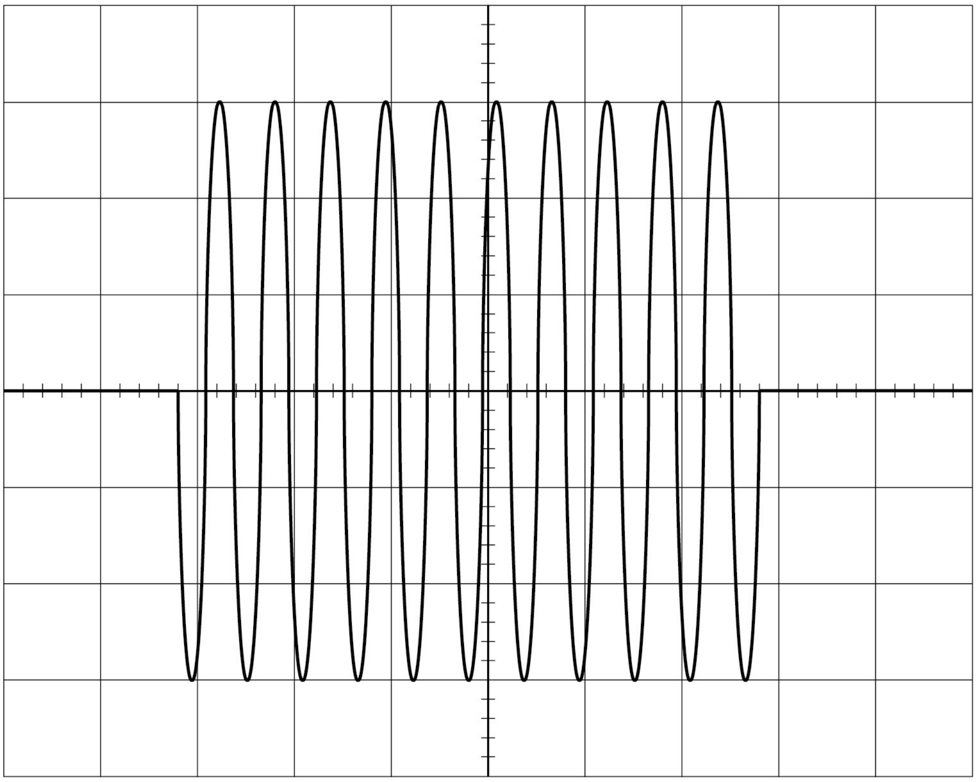
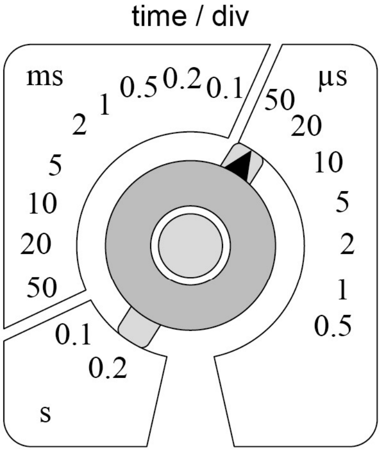


Figure 4 shows the time-base setting of the oscilloscope.

Figure 4



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0 1 . 2 The distance between **L** and **R** in **Figure 1** is 0.870 m.

Deduce the speed of sound in the steel rod.

[3 marks]

speed of sound = ____________________ $m\ s^{-1}$

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]

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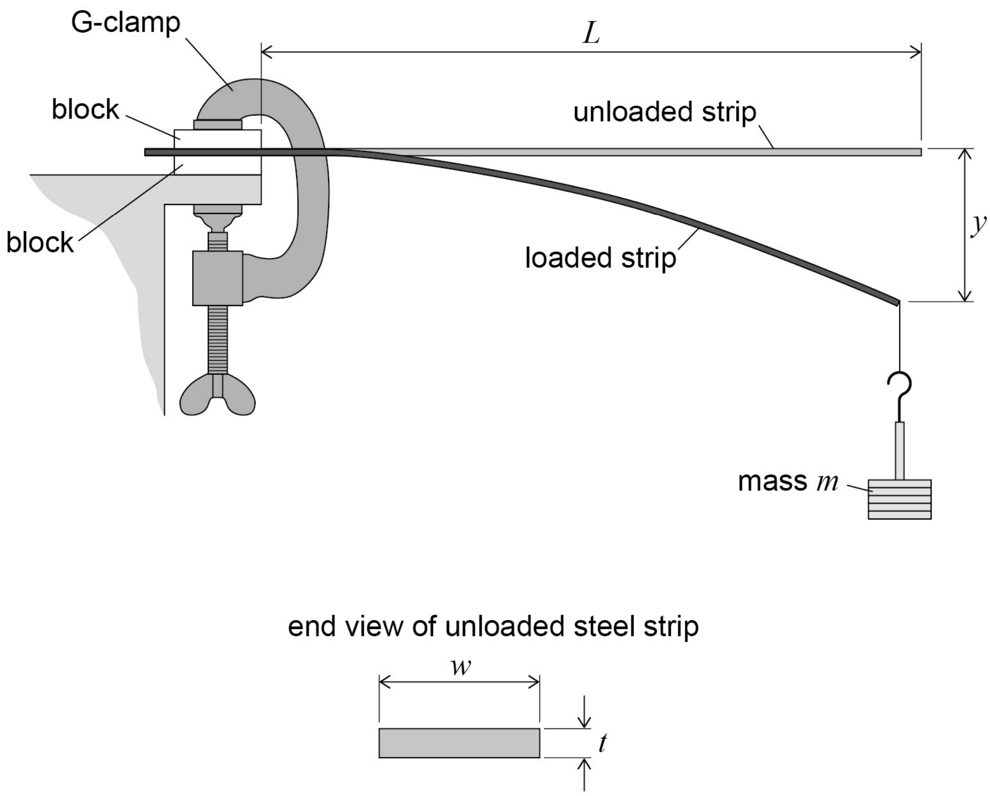
0 2 **Figure 5** shows a strip of steel of rectangular cross-section clamped at one end. The strip extends horizontally over the edge of a bench.

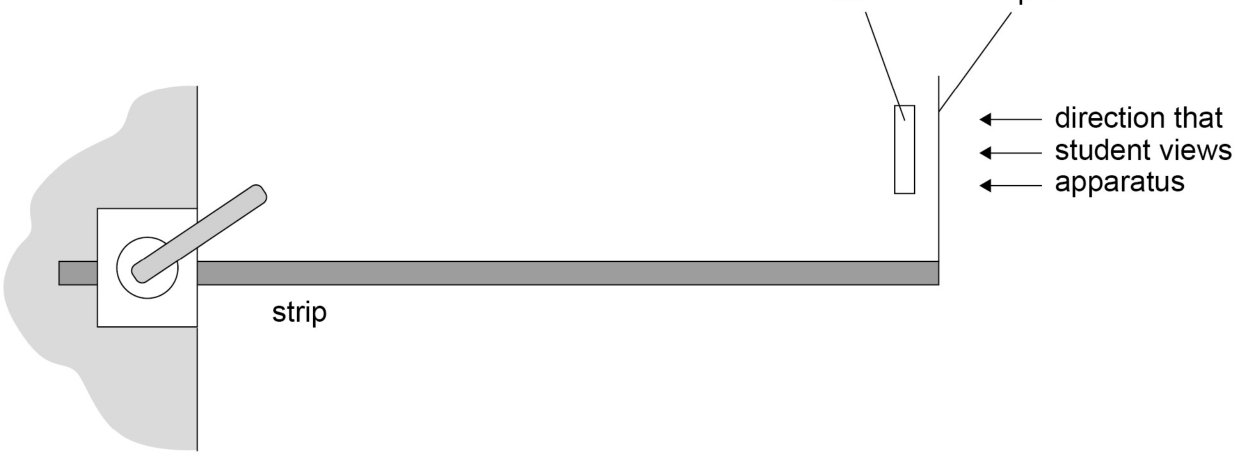
Figure 5



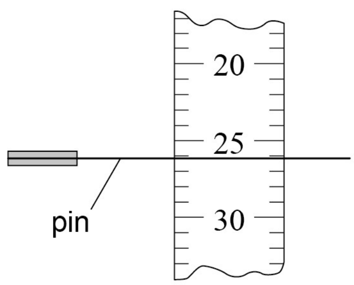
0 2 . 1 A mass m is suspended from the free end of the strip.
This produces a vertical displacement y.
A student intends to measure y with the aid of a horizontal pin fixed to the free end of the steel strip.
She positions a clamped vertical ruler behind the pin, as shown in **Figure 6**.

Figure 6

plan view



view seen by student



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]

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Question 2 continues on the next page

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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 cm
t is the thickness of the strip and is approximately 1 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 cm is available
- m must be made using a 50 g mass hanger and up to four additional 50 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]

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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]

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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]

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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]

uncertainty = ____________________ mm^3

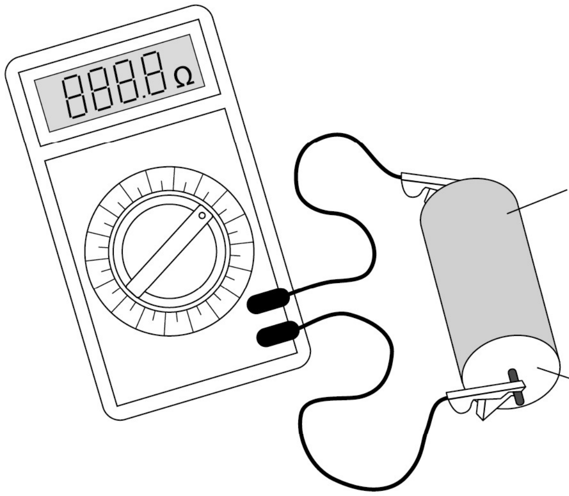
Question 3 continues on the next page

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 5.83×10^{-5} 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]

ρ = ______________________ unit = ______________________

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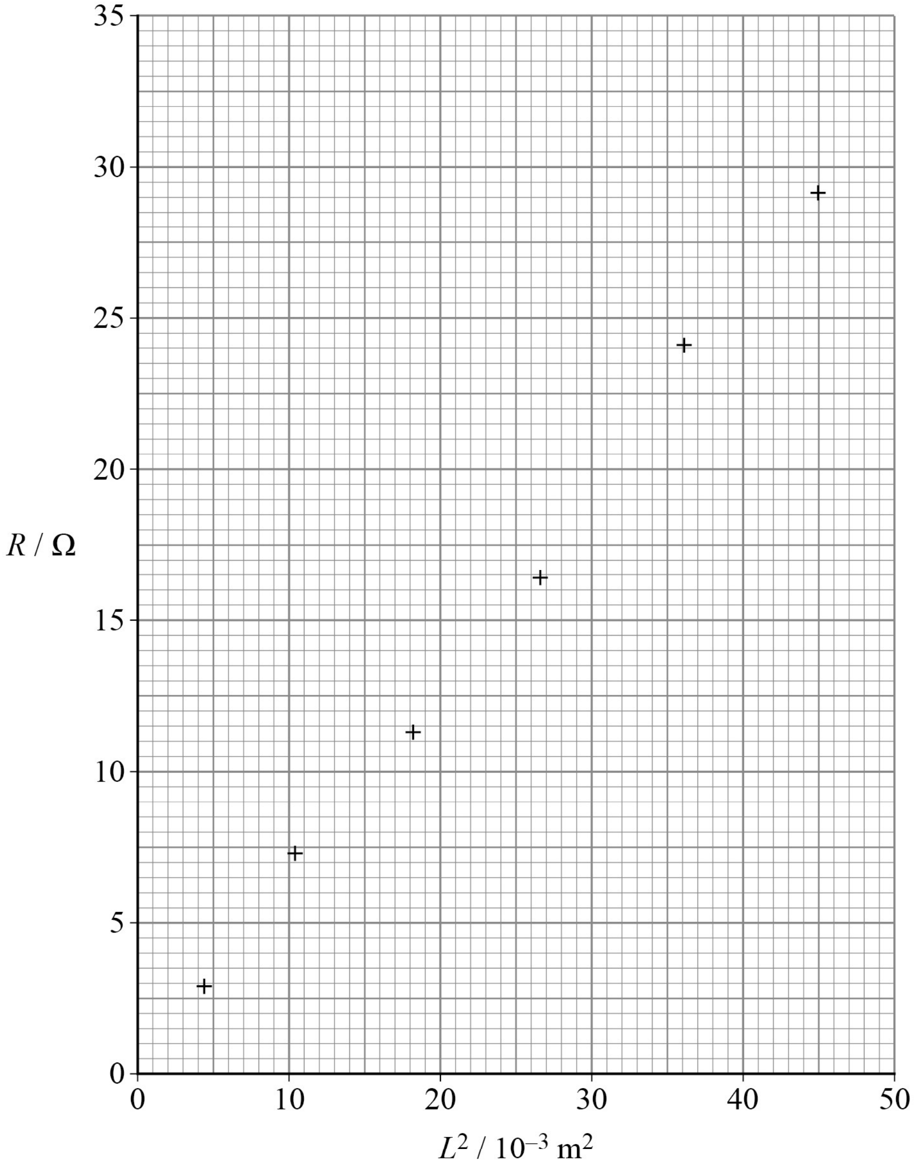
Figure 8



11

Turn over for the next question

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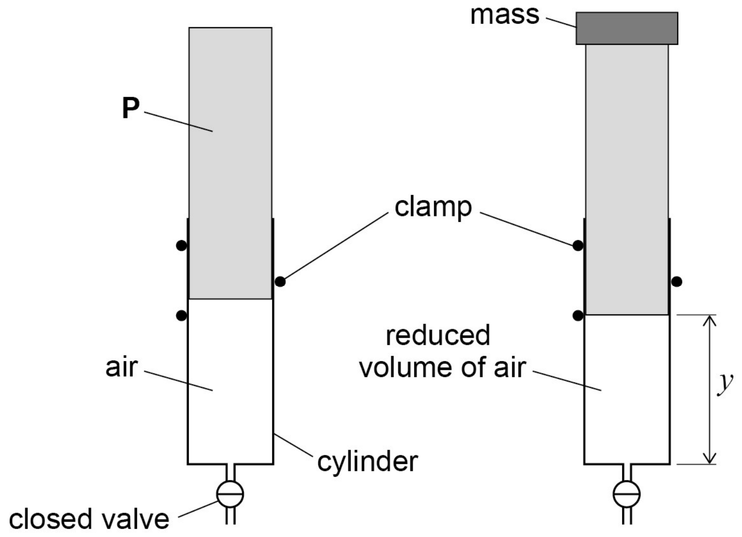
0 4 **Figure 9** shows air trapped in a vertical cylinder by a valve and a piston **P**.
The valve remains closed throughout the experiment.

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]

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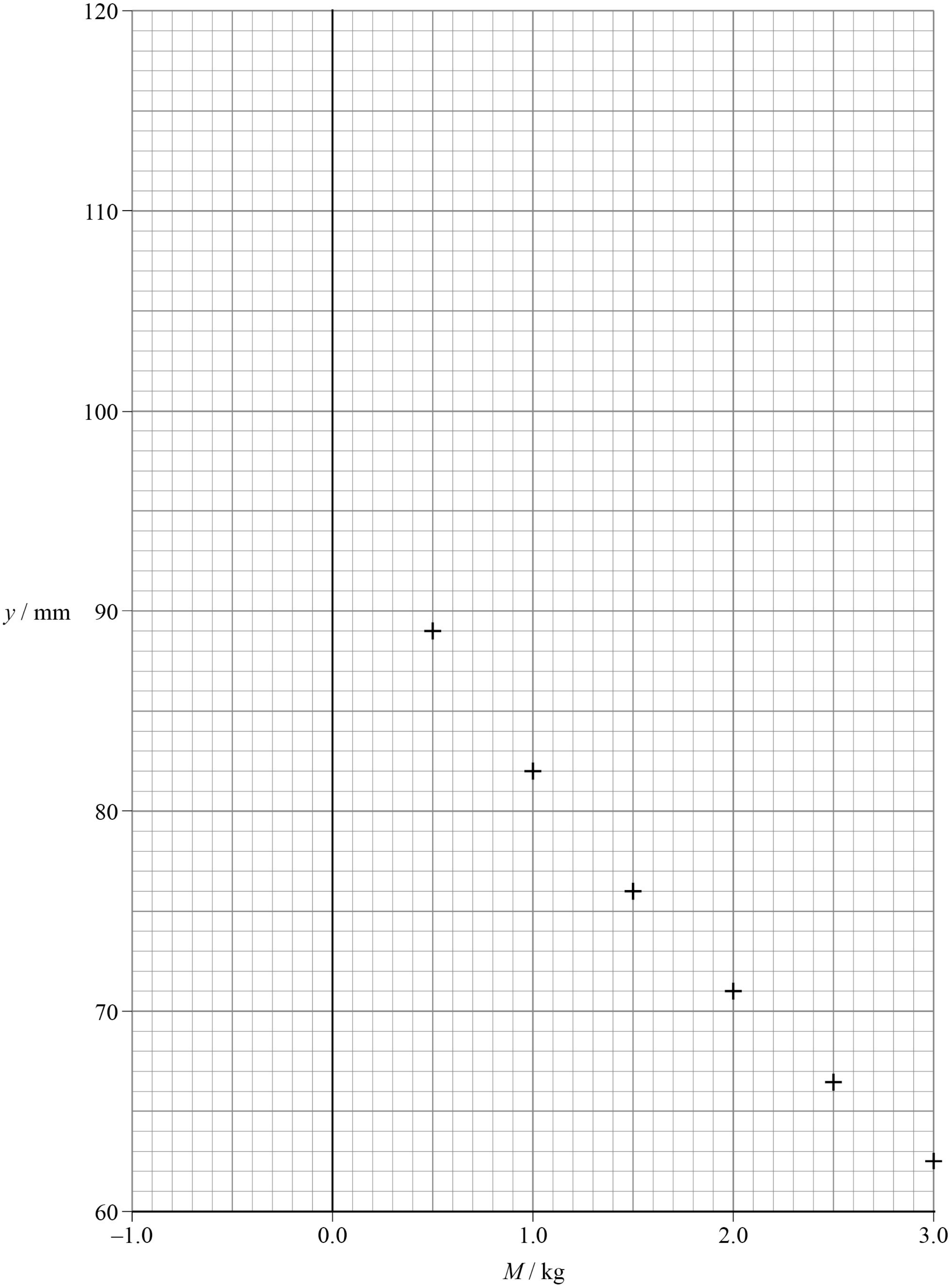
Figure 10



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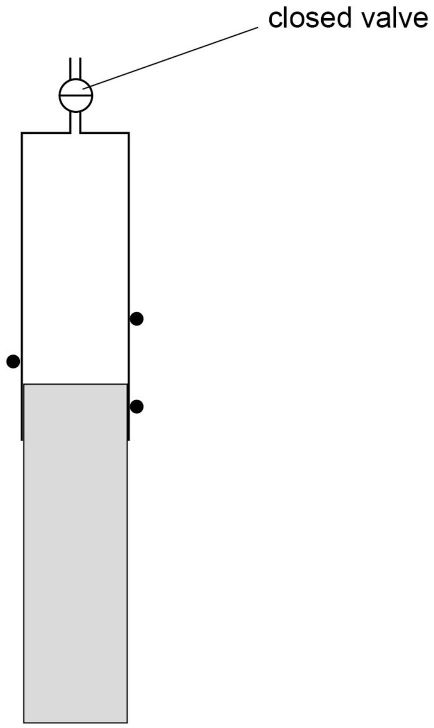
0 4 . 2 The masses are removed and the cylinder is inverted.
P moves downwards without friction before coming to rest, as shown in **Figure 11**.

Figure 11



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

[3 marks]

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0 4 . 3 The mass of **P** is 0.350 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]

y = ______________________ mm

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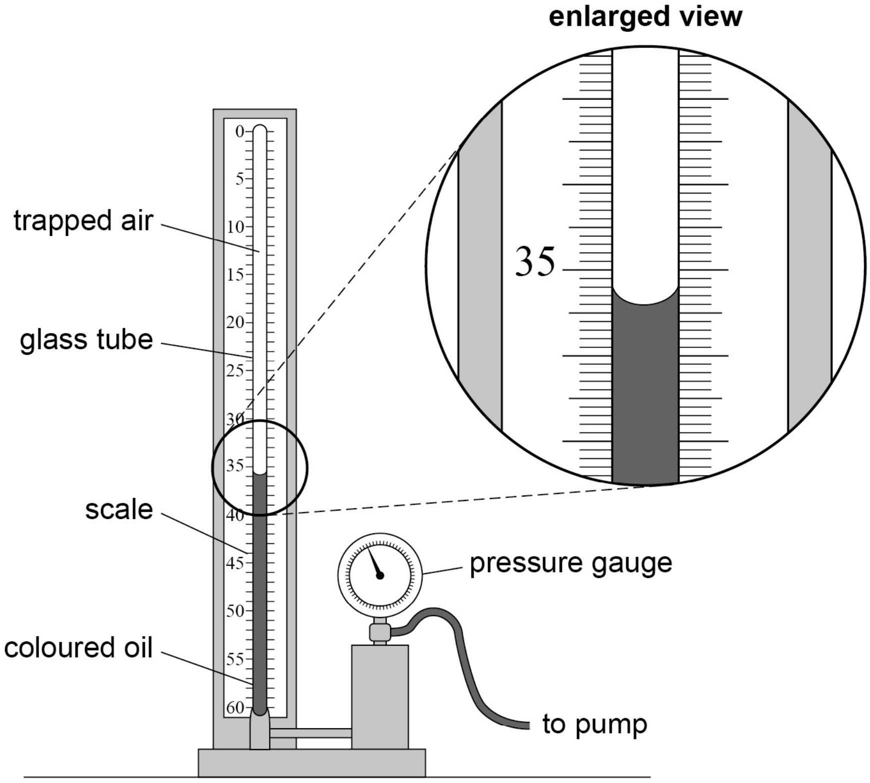
Figure 12 shows apparatus used in schools to investigate Boyle's law.

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]

volume = ______________________ cm^3

Question 4 continues on the next page

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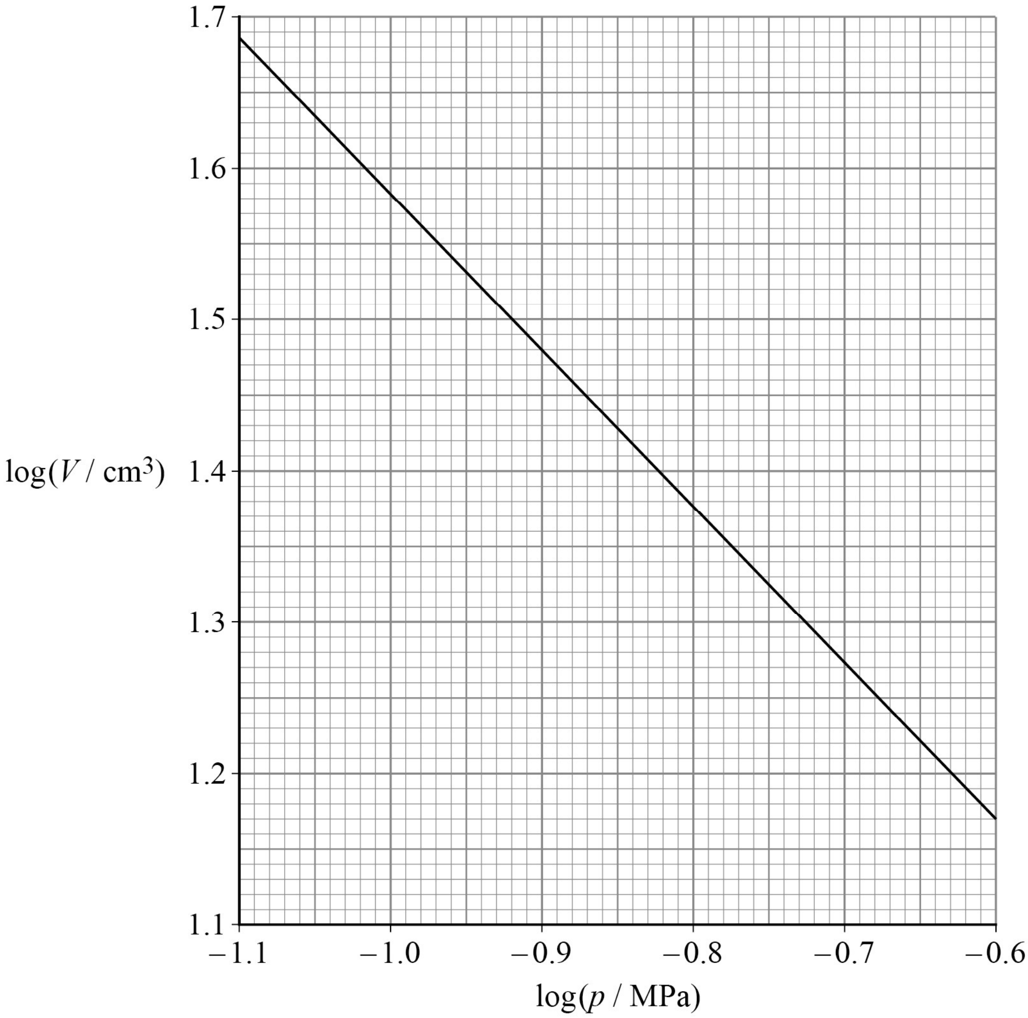
0 4 . 5 **Figure 13** shows data obtained using the apparatus in **Figure 12**.

Figure 13



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

[3 marks]

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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]

$V =$ ____________________ 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]

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END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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