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

Friday 5 June 2020 Afternoon

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.

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	
TOTAL	

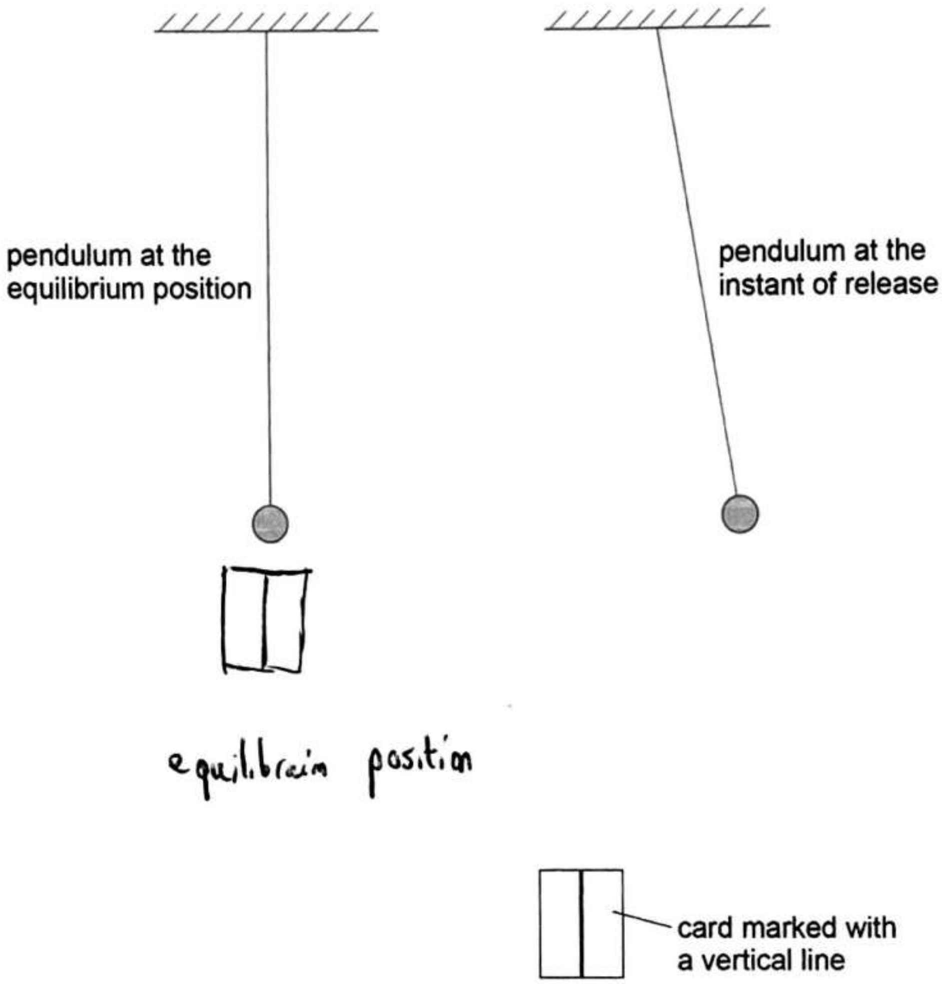
Section A

Answer **all** questions in this section.

0 1 A simple pendulum performs oscillations of period T in a vertical plane.

Figure 1 shows views of the pendulum at the equilibrium position and at the instant of release. **Figure 1** also shows a rectangular card marked with a vertical line.

Figure 1



0 1 . 1 The card can be used as a fiducial mark to reduce uncertainty in the measurement of T.

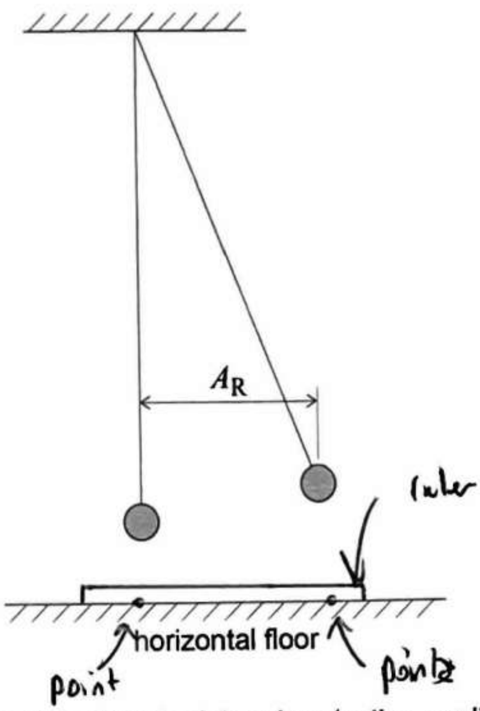
Annotate **Figure 1** to show a suitable position for the fiducial mark.
Explain why you chose this position.

[2 marks]

This is where the pendulum is moving fastest.

0 1 . 2 The period of the pendulum is constant for small-amplitude oscillations.
Figure 2 shows an arrangement used to determine the maximum amplitude that can be considered to be small, by investigating how T varies with amplitude.

Figure 2



Describe a suitable procedure to determine A_R, the amplitude of the pendulum as it is released.
You may add detail to **Figure 2** to illustrate your answer.

[2 marks]

place a ruler horizontal as shown on the diagram, and use it to measure the distance between the point, to find A_R. To eliminate parallax error, use a set square with a vertical edge.

Question 1 continues on the next page

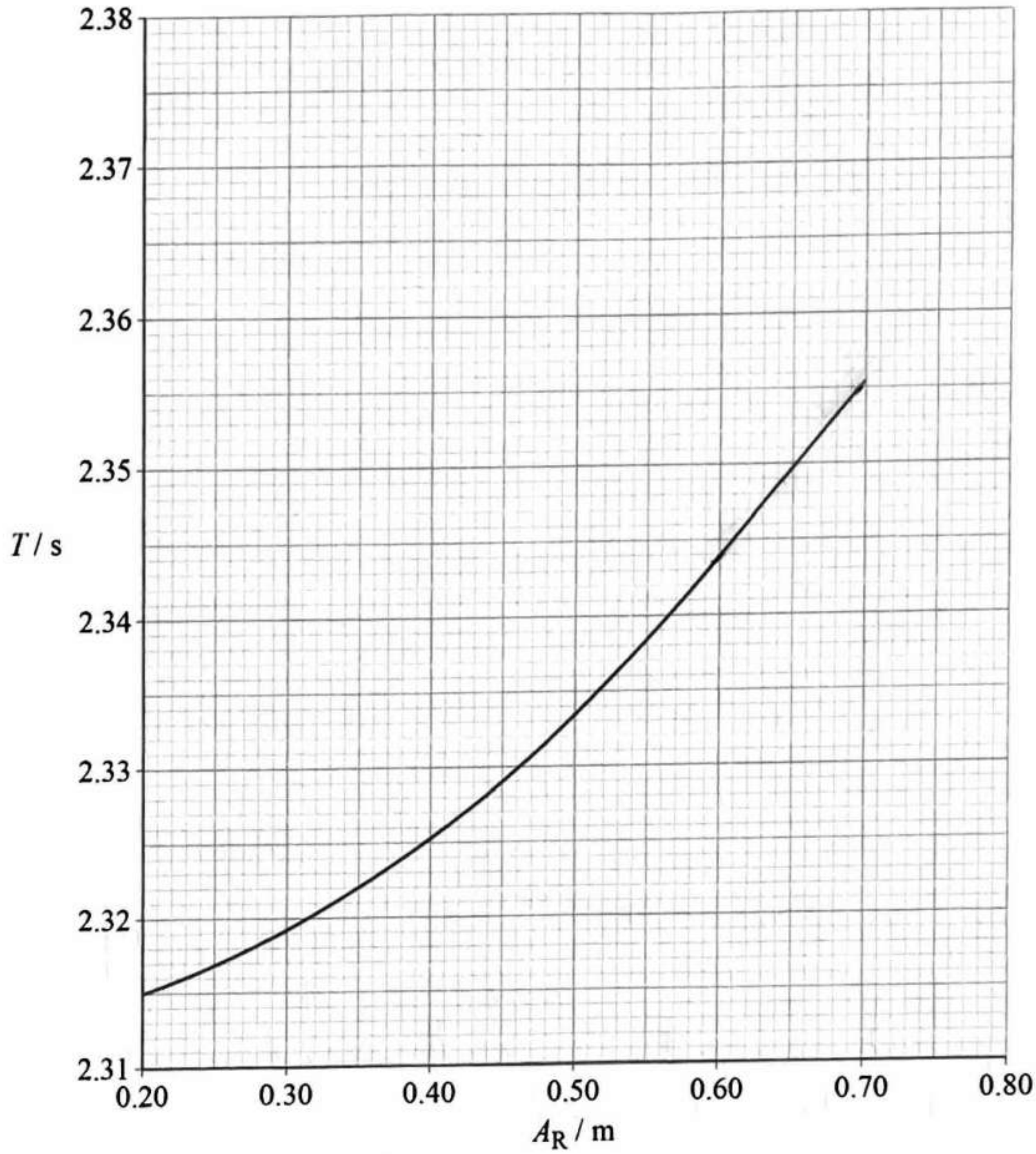
Turn over ▶

IB/M/Jun20/7408/3A

Do not write outside the box

0 1 . 3 **Figure 3** shows some of the results of the experiment.

Figure 3



Estimate, using **Figure 3**, the expected percentage increase in T when A_R increases from 0.35 m to 0.70 m.
Show your working.

[3 marks]

$A_R = 0.35$ m $T = 2.322$

$A_R = 0.70$ m $T = 2.355$

$$\frac{2.355}{2.322} \times 100 = 101.4\%$$

percentage increase = 1.4 %

Question 1 continues on the next page

In another experiment the pendulum is released from a fixed amplitude.
The amplitudes A_n of successive oscillations are recorded, where $n = 1, 2, 3, 4, 5...$.

Table 1 shows six sets of readings for the amplitude A_5.

Table 1

A_5 / m	0.217	0.247	0.225	0.223	0.218	0.224

0 1 . 4 Determine the result that should be recorded for A_5.
Go on to calculate the percentage uncertainty in this result.

[3 marks]

I would disregard the anomalous result 0.247.
Then I would use the values to calculate a mean.

$\frac{0.217 + 0.225 + ...}{5} = 0.221$ m

$\Delta x = \frac{0.225 - 0.217}{2} = 4 \times 10^{-3}$

$A_5 =$ 0.221 m

percentage uncertainty = $\pm 4 \times 10^{-3}$ %

0 1 . 5 **Table 2** shows results for A_n and the corresponding value of $\ln(A_n / \text{m})$ for certain values of n.

Table 2

n	A_n / m	$\ln(A_n / \text{m})$
2	0.238	−1.435
4	0.225	−1.492
7	0.212	−1.551
10	0.194	−1.640
13	0.183	−1.698

Complete **Table 2**.

[1 mark]

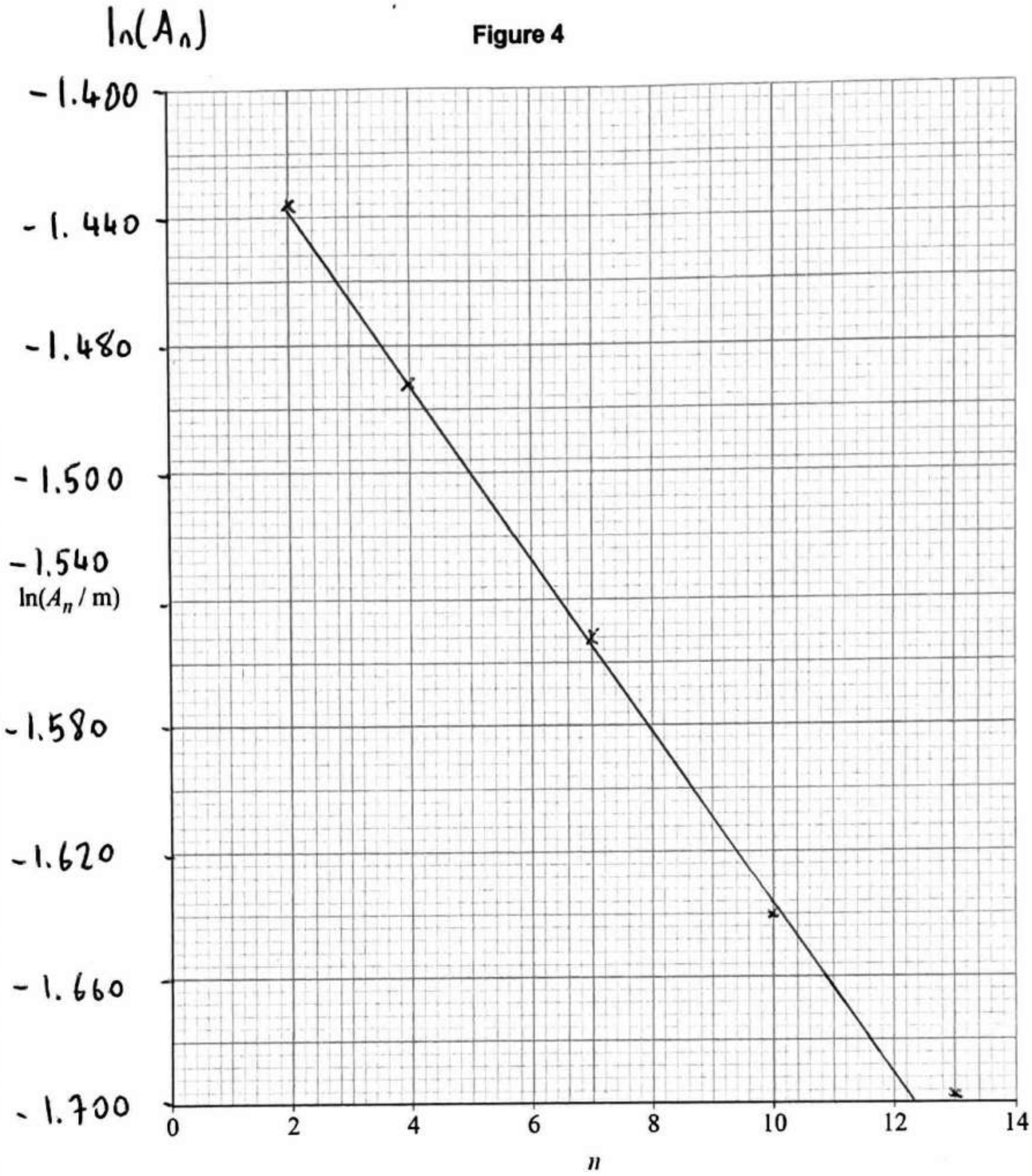
Maths Made Easy

Do not write outside the box

0 1 . 6 Plot on **Figure 4** a graph of $\ln(A_n / \mathrm{m})$ against n.

[2 marks]

Figure 4



Question 1 continues on the next page

0 1 . 7 It can be shown that

$$A_n = A_0\, \delta^{-n}$$

where A_0 is the amplitude of release of the pendulum
δ is a constant called the damping factor.

Explain how to find δ from your graph.
You are **not** required to determine δ.

[2 marks]

$\ln(A_n) = \ln(A_0 \delta^{-n})$

$\ln(A_n) = \ln A_0 + \ln \delta^{-n}$

$\ln A_n = \ln A_0 - n \ln \delta$

using $y = mx + c$

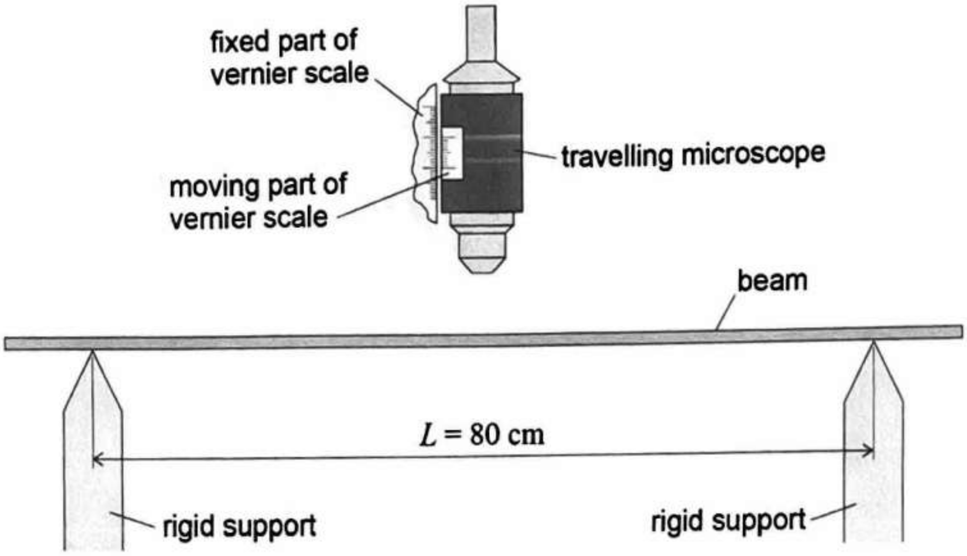
y is $\ln A_n$ $\quad -\ln \delta =$ gradient

$e^{-\text{gradient}} = \delta$

15

0 2 **Figure 5** shows apparatus used to investigate the bending of a beam.

Figure 5



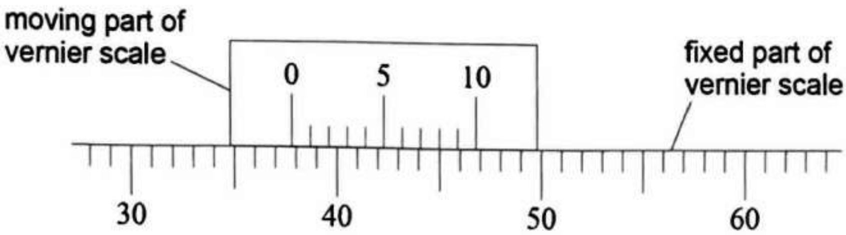
The beam is placed horizontally on rigid supports.
The distance L between the supports is 80 cm.

A travelling microscope is positioned above the midpoint of the beam and focused on the upper surface.

Do not write outside the box

0 2 . 1 **Figure 6** shows an enlarged view of both parts of the vernier scale.

Figure 6



The smallest division on the fixed part of the scale is 1 mm.

What is the value of the vernier reading R_0 in mm?
Tick (✓) **one** box.

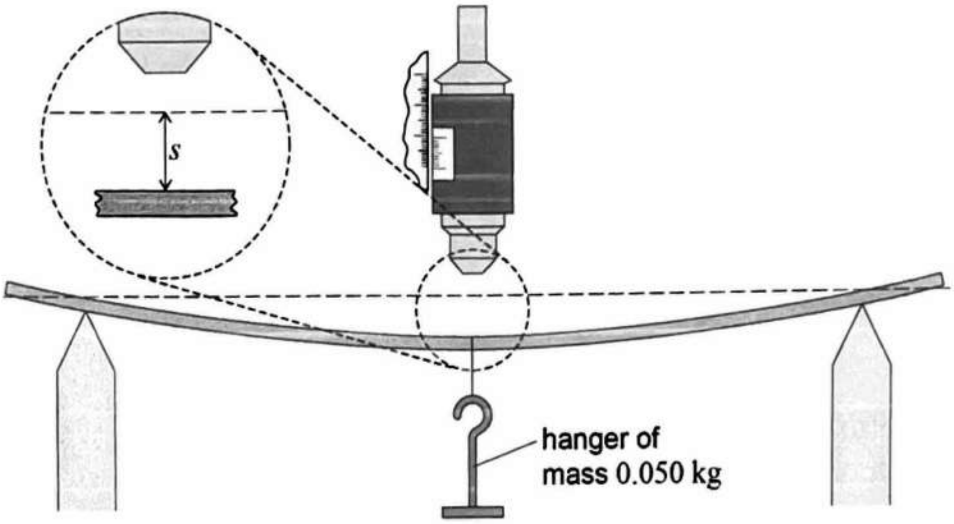
[1 mark]

34.8	☐
37.8	☑
45.8	☐
49.8	☐

Question 2 continues on the next page

0 2 . 2 **Figure 7** shows the beam bending when a hanger of mass 0.050 kg is suspended from the midpoint.

Figure 7



The microscope is refocused on the upper surface and the new vernier reading R is recorded.
The vertical deflection s of the beam is equal to $(R - R_0)$.

The total mass m suspended from the beam is increased in steps of 0.050 kg.
A value of s is recorded for each m up to a value of $m = 0.450$ kg.
Further values of s are then recorded as m is decreased in 0.050 kg steps until m is zero.

Student **A** performs the experiment and observes that values of s during unloading are **sometimes** different from the corresponding values for loading.

State the type of error that causes the differences student **A** observes.

[1 mark]

random error

0 2 . 3 Student **B** performs the experiment using a thinner beam but with the same width and made from the same material as before.

Discuss **one** possible advantage and **one** possible disadvantage of using the thinner beam.

[3 marks]

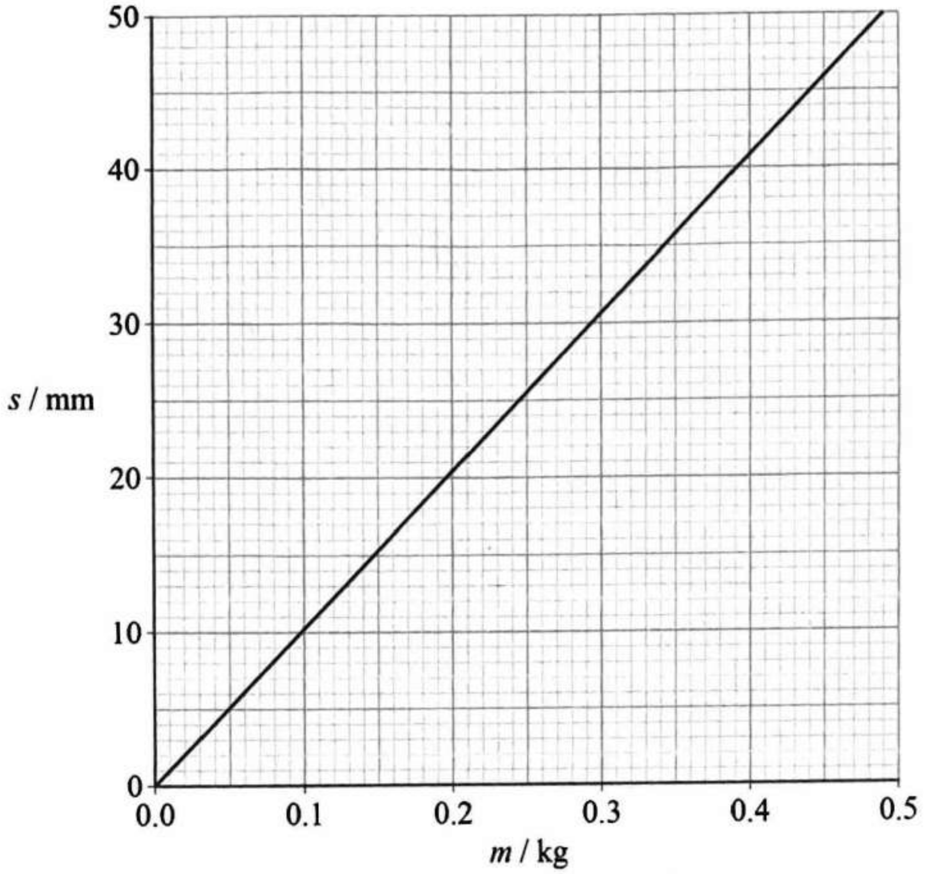
Advantage An advantage of using the thinner beam is that the same applied load produces large values of s. This means the error in s is reduced.

Disadvantage The beam could undergo plastic deformation, meaning the graph will be non-linear.

Question 2 continues on the next page

0 2 . 4 **Figure 8** shows the best-fit line produced using the data collected by student **A**.

Figure 8



It can be shown that $s = \dfrac{\eta m}{E}$

where E is the Young modulus of the material of the beam and η is a constant.

~~$\frac{s}{m} = \frac{\eta}{E}$~~

~~$\frac{50 \times 10^{-3}}{0.49} = \frac{\eta}{E}$~~

~~$E = \eta / 0.102$~~

~~$E = 9.8\eta$~~

~~$E = \eta / 0.102$~~

Deduce in s^{-2} the order of magnitude of η.

$E = 1.14$ GPa

[4 marks]

$$\frac{S}{m} = \frac{\eta}{E}$$

$$1.14 \times 10^9 \times \frac{50 \times 10^{-3}}{0.49} = 1.16 \times 10^8$$

order of magnitude of η = 10^8 s^{-2}

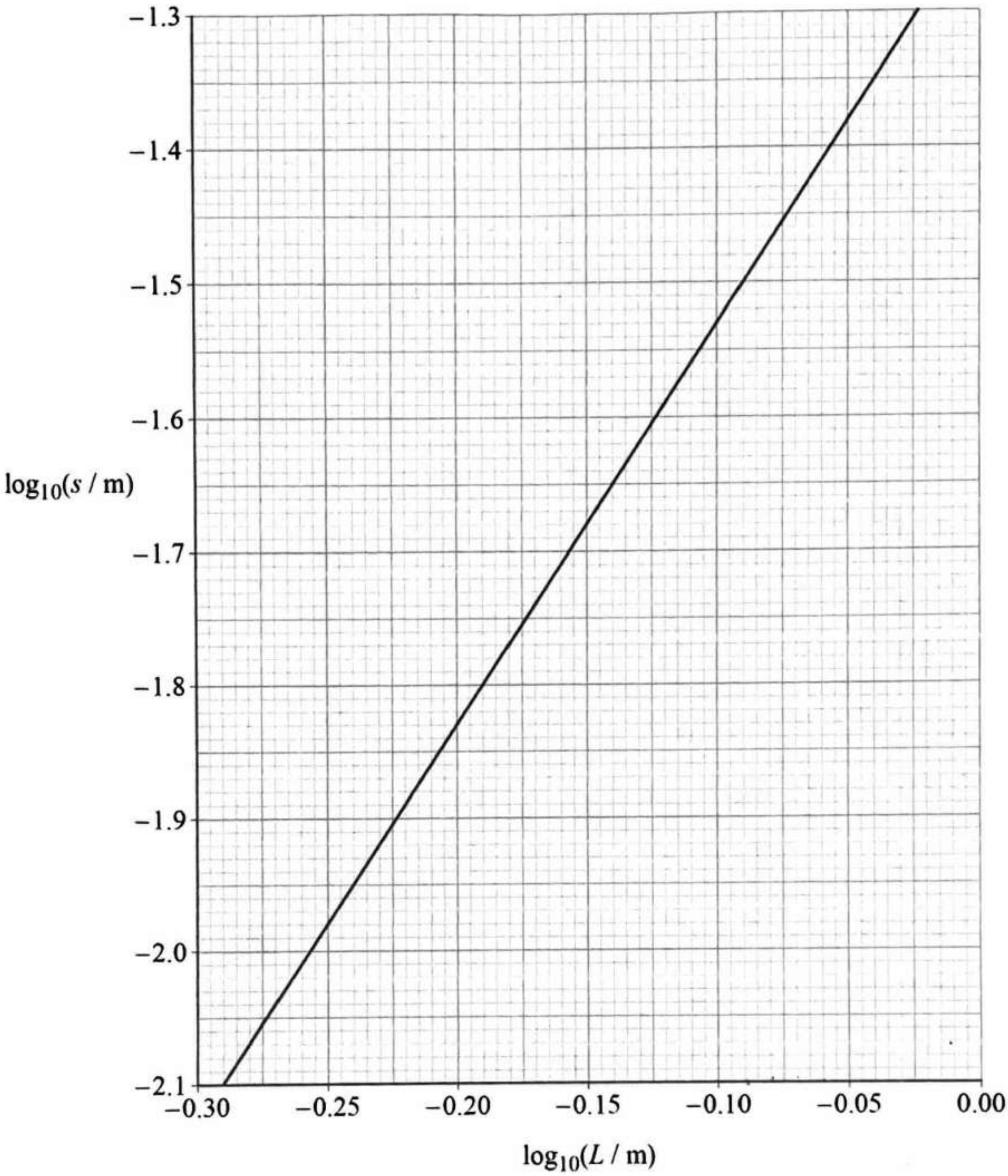
Question 2 continues on the next page

Turn over ▶

0 2 . 5 Student **C** performs a different experiment using the same apparatus shown in **Figure 5** on page 10.
A mass M is suspended from the midpoint of the beam.
The vertical deflection s of the beam is measured for different values of L.

Figure 9 shows a graph of the results for this experiment.

Figure 9



Do not write outside the box

Figure 9 shows that $\log_{10}(s\ /\ \text{m})$ varies linearly with $\log_{10}(L\ /\ \text{m})$.

State what this shows about the mathematical relationship between s and L.
You do **not** need to do a calculation.

[1 mark]

$s \propto L^n$

0 2 . 6 Deduce, using **Figure 9**, the value of s when $L = 80$ cm.

[2 marks]

$\log_{10}(80 \times 10^{-2})$

$= -0.097$

-1.52

$\log_{10}(s) = -1.52$

$10^{-1.52} = 0.03$ m

$s =$ 0.0030 m

0 2 . 7 Determine M using **Figure 8**.

[1 mark]

Gradient of figure 8 =

$\frac{50 \times 10^{-3}}{49} = 0.102$

$M = 0.102 \times 0.003$

$= 3 \times 10^{-4}$

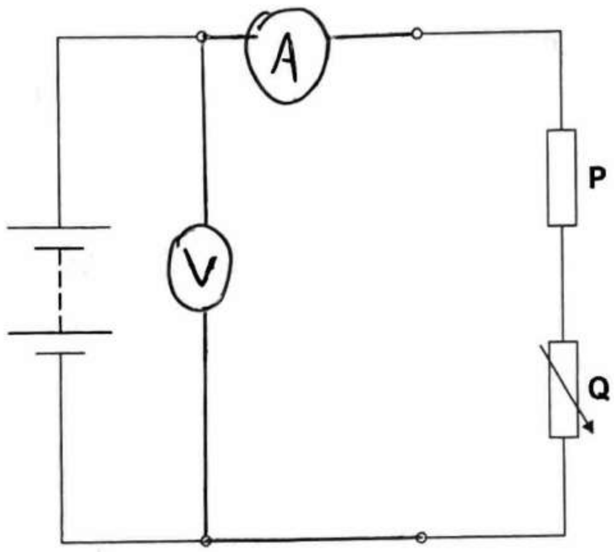
$M =$ ~~0.01~~ 3.1×10^{-4} kg

13

0 3 **Figure 10** shows a partly-completed circuit used to investigate the emf ε and the internal resistance r of a power supply.

The resistance of **P** and the maximum resistance of **Q** are unknown.

Figure 10



0 3 . 1 Complete **Figure 10** to show a circuit including a voltmeter and an ammeter that is suitable for the investigation.

[1 mark]

0 3 . 2 Describe

- a procedure to obtain valid experimental data using your circuit
- how these data are processed to obtain ε and r by a graphical method.

[4 marks]

1st read the values on the ammeter and voltmeter and record these. Then change the resistance of the variable resistor, Q, and take repeat readings at different resistances. Then plot a graph of V against I.

ε = ~~a vertical~~ y axis intercept

r = - gradient

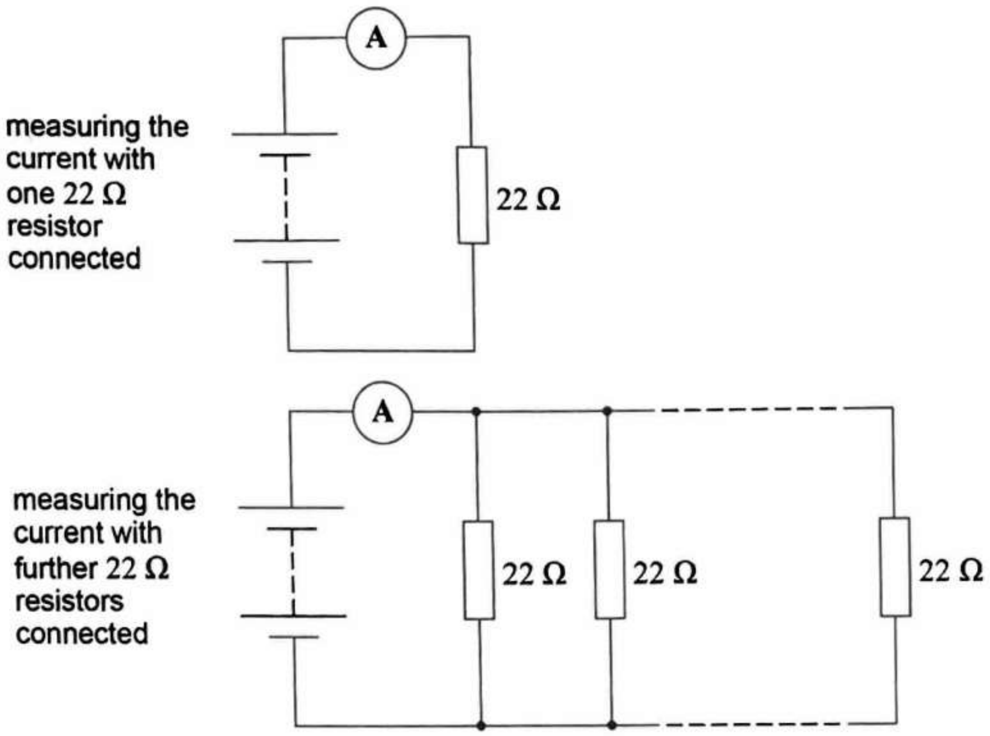
(V = r I + ε equation)

Question 3 continues on the next page

Do not write outside the box

Figure 11 shows a different experiment carried out to confirm the results for ε and r.

Figure 11



Initially the power supply is connected in series with an ammeter and a 22 Ω resistor. The current I in the circuit is measured.

The number n of 22 Ω resistors in the circuit is increased as shown in **Figure 11**. The current I is measured after each resistor is added.

It can be shown that

$$\frac{22}{n} = \frac{\varepsilon}{I} - r$$

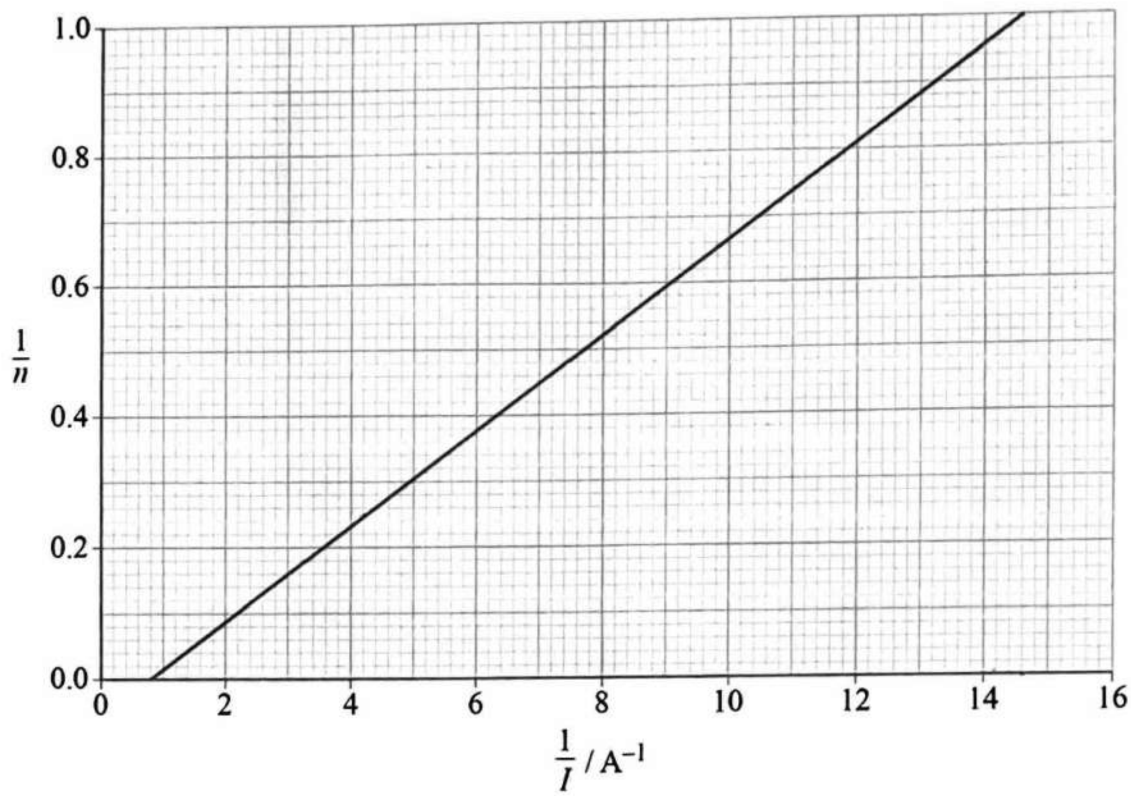
Figure 12 on page 22 shows a graph of the experimental data.

Question 3 continues on the next page

Maths Made Easy

Do not write outside the box

Figure 12



0 3 . 3 Show that ε is about 1.6 V.

[2 marks]

gradient = $\frac{1}{n} \div \frac{1}{I} = \frac{I}{n}$

$= \frac{1}{14.6 - 0.68} = $ ~~0.0704~~ 0.0725

~~= 0.6 - 0.8~~

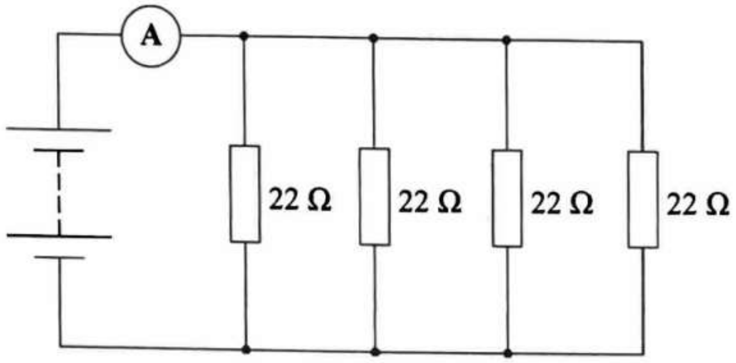
$\varepsilon = \frac{IR}{n} = 0.0725 \times 22$

$= 1.59$

Do not write outside the box

0 3 . 4 **Figure 13** shows the circuit when four resistors are connected.

Figure 13



Show, using **Figure 12**, that the current in the power supply is about 0.25 A.

[1 mark]

$\frac{1}{I} = 4.2 \quad I = 0.24\ A$

0 3 . 5 Deduce, for the circuit shown in **Figure 13**,

- the potential difference (pd) across the power supply
- *r*.

[4 marks]

The resistance of the circuit is $4 \times \frac{1}{22} = \frac{1}{R_T}$

$R_T = \frac{22}{4} = 5.5$

V = IR = 5.5 × 0.25 = 1.38 V

$\varepsilon = I(R + r)$

$1.59 = 0.25(5.5 + r)$

r =

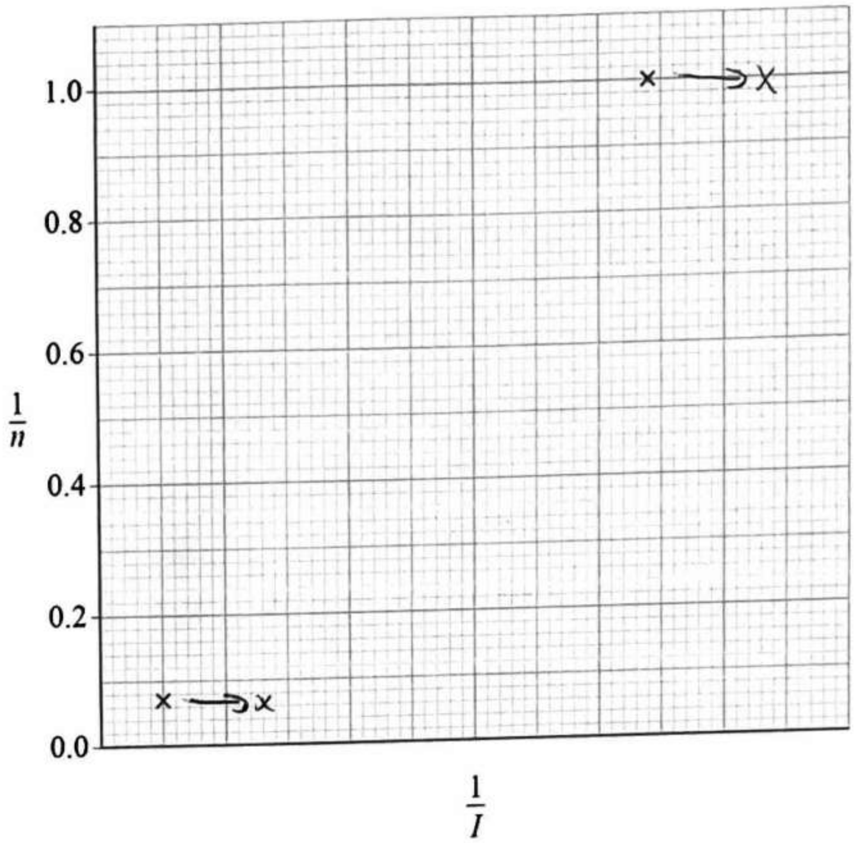
pd = 1.38 V

r = 0.86 Ω

Question 3 continues on the next page

0 3 . 6 **Figure 14** shows the plots for $n = 1$ and $n = 14$

Figure 14



Three additional data sets for values of n between $n = 1$ and $n = 14$ are needed to complete the graph in **Figure 14**.

Suggest which additional values of n should be used.
Justify your answer.

[3 marks]

n= 2 and n=3

This will improve distribution of points.

0 3 . 7 The experiment is repeated using a set of resistors of resistance 27 Ω.

The relationship between n and I is now

$$\frac{27}{n} = \frac{\varepsilon}{I} - r$$

Show on **Figure 14** the effect on the plots for $n = 1$ and $n = 14$
You do **not** need to do a calculation.

[2 marks]

17

$\frac{27}{n} = \varepsilon \frac{1}{I} - r$

END OF QUESTIONS