

Please write clearly in block capitals.

Centre number

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Candidate number

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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

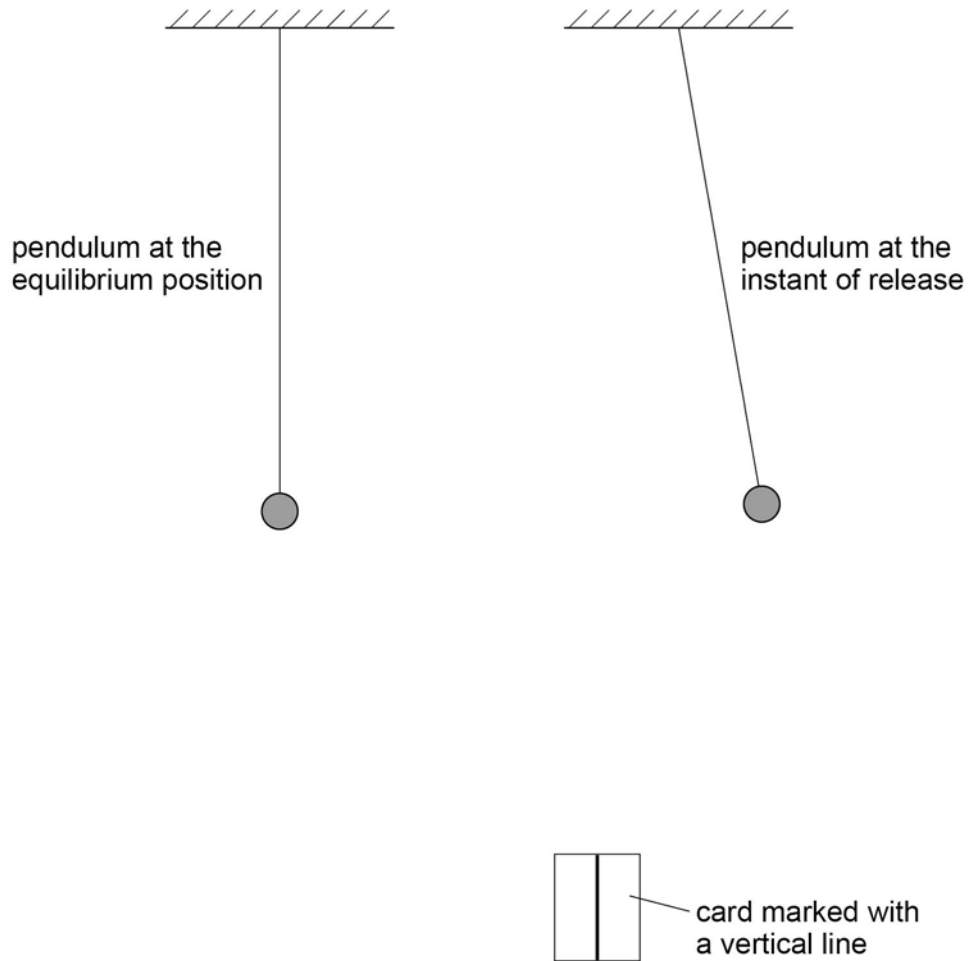
Answer **all** questions in this section.

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 .

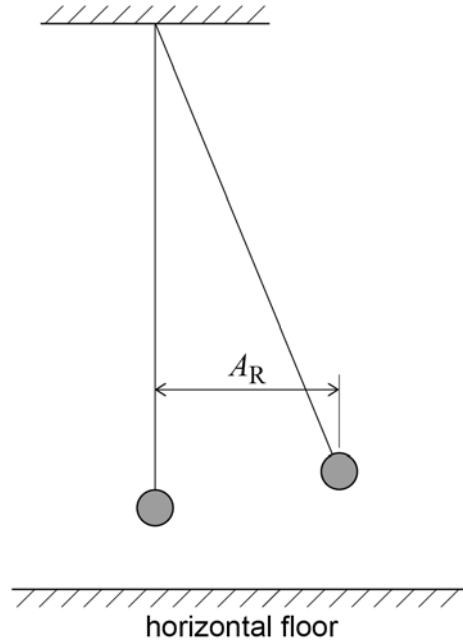
Annotate **Figure 1** to show a suitable position for the fiducial mark.
Explain why you chose this position.

[2 marks]



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]

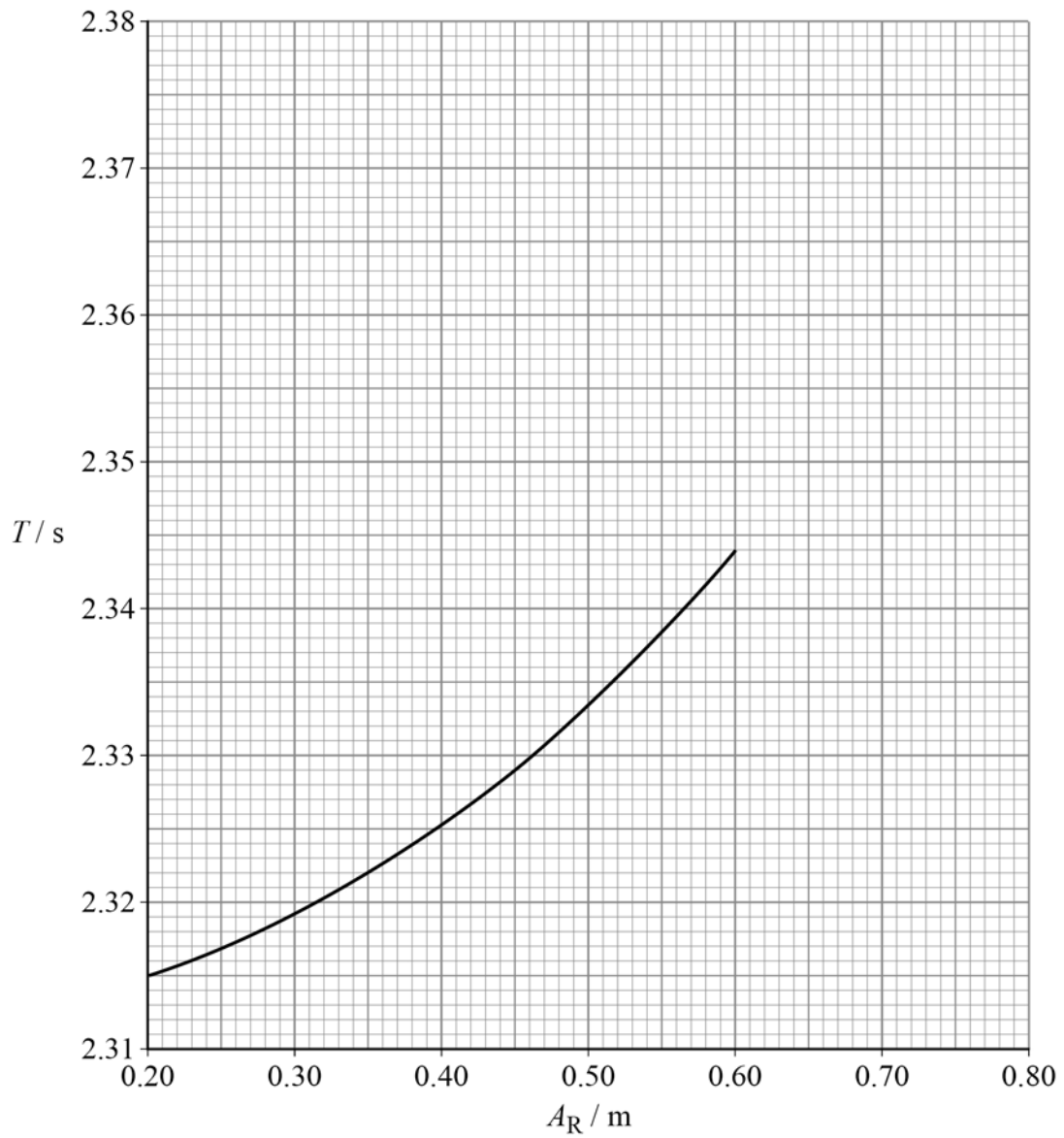
Question 1 continues on the next page

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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]

percentage increase = _____ %

Question 1 continues on the next page

Turn over ►



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

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
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- 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]

$$A_5 = \underline{\hspace{2cm}} \text{ m}$$

$$\text{percentage uncertainty} = \underline{\hspace{2cm}} \%$$

- 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	
7	0.212	-1.551
10	0.194	-1.640
13	0.183	-1.698

Complete **Table 2**.

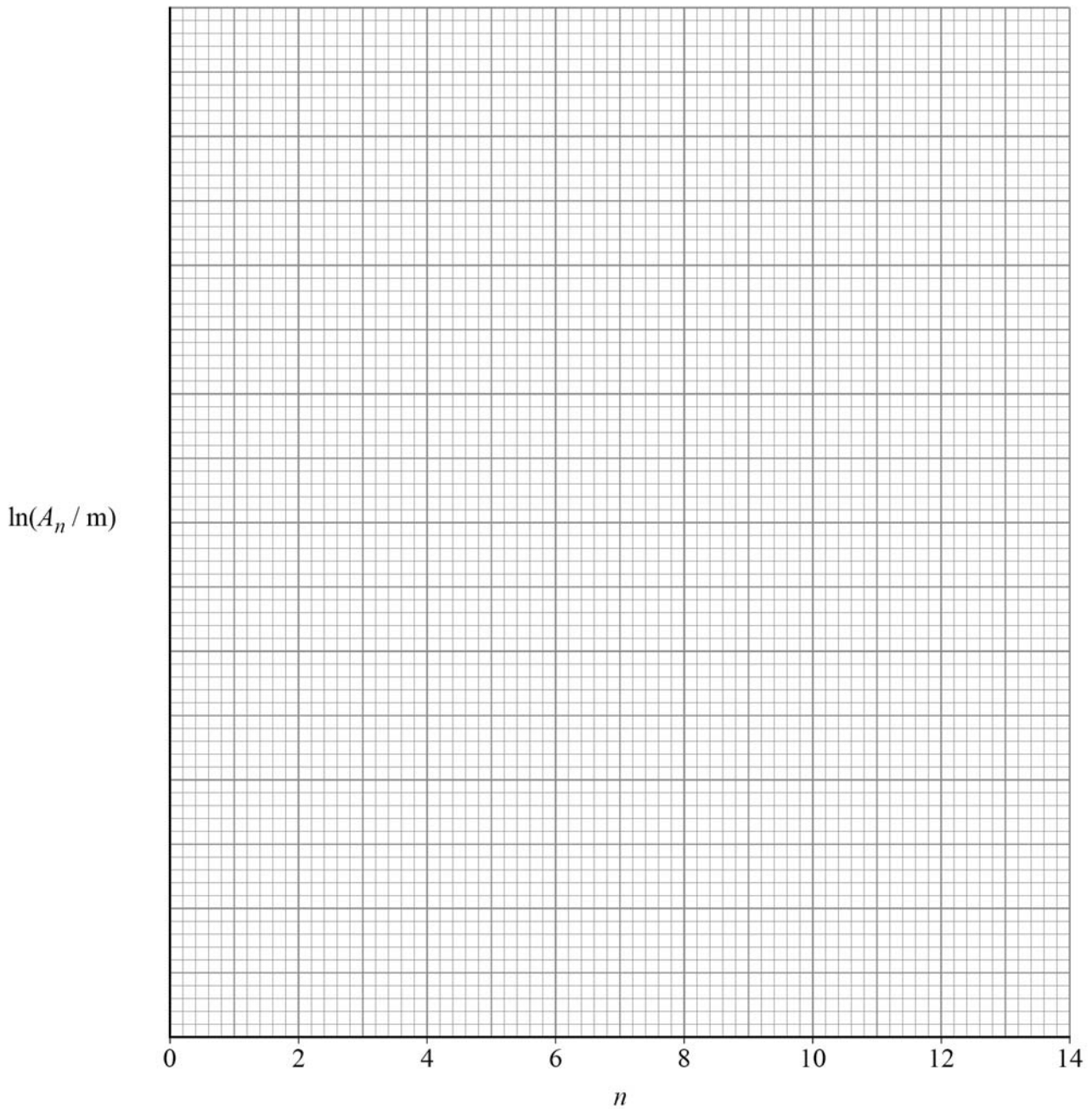
[1 mark]



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

[2 marks]

Figure 4



Question 1 continues on the next page

Turn over ►



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]

15



Turn over for the next question

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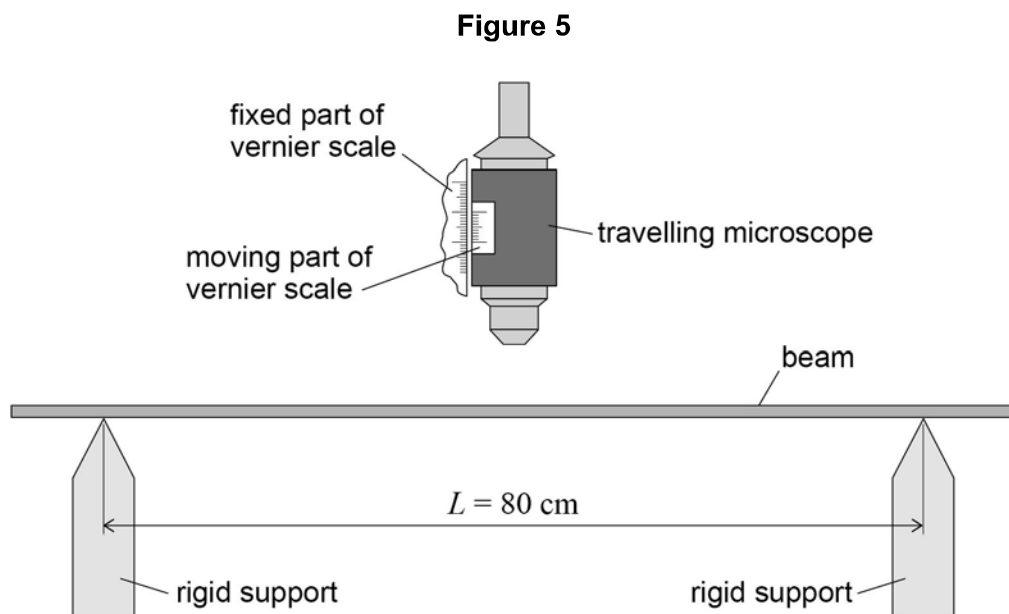
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0 2

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



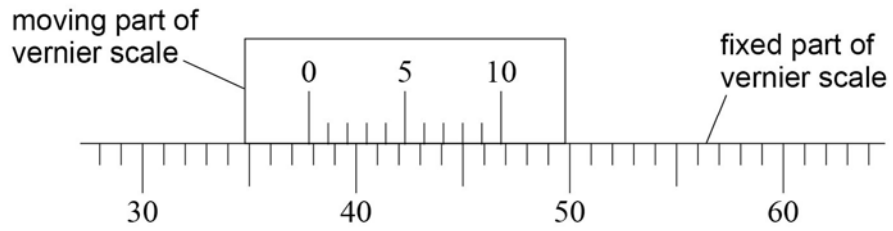
The beam is placed horizontally on rigid supports.
The distance L between the supports is 80 cm.

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



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]

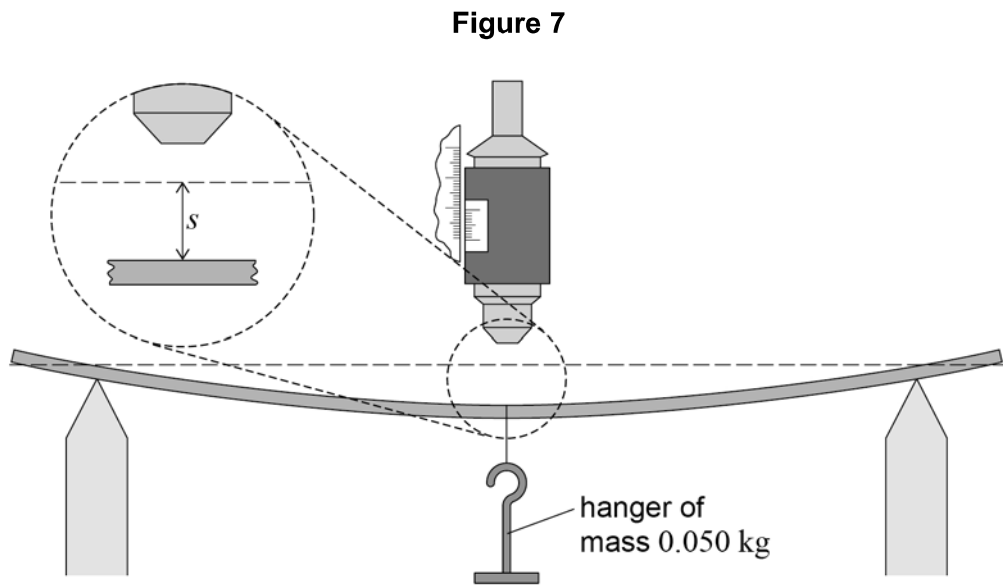
- 34.8
- 37.8
- 45.8
- 49.8

Question 2 continues on the next page

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



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]



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 _____

Disadvantage _____

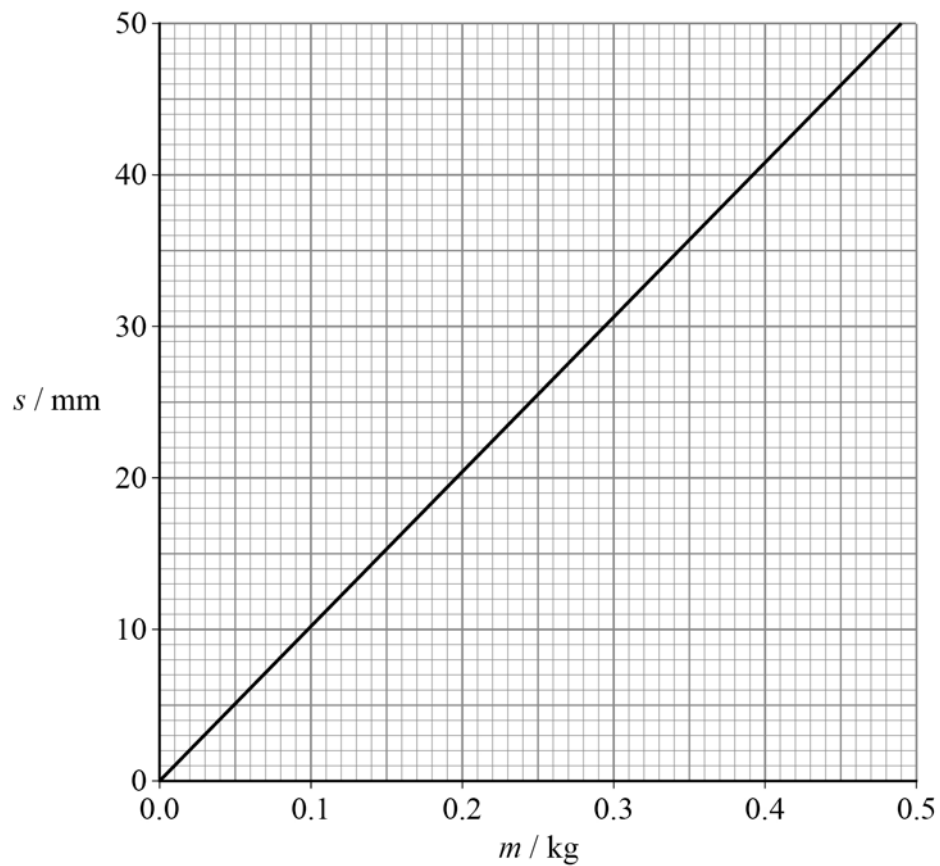
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0 2 . 4 Figure 8 shows the best-fit line produced using the data collected by student A.

Figure 8



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

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



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

$$E = 1.14 \text{ GPa}$$

[4 marks]

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order of magnitude of $\eta =$ _____ 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

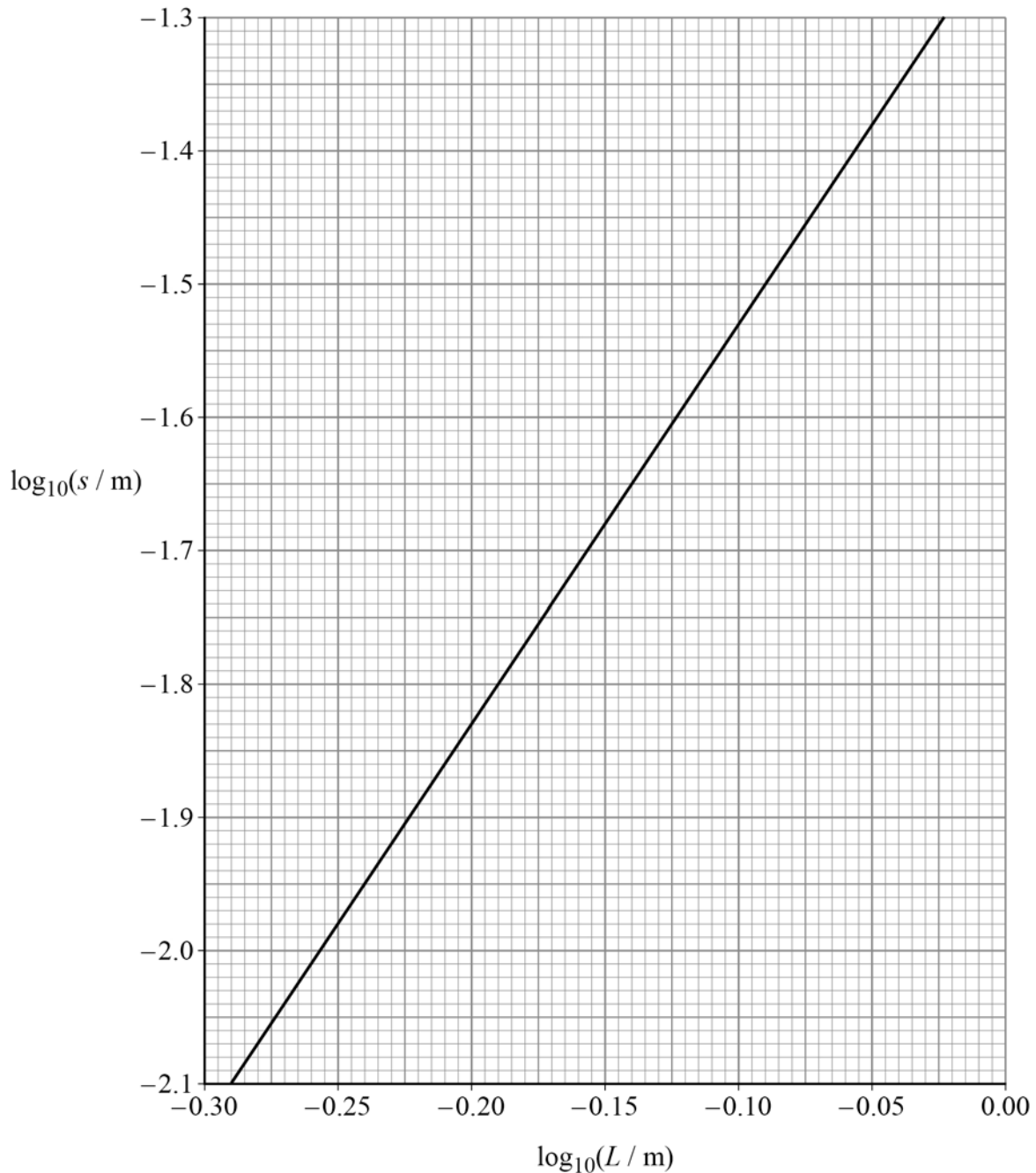


Figure 9 shows that $\log_{10}(s / \text{m})$ varies linearly with $\log_{10}(L / \text{m})$.

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

[1 mark]

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

[2 marks]

$s =$ _____ m

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

[1 mark]

$M =$ _____ kg

13

Turn over ►

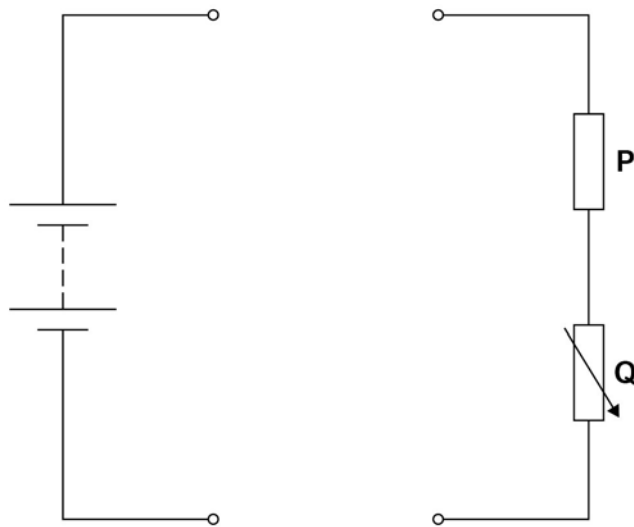


0 3

Figure 10 shows a partly-completed circuit used to investigate the emf \mathcal{E} 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]



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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]

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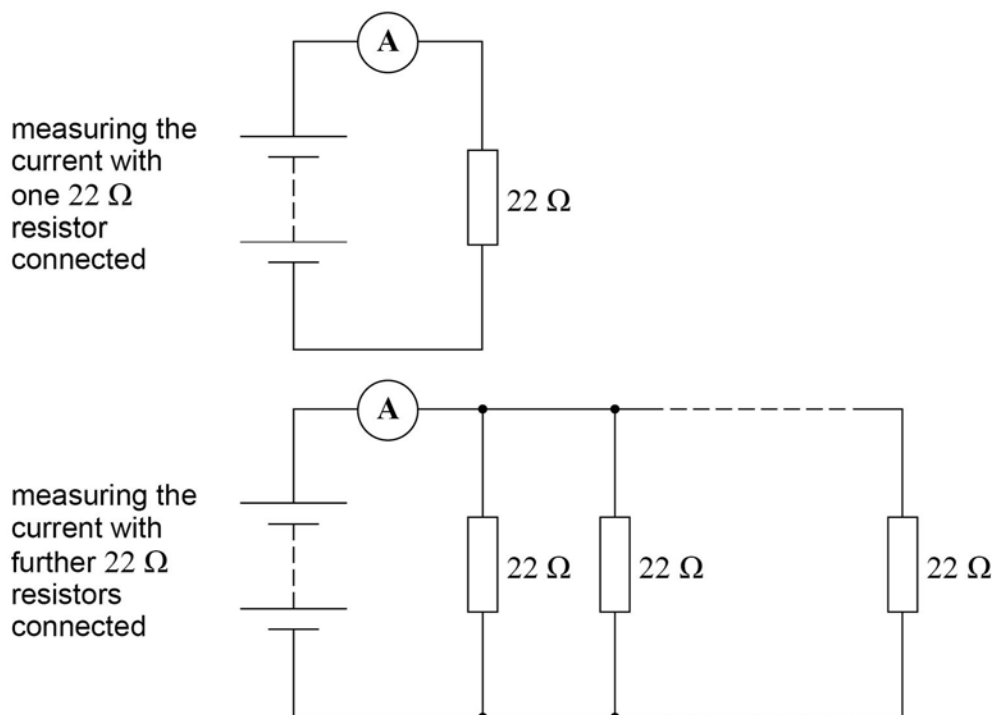
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Figure 11 shows a different experiment carried out to confirm the results for ε and r .

Figure 11



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

The number n of $22\ \Omega$ 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

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

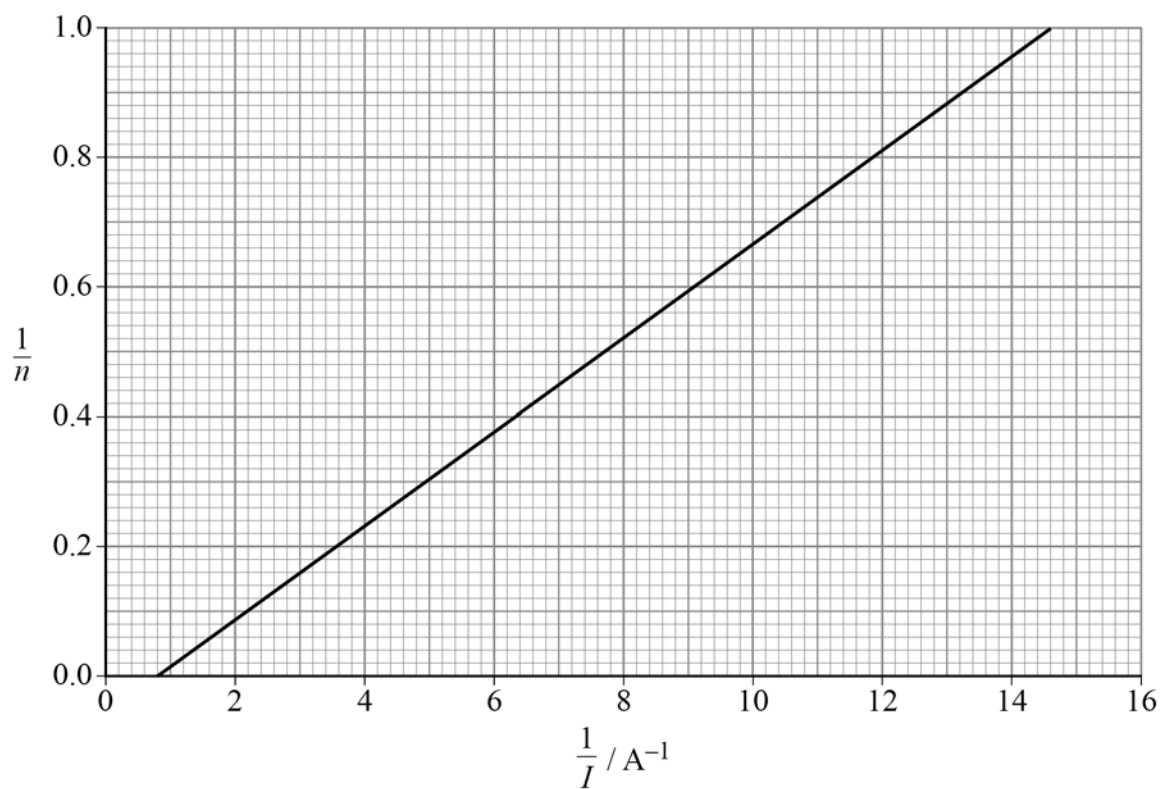
Figure 12 on page 22 shows a graph of the experimental data.

Question 3 continues on the next page

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Figure 12



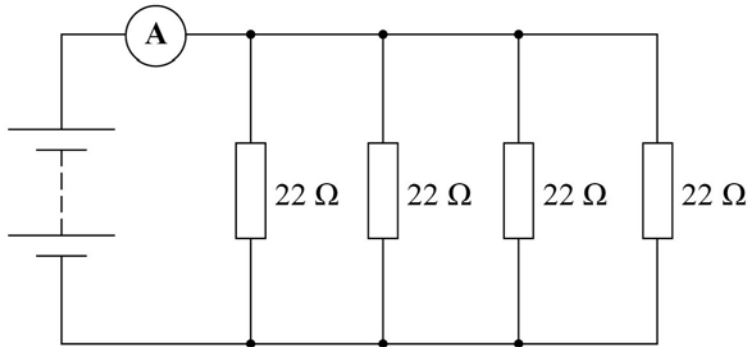
0 3 . 3 Show that ε is about 1.6 V.

[2 marks]



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]

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

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

[4 marks]

pd = _____ V

r = _____ Ω

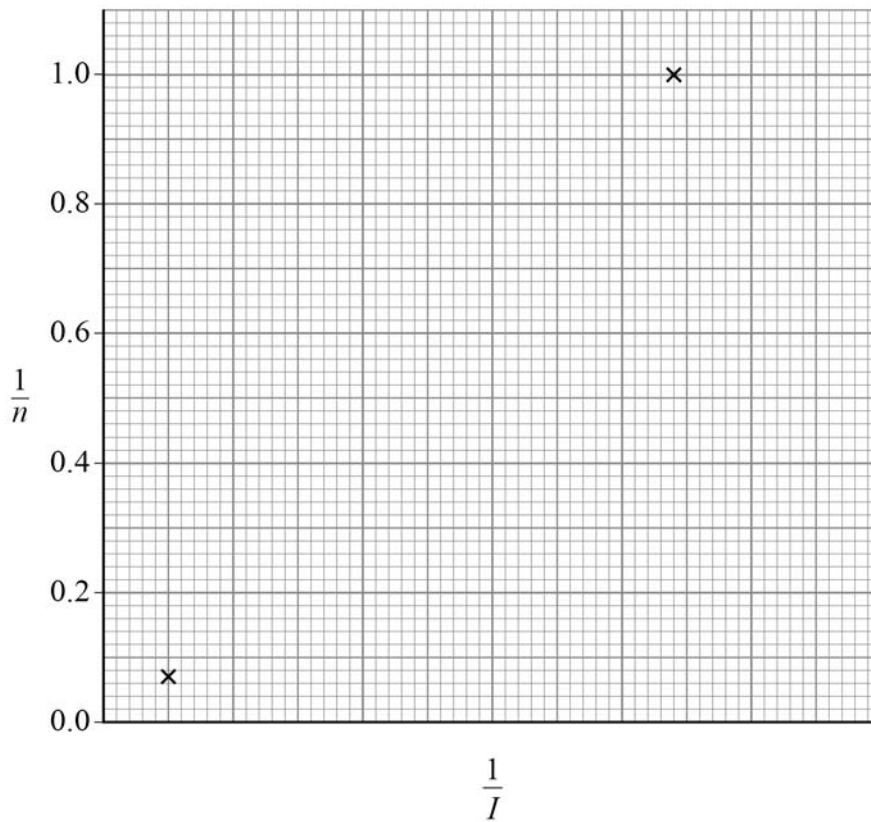
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0 3 . 6 Figure 14 shows the plots for $n = 1$ and $n = 14$

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]



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

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

END OF QUESTIONS



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Question number	Additional page, if required. Write the question numbers in the left-hand margin.

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