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.

For Examiner's Use	
Question	Mark
1	
2	
3	
TOTAL	

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.

Do not write outside the box

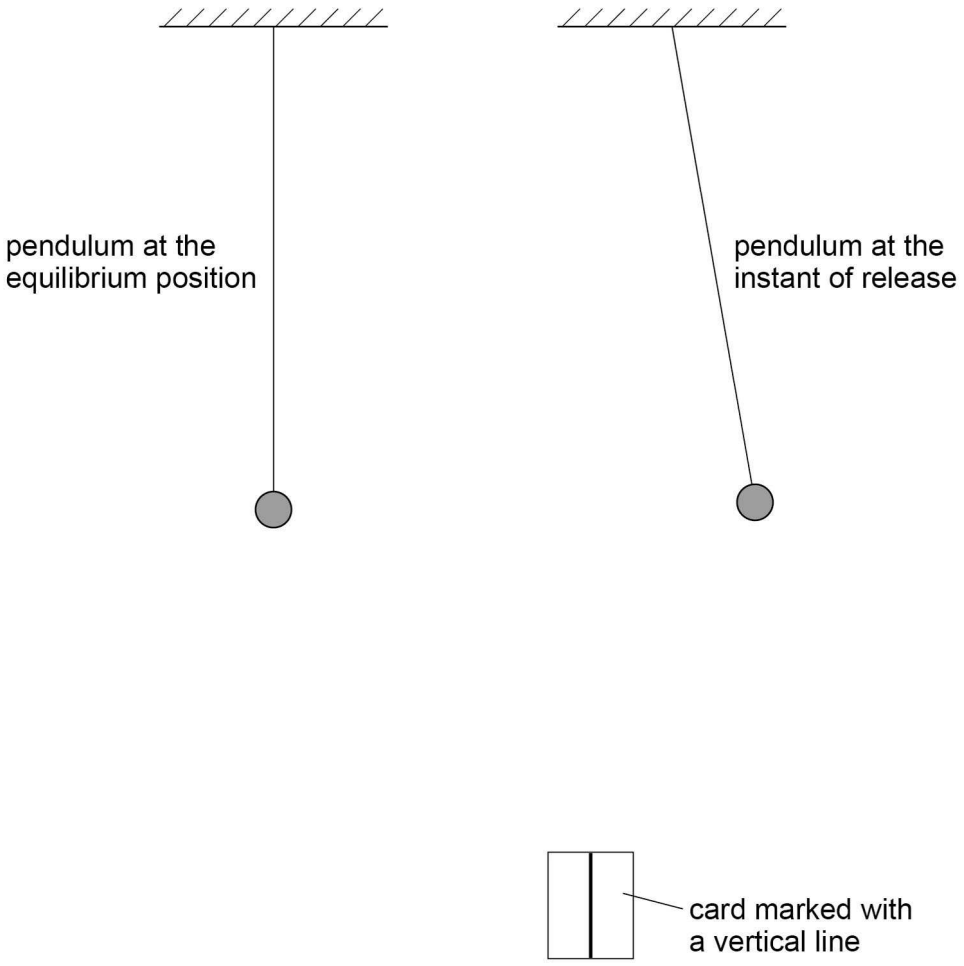
Section A

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.

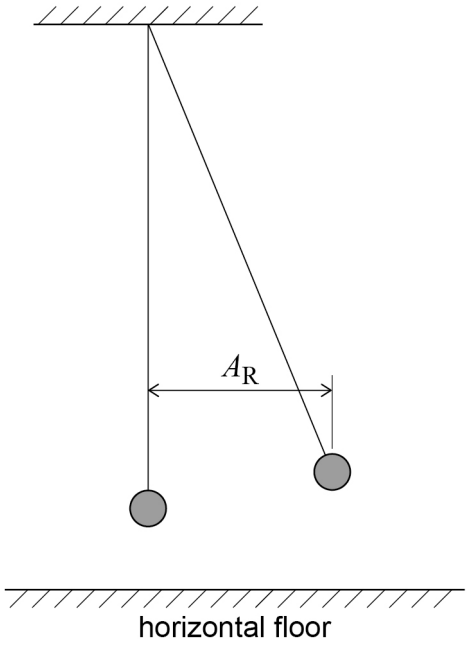
Annotate **Figure 1** to show a suitable position for the fiducial mark.
Explain why you chose this position.

[2 marks]

Do not write outside the box

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



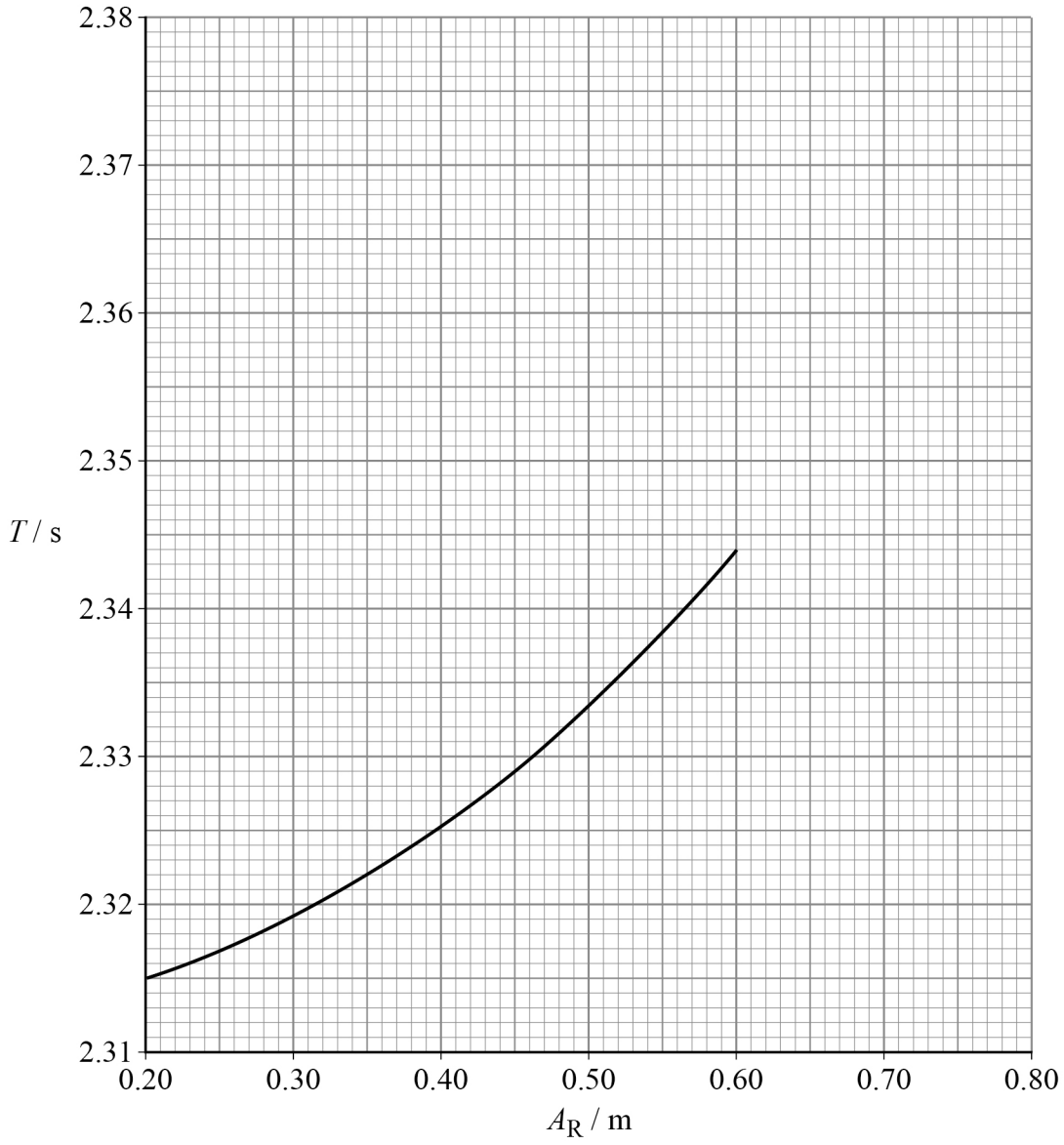
Describe a suitable procedure to determine A_R, the amplitude of the pendulum as it is released.
You may add detail to **Figure 2** to illustrate your answer.

[2 marks]

Question 1 continues on the next page

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

Figure 3



Do not write outside the box

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

[3 marks]

percentage increase = _____ %

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]

$A_5 =$ _____ m

percentage uncertainty = _____ %

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**.

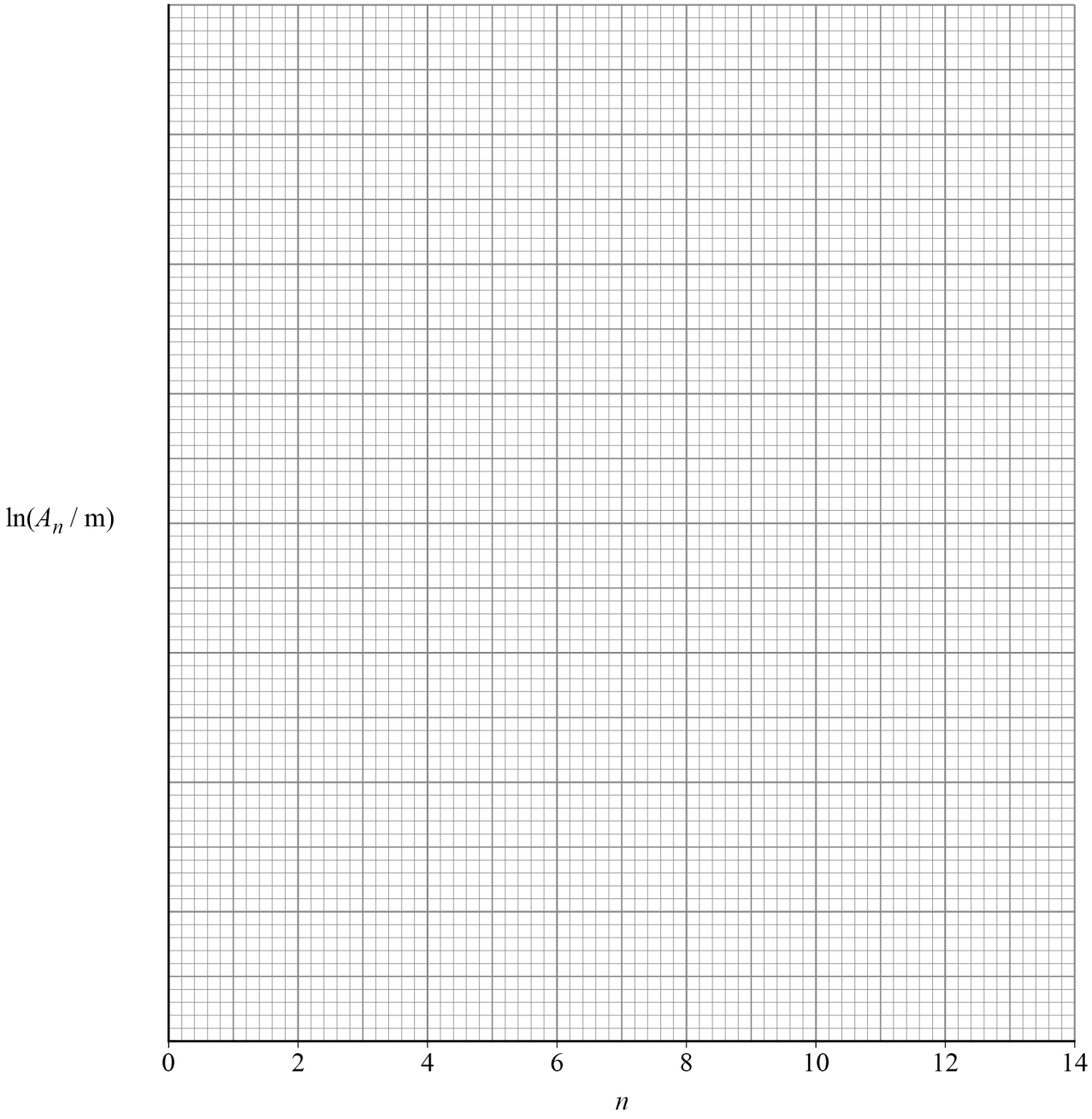
[1 mark]

Do not write outside the box

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

[2 marks]

Figure 4



Question 1 continues on the next page

Do not write outside the box

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

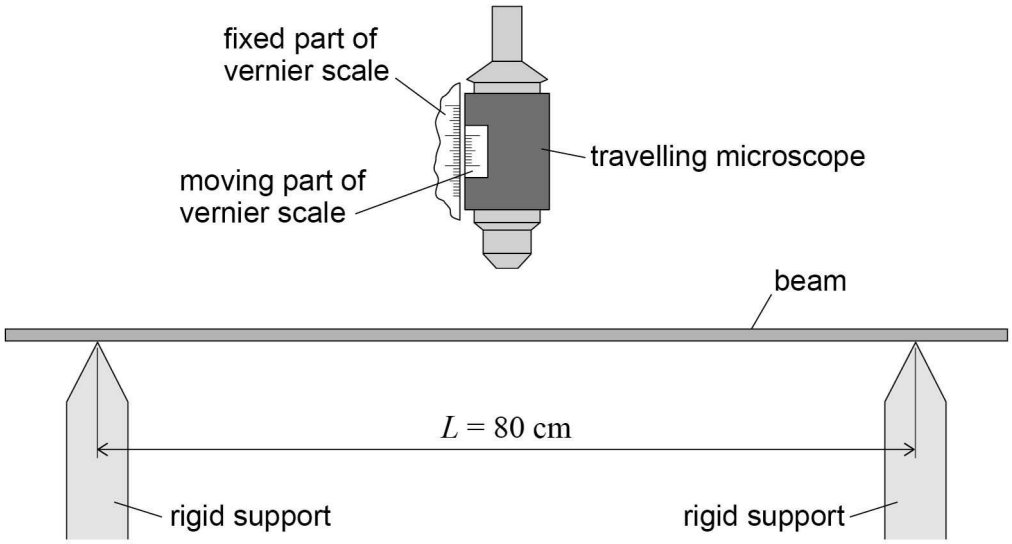
Do not write outside the box

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

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

Figure 5



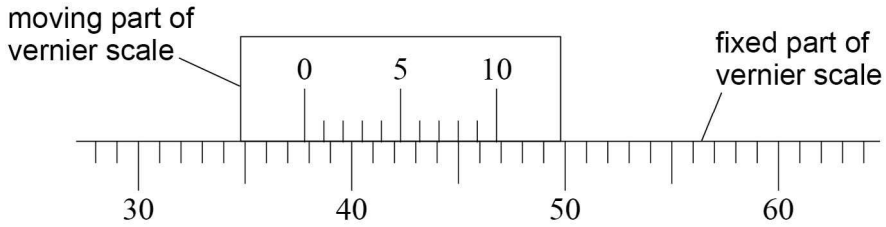
The beam is placed horizontally on rigid supports.
The distance L between the supports is 80 cm.

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 $1\ \text{mm}$.

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

[1 mark]

34.8 ☐

37.8 ☐

45.8 ☐

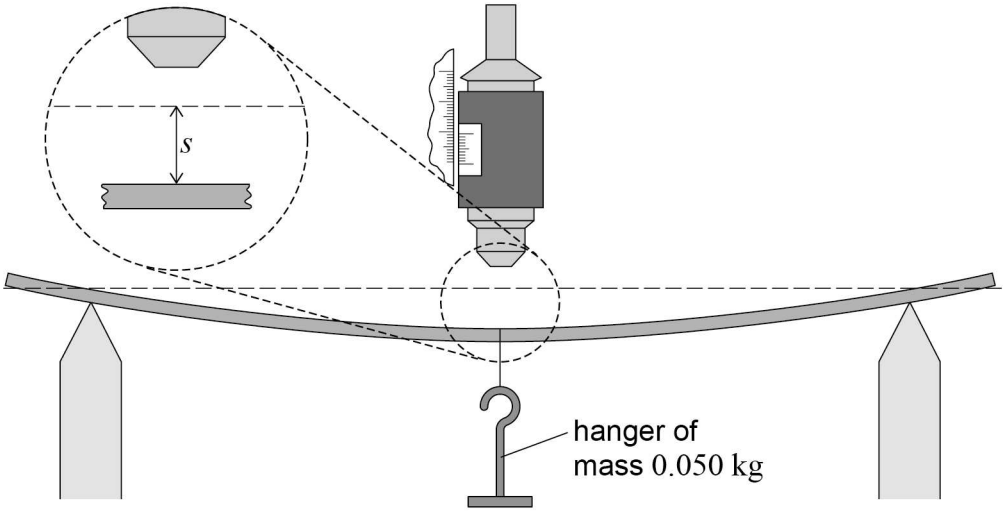
49.8 ☐

Question 2 continues on the next page

Do not write outside the box

0 2 . 2 **Figure 7** shows the beam bending when a hanger of mass $0.050\ \text{kg}$ 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 $0.050\ \text{kg}$.
A value of s is recorded for each m up to a value of $m = 0.450\ \text{kg}$.
Further values of s are then recorded as m is decreased in $0.050\ \text{kg}$ 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]

Do not write outside the box

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 _____

_____

_____

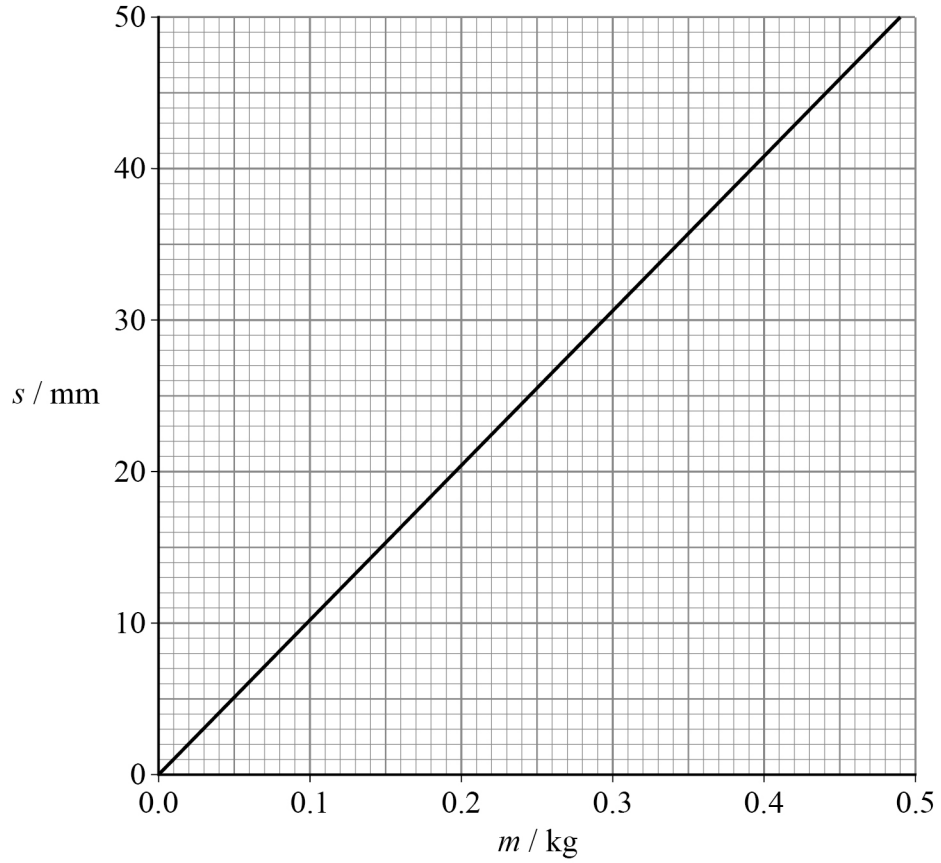
_____

_____

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

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.

$E = 1.14$ GPa

[4 marks]

order of magnitude of η = _____ s^{-2}

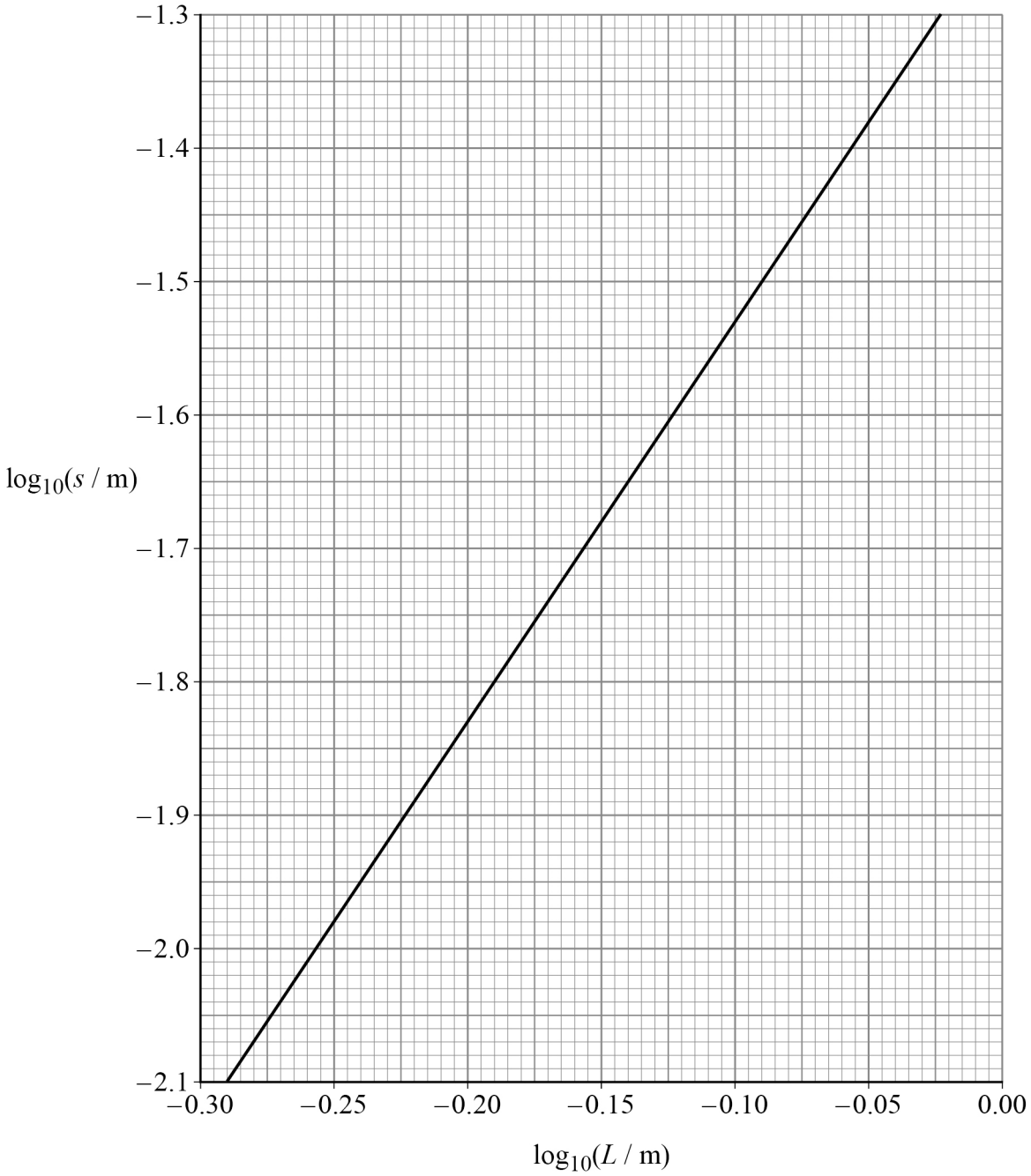
Question 2 continues on the next page

Do not write outside the box

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]

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

[2 marks]

$s =$ _____ m

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

[1 mark]

$M =$ _____ kg

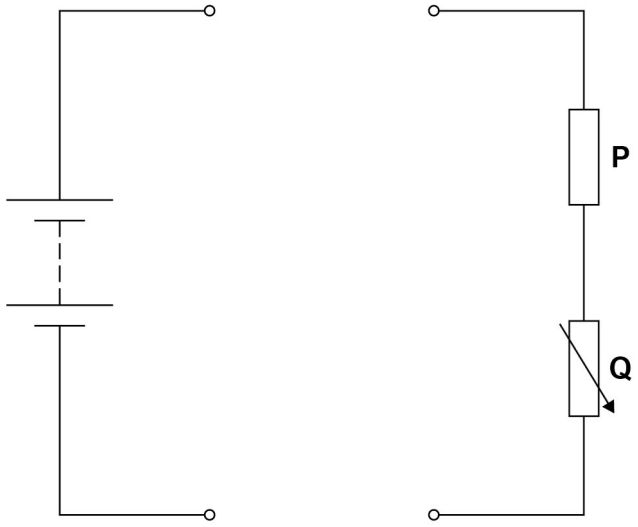
13

Do not write outside the box

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]

Do not write outside the box

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]

Question 3 continues on the next page

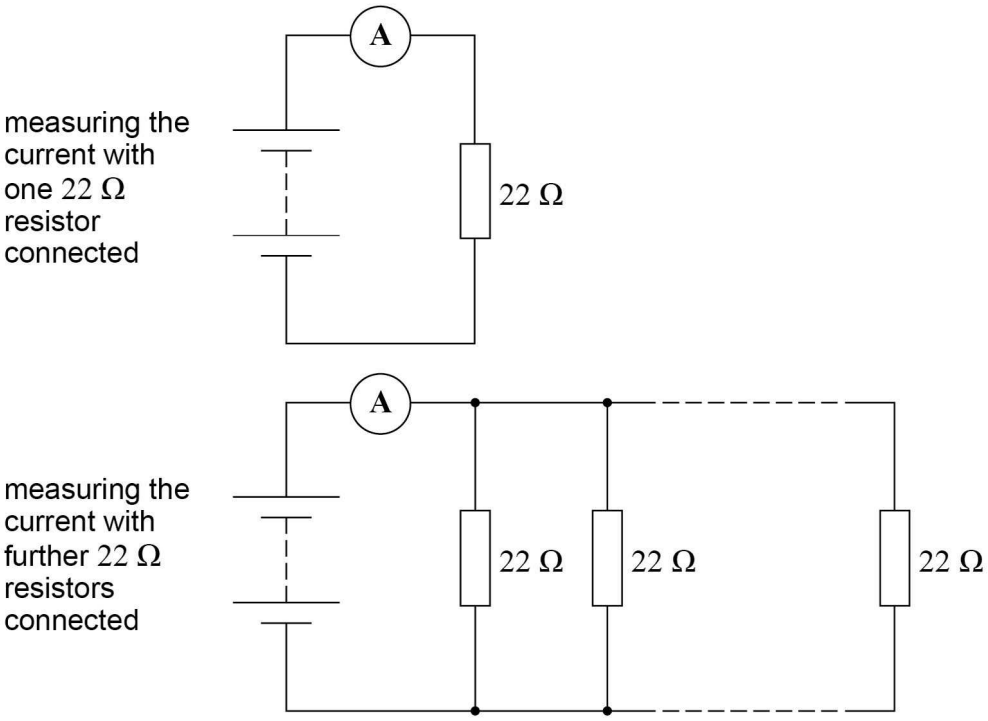
Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

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

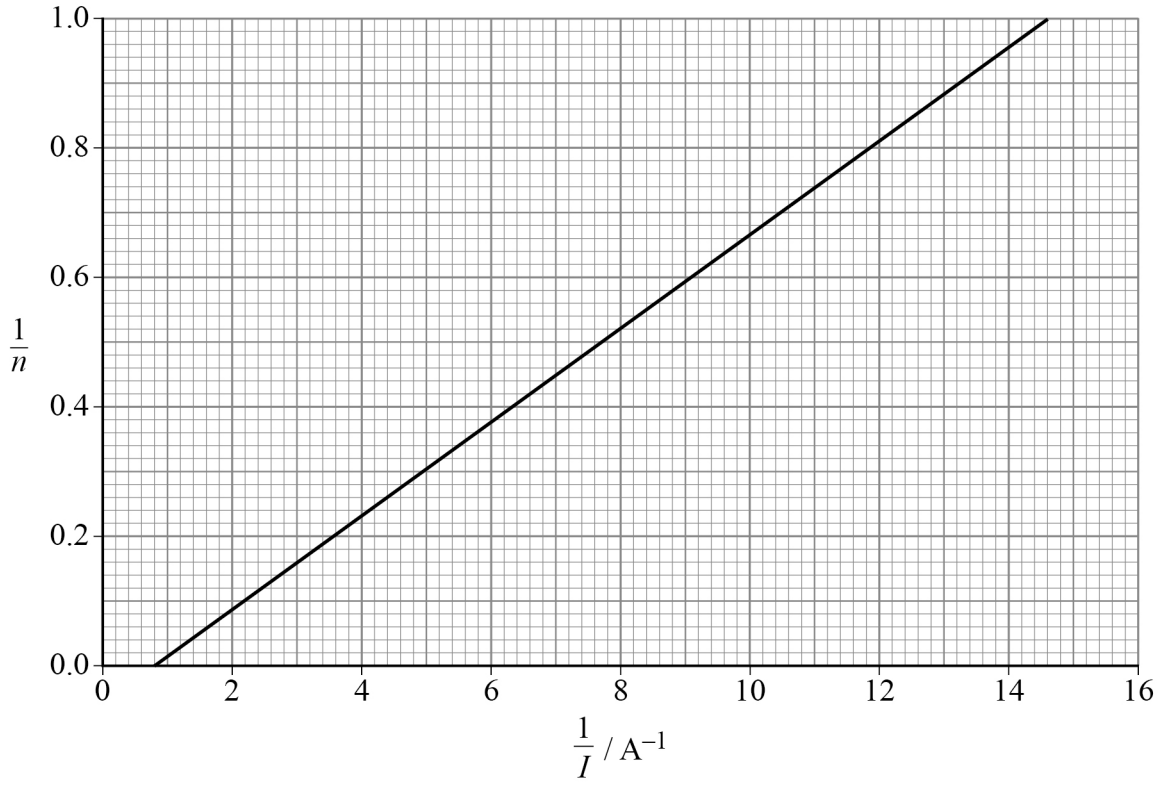
$$\frac{22}{n} = \frac{\varepsilon}{I} - r$$

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

Question 3 continues on the next page

Do not write outside the box

Figure 12



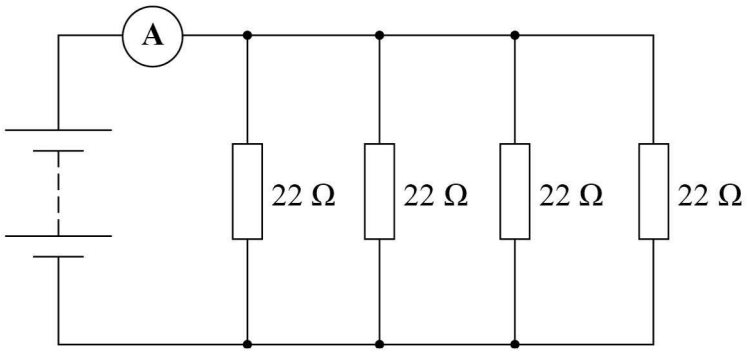
0 3 . 3 Show that ε is about 1.6 V.

[2 marks]

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]

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

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

[4 marks]

pd = _____ V

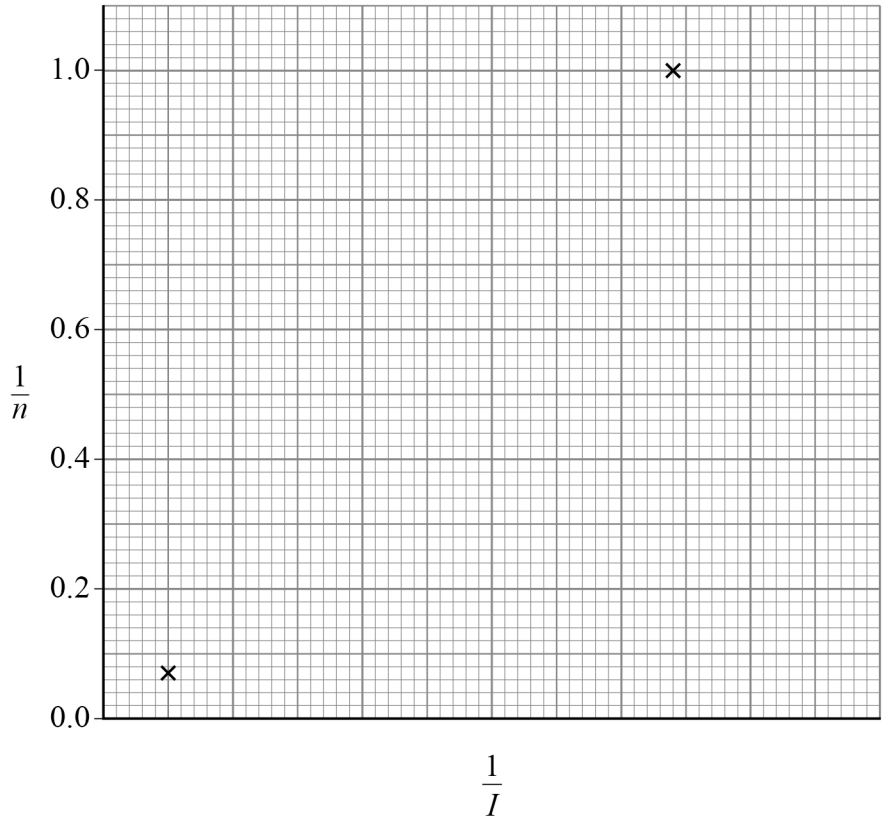
r = _____ Ω

Question 3 continues on the next page

Do not write outside the box

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]

Do not write outside the box

0 3 . 7 The experiment is repeated using a set of resistors of resistance $27\ \Omega$.

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

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

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

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**
	Copyright information For confidentiality purposes, all acknowledgements of third-party copyright material are published in a separate booklet. This booklet is published after each live examination series and is available for free download from www.aqa.org.uk. Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team.