A

Surname ______________________

Other Names ______________________

Centre Number ______________________

Candidate Number ______________________

Candidate Signature ______________________

I declare this is my own work.

A-level
PHYSICS

Paper 3
Section A

7408/3A

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.

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

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

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.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do not write 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.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

SECTION A

Answer ALL questions in this section.

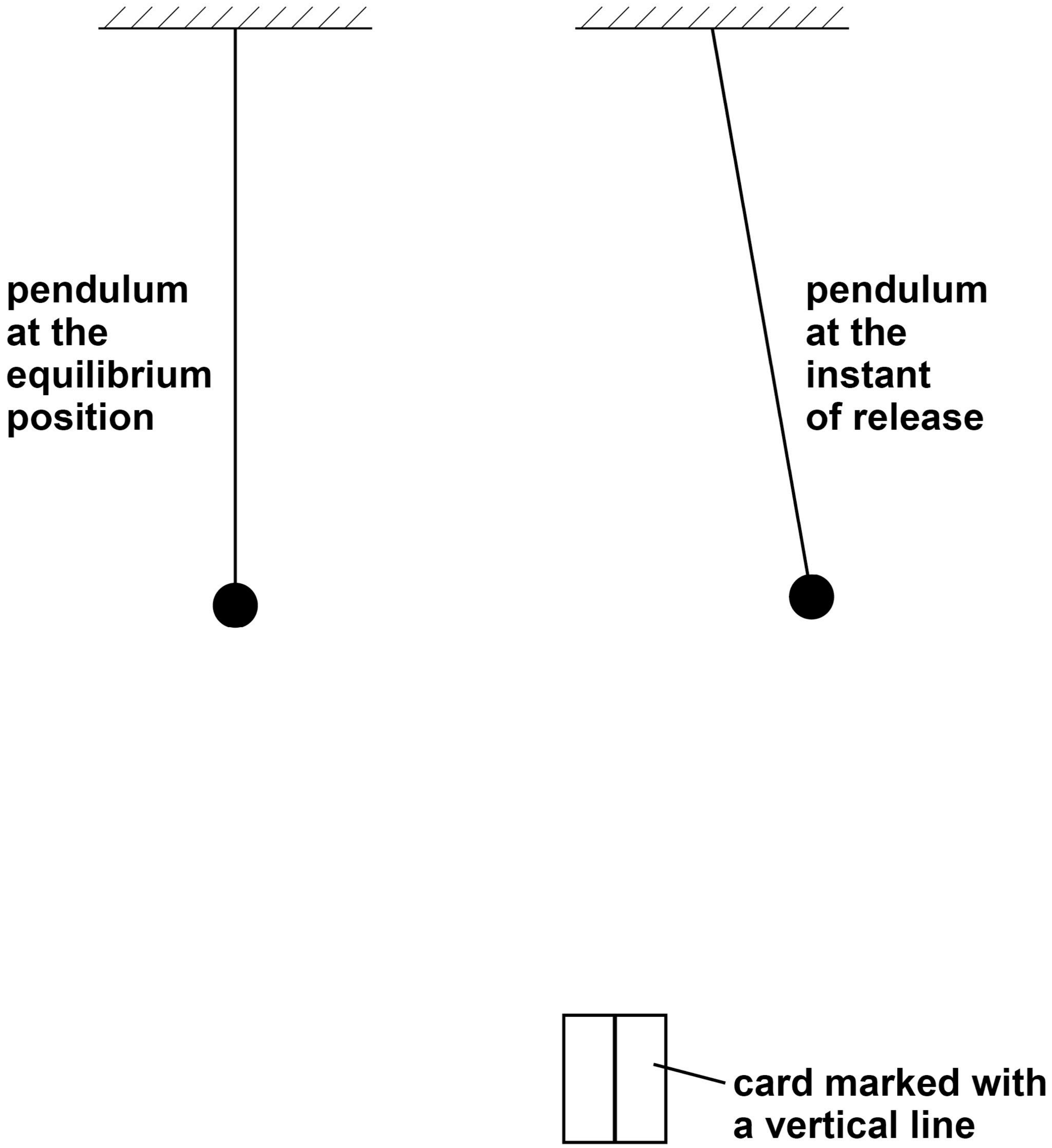
0 1 A simple pendulum performs oscillations of period T in a vertical plane.

FIGURE 1, on the opposite page, 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.

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]

FIGURE 1

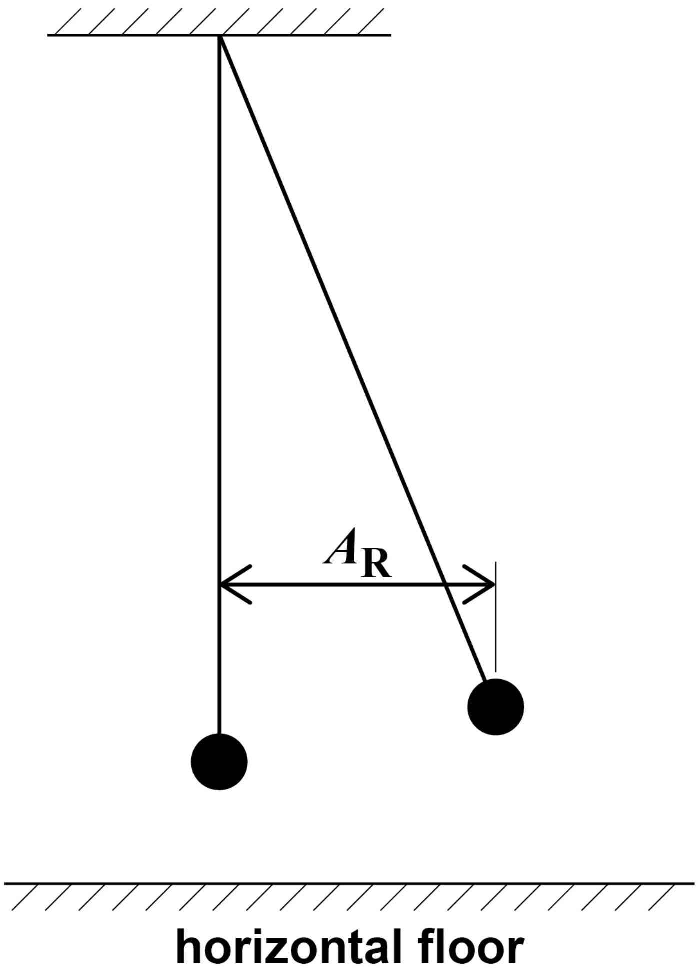


[Turn over]

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, on the opposite page, to illustrate your answer.
[2 marks]

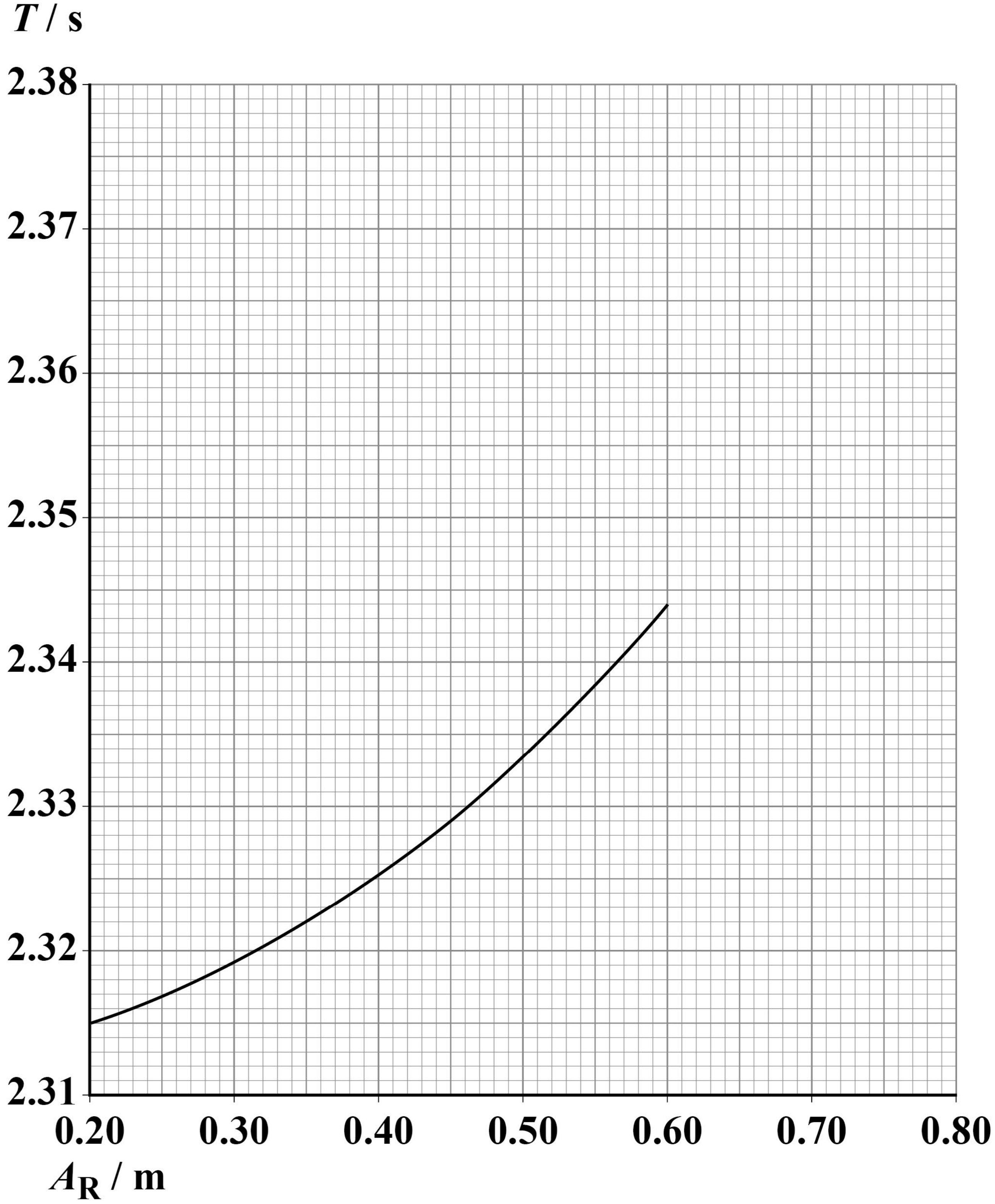
0 1 . 3 FIGURE 3, on the opposite page, shows some of the results of the experiment.

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 = ____________________ %

FIGURE 3



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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 = ________________%

[Turn over]

01.5 TABLE 2 shows results for A_n and the corresponding value of $\ln(A_n / \mathrm{m})$ for certain values of n.

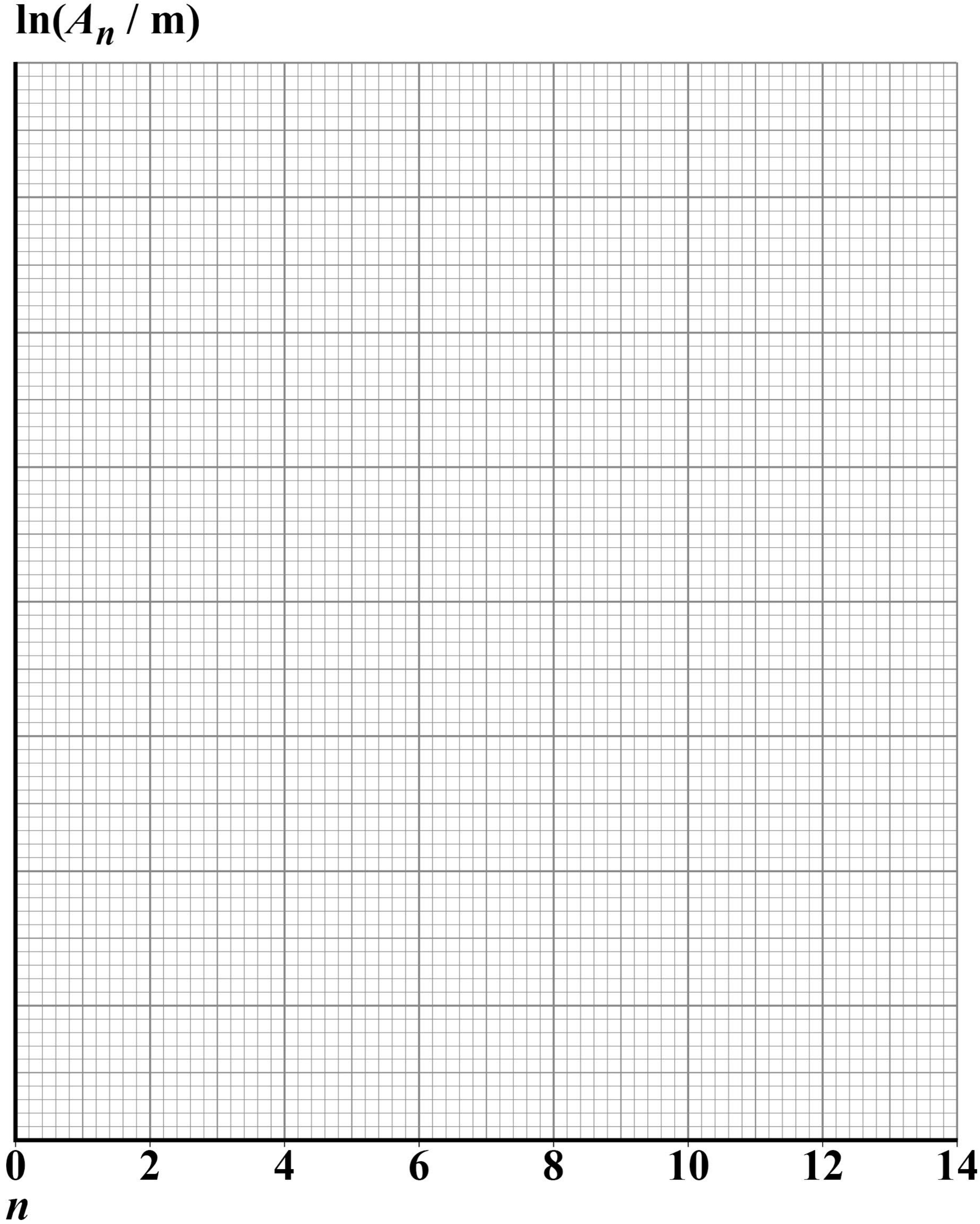
TABLE 2

n	A_n / m	$\ln(A_n / \mathrm{m})$
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]

01.6 Plot on FIGURE 4, on the opposite page, a graph of $\ln(A_n / \mathrm{m})$ against n. [2 marks]

FIGURE 4



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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.

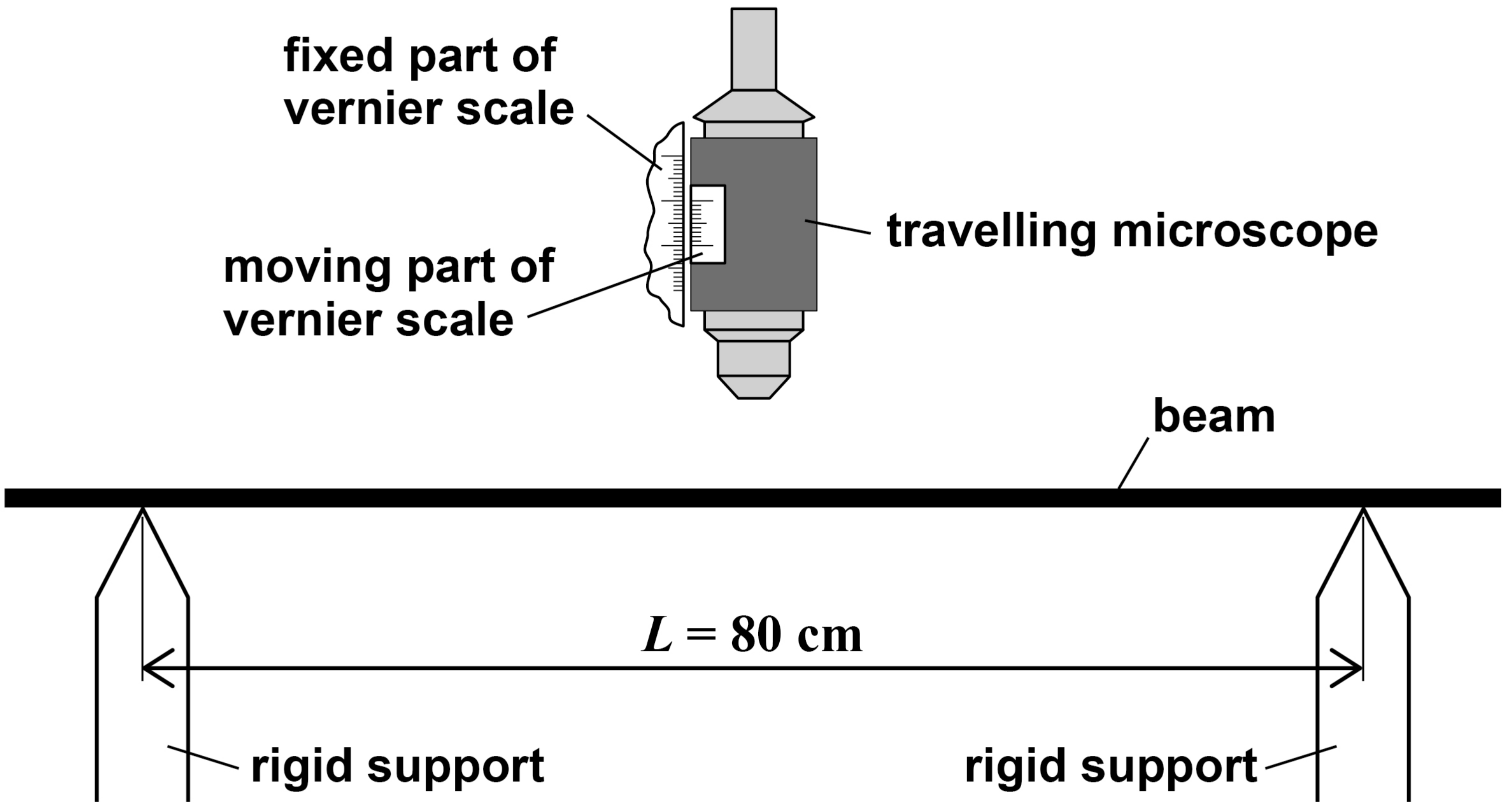
Explain how to find δ from your graph.

You are NOT required to determine δ.

[2 marks]

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.

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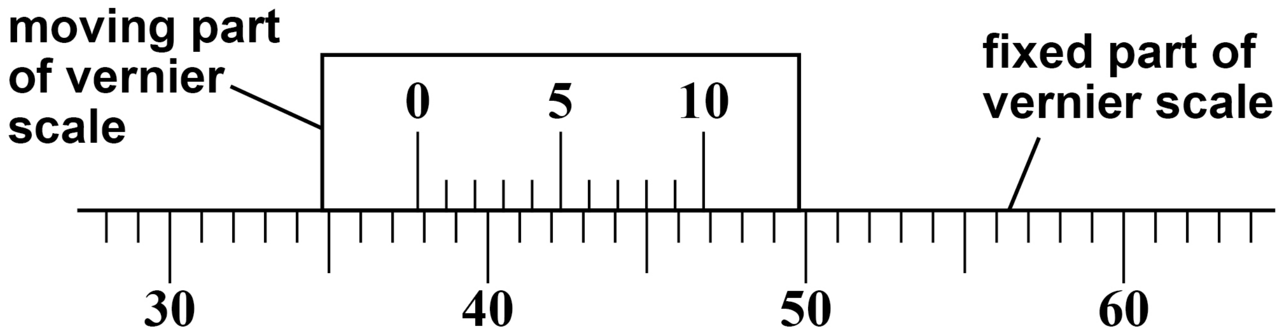
0 2 . 1 FIGURE 6 shows an enlarged view of both parts of the vernier scale.

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**

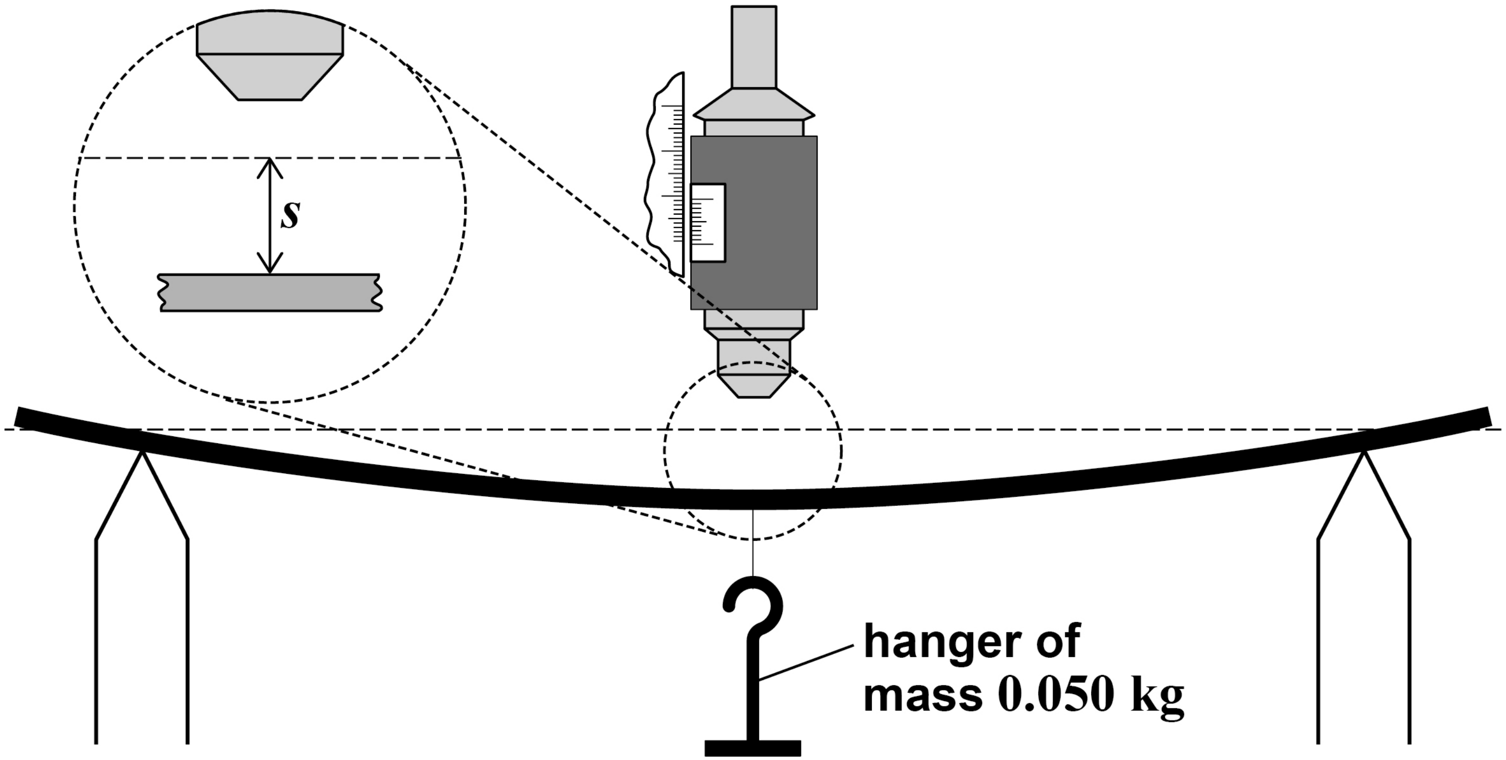
☐ **45.8**

☐ **49.8**

[Turn over]

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 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]

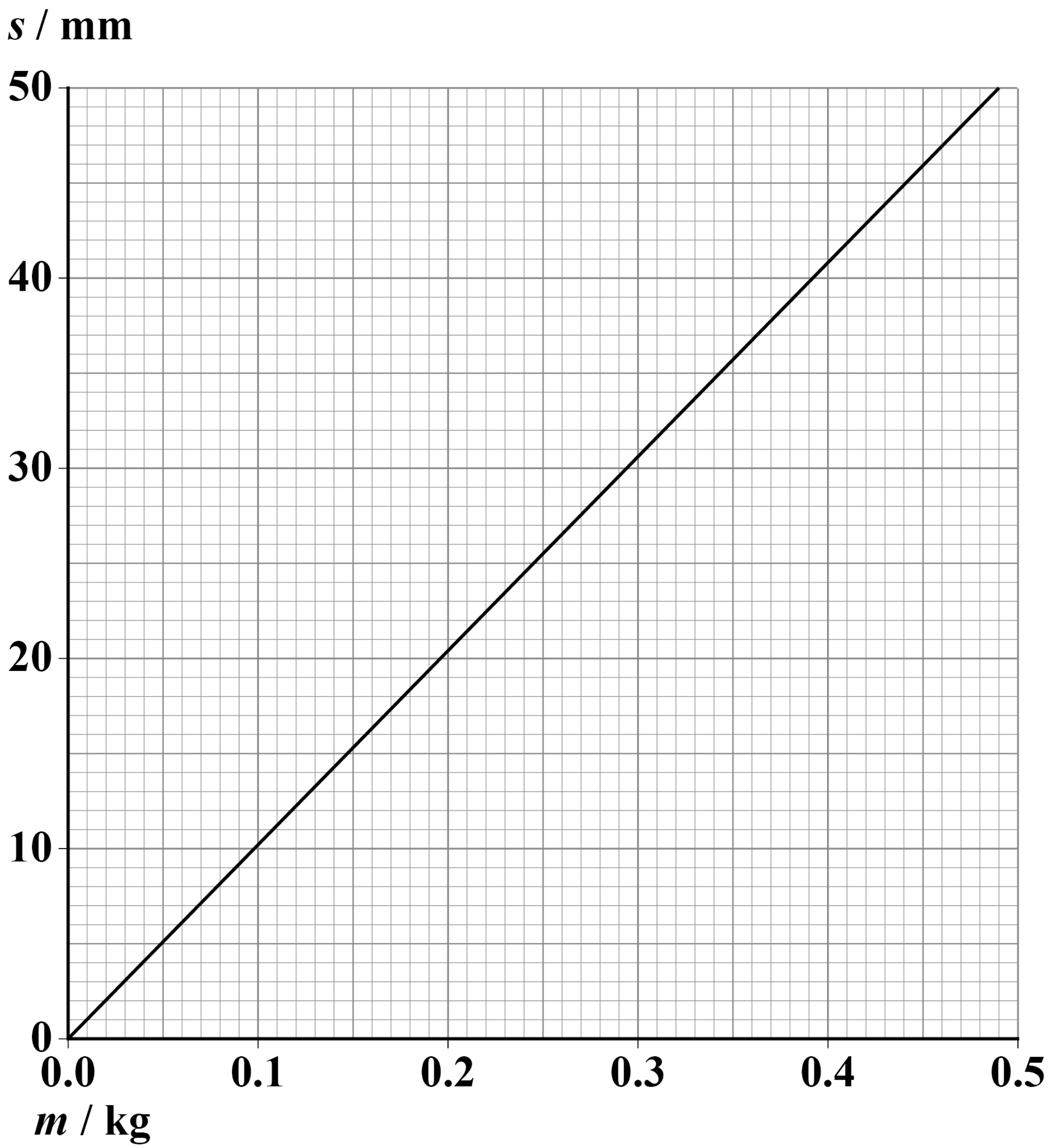
Advantage ______________________________

Disadvantage

[Turn over]

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.

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

$E = 1.14$ GPa

[4 marks]

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

0 2 . 5 **Student C performs a different experiment using the same apparatus shown in FIGURE 5 on page 16.**

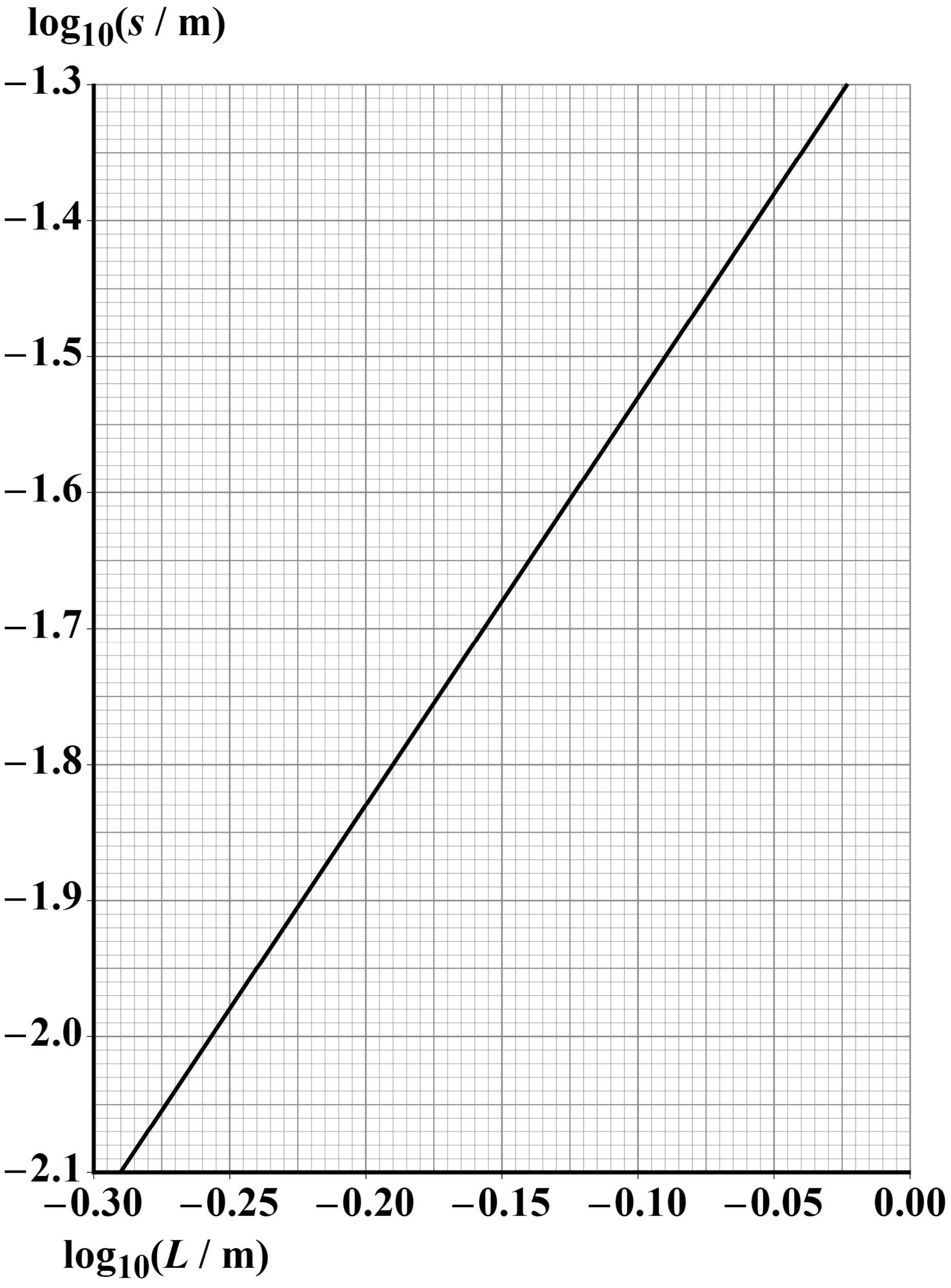
A mass M is suspended from the midpoint of the beam. The vertical deflection s of the beam is measured for different values of L.

FIGURE 9, on the opposite page, shows a graph of the results for this experiment.

FIGURE 9 shows that $\log_{10}(s \,/\, \mathrm{m})$ varies linearly with $\log_{10}(L \,/\, \mathrm{m})$.

State what this shows about the mathematical relationship between s and L. You do NOT need to do a calculation. [1 mark]

FIGURE 9



$\log_{10}(s / \mathrm{m})$
−1.3
−1.4
−1.5
−1.6
−1.7
−1.8
−1.9
−2.0
−2.1
−0.30
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
$\log_{10}(L / \mathrm{m})$

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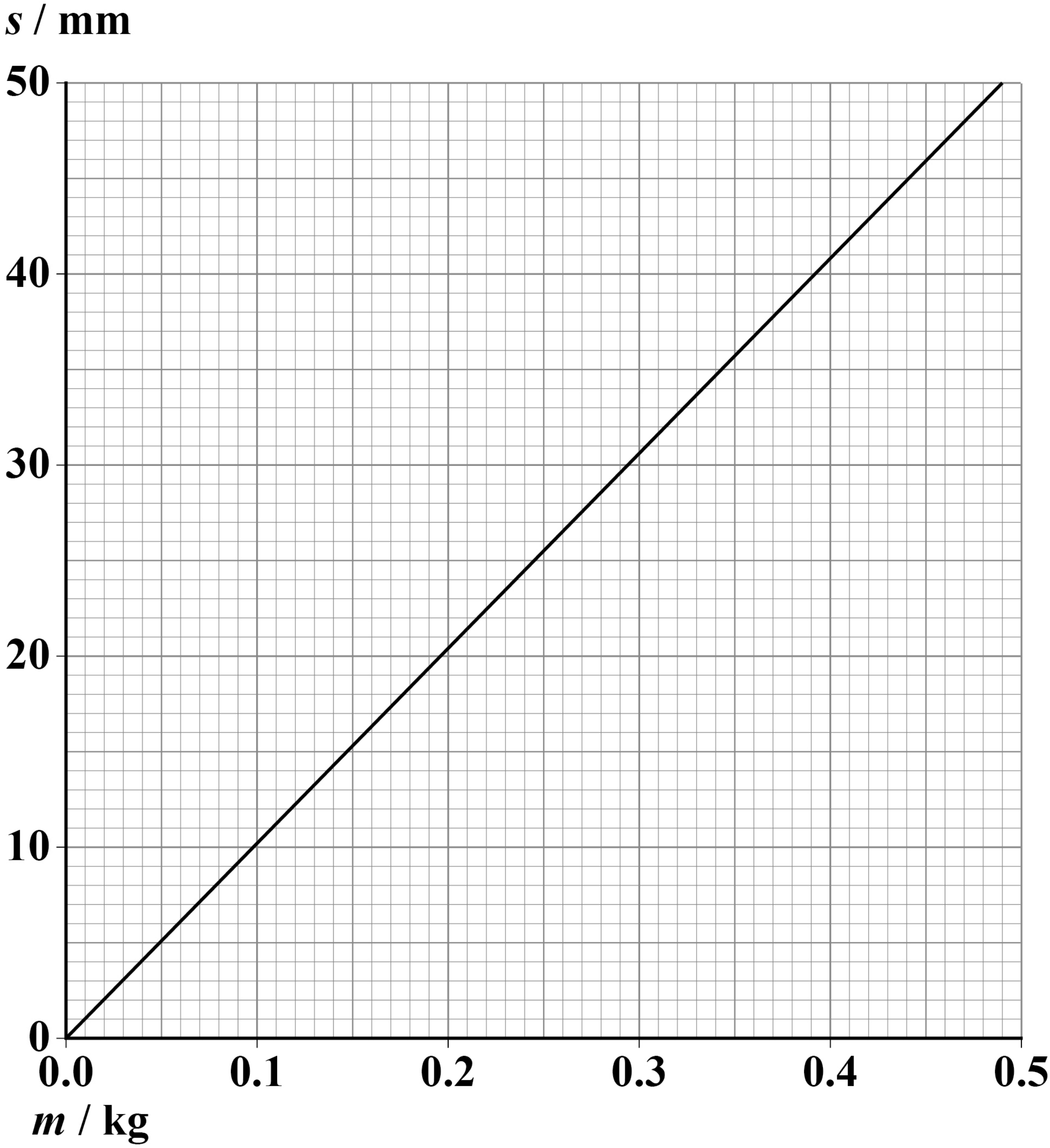
0 2 . 6 **Deduce, using FIGURE 9 on page 27, the value of s when $L = 80\ \text{cm}$. [2 marks]**

$s =$ ____________________________ m

[Turn over]

REPEAT OF FIGURE 8



0 2 . 7 Determine M using FIGURE 8. [1 mark]

M = ______________________ kg

[Turn over]

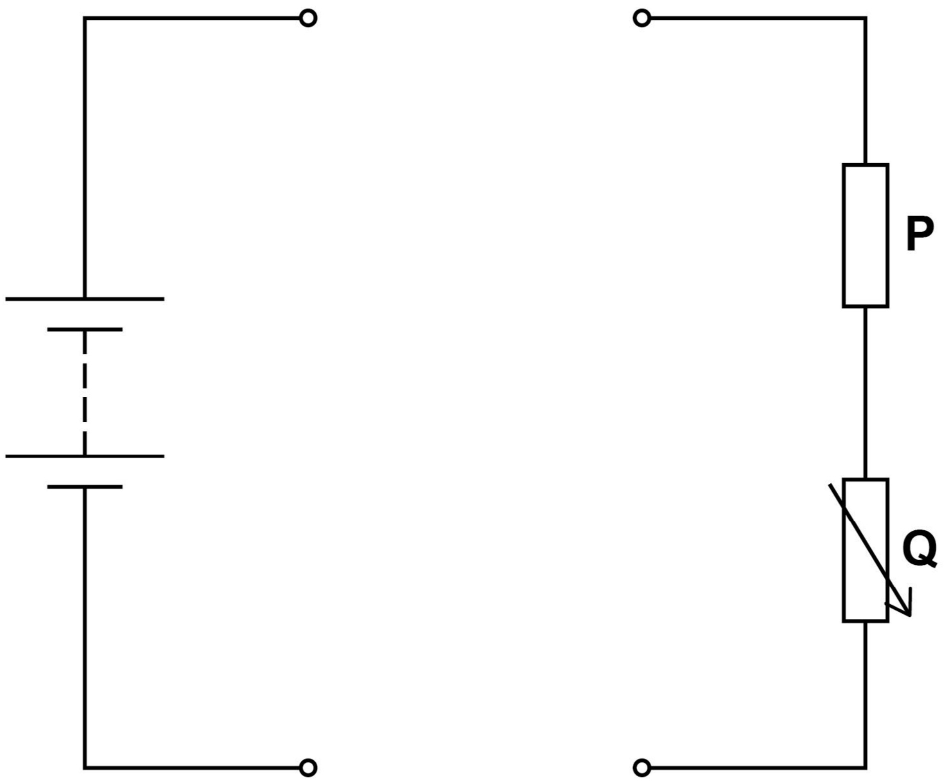
___
13

0 3 FIGURE 10, on the opposite page 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.

0 3 . 1 Complete FIGURE 10 to show a circuit including a voltmeter and an ammeter that is suitable for the investigation. [1 mark]

FIGURE 10



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03.2 **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]

[Turn over]

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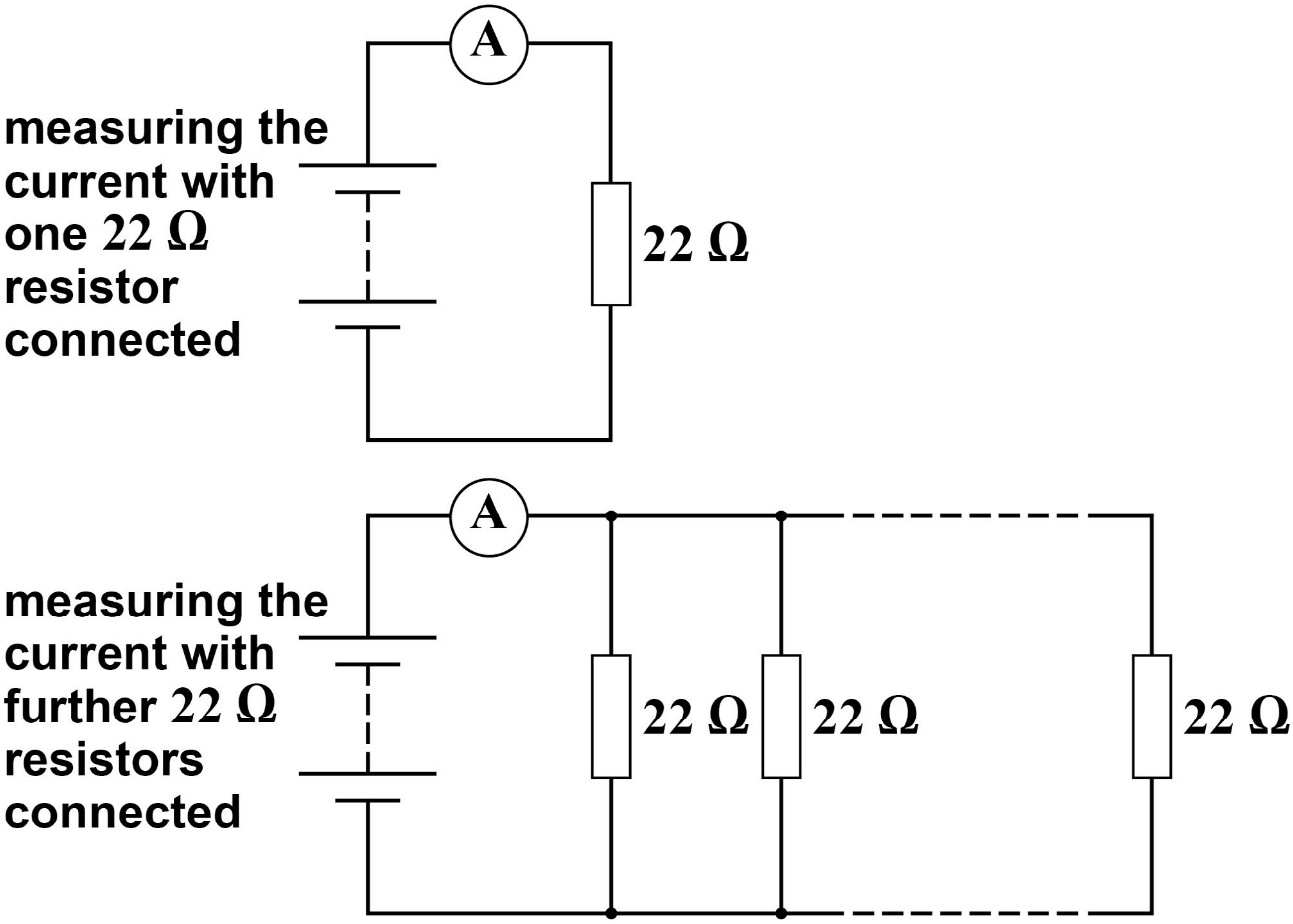
[Turn over]

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

FIGURE 11



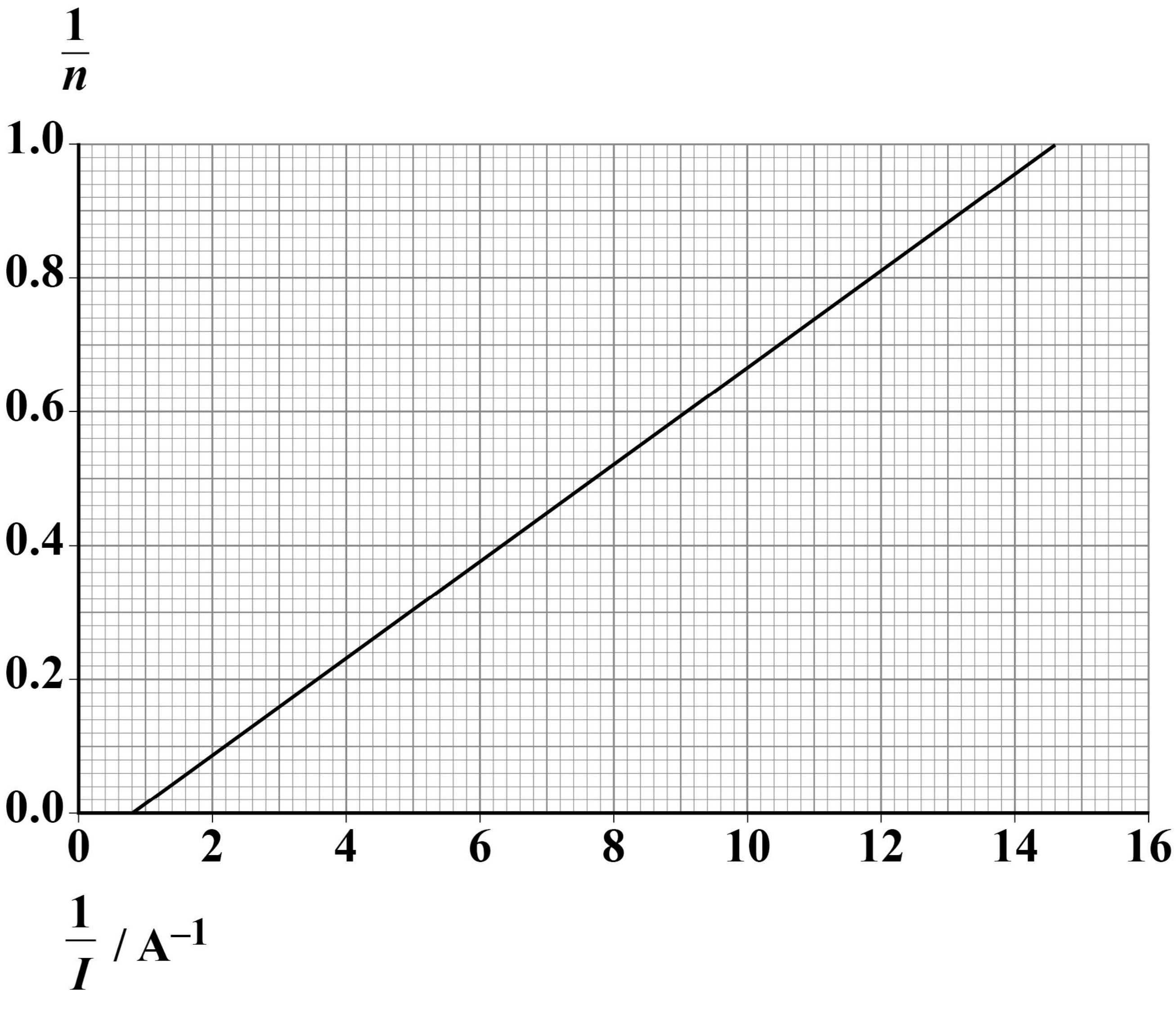
Initially the power supply is connected in series with an ammeter and a $22\ \Omega$ resistor. The current I in the circuit is measured.

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

FIGURE 12 shows a graph of the experimental data.

FIGURE 12



[Turn over]

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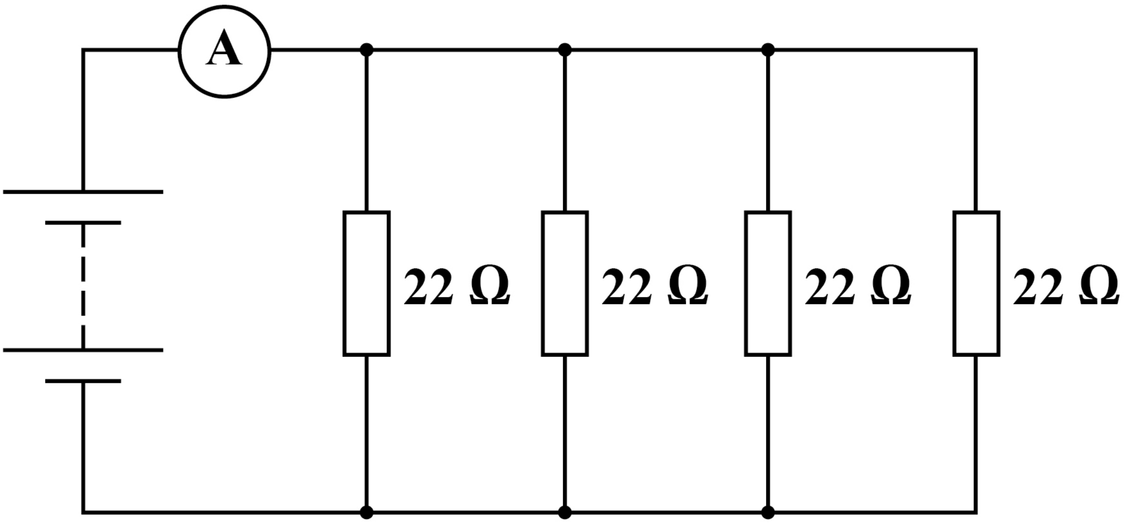
0 3 . 3 **Show that ε is about $1.6\ \mathrm{V}$. [2 marks]**

[Turn over]

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*.**

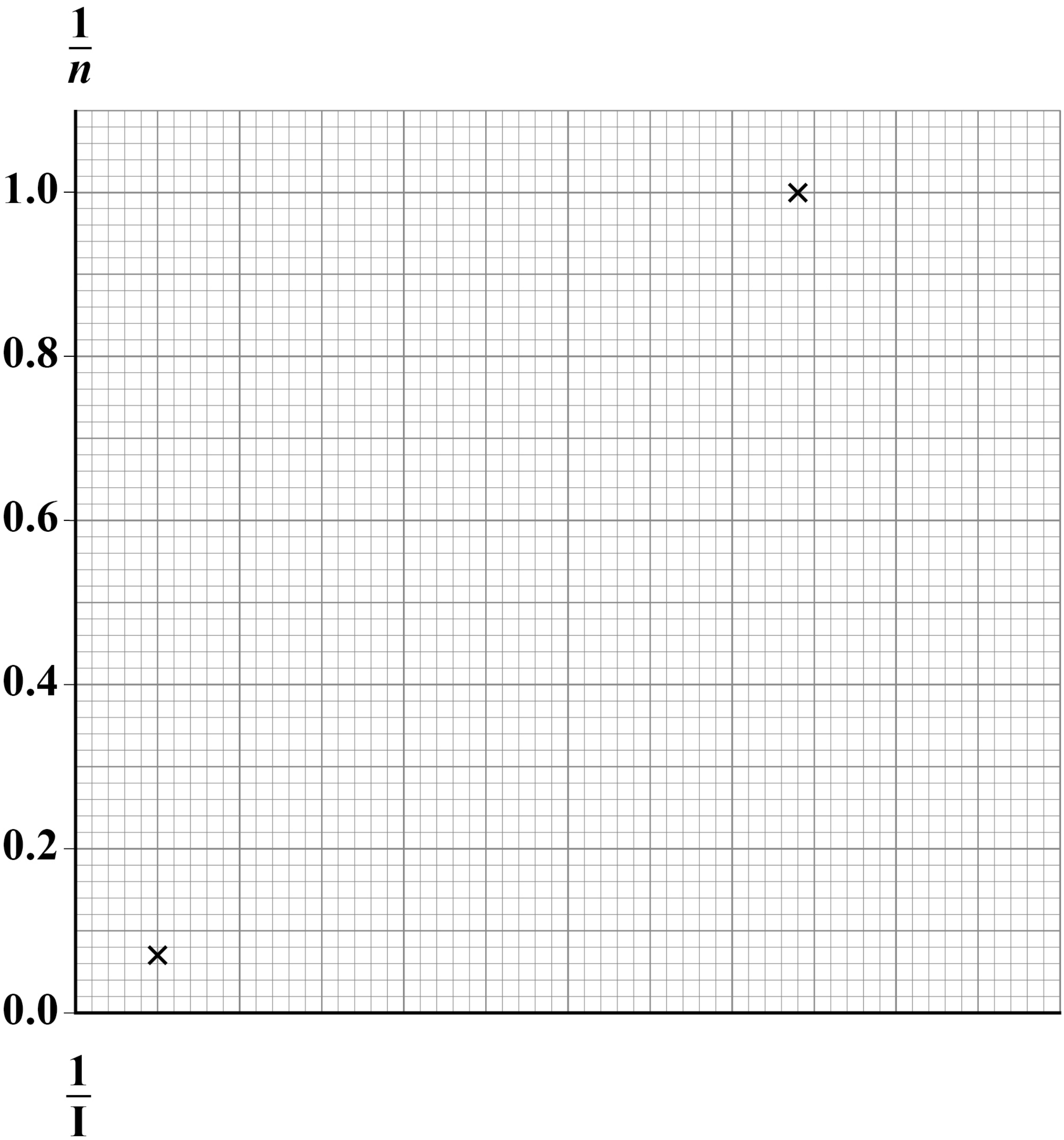
[4 marks]

pd = ____________________________ V

r = ____________________________ Ω

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

FIGURE 14



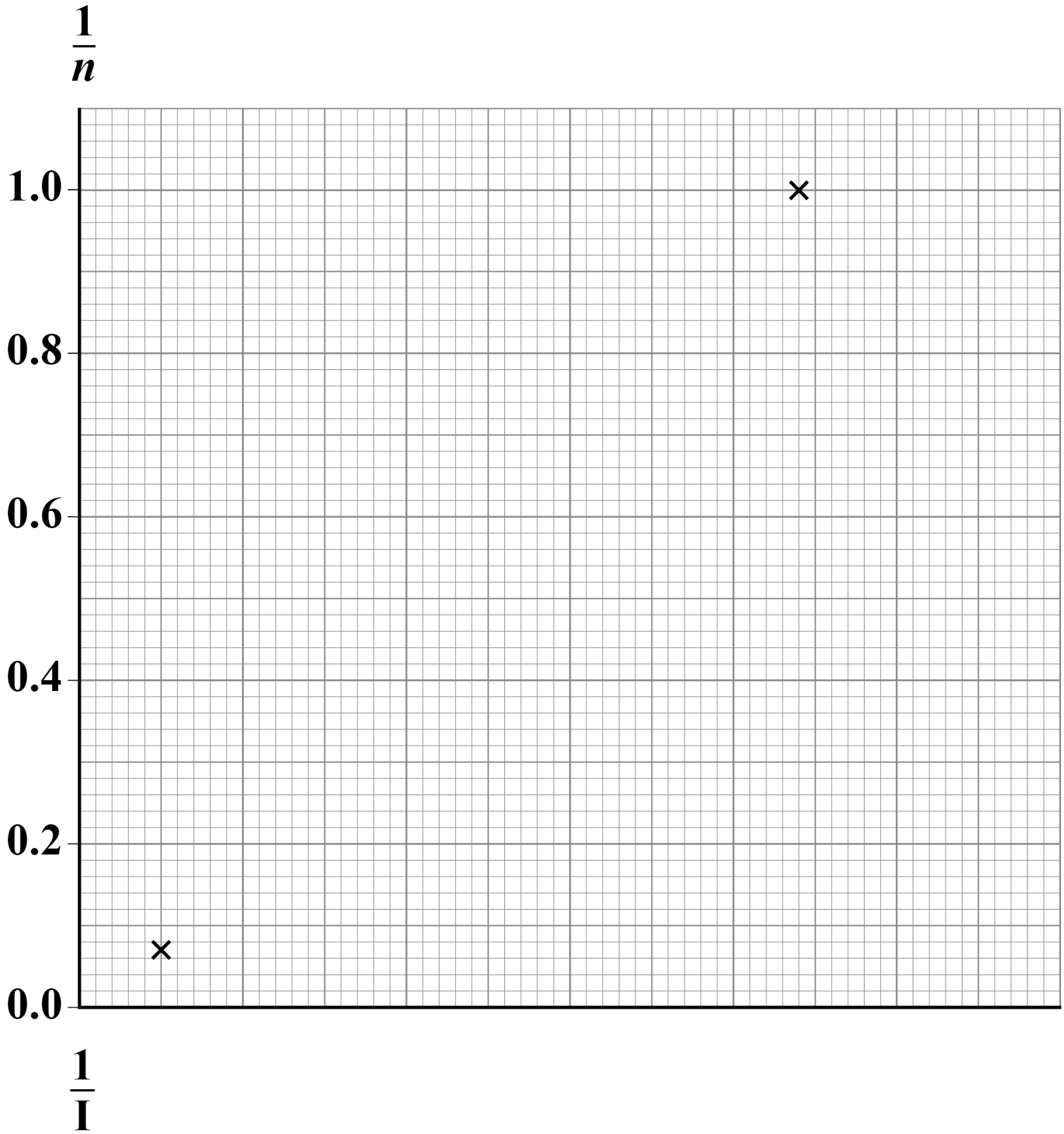
THREE additional data sets for values of n between $n = 1$ and $n = 14$ are needed to complete the graph in FIGURE 14.

Suggest which additional values of n should be used.

Justify your answer. [3 marks]

[Turn over]

REPEAT OF FIGURE 14



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]

END OF QUESTIONS

17

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

Additional page, if required.

Write the question numbers in the left-hand margin.

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For Examiner's Use	
Question	Mark
1	
2	
3	
TOTAL	

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2 0 6 A 7 4 0 8 / 3 A