

Please write clearly in block capitals.

Centre number

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Candidate number

8	3	7	0
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Surname Matheson

Forename(s) Lewis

Candidate signature 

I declare this is my own work.

A-level PHYSICS

Paper 3
Section A

A Level Physics Online . com

Monday 17 June 2024

Morning

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	
TOTAL	



Section AAnswer **all** questions in this section.**0 1**

This question is based on a method to determine the resistivity of a wire (required practical activity 5).

Figure 1 shows a micrometer screw gauge.

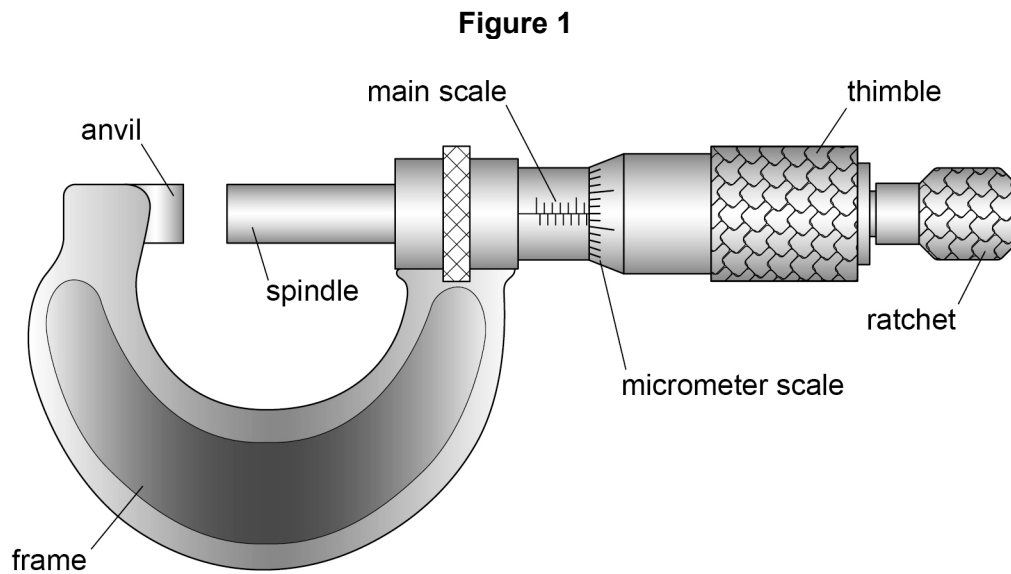
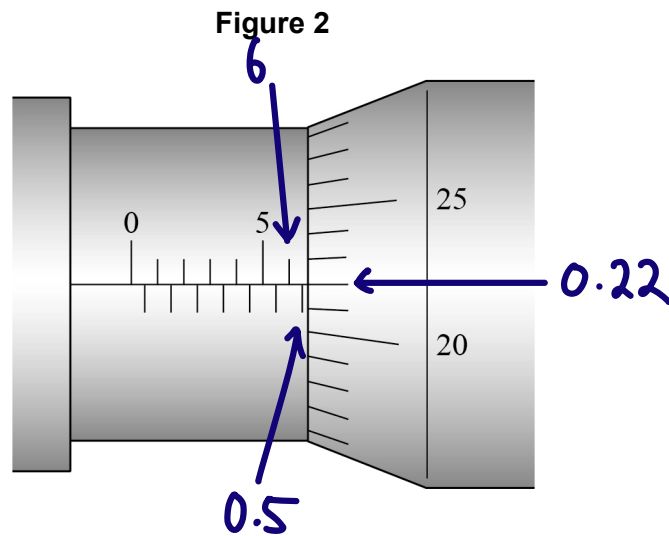


Figure 2 shows an enlarged view of the scales.



0 1 . 1 State, in mm, the resolution of the main scale.

[1 mark]

resolution = ± 0.5 mm

0 1 . 2 What is the reading on the micrometer?

Tick (✓) **one** box.

[1 mark]

6.22 mm

6.72 mm ✓

6.78 mm

8.22 mm

0 1 . 3 A wire X is placed in the gap between the anvil and the spindle.

State and explain how this gap is closed just before taking a reading of the diameter of X.

[1 mark]

Using the ratchet, until it just clicks. This is so it doesn't deform the wire. ✓

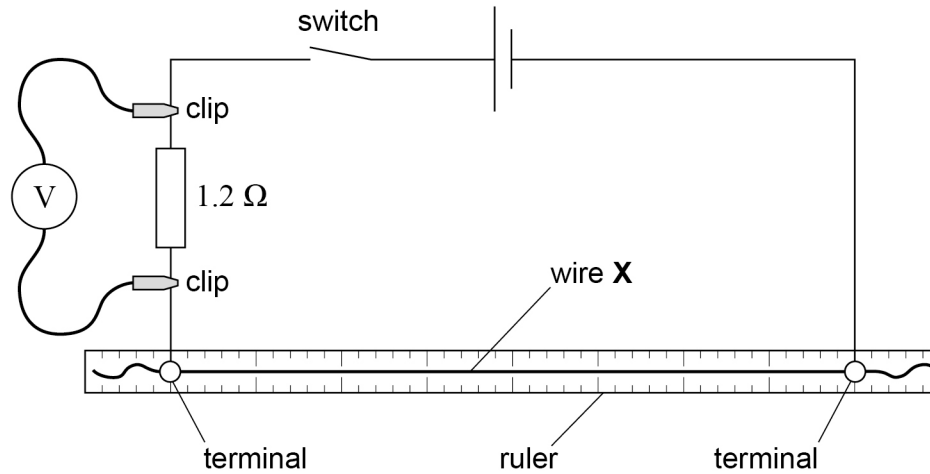
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Figure 3 shows a circuit used to determine the resistance per metre of wire **X**.

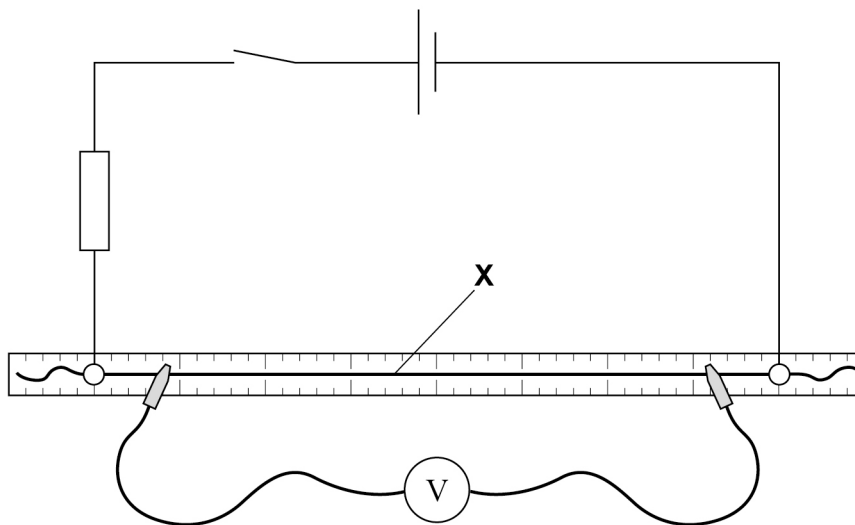
Figure 3



Two terminals are used to mount **X** on a ruler.
Clips are used to connect a voltmeter across the 1.2Ω resistor.
When the switch is closed, the voltmeter reading is 931 mV .

The switch is then opened and the voltmeter is connected to **X** as shown in **Figure 4**.

Figure 4



0 1 4 When the switch is closed, the voltmeter reading is 397 mV.

Show that, for the arrangement in **Figure 4**, the resistance R of the wire between the clips is about 0.5Ω .

[2 marks]

$$I = \frac{V}{R} = \frac{0.931}{1.2} = 0.7758 \text{ A} \checkmark$$

$$R = \frac{V}{I} = \frac{0.397}{0.7758} = \underline{0.512} \checkmark \approx 0.5 \Omega$$

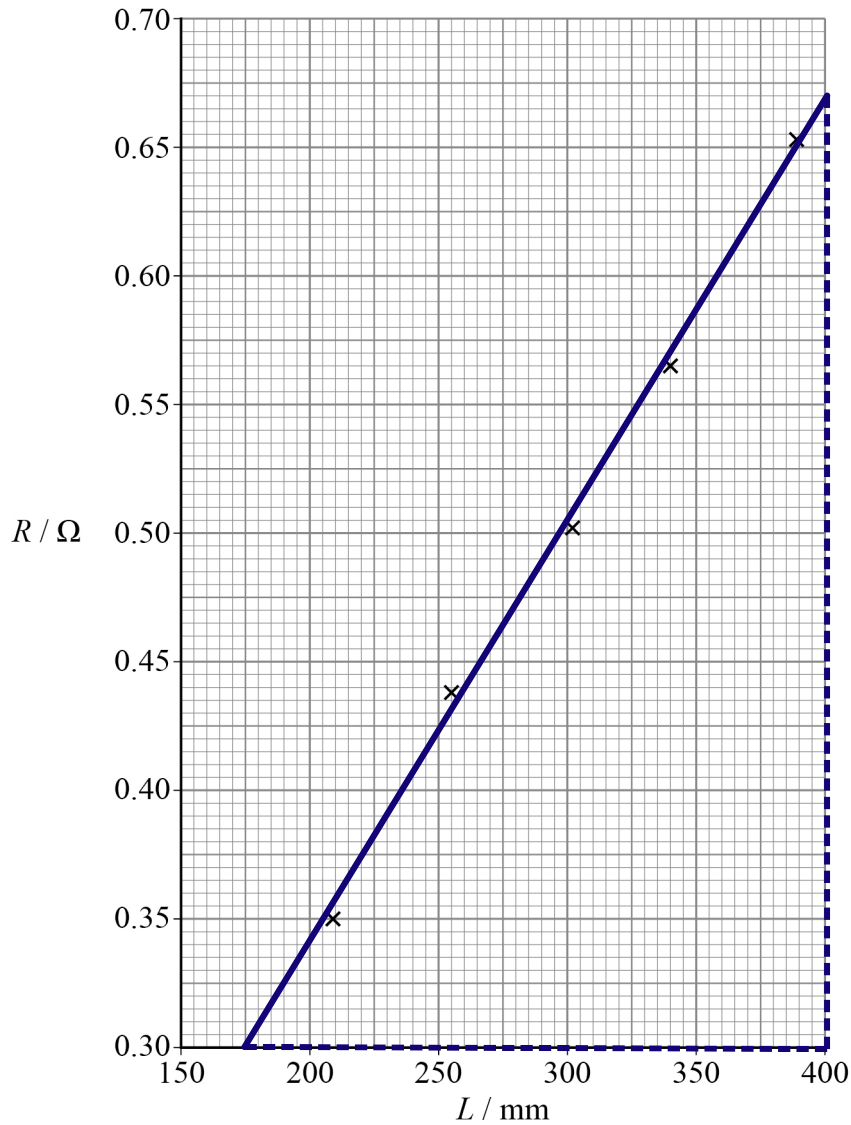
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The length of wire between the clips is L .
Values of R are determined for different values of L .
Figure 5 shows these data.

Figure 5



0 1 . 5 Determine the resistance per metre of X.

[2 marks]

$$\text{Gradient} = \frac{0.67 - 0.30}{(400 - 175) \times 10^{-3}} = 1.64$$

resistance per metre = 1.6 $\Omega \text{ m}^{-1}$



0 1 . 6

Table 1 shows the resistance per metre of various metal wires.
The diameter of **X** is one of the values of d shown in **Table 1**.

Table 1

d / mm	Resistance per metre of wire / $\Omega \text{ m}^{-1}$			
	copper	tungsten	alumel	nichrome
0.38	0.151	0.504	3.15	9.73
0.93	0.0247	0.0824	0.515	1.59
1.63	0.00805	0.0268	0.168	0.518
2.08	0.00494	0.0165	0.103	0.318
3.66	0.00160	0.00532	0.0333	0.103

Identify the metal used for **X**.

Go on to determine the resistivity of the metal.
State an appropriate SI unit for your answer.

[4 marks]

$$\rho = \frac{RA}{L} = \frac{R \cdot \pi d^2}{4} = 1.59 \times \frac{\pi \times (0.93 \times 10^{-3})^2}{4}$$

$$\rho = 1.08 \times 10^{-6}$$

metal used for **X** = Nichrome ✓
 resistivity = 1.1×10^{-6} ✓ SI unit = $\Omega \text{ m}$ ✓

Question 1 continues on the next page

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0 1 . 7

A student adds error bars for R and L to each point on **Figure 5**.

She estimates that

- each value of R has a percentage uncertainty of 6%
- each value of L has an absolute uncertainty of 5 mm.

Compare her error bars for the point at $L = 209$ mm with her error bars for the point at $L = 388$ mm.

[2 marks]

$$L = 209 \text{ mm} \quad L \text{ from } 204 \text{ to } 214 \text{ mm}$$

$$R = 0.35 \Omega \quad R \text{ from } 0.329 \text{ to } 0.371 \Omega$$

$$L = 388 \text{ mm} \quad L \text{ from } 383 \text{ to } 393 \text{ mm}$$

$$R = 0.652 \quad R \text{ from } 0.613 \text{ to } 0.691 \Omega \quad \checkmark$$

For both points, the horizontal error bar for L is the same width. For the vertical error bar, it is much bigger for a larger value of R , 0.078 compared to 0.042 Ω . \checkmark



0 1 . 8

Outline how error bars are used to determine the uncertainty in the gradient of a linear graph.

[2 marks]

Draw the worst acceptable straight line that passes through all the error bars. ✓
The uncertainty in the gradient will be equal to the difference between the gradient of the worst acceptable line and the line of best fit. ✓

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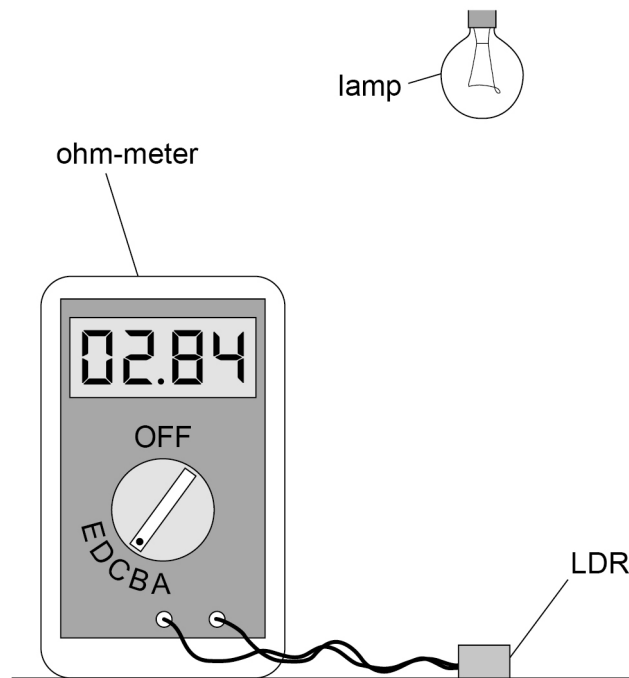
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0 2

Figure 6 shows apparatus used to investigate how the resistance R of a light-dependent resistor (LDR) varies with illumination.

Figure 6

The ohm-meter

- **always** displays a four-digit reading of R
- can be set to the different ranges **A** to **E** shown in **Table 2**.

Table 2

Setting	Maximum reading displayed	Minimum (non-zero) reading displayed	Unit
range A	199.9	000.1	Ω
range B	1999	0001	Ω
range C	19.99	00.01	$k\Omega$
range D	199.9	000.1	$k\Omega$
range E	1.999	0.001	$M\Omega$



- 0 2 . 1 Explain why the reading displayed in **Figure 6** shows that the ohm-meter is set to range **C**.

[1 mark]

The decimal point is between the 2nd and 3rd digit. ✓

- 0 2 . 2 The quantity E_V is a measure of the intensity of the light incident on the LDR. The SI unit of E_V is the lux (lx).

The resistance R of the LDR is given by

$$\log(R / \Omega) = -0.772 \log(E_V / \text{lx}) + 5.09$$

Show that E_V for the arrangement shown in **Figure 6** is about 130 lx.

[2 marks]

$$R = 2.84 \text{ k} \Omega \checkmark$$

$$\log R = -0.772 \log E_V + 5.09$$

$$E_V = 10^{(\log R - 5.09) / -0.772}$$

$$E_V = 10^{(\log 2840 - 5.09) / -0.772}$$

$$E_V = \underline{131.8} \checkmark \approx 130 \text{ lx}$$

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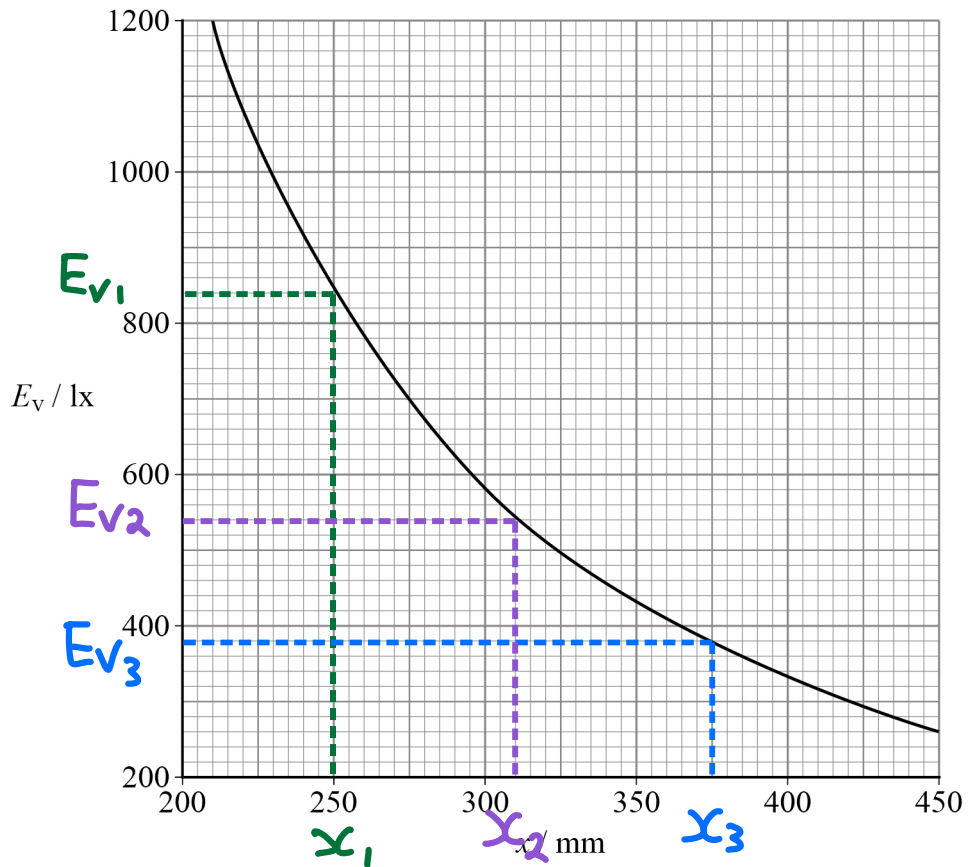


R is recorded for different values of the vertical distance x between the lamp and the LDR.

E_V is calculated for each value of R .

Figure 7 shows how E_V varies with x .

Figure 7



It can be shown that $E_V \propto \frac{1}{x^2}$

0 2 3

Describe a method to show that **Figure 7** confirms this relationship. You do not need to show any calculations.

[2 marks]

$$E_V x^2 = \text{Constant}$$

Take data for several values of x and E_V from the line of best fit. ✓ Multiply $E_V \times x^2$ and it should give a constant value if this relationship is true. ✓

0 2 4

Deduce the value of x when $E_V = 130$ lx.

[2 marks]

$$E_{V_3} x_3^2 = E_{V_{130}} \cdot x_{130}^2$$

$$x_{130} = \sqrt{x_3^2 \cdot \frac{E_{V_3}}{E_{130}}} = \sqrt{375^2 \times \frac{380}{130}}$$

$$x_{130} = 641$$

$$x = \underline{641} \text{ ✓ mm}$$

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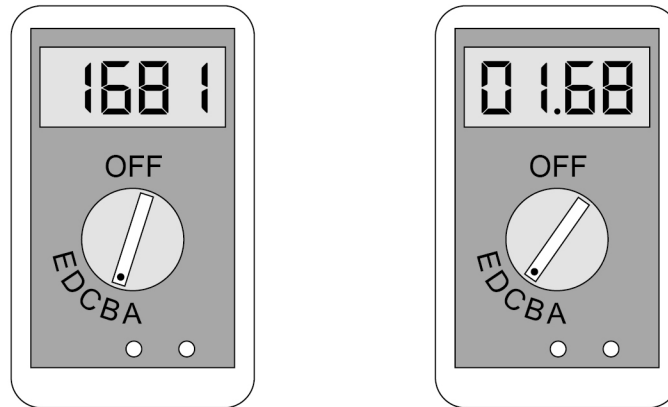
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0 2 . 5 R is measured when $x = 450$ mm.

Figure 8 shows how the ohm-meter displays the values of R when set to range **B** and when set to range **C**.

Figure 8



The uncertainty of the reading on the ohm-meter is $\pm 2\%$ of the displayed reading plus ± 2 in the least significant digit.

This means that:

- using range **B** the **maximum** value of R is $1.02 \times 1681 + 2 = 1717 \Omega$
- using range **C** the **minimum** value of R is $0.98 \times 1.68 - 0.02 = 1.63 \text{ k}\Omega$.



Complete **Table 3**.

Go on to explain whether range **B** or range **C** should be used to measure R .

[2 marks]

Table 3

Setting	Minimum R	Maximum R
range B	<u>1645</u> Ω	1717 Ω
range C	1.63 k Ω	<u>1.73</u> k Ω



$$B_{\min} = 0.98 \times 1681 - 2 = 1645 \Omega$$

$$C_{\max} = 1.02 \times 1.68 + 0.02 = 1.73 \text{ k}\Omega$$

Range B should be used to measure values of R , as with a smaller range in the single reading the percentage uncertainty will be lower. ✓

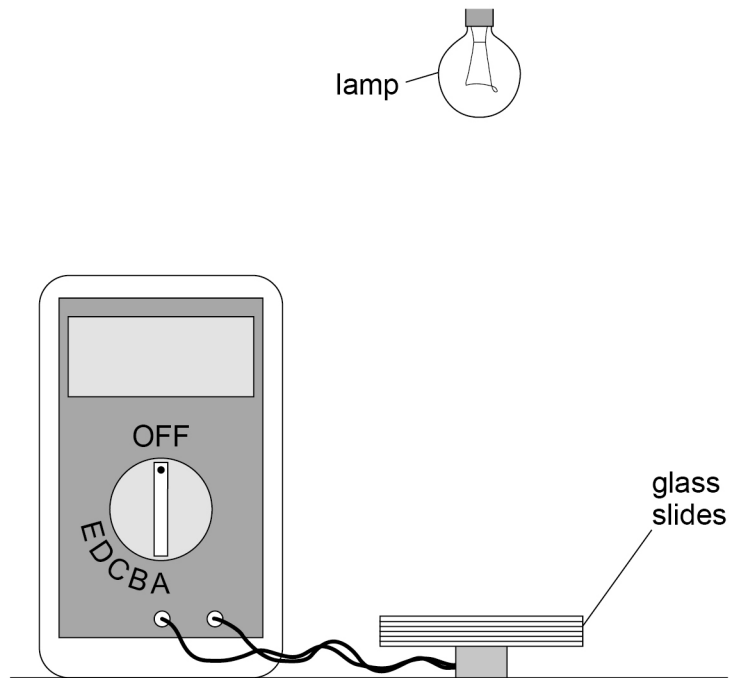
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Figure 9 shows the LDR being used to investigate the transmission of light through glass slides.

Figure 9



The lamp and ohm-meter are switched on.

R is recorded with different numbers of slides placed on the LDR.

E_V is calculated for each value of R .

0 2 6

The positions of the lamp and the LDR are not changed during the experiment.

Identify **two** other control variables.

[2 marks]

1 Background light levels in the room. ✓

2 Brightness of the lamp. ✓



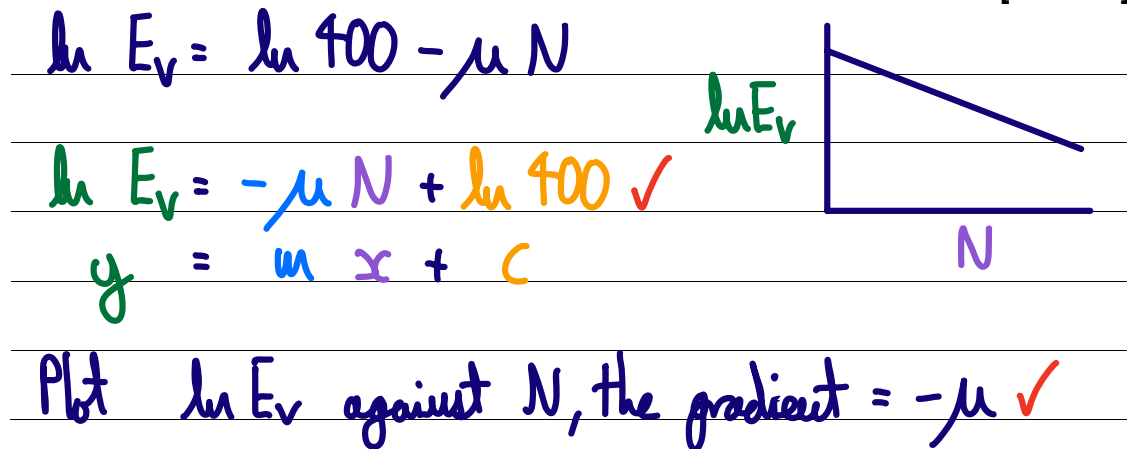
0 2 . 7 For the arrangement in **Figure 9** it can be shown that

$$E_V = 400 e^{-\mu N}$$

where N is the number of slides
 μ is a constant.

Explain how μ can be determined from a linear graph.

[2 marks]



0 2 . 8 In an experiment $\mu = 9.0 \times 10^{-2}$

Deduce the minimum number of slides needed to reduce E_V by 50%.

[2 marks]

$$200 = 400 e^{-9.0 \times 10^{-2} \cdot N}$$

$$\ln \frac{200}{400} = -9.0 \times 10^{-2} N \checkmark$$

$$N = \frac{\ln 2}{9.0 \times 10^{-2}} = 7.70$$

number of slides = 8 \checkmark

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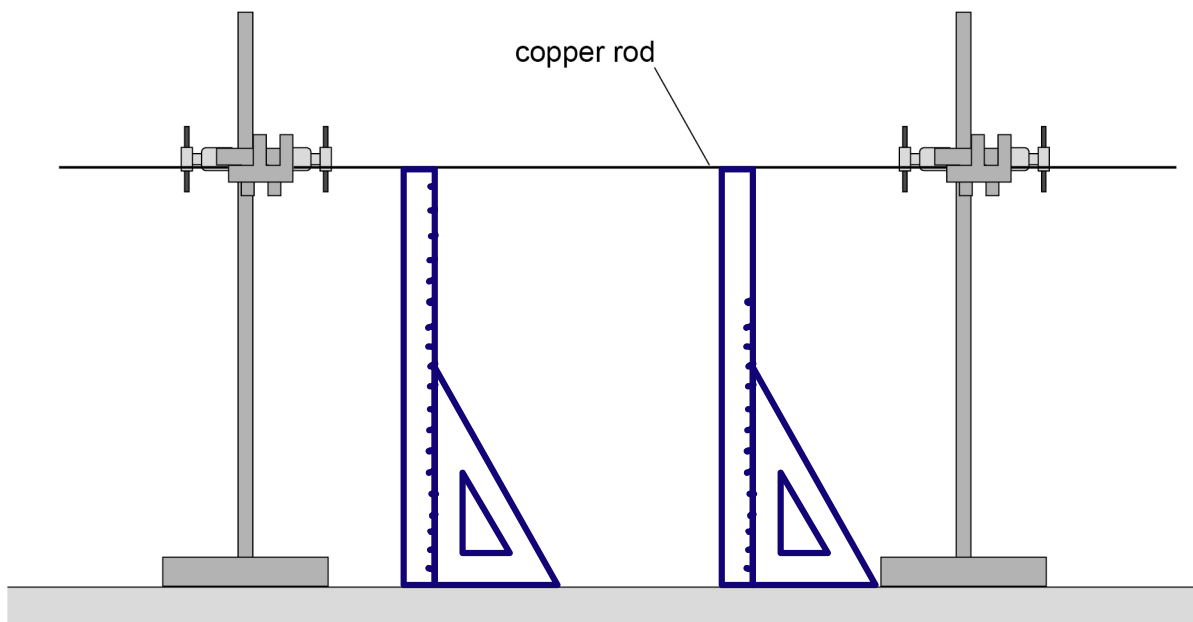


0 3

This question is about a method to investigate how the force on a conductor varies with flux density and current (required practical activity 10).

Figure 10 shows a copper rod clamped above a horizontal bench.

Figure 10



0 3 . 1

Describe a method to show that the copper rod is horizontal.
Your method must include the use of a metre ruler.
You may annotate **Figure 10**.

[3 marks]

Use a metre ruler to measure the height at multiple ✓ points along the rod to ensure it is a consistent height above the bench. ✓

Each time, use a set square to ensure the metre ruler is vertical, ensuring it is in contact with the bench and ruler. ✓

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Figure 11 shows the copper rod positioned above a digital balance.

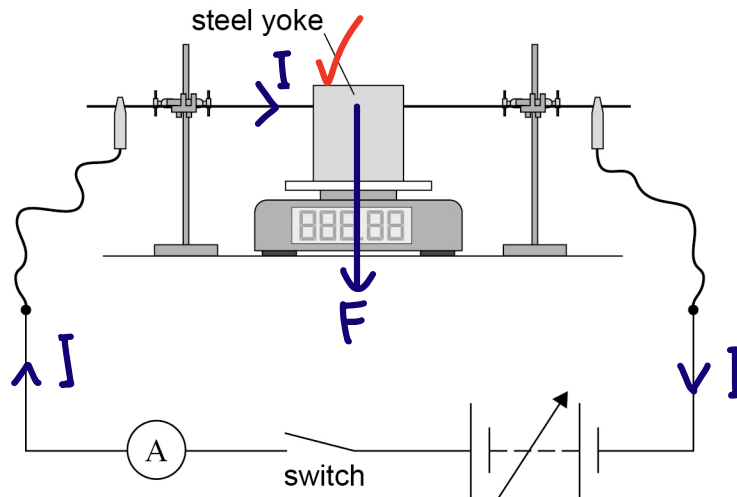
Two identical magnets are mounted on a steel yoke with their opposite poles facing each other.

The balance is zeroed.

The yoke is then placed on the balance so that a horizontal uniform magnetic field is applied perpendicular to the copper rod.

The ends of the rod are connected as shown.

Figure 11



0 3 . 2

When the switch is open, the reading on the balance shows the mass of the yoke and the two magnets.

When the switch is closed, the reading on the balance decreases.

Explain, with reference to **Figure 11**, the direction of the horizontal magnetic field.

[3 marks]

Reading decreases \therefore force on yoke is upwards \therefore force on rod is in opposite direction (N.III) and downwards. ✓
Using Fleming's left-hand rule, the magnetic field is out of the page. ✓



The current I in the rod is varied.

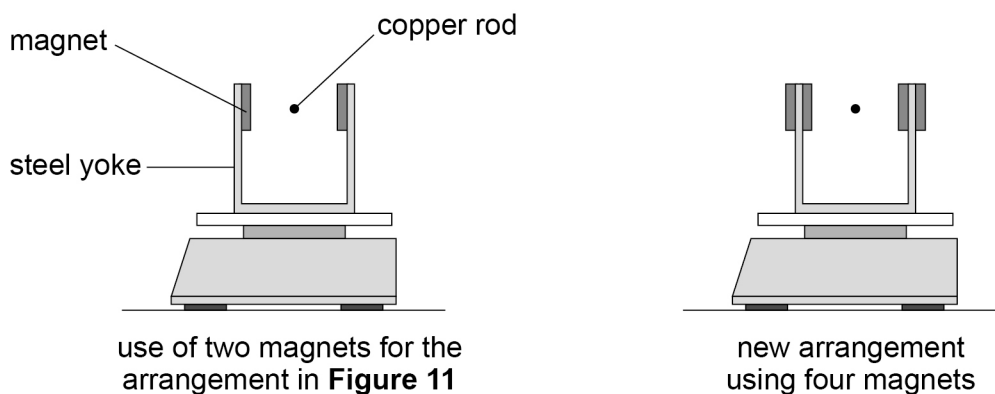
The balance reading M_1 is recorded for different values of I .

The switch is now opened.

Two additional magnets, identical to those used before, are attached to the yoke.

Figure 12 shows how this new arrangement compares with the arrangement in **Figure 11**.

Figure 12



The balance reading with four magnets attached to the yoke is M_2 .

With the switch open, M_2 is the mass of the yoke and the four magnets.

The switch is now closed.

M_2 is recorded for different values of I .

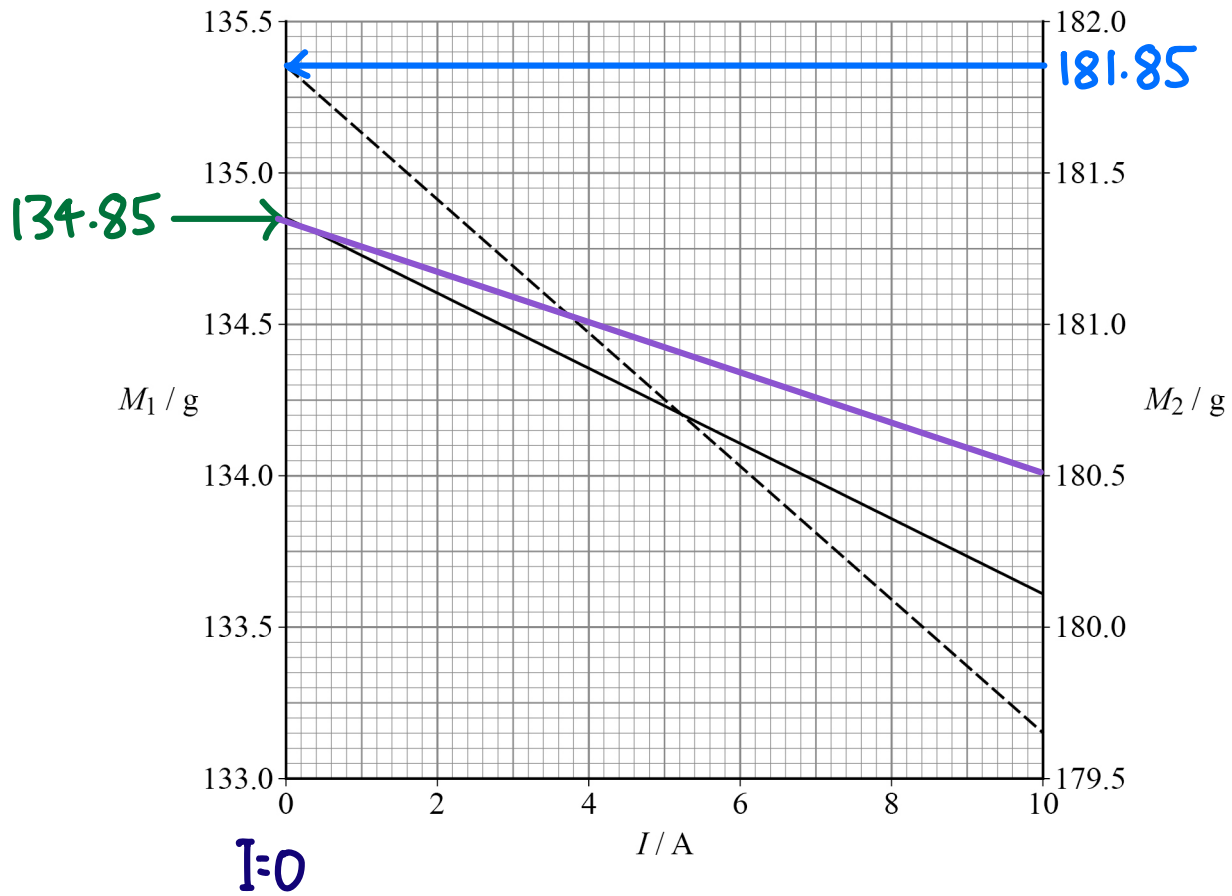
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Figure 13 shows data from both experiments.
Values of M_1 and M_2 are plotted using different vertical axes.

Figure 13



The solid line ——— shows the variation of M_1 with I

The dashed line - - - - shows the variation of M_2 with I



It can be shown that

$$M = kBI + nZ + Y$$

where

M = balance reading when the current is I

B = magnetic flux density of the horizontal uniform magnetic field

n = number of magnets attached to the yoke

Z = mass, in g, of each magnet

Y = mass, in g, of the yoke

k is a constant.

0 3 . 3 Deduce the fundamental base units for k .

[3 marks]

$$kBI = M$$

$$k = \frac{M}{BI}$$

$B = \frac{F}{IL} = \frac{\text{kg m s}^{-2}}{\text{A m}} = \text{kg s}^{-2} \text{A}^{-1}$ ✓

$$k = \frac{\text{kg}}{\text{kg s}^{-2} \text{A}^{-1} \text{A}} = \text{s}^2$$

fundamental base units = s^2 ✓

0 3 . 4 Determine Y .

When $I = 0$ $M = nZ + Y$

[3 marks]

$$M_1 = 2Z + Y \quad 2M_1 = 4Z + 2Y \quad \textcircled{1}$$

$$M_2 = 4Z + Y \quad \textcircled{2}$$

$$\textcircled{1} - \textcircled{2} \quad 2M_1 - M_2 = Y \quad \checkmark$$

$$Y = (2 \times 134.85) - 181.85 = 87.85 \quad \checkmark$$

$$Y = \underline{87.85} \quad \checkmark \quad \text{g}$$

Question 3 continues on the next page

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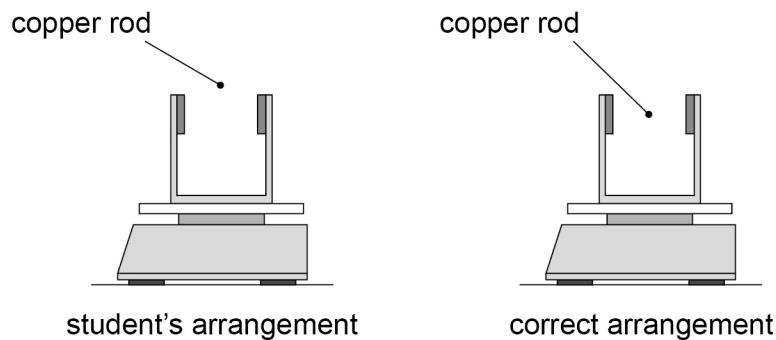


0 3 . 5

A student sets up the apparatus with the copper rod positioned incorrectly.

Figure 14 shows how the student's arrangement compares with the correct arrangement.

Figure 14



The student produces a graph of M_1 against I .

Compare the student's graph with the graph of M_1 against I (the solid line) in **Figure 13**.

Explain your answer.

[3 marks]

$$M_1 = kBI + nZ + Y$$

$$y = mx + c$$

The y -intercept (where $I = 0$) would be in the same place as the mass of the yoke and magnets will remain the same. ✓
 But as the field strength B is smaller in the student's arrangement, the gradient would be less steep. ✓
 (purple line) This is because the force for each current would be lower. ✓

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END OF QUESTIONS



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