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

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.

| 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.

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## Section A

Answer **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 1**

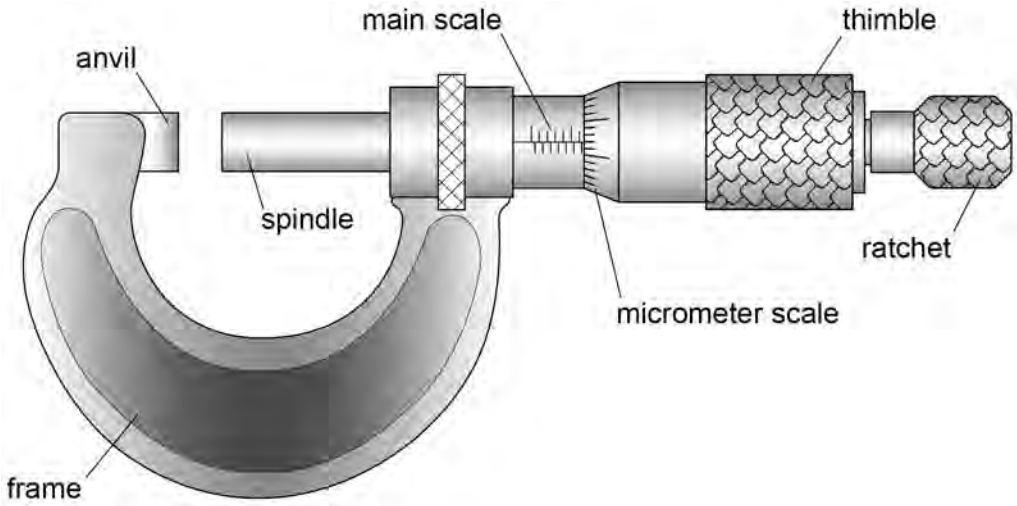
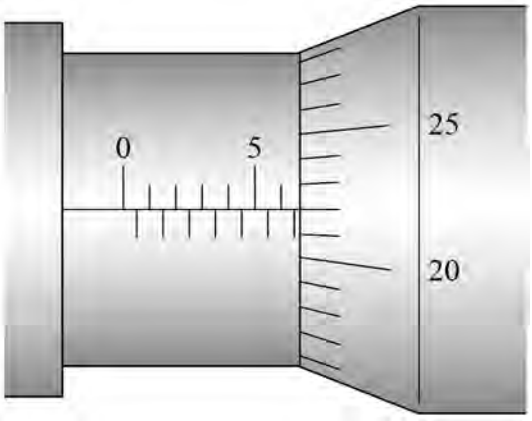



**Figure 2** shows an enlarged view of the scales.

**Figure 2**



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

**[1 mark]**

resolution = _____ 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]**

_____

_____

_____

**Question 1 continues on the next page**

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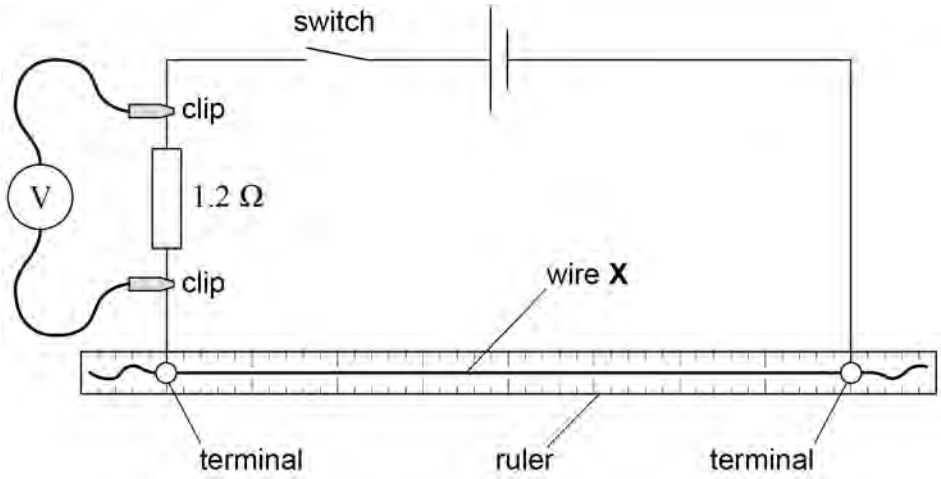
**Figure 3** shows a circuit used to determine the resistance per metre of wire **X**.

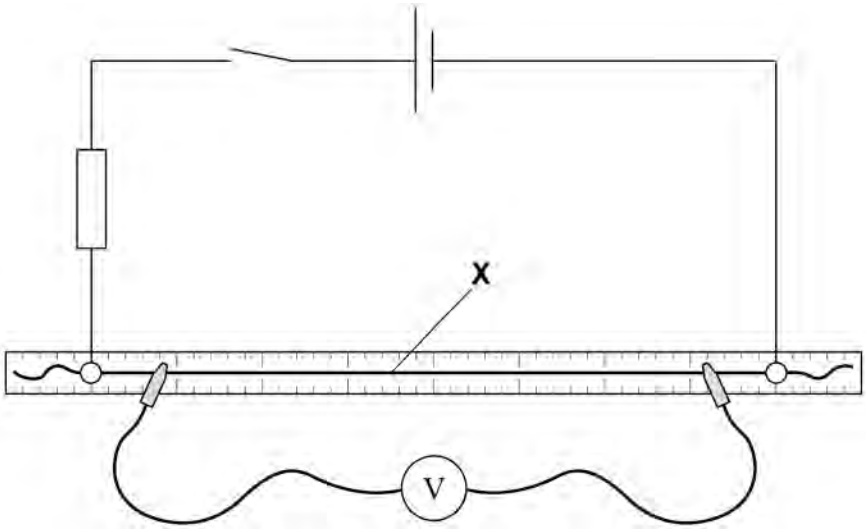
**Figure 3**




Two terminals are used to mount **X** on a ruler.
Clips are used to connect a voltmeter across the $1.2\ \Omega$ resistor.
When the switch is closed, the voltmeter reading is $931\ \text{mV}$.

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

**Figure 4**



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**0 1 . 4** When the switch is closed, the voltmeter reading is $397\ \text{mV}$.

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

**[2 marks]**

**Question 1 continues on the next page**

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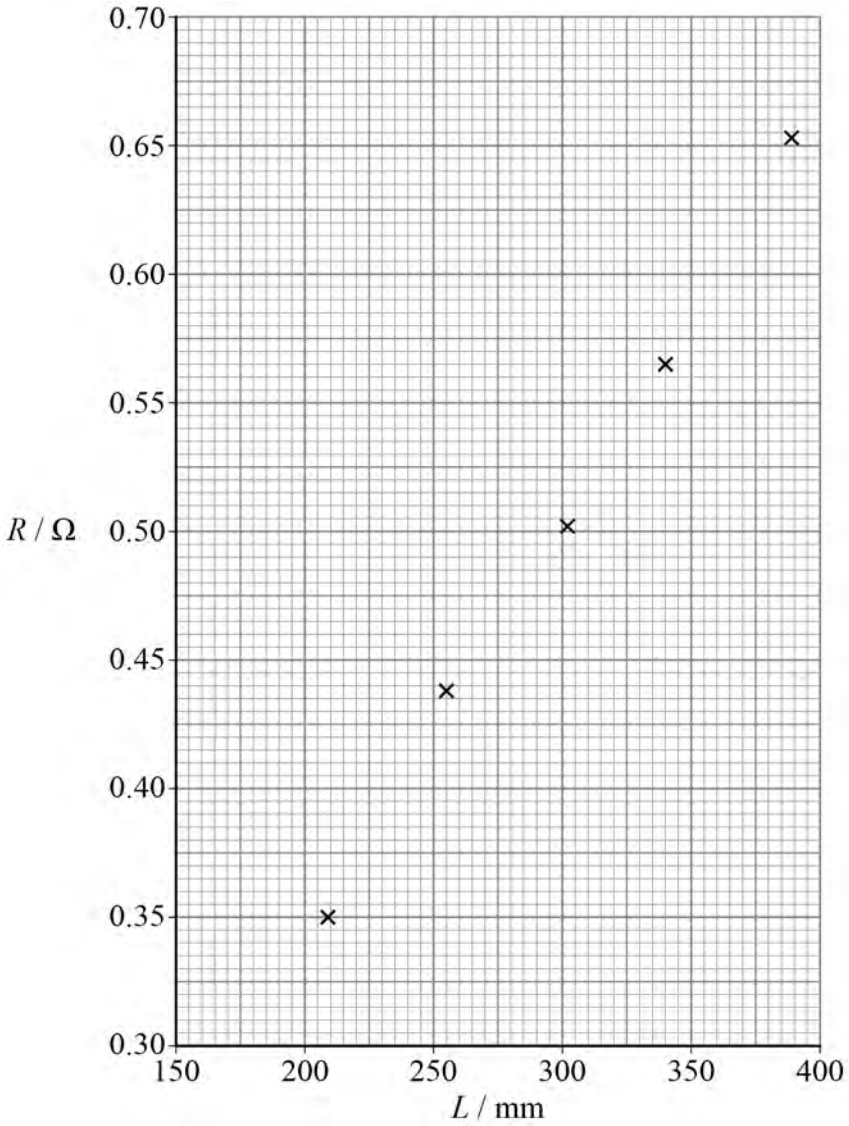
The length of wire between the clips is $L$.
Values of $R$ are determined for different values of $L$.
**Figure 5** shows these data.

**Figure 5**




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

**[2 marks]**

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

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**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**

| | Resistance per metre of wire / $\Omega\ m^{-1}$ | | | |
|---|---|---|---|---|
| $d$ / mm | 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]**

metal used for **X** = _____

resistivity = _____ SI unit = _____

**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 $5\ \text{mm}$.

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

**[2 marks]**

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**0 1 . 8** Outline how error bars are used to determine the uncertainty in the gradient of a linear graph.

**[2 marks]**

15

**Turn over for the next question**

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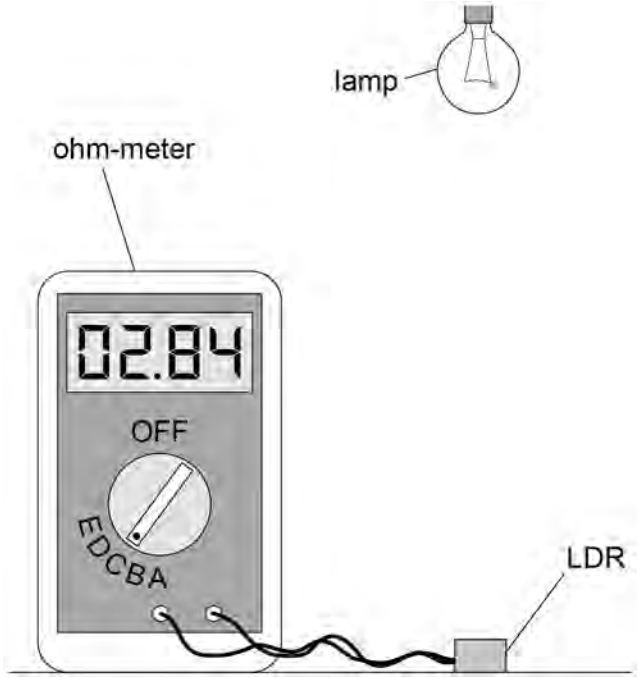
**0 2** **Figure 6** shows apparatus used to investigate how the resistance $R$ of a light-dependent resistor (LDR) varies with illumination.

**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 | kΩ |
| range **D** | 199.9 | 000.1 | kΩ |
| range **E** | 1.999 | 0.001 | MΩ |

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

**[1 mark]**

**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]**

**Question 2 continues on the next page**

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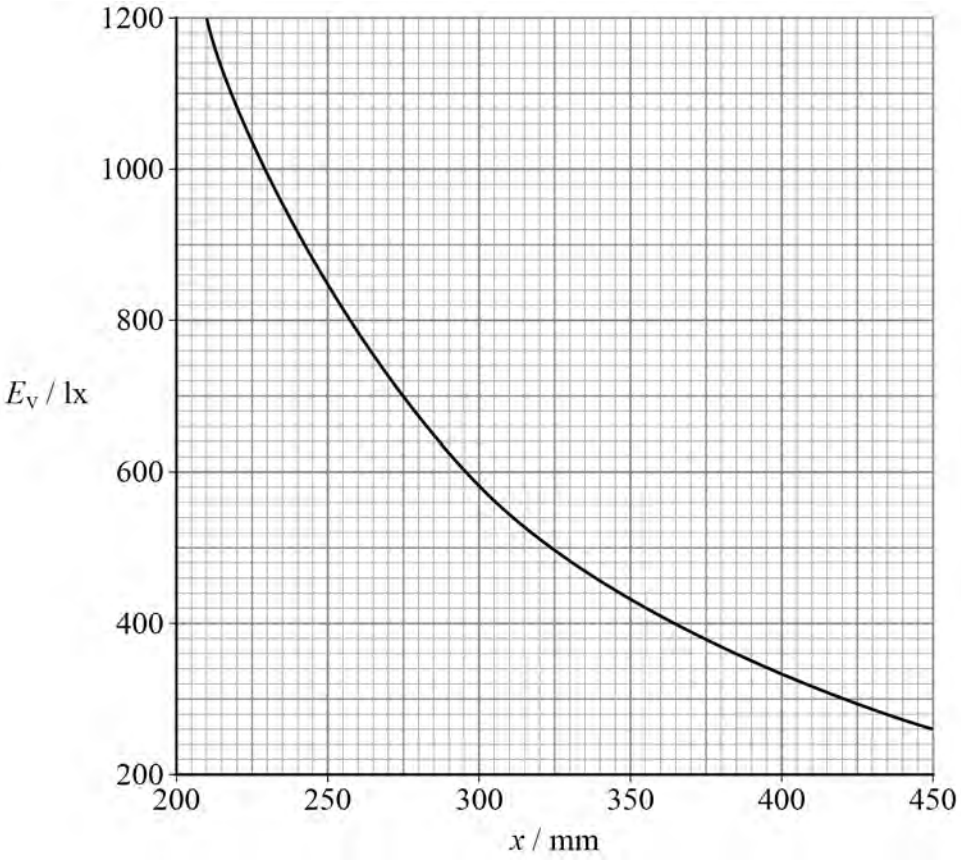
$R$ is recorded for different values of the vertical distance $x$ between the lamp and the LDR.
$E_V$ is calculated for each value of $R$.

**Figure 7** shows how $E_V$ varies with $x$.

**Figure 7**



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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]**

**0 2 . 4** Deduce the value of $x$ when $E_V = 130$ lx.

**[2 marks]**

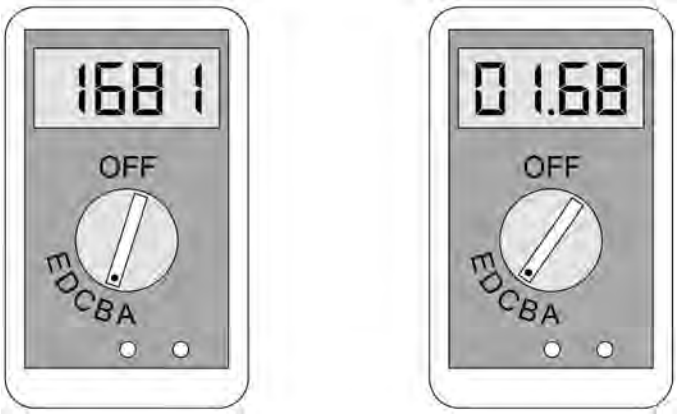
$x =$ _____ mm

**Question 2 continues on the next page**

Do not write outside the box

**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 ±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 $0.98 \times 1.68 - 0.02 = 1.63\ \text{k}\Omega$.

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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** | _____ Ω | 1717 Ω |
| range **C** | 1.63 kΩ | _____ kΩ |

**Question 2 continues on the next page**

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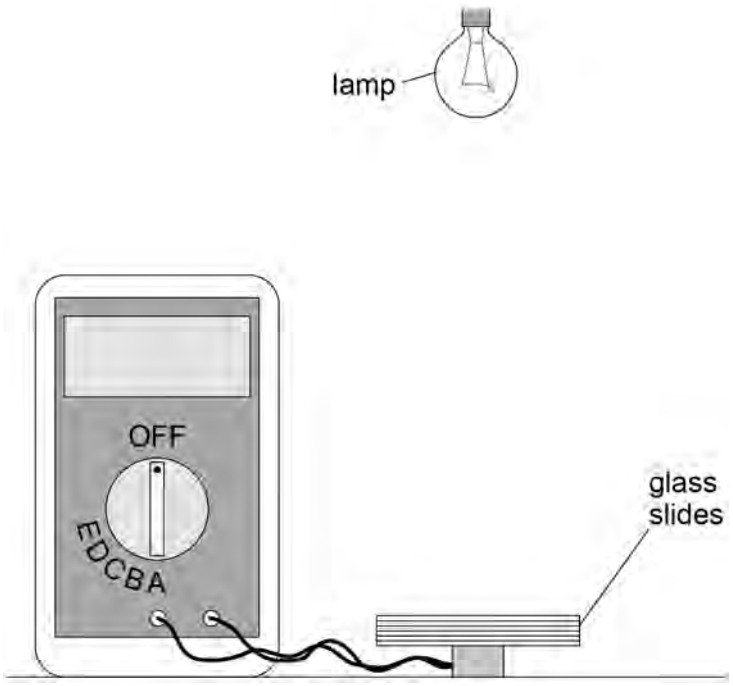
**Figure 9** shows the LDR being used to investigate the transmission of light through glass slides.

**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 _____

_____

2 _____

_____

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**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
$\mu$ is a constant.

Explain how $\mu$ 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]**

number of slides = _____

15

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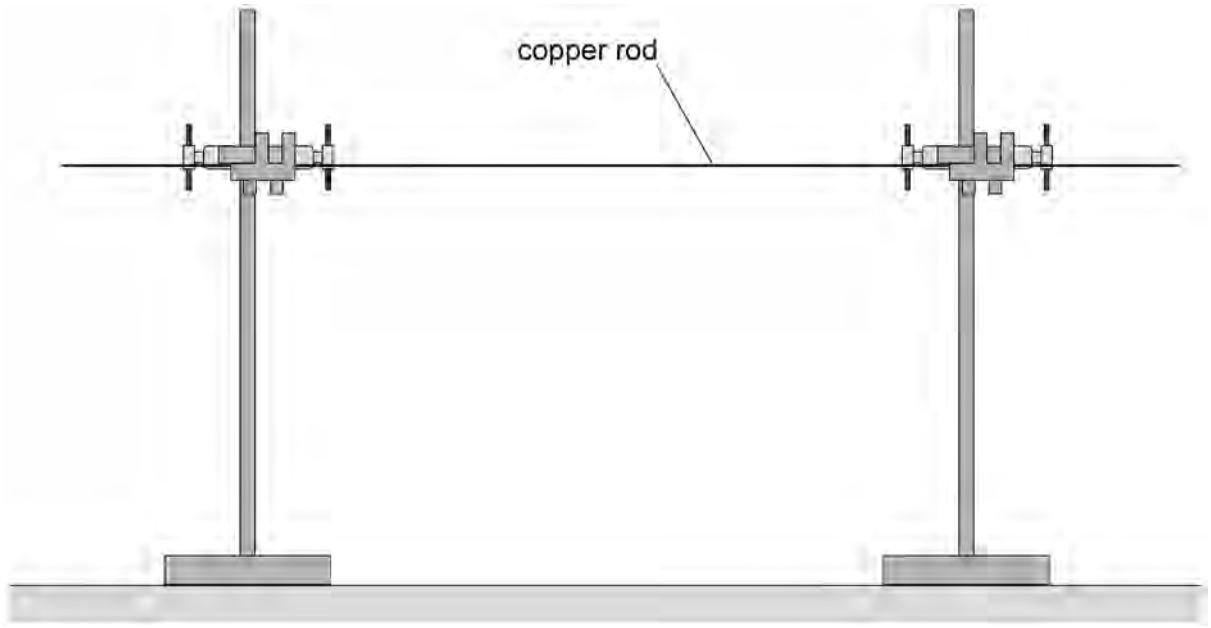
**0 3** This question is about a method to investigate how the force on a conductor varies with flux density and current (required practical activity 10).

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

**Figure 10**



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**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]**

**Question 3 continues on the next page**

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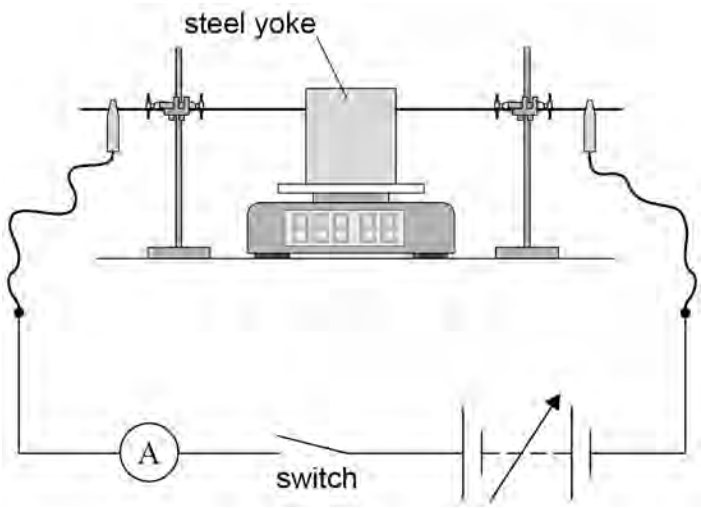
**Figure 11** shows the copper rod positioned above a digital balance.

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.

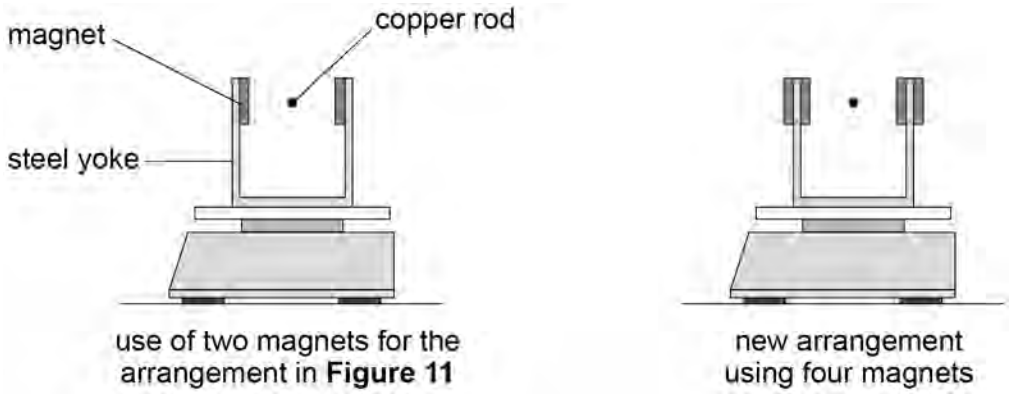
**[3 marks]**

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 $I$.

**Question 3 continues on the next page**

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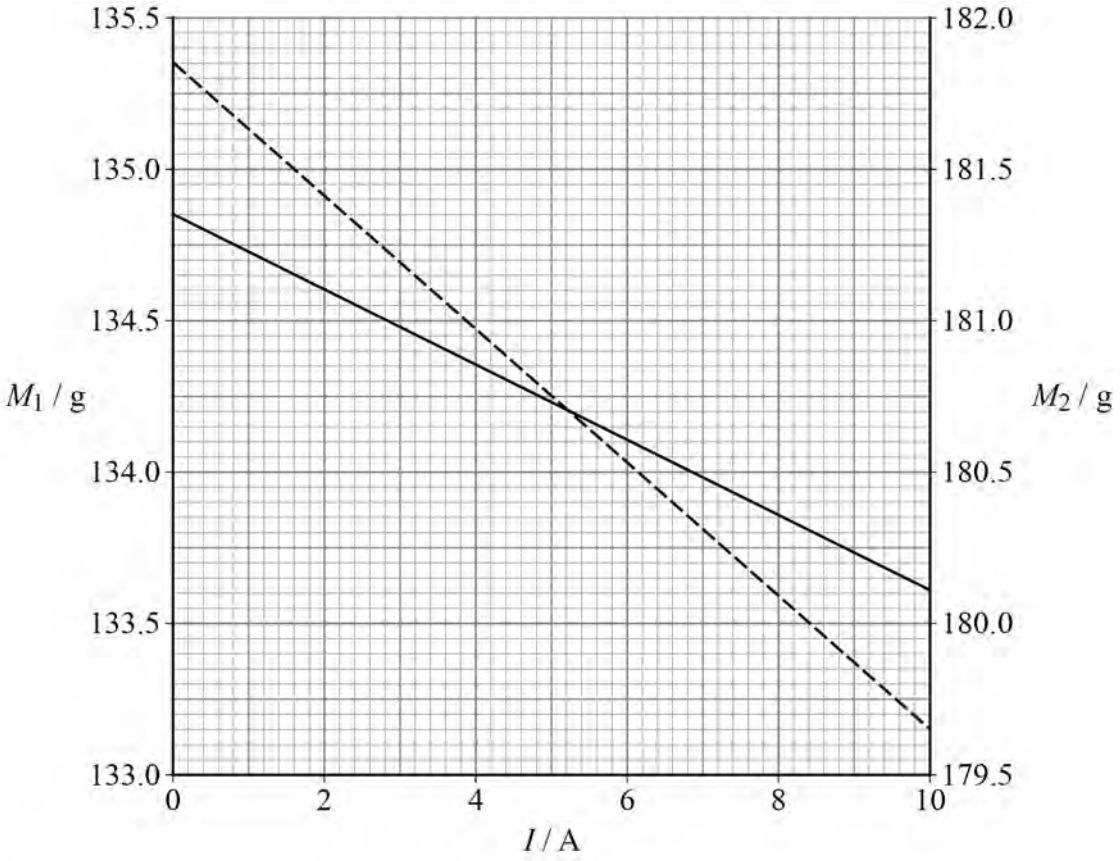
**Figure 13** shows data from both experiments.
Values of $M_1$ and $M_2$ are plotted using different vertical axes.

**Figure 13**




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

The dashed line – – – – – shows the variation of $M_2$ with $I$

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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]**

fundamental base units = _____

**0 3 . 4** Determine $Y$.

**[3 marks]**

$Y$ = _____ g

**Question 3 continues on the next page**

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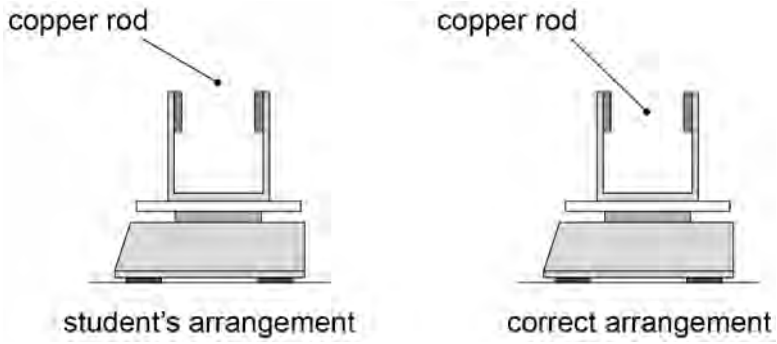
**0 3 . 5** A student sets up the apparatus with the copper rod positioned incorrectly.

**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]**

15

**END OF QUESTIONS**

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**ANSWER IN THE SPACES PROVIDED**

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