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Exam Preparation and Free Resources

Name of the Student:_____

Max. Marks : 19 Marks

Time : 19 **Minutes**

Q1.

This question is about using a digital balance to investigate the force on a wire placed in a magnetic field when there is an electric current in the wire.

A student carries out the procedure shown in **Figure 1** and **Figure 2**.
A metre ruler is pivoted at the 1.0 cm mark and a prism is placed on a digital balance. The free end of the ruler is raised and the balance is turned on and then set to zero, as shown in **Figure 1**.

Figure 1

free end of metre
ruler raised

000.00 g

digital balance
(turned on and then set to zero)
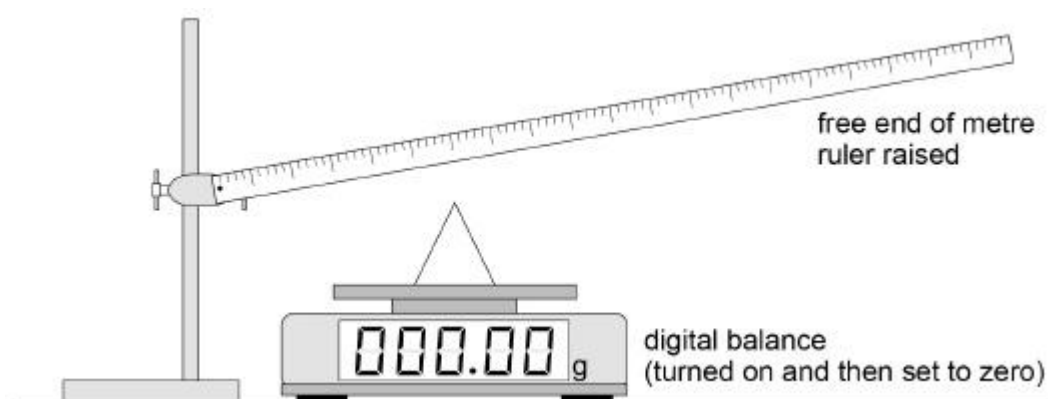
The ruler is then supported by the prism with the apex of the prism at the 30.0 cm mark as shown in **Figure 2**. The height of the pivot is adjusted so that the ruler is horizontal.

Figure 2

metre ruler supported
by the prism

214.66 g
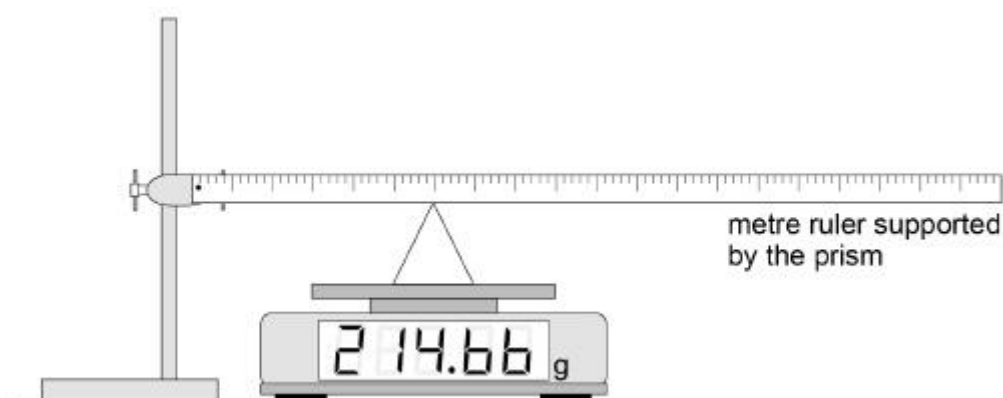
(a)   Deduce the mass of the ruler.
State **one** assumption you make.

mass of ruler = _____ g

assumption _____

_____

(3)

(b)   The student attaches a uniform wire to the upper edge of the ruler, as shown in **Figure 3**.

The ends of the wire are connected to terminal blocks **P** and **Q** which are fixed firmly to the bench. A power supply and an ammeter are connected between **P** and **Q**.

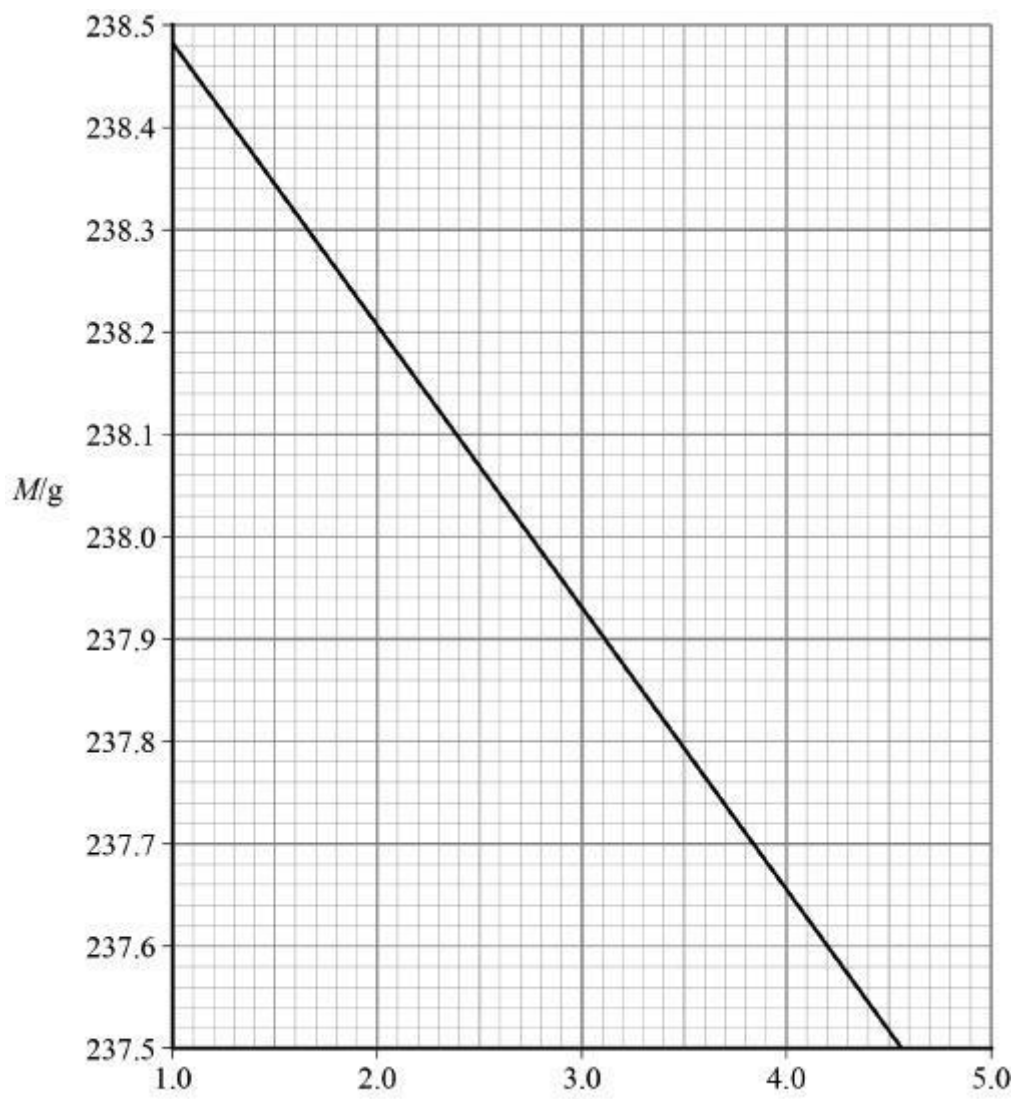These modifications cause the balance reading to increase slightly.

A horizontal uniform magnetic field is applied, perpendicular to the wire, between the 85 cm and 90 cm marks, as shown in the close-up diagram in **Figure 3**.

Figure 3
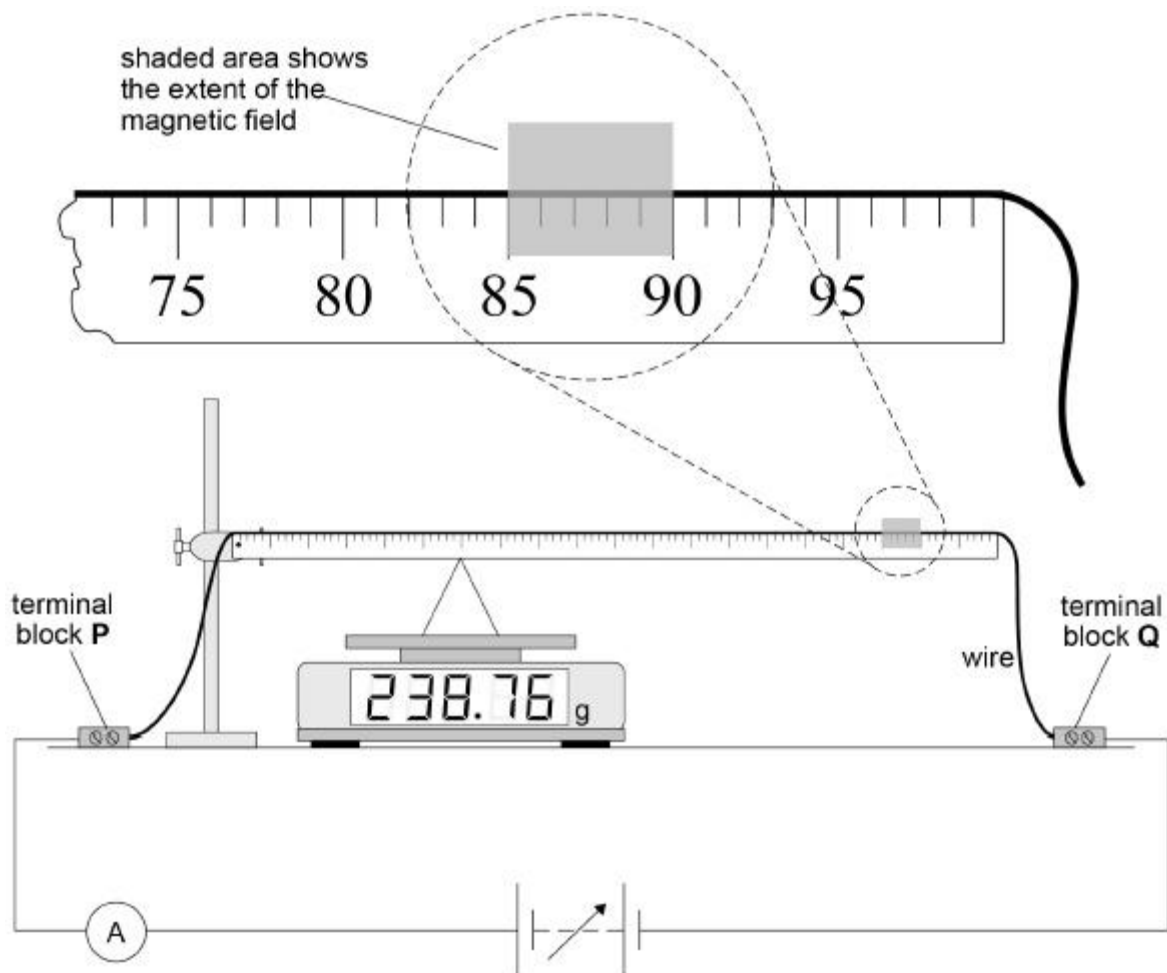
The balance reading M is recorded for increasing values of current I.
A graph of these data is shown in **Figure 4**.

Figure 4

State and explain the direction of the horizontal uniform magnetic field.

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(3)

(c)   It can be shown that B, the magnitude of the magnetic flux density of the horizontal uniform magnetic field, is given by

$$B = \frac{\sigma}{3L}$$

where

σ = change in force acting on the prism per unit current in the wire

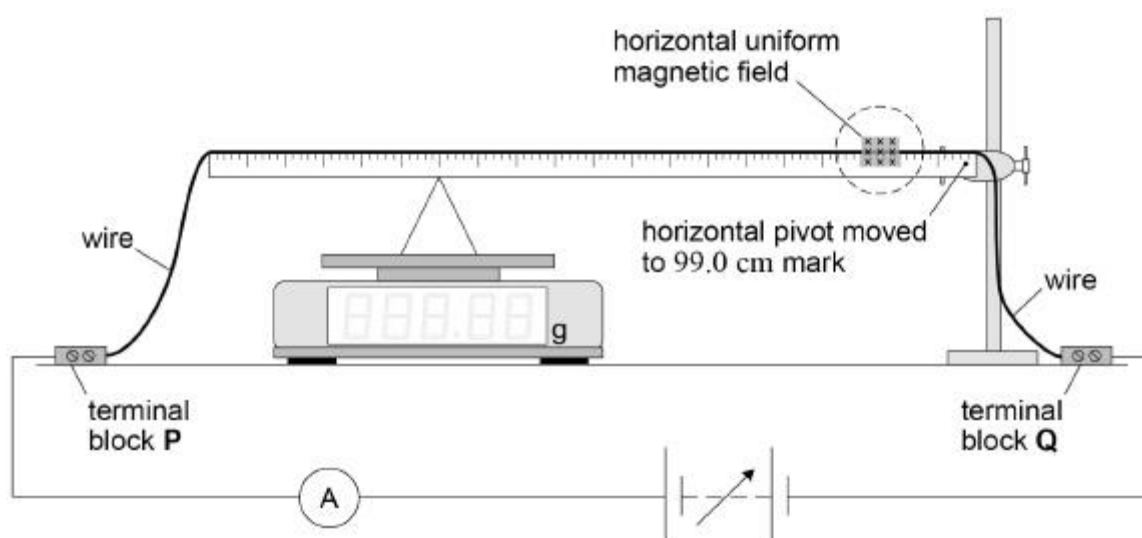L = length of the region where the magnetic field cuts through the wire.

Determine B.

$B =$ _____ T

(3)

(d) The experiment is repeated with the ruler pivoted at the 99.0 cm mark.
Nothing else is changed from **Figure 3**.

This arrangement is shown in **Figure 5**.

Figure 5

Tick (✔) **one** box in row 1 and **one** box in row 2 of the table to identify the effect, if any, on the magnitude of the forces acting on the apparatus as a certain current is passed through the wire.

Tick (✔) **one** box in row 3 and **one** box in row 4 of the table to identify the effect, if any, on the graph produced for this modified experiment compared with the graph in **Figure 4**.

		Reduced	No effect	Increased
1	Force acting on the current-carrying wire due to the horizontal uniform magnetic field			
2	Force acting on the prism due to the pivoted ruler			
3	Gradient of the graph			
4	Vertical intercept of the graph			

(3)

(e) **Figure 6** shows the balance being used to measure the forces between two wires.
The connections joining these wires to the power supply are not shown.

The pan of the balance moves a negligible amount during use and it supports a straight
conducting wire **X** of horizontal length L.
Terminal blocks are used to connect **X** into the circuit. The weight of these does not affect the
balance reading.
A second conducting wire **Y** is firmly supported a distance d above **X**.

Show, by adding detail to **Figure 6**, the wire connections that complete the circuit.
The currents in **X** and **Y** must have the same magnitude and be in the directions indicated.

Figure 6
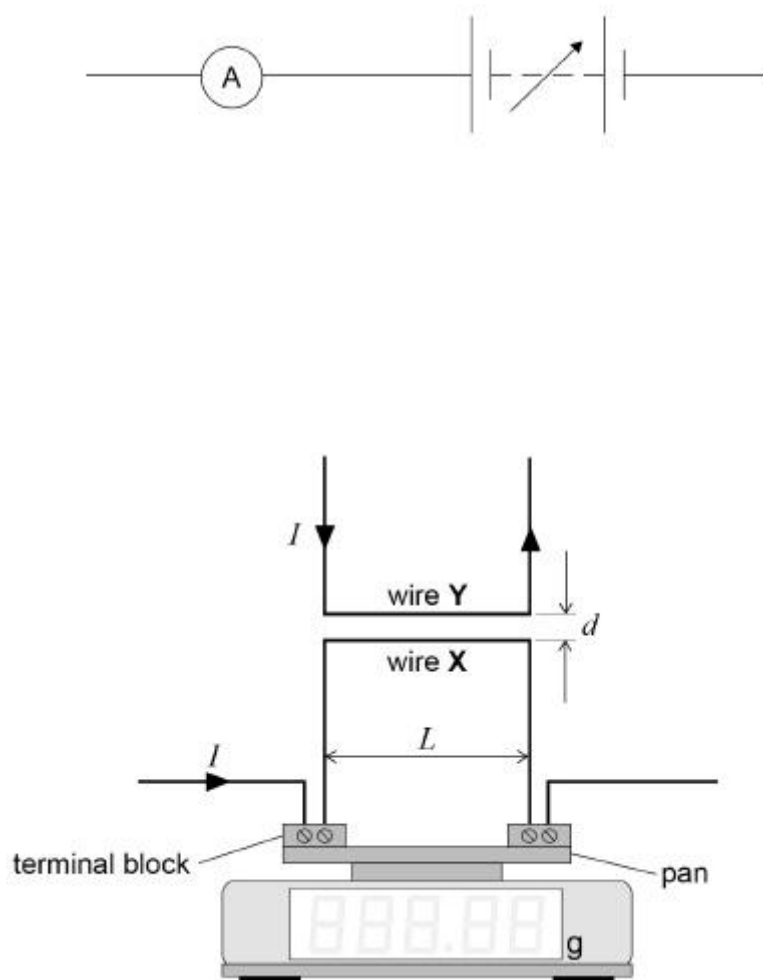
(2)

(f) The vertical force F on wire **X** due to the magnetic field produced by wire **Y** is given by

$$F = \frac{kI^2L}{d}$$

where

k is a constant
d is the perpendicular distance between **X** and **Y**
I is the current in the wires

and
L is the horizontal length of wire **X**.

A student wants to measure k using the arrangement in **Figure 6**.

The student is told that the following restrictions must apply:

- L is fixed
- I must not exceed 5.0 A
- the result for k must be obtained using a **graphical method**
- the experimental procedure must involve **only one** independent variable.

Explain what the student could do to find k.

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(5)
(Total 19 marks)