

Question 1

You are provided with the following:

- Micrometer screw gauge (may be shared)
- Centre zero galvanometer
- Resistor labelled R
- Jockey
- Resistance wire labelled N mounted on a half metre rule
- Resistance wire labelled Q mounted on a half metre rule
- Resistance wire labelled Y mounted on a metre rule with ends marked A and B
- Switch
- Connecting wires
- A cell in a cell holder

Proceed as follows:

- (a) Using the micrometer screw gauge, measure and record the diameter of the wire labelled Q

$$d = 0.34 - 0.40 \text{ mm}$$

$$d = \dots\dots\dots \text{ m}$$

Correct conversion to 5 dp or 1 dp in standard form (1 mark)

- (b) Set up the circuit as shown in Figure 1

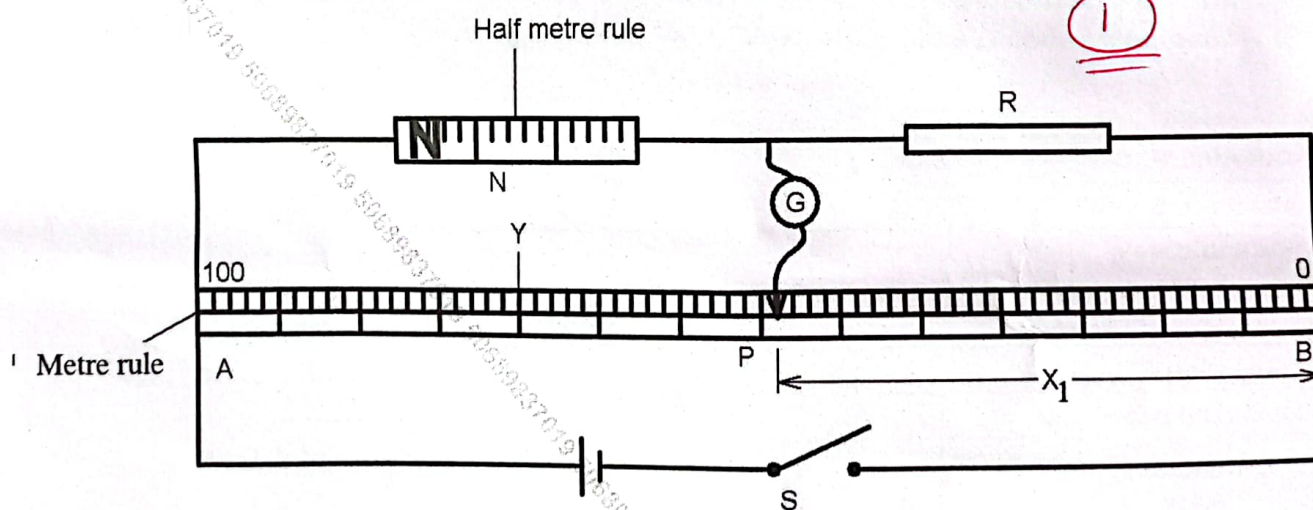


Figure 1



- (i) Close the switch. Using the jockey tap at various points on wire Y to obtain a balance point P at which the galvanometer shows zero deflection.

Measure and record the balance length $PB = X_1$

$$X_1 = 47.0 - 67.0 \dots \text{cm} \quad 1 \text{ dp} \quad \checkmark \quad (1 \text{ mark})$$

- (ii) Determine the resistance N given that: $\frac{10}{X_1} = \frac{N}{100 - X_1}$ (1 mark)

- correct substitution of candidate's value $\checkmark \frac{1}{2}$
 - correct evaluation to at least 3 sf $\checkmark \frac{1}{2}$
 or exact
 No unit

- (c) (i) Open the switch and interchange R and N. Close the switch and obtain the new balance length X_2

$$X_2 = (100 - x_1) + 10 \dots \text{cm} \quad 1 \text{ dp} \quad (1 \text{ mark})$$

- (ii) Determine a second value of N given: $\frac{N}{X_2} = \frac{10}{100 - X_2}$ (1 mark)

- correct substitution of candidate's value $\checkmark \frac{1}{2} \text{ mark}$
 - correct evaluation to 3 sf or exact $\checkmark \frac{1}{2} \text{ mark}$
 (ignore units)

- (d) Determine the average value of \bar{N} (1 mark)

Principle of averaging $\checkmark \frac{1}{2} \text{ mark}$
 correct evaluation to at least 3 sf or exact $\checkmark \frac{1}{2}$
 (ignore units)
 ignore



- (e) Without disconnecting the whole circuit, replace the resistor R with the wire labelled Q and adjust the length of N to $l = 25$ cm as shown in Figure 2.

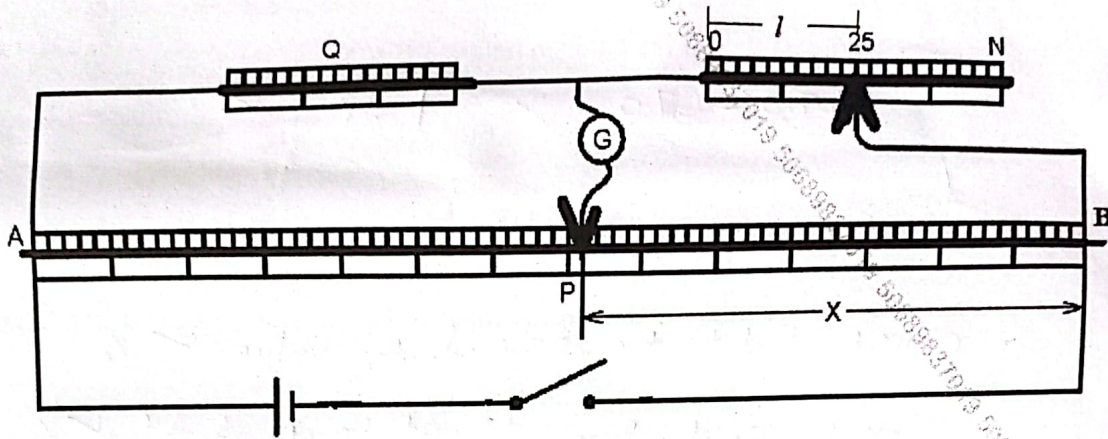


Figure 2

- (i) Determine the balance length X and record it in Table 1.
 (ii) Repeat part e (i) for other values of length l of wire N shown in Table 1 and complete Table 1

(5 marks)

Table 1

l (cm)	25	30	35	40	45	50
X (cm)	27.0-47.0 37.0	31.0-51.0 41.0	36.0-56.0 46.0	39.0-59.0 49.0	41.0-61.0 51.0	44.0-64.0 54.0
$\frac{1}{l} \text{ cm}^{-1}$	0.04	0.0333	0.0285 or 0.0286	0.025	0.0222	0.02
$\frac{1}{x} (\text{cm}^{-1})$	Repeat for at least 4 correct sf or exact					

$\pm 10 \text{ cm}$
At least 3 sf or exact

2
1
1
 → At least 1 dp @ correct value 1/2 MK for Max of 4 values (2 MKs)
 → increasing trend from 1st correct value
 → For at least 4 correct value 1 MK.
 Any for 0



(f) On the grid provided, plot a graph of $\frac{1}{x}$ (y-axis) against $\frac{1}{l}$.

(4 marks)

⇒ Axis labeled with quantity and units ✓ (1mk)

⇒ Scale - simple, uniform and accommodate all points on the table ✓ (1mk)

⇒ Plotting - exact, within 1 s.s - 1/2mk each to a max of 4 points ✓ (2mk)

must be within the accuracy of candidate's scale used

⇒ Line - straight line with positive gradient passing through at least 3 correctly plotted points within 1 s.s ✓ (1mk)

N.B For misplaced powers of 10 - mark plotting and drawing line to a max of 0 mk



(g) Determine the slope S of the graph.

(2 marks)

No line, no slope

Correct change in y ✓ ½ mc

Correct change in x ✓ ½ mc

Correct evaluation to 3sf or exact ✓ 1mc
(ignore ~~units~~ units)

(h) Given that: $\frac{1}{X} = \frac{Q}{2N} \frac{1}{l} + \frac{1}{100}$, determine the:

(i) value of Q

(2 mark)

Alternative 1

* $y = mx + c$

$\frac{Q}{2N} = \text{slope or implied } \checkmark \frac{1}{2} \text{ mc}$

* Correct substitution of slope and N of conductivity value ✓ ½ mc

* Correct evaluation to at least 3sf or exact ✓ 1mc

(ignore units)

Alternative 2

Using Pnts on the

line, with

Correct substitution

of $\frac{1}{x}$ and $\frac{1}{l}$

from our line

and N ✓ (1mc)

Correct evaluation

of d to (ii)

at least 3sf

or exact ✓ 1mc

(ignore units)

(ii) Constant p given that: $Q = \frac{2p}{\pi d^2}$

(1 mark)

Correct substitution of Q, $\pi = 3.142$ or $\frac{22}{7}$ or π and d in mm
or π or implied ✓ (½ mc)

Correct evaluation of p to at least 3sf or exact, (ignore unit) ✓ (½ mc)



QUESTION 2

You are provided with the following:

- Micrometer screw gauge (may be shared)
- Weighing balance (may be shared)
- Match box (to be shared)
- Piece of candle
- Water in a measuring cylinder labelled W
- Piece of white sewing thread
- Some tissue paper
- Liquid L in a measuring cylinder
- Stop watch
- Half meter rule
- Seven (7) steel balls placed in a beaker
- Plastic drinking straw

Proceed as follows:

- (a) (i) Wrap five of the steel balls with a small piece of tissue and place them on the weighing balance to measure the mass of the five balls and determine the mass m of one ball.

$(0.0024 - 0.0023 \text{ kg}) m = \dots$ $1.2 - 1.5 \text{ g}$ ($\frac{1}{2}$ mk) \rightarrow $(0.24 \text{ g} - 0.3 \text{ g})$ kg (1 mark)
Correct conversion in kg ($\frac{1}{2}$ mark) for 1 ball

- (ii) Using the micrometer screw gauge, measure and record the diameter d of one steel ball

$d = \dots 3.50 - 4.10 \dots$ mm 2 dp (closed range) (1 mark)
 $d = \dots$ m $\frac{1}{2}$ Correct conversion to 5 dp or 2 dp to standard form $\frac{1}{2}$ mk

- (b) Determine the:

- (i) volume v of the steel ball given that $v = \frac{\pi d^3}{6}$ (1 mark)

\dots Correct sub of d (either mm or m) $\frac{1}{2}$ mk
and $\pi =$
 \dots
Correct evaluation to 3 sf or exact $\frac{1}{2}$ mk
(Ignore units)



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(ii) density ρ of the steel ball.

(2 marks)

$\rho = \frac{m}{V}$ or $\rho = \frac{m}{\frac{1}{6}\pi r^3}$
 $\rho = \frac{m}{\frac{1}{6}\pi (\frac{d}{2})^3}$
 Correct evaluation 3 sf or exact, (\checkmark 1mk)
 (Ignore units)

(c) Wind the thread provided around the straw as shown in Figure 3 to make 10 closely packed turns. Mark with a pen the start and the end of the 10 turns.

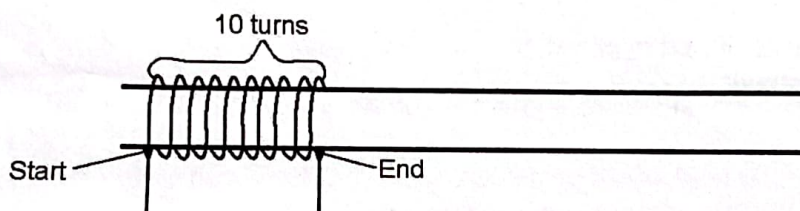


Figure 3

(i) Unwind the thread and spread it along the half metre rule to measure the length l between the two marked points at the start and the end.

$$l = 16.0 - 20.0 \text{ cm, 1 dp, closed range} \quad (1 \text{ mark})$$

(ii) Hence determine the diameter D of the straw given that the circumference C is given by: $C = \pi D$

(2 marks)

$C = \pi D$
 $D = \frac{C}{\pi}$
 Correct determination of circumference ($\frac{L}{10}$) \checkmark 1mk
 Correct evaluation of C in the formula $\frac{1}{2}$ rule
 Correct evaluation of D to 3 sf or exact (1mk)
 (Ignore units)

(d) (i) Light the candle and deposit 2 or 3 drops of molten wax on the bench. Seal one end of the straw by dipping it in the molten wax for a few seconds until the wax at the end of the straw solidifies.

(Ensure the seal is water tight)



- (ii) Put the seven steel balls provided into the straw and place it in water in the measuring cylinder so that it floats vertically. Measure the depth h_0 of the straw below the water. (See Figure 4)

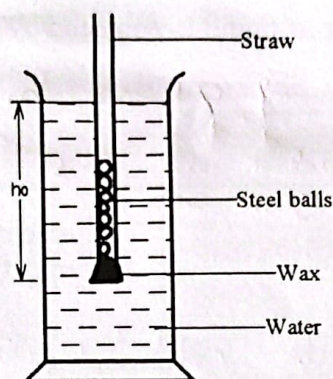


Figure 4

$h_0 = 9.5 - 11.5$ cm 1 dp a must $\frac{1}{2}$ mc.

$h_0 = \dots$ m correct conversion 3 dp $\frac{1}{2}$ mc (1 mark)

- (iii) Given that the volume of a cylinder of radius r and height h is given by $\pi^2 h$, determine the volume of water displaced by the straw. (2 marks)

Alternative 1
 \Rightarrow using m, determination of r in m $\frac{1}{2}$ mc \rightarrow determination of r in cm $\frac{1}{2}$ mc.
 \Rightarrow substitution of r and h in m $\frac{1}{2}$ mc. \rightarrow sub of r and h in cm $\frac{1}{2}$ mc.
 \Rightarrow correct evaluation to 3 sf or exact $\frac{1}{2}$ mc. \rightarrow correct evaluation to 3 sf or exact $\frac{1}{2}$ mc.

- (e) Remove the straw with its contents from the water and wipe it dry using a tissue paper. Place the straw with the seven steel balls into liquid L so that it floats vertically.



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- (i) Measure the depth h_1 of the straw in the liquid.

$$h_1 = 7.5 - 9.5 \dots\dots\dots \text{cm}$$

1 dp (closed range)
 Correct conversion to m 3 dp or 1 dp in std form (1/2 mark)
 (1 mark)

- (ii) Determine the volume of liquid L displaced by the straw. (1 mark)

Correct sub of r and h_1 in the same units 1/2 mark

Correct evaluation to 3 sf or exact 1/2 mark
 (1 ignore units)

- (iii) Determine constant n given that $n = \frac{\text{volume of displaced water}}{\text{volume of displaced liquid L}} \times 1000$ (1 mark)

Correct sub of candidate value in the formulae 1/2 mark

Correct evaluation to 3 sf or exact 1/2 mark

- (f) Remove the straw from liquid L. Return the steel balls into the beaker. Place one steel ball at the centre of the surface of liquid L and release it so that it falls through the liquid.

- (i) Using the stop watch, measure the time t the ball takes to fall from the 200 ml mark of the measuring cylinder to the 40 ml mark.

- (ii) Repeat f(i) for one other ball and record in Table 2 the time t taken (2 marks)

Table 2

Ball	Time taken
1	2.15 - 3.15 2dp must
2	2.15 - 3.15 2dp must

(ignore units)

- (iii) Determine the average time \bar{t} taken by the steel balls to fall through the liquid. (1 mark)

$$\bar{t} =$$

- Principle of averaging 1/2 mark

- Correct evaluation 3 sf or exact 1/2 mark

(ignore units)



- (g) (i) Measure the distance x between the 200 ml mark and the 40 ml mark.

$$x = \dots 13.0 - 15.0 \dots \text{ cm}$$

$$x = \dots \text{ Conversion to 3 dp } \dots \text{ m}$$

1 dp a must a closed range ✓ 1/2 mark

or 2 dp in standard form ✓ 1/2 mark

(1 mark)

- (ii) Determine the average velocity \bar{v} of the ball.

(1 mark)

- Correct sub of x in either cm/m and \bar{v} ✓ 1/2 mark

- Correct evaluation to 3 sf or exact ✓ 1/2 mark
(ignore units)

- (iii) Determine constant Z given that: $Z = \frac{11}{20}(\rho - n)\frac{d^2}{V}$

(1 mark)

- Correct substitution of ρ , n and d and ✓ 1/2 mark

- Correct evaluation 3 sf or exact ✓ 1/2 mark

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