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 ..... mm ½ } 2dp closed range

d = ... m

Correct conversion to 3 dp or 1 dp in standard form ½ (1 mark)

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

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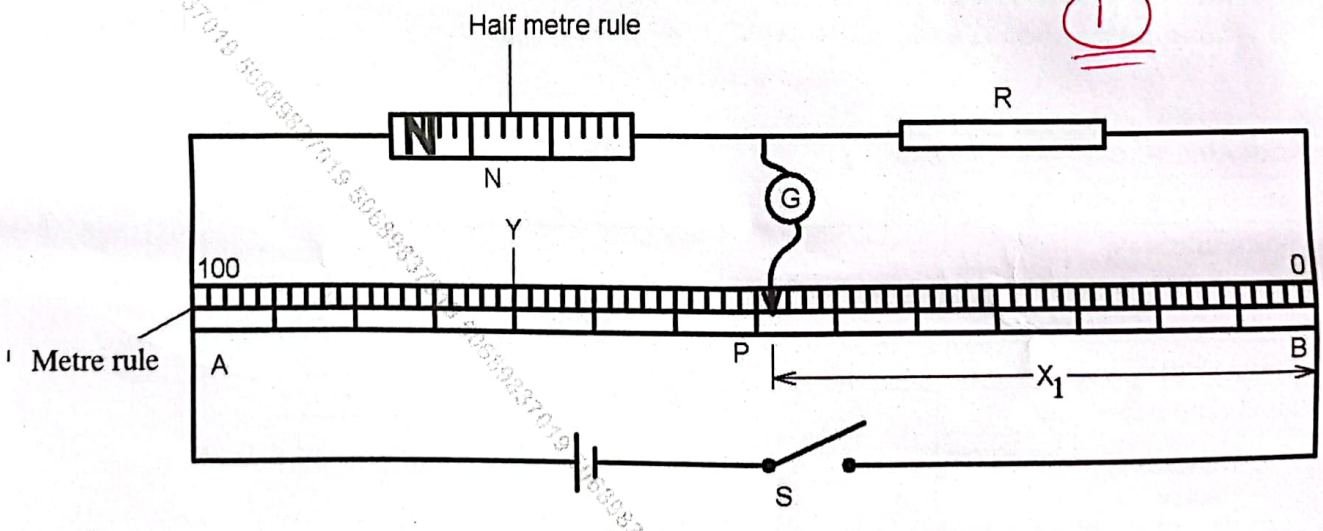


Figure 1

(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 ..... cm 1 dp ✓ (1 mark)

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

- correct Substitution of candidates value ✓ ½
- Correct evaluation to at least 3 Sf ✓ ½ 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 = $(100 - X_1) \pm 10$ ..... cm 1 dp (1 mark)

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

- correct Substitution of candidates value ✓ ½ Mk
- Correct evaluation to 3 Sf or exact ✓ ½ Mk.

(Ignore units)

(d) Determine the average value of $\overline{N}$ (1 mark)

Principle of averaging ✓ ½ Mk. ✓ ½

Correct evaluation to at least 3 Sf or exact

(~~No~~ 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 the **Figure 2.**

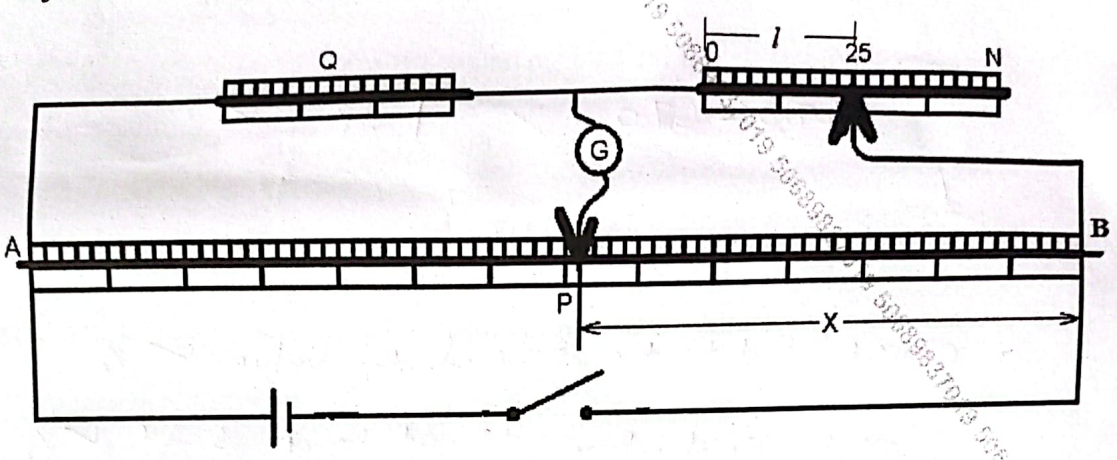


Figure 2

(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**

Table 1 (5 marks)

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
$\frac{1}{l} cm^{-1}$	0·04	0·0333	0·0285 OR 0·0286	0·025	0·0222	0·02
$\frac{1}{x} (cm^{-1})$	Reciprocal to exact		at least 4 correct Sf			OR

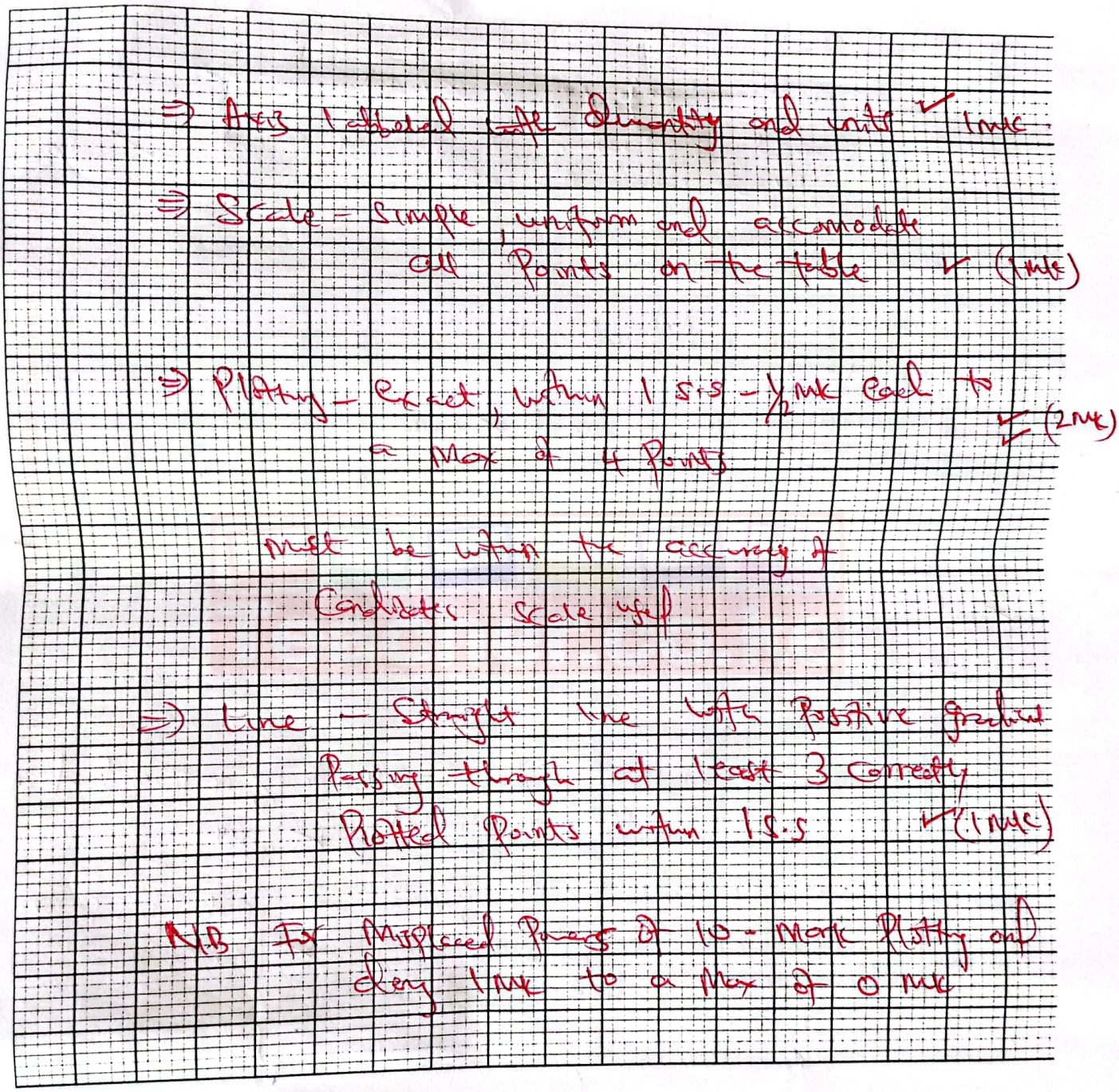
2 ±10 cm. At least 3 Sf or exact

1 At least 1 dp @ correct value ½ Mk for Nox of 4 values. (2 Mks)

1 → Increasing Trend from 1st correct Value for at least 4 correct Value ✓ 1 Mk.

Any Aur 0

(f) On the grid provided, plot a graph of $\frac{1}{x}$ (y- axis) against $\frac{1}{l}$. (4 marks)



⇒ Axis labelled with Quantity and units ✓ 1mk

⇒ Scale - Simple, uniform and accomodate all Points on the table ✓ (1mk)

⇒ Plotting - Exact, within 1 s.s - ½ mk 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)

NB For Misplaced Points of 10 - Mark Plotting and deny 1mk 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 mk.

Correct change in x ✓½ mk

Correct evaluation to 3sf or exact ✓ 1mk

(ignore ~~wrong~~ 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

* $y = mx + c$

$\frac{Q}{2N}$ = slope or implied ✓½ mk.

* Correct Substitution of slope and N of candidates value ✓½ mk

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

(ignore units)

Alternative 2

Using pts on the line, with correct substitution of $\frac{1}{x}$ and $\frac{1}{l}$ from own line and N ✓(1mk)

Correct evaluation of d to at least 3sf or exact ✓1mk.

(ignore units)

(ii) Constant ρ given that: $Q = \frac{2\rho}{\pi d^2}$ (1 mark)

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

Correct evaluation of ρ to at least 3 s.f or exact, (ignore unit) ✓(½ mk)

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 - 0.0023kg) ***m*** = 1·2 − 1·5 g (½ mk) → (0·24g − 0·3 g) ✓ ..... kg (1 mark)

Correct Conversion in kg (½ mks) for 1 ball

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

d = 3.50 − 4.10 mm 2dp (closed range (1 mark)

d = ✓ Correct conversion to 5 dp or 2 dp to standard form ✓½ Mk ..... m

(b) Determine the:

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

Correct Sub of d (either mm or m) ✓½ Mk and π =

Correct Evaluation to 3 S.f or exact ✓½ Mk (Ignore units)

(ii) density ρ of the steel ball. (2 marks)

+ Formulae for the density or implied ✓½
+ Correct Sub of m and V ✓½ mk
Correct evaluation 3 s.f or exact, (✓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.

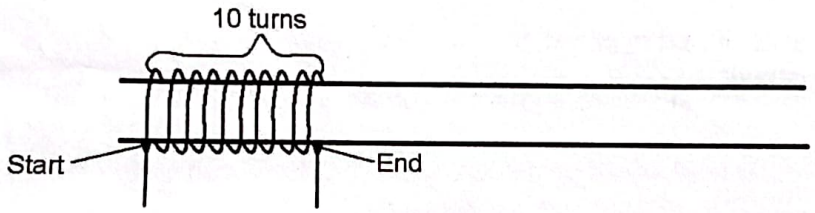


Figure 3

(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 cm (1 dp, closed range) (1 mark)

(ii) Hence determine the diameter ***D*** of the straw given that the circumference C is given by: $C = \pi D$ (2 marks)

- Correct determination of Circumference $\left(\frac{L}{10}\right)$ ✓½ mk
- Correct evaluation of C in the formula ½ mk
- 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 **ho** of the straw below the water. ***(See Figure 4)***

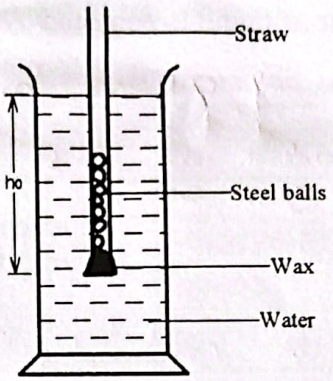


Figure 4

ho = 9·5 - 11·5 ..... cm 1 dp a Mark ✓½ MK.

ho = Correct answer in m 3 dp ½ MK ..... m (1 mark)

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

Alternative 1

⇒ using m, determination of r in m ✓½MK

⇒ Substitution of r and h in m ✓½MK

⇒ correct evaluation to 3 sf or exact ✓1MK

Using cm

⇒ determination of r in cm ✓½MK.

⇒ Sub of r and h in cm ✓½MK

⇒ correct evaluation to 3 sf or exact ✓1MK.

(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.

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

h_1 = 7.5 - 9.5 cm 1dp (closed range

h_1 = Correct conversion to m 3dp or 1dp in std form (½ Mk)

(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 ✓½ Mk.

Correct evaluation to 3 sf or exact ½ Mk

(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's value in the formulae ✓½ Mk.
- Correct evaluation to 3 sf or exact ✓½ Mk

(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 ✓½ Mk
- Correct evaluation 3 sf or exact ✓½ Mk.

(Ignore units)

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

$x =$ 13.0 - 15.0 cm 1 dp a must a closed range ✓½ Mk.

$x =$ Conversion to 3 dp or 2 dp in standard form ✓½ Mk
m (1 mark)

(ii) Determine the average velocity $\overline{V}$ of the ball. (1 mark)

- Correct Sub of x in either cm/m ✓½ Mk.
- Correct evaluation to 3 S.f. or exact ½ Mk
(Ignore units)

(iii) Determine constant $\mathcal{Z}$ given that: $\mathcal{Z} = \frac{11}{20}(\rho - n)\frac{d^2}{V}$ (1 mark)

- Correct Substitution of ρ, n and d and V ✓½ Mk.
- Correct evaluation 3 Sf or exact ✓½ Mk.

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