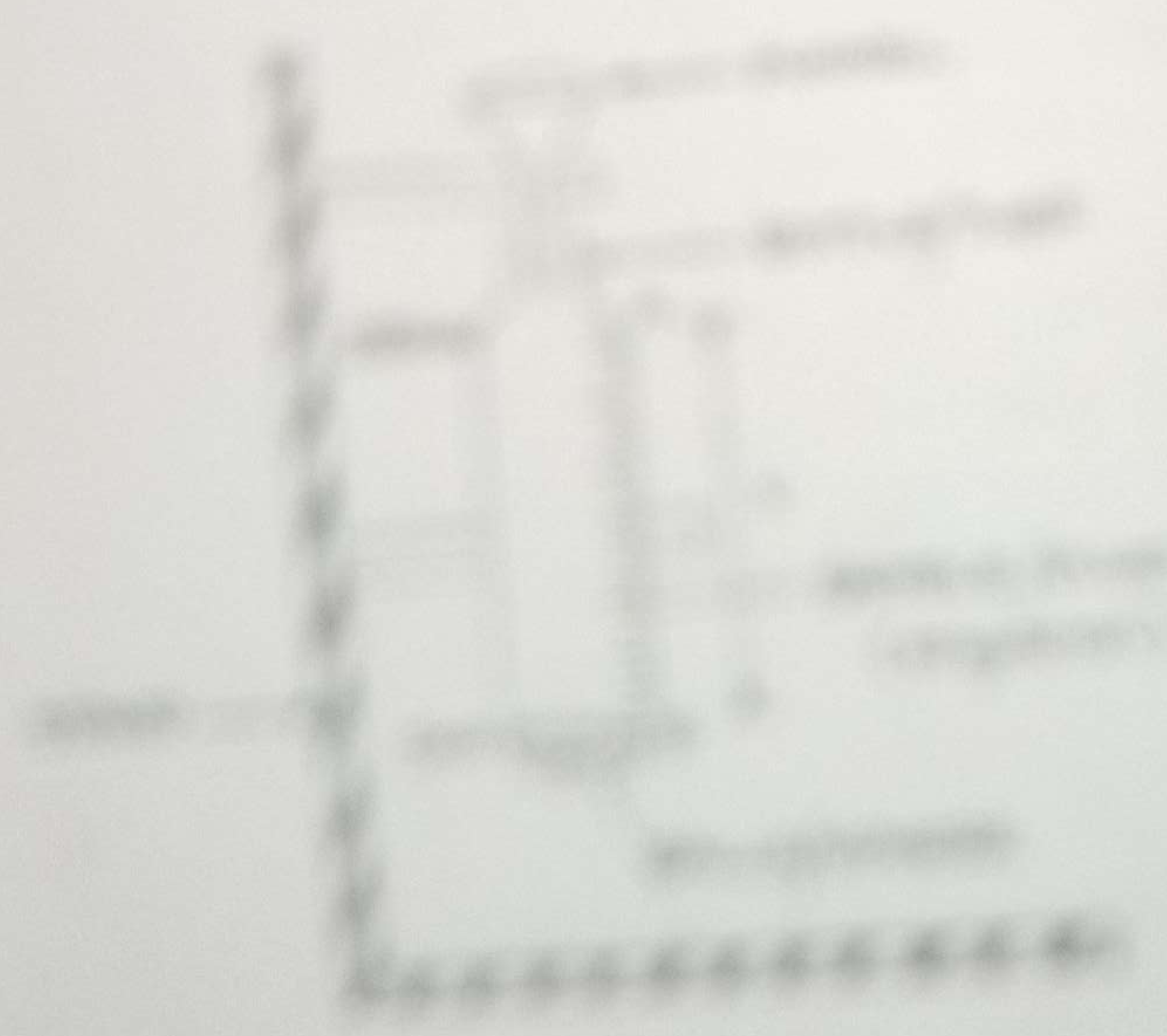


## PROCEDURE

A ball of known diameter is held above the tube of diameter 28.2mm and length 220mm. A stop watch is set to zero.
The initial temperature of the fluid is taken using a thermometer. The ball sphere is then released from rest. The time taken for the ball to fall through height L (A to B) is recorded using the stop watch. This is done sequently for five times and the time of each ball noted twice and the average time taken. The total average time is calculated for the reading. The final temperature of the fluid is taken. The reading is finally used to calculate other parameters e.g velocity, specific weight of sphere, specific weight of fluid, observation and conclusion

## TABLE OF RESULTS

- Weight of bottle + water ....266g
- Weight of bottle + Fluid .... 250g
- Weight of bottle empty ....130g
- Weight of water alone .....136g
- Weight of fluid alone .... 120g
- diameter of sphere ...... 2.8mm
- diameter of tube ...... 28.2mm
- Weight of sphere ........0.126g
- Specific Weight of Sphere ($\gamma_s$)....107534.37
- Specific Weight of fluid ($\gamma_L$) .... 0.857
- Length of tube bottle.......... 22cm
- Initial temperature ..........34°c
- final temperature ..........35°c
- 1cm$^3$ of water at 4°c..........1g
- time of fall of sphere..........4.934sec





## TABLE OF READINGS

| S N | TIME A(s) | TIME B(s) | AVG TIME (s) | L (cm) | VELOCITY (m/s) |
|---|---|---|---|---|---|
| 1 | 5.25 | 5.25 | 5.250 | 22 | 0.0419 |
| 2 | 4.99 | 4.93 | 4.960 | 22 | 0.0444 |
| 3 | 4.89 | 4.85 | 4.870 | 22 | 0.0452 |
| 4 | 4.83 | 4.76 | 4.795 | 22 | 0.0459 |
| 5 | 4.83 | 4.76 | 4.795 | 22 | 0.0459 |
| | | | 4.934 | 22 | 0.0447 |

## CALCULATION AND SOLUTIONS

Average time of fall

$$= \frac{5.250 + 4.960 + 4.870 + 4.795 + 4.795}{5}$$

$$= \frac{24.67}{5} = \underline{4.934 \text{ secs}}$$

$$\text{Velocity} = \frac{\text{Distance covered by balls (A to B)}}{\text{Average time of fall}}$$

$$= \frac{0.22m}{4.934 sec} = \underline{0.045 m s}$$

Average temperature of sample fluid

$$= \frac{\text{Initial temp} + \text{final temp}}{2}$$

$$= \frac{34^\circ c + 35^\circ}{2} = \frac{69}{2} = \underline{34.5^\circ c}$$

$$\text{Specific weight of sphere} = \frac{\text{weight of sphere} = mg}{\text{vol of sphere} \quad = v}$$

$$\text{Volume of sphere } (v) = \frac{4}{3}\pi r^3 = \frac{4}{3} \times \pi \times \left(\frac{d}{2}\right)^3 = \frac{4\pi d^3}{24}$$

$$v = \frac{\pi d^3}{6} \quad d = 2.8mm = 2.8 \times 10^{-3} m$$

$$v = \frac{22/7 \times (2.8 \times 10^{-3})}{6} = \underline{1.1494 \times 10^{-8} m^3}$$

mass of sphere $m = 0.126g = 0.126 \times 10^{-3} kg$

weight of sphere $= mg = 0.126 \times 10^{-3} \times 9.81 = \underline{1.236 \times 10^{-3} N}$



$\frac{0.0616}{7/6}$ $\frac{0.0616}{7} \div \frac{6}{6}$ BODMAS



Specific weight of sphere

$$= \frac{1.236 \times 10^{-3} N}{1.149 \times 10^{-8} m^3} = \underline{107{,}53437 Nm^{-3}}$$

Specific weight of fluid

$$= \frac{\text{Weight of fluid}}{\text{Volume of fluid}}$$

Volume of fluid:

$$\text{Volume of tube} = \pi r^2 h = \pi \left(\frac{d}{2}\right)^2 h = \frac{\pi d^2 h}{4}$$

Diameter of tube $= 28.2mm = 28.2 \times 10^{-3} m$

Length/height of bottle $= 22cm = 0.22m$

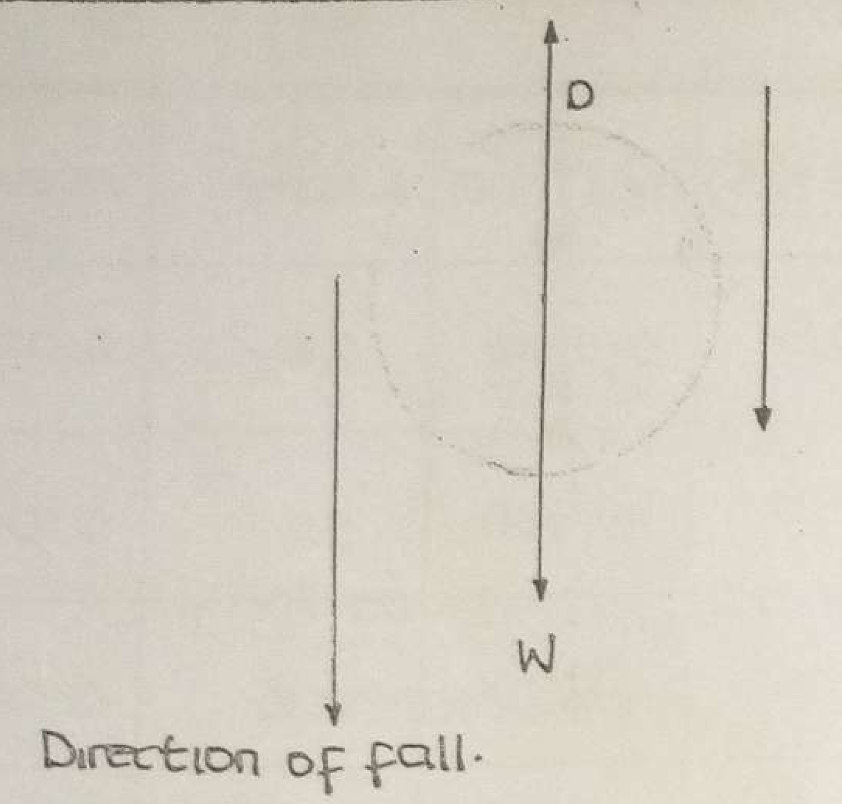
$$\text{Volume of fluid, } V = \frac{\frac{22}{7} \times (28.2 \times 10^{-3})^2 \times 0.22}{4} = \underline{1.3741 m^3}$$

Weight of fluid = weight of bottle + fluid − weight of empty bottle

$= 250 - 130 = 120g = 120 \times 10^{-3} Kg = 0.12 Kg$

$$\therefore \text{specific weight of fluid} = \frac{0.12 \times 9.81}{1.3741} = \underline{0.857 Nm^{-3}}$$

## DERIVATION OF ABSOLUTE VISCOSITY FORMULA




D = Viscouse force (drag force)
F = upthrust
W = Weight of sphere

From the diagram above at equilibrum conditions

$D + F - W = 0$

$D = 6\pi \mu r v$

r = radius of sphere

$F = \gamma_L V_s$

$r_L$ = Specific weight of fluid

$V_s$ = Volume of sphere

$W = \gamma_s V_s$

$\gamma_s$ = specific weight of sphere

$V_s$ = volume of sphere

$D + F - W = 0$

$\Rightarrow 6\pi \mu \gamma v + \gamma_L V_s - \gamma_s V_s = 0$

$\Rightarrow 6\pi \mu (d/2) v + \gamma_L \pi d^3/6 - \gamma_s \pi \left(\frac{d^3}{6}\right) = 0$

$$\frac{6\pi \mu d v}{2} + \frac{\gamma_L \pi d^3}{6} = \frac{\gamma_s \pi d^3}{6}$$

$$3\pi \mu d v = (\gamma_s - \gamma_L) \cdot \frac{\pi d^3}{6}$$

$$\mu = \frac{\pi d^3 (\gamma_s - \gamma_L)}{6 \times 3 \times \pi \times d \times v}$$

$$\mu = \frac{d^2 (\gamma_s - \gamma_L)}{18 v} \quad \text{QED}$$

where $\mu$ = The absolute viscosity of the fluid

V = velocity of the sphere





## PRECAUTIONS

- I avoided error due to parallax when measuring distances with the steel rule by looking directly above or parallel to the apparatus
- I avoided any shaking or tilting of the table
- I avoided zero error when using the stop watch
- Discussion were totally avoided for maximum concentration and observation.

## OBSERVATIONS

- The time of fall of the sphere ball decreased from ball 1 to ball 5 as a result of the increase in temperature
- The velocity of the ball also increased from ball 1 to ball 5 with respect to the increment in temperature
- The specific height of the ball is greater than that of fluid sample
- There was increase in temperature

## CONCLUSION

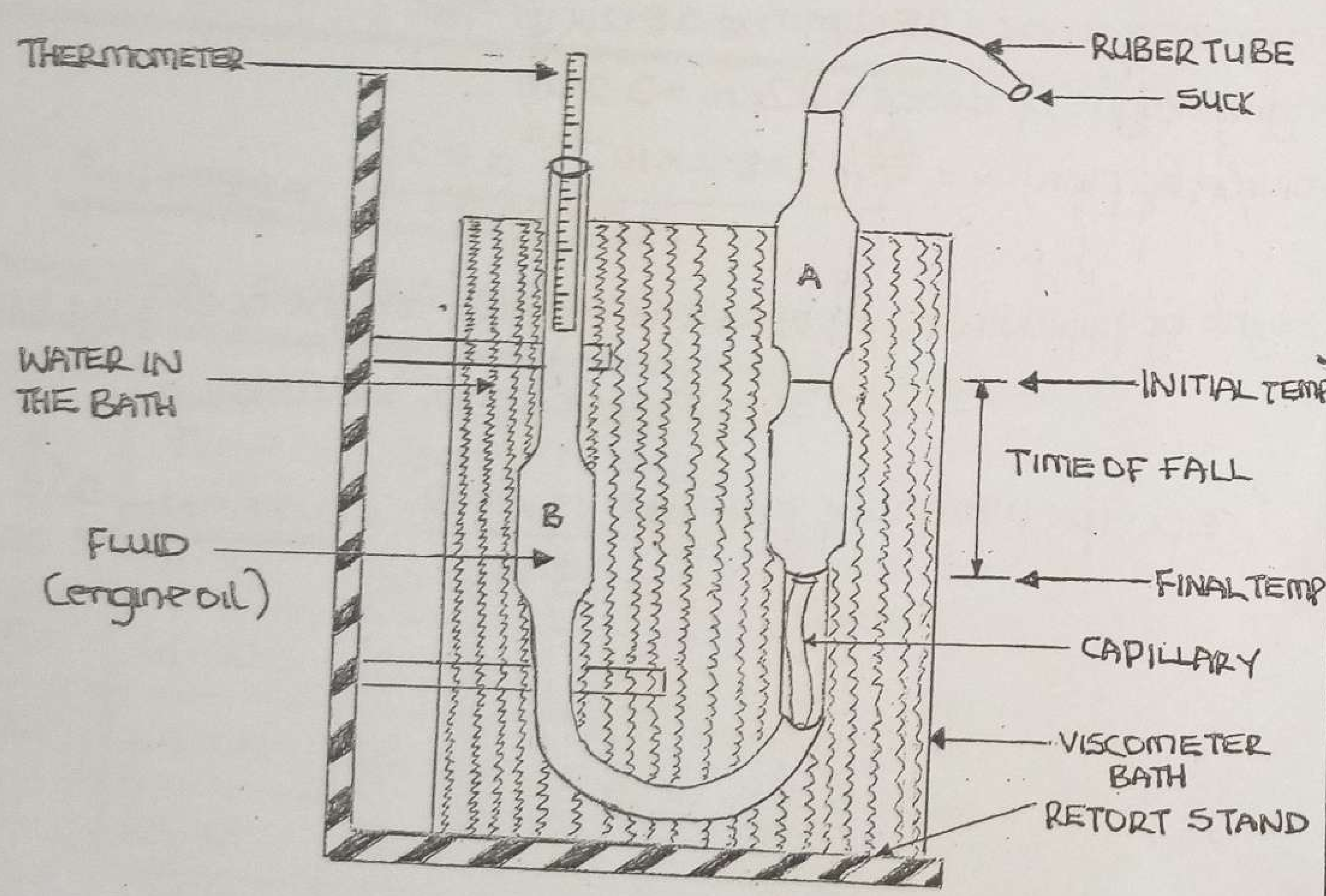
It can thus be concluded that, temperature has an effect on viscosity as was observed from our table, readings, calculations and inferences.

## EXPERIMENT TWO

**TITLE:** KINEMATIC VISCOSITY MEASUREMENT

**AIM:** To measure the Kinematic viscosity of a given sample.

**APPARATUS:** The oswald capillary viscometer (see drawing attached) a thermometer, stop watch and viscosity Bath with water.




OSWALD CAPILLARY VISCOMETER





A capillary is a tube inside the viscometer

### FUNCTIONS OF CAPILLARY TUBE

- makes your work efficient
- Helps you determine rate of work
- Helps you determine time
- Helps to solve for Kinematic viscosity

### PROCEDURE

Arrange the apparatus as shown in the diagram, making sure that the U-tube stands perfectly vertical. fill the storage bud B with the sample to the level B as shown in the diagram. Draw the Liquid by means of rubber tubing attached to the measuring bulb by sucking from bulb B to bulb A such that the liquid meniscus stands above mark a.

Now record the initial temperature and allow the liquid to fall with a stop watch measuring the time required for the liquid with meniscus 'a' to fall to the mark 'b'. Take the final temperature. Repeat the process five times and tabulate your result. Ask your instructor for the tube constant and determine the Kinematic viscosity.

## TABLE OF RESULT A

| | INITIAL TEMP (°C) | FINAL TEMP (°C) | AVERAGE TEMP (°C) | TIME OF FALL (SEC) | $\sqrt{\ } = KT$ $K = 2$ |
|---|---|---|---|---|---|
| 1 | 28.0 | 28.0 | 28.00 | 20 | 40 strokes 28°C |
| 2 | 28.5 | 30.0 | 29.25 | 18 | 36 " " 29.25°C |
| 3 | 30.5 | 40.0 | 35.25 | 16 | 32 " " 35.25°C |
| 4 | 41.5 | 45.0 | 43.25 | 12 | 24 " " 43.25°C |
| 5 | 45.0 | 45.5 | 45.25 | 10 | 20 " " 45.25°C |
| | AVERAGE | | 36.00 | 15.2 sec | 30.4 " " 36.2°C |

## TABLE OF RESULT B

TEMPERATURE IS INCREASED BY 10°C = 45.50 + 10 = 55.50°C

| | INITIAL TEMP (°C) | FINAL TEMP (°C) | AVERAGE TEMP (°C) | TIME OF FALL (SEC) | $\sqrt{\ } = KT$ $K = 2$ |
|---|---|---|---|---|---|
| 1 | 55.50 | 55.50 | 55.00 | 8 | 16 strokes 55.50°C |
| 2 | 60.00 | 61.00 | 60.50 | 7 | 14 " " 60.50° |
| 3 | 62.00 | 64.00 | 63.00 | 6 | 12 " " 63.00°C |
| 4 | 65.00 | 65.00 | 65.00 | 5.8 | 11.6 " " 65.00 |
| 5 | 65.50 | 70.00 | 67.75 | 5 | 10 " " 67.75 |
| | AVERAGE | | 62.25 | 6.36 sec | 12.72 " " 62.25 |





## ⓘ REASON FOR THE DIFFERENCE BETWEEN THE RESULTS A AND B

The increase in temperature causes a corresponding increase in the average kinetic energy of fluid particles, thereby reducing the cohesive forces between the fluid molecules. As a result of this, the kinematic viscosity (which to some extent measures the cohesive forces between the molecules) will decrease with the corresponding increase in the temperature of the fluid molecules.

Thus from table A, the average kinematic viscosity is 30.4 strokes at 36.2°C. At table two, the kinematic viscosity is 12.72 strokes at 62.25°C

## PRECAUTIONS

During the experiment, I

1. Avoided error due to parallax when taking readings from stop watch, thermometer and also when noticing time of fall from the oswald capillary viscometer
2. Avoided the zero error on the stop watch apparatus
3. Heating was not done above the viscometer but through a water bath. This was done to avoid abnormal readings and loss of apparatus
4. The specimen (engine oil) was properly sucked until it was above mark a in the oswald capillary viscometer

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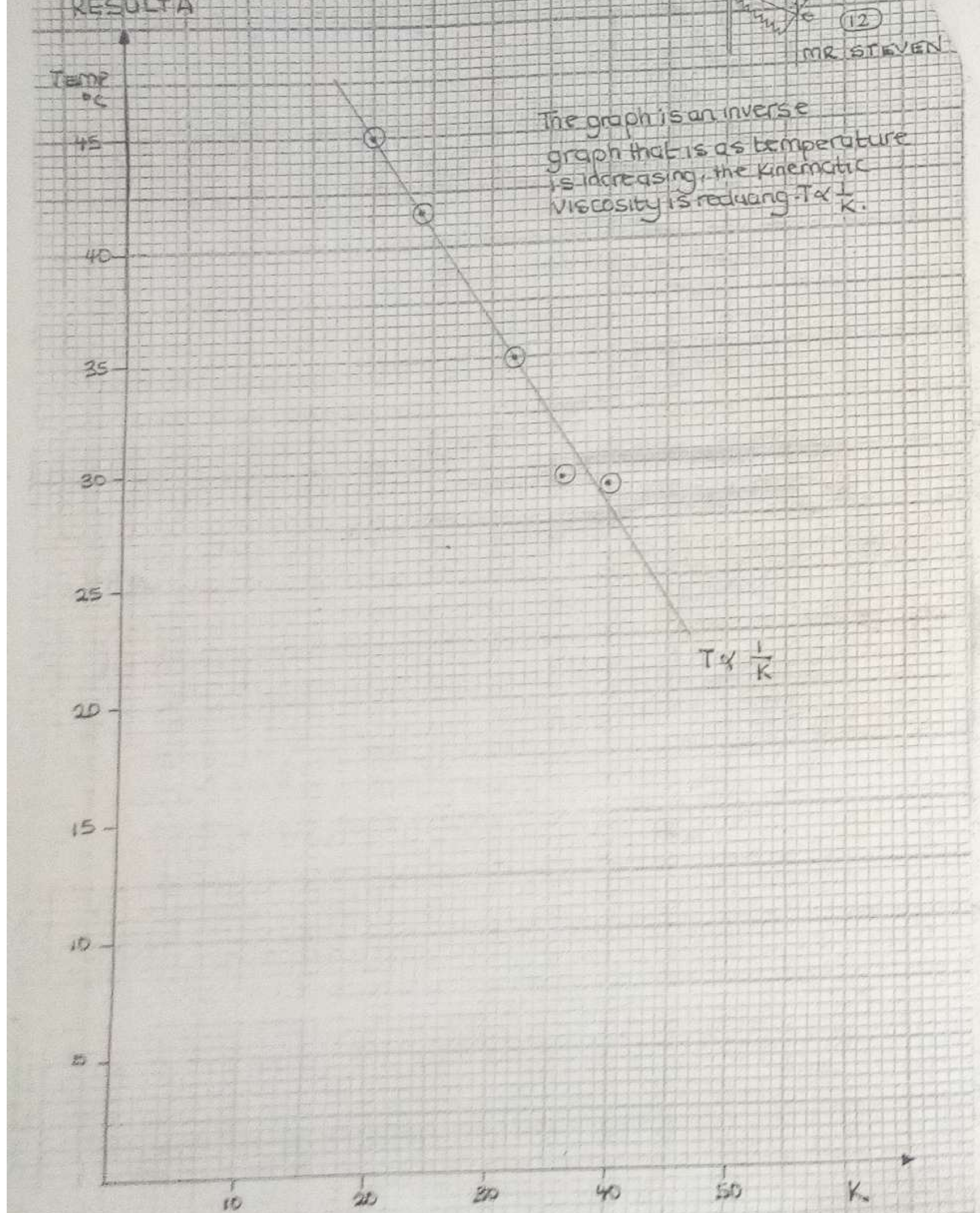
Graph of Temperature against Kinematic viscosity

Scale: 2cm to rep 5unit on temperature (°C)

2cm to rep 10 unit on K

RESULT A

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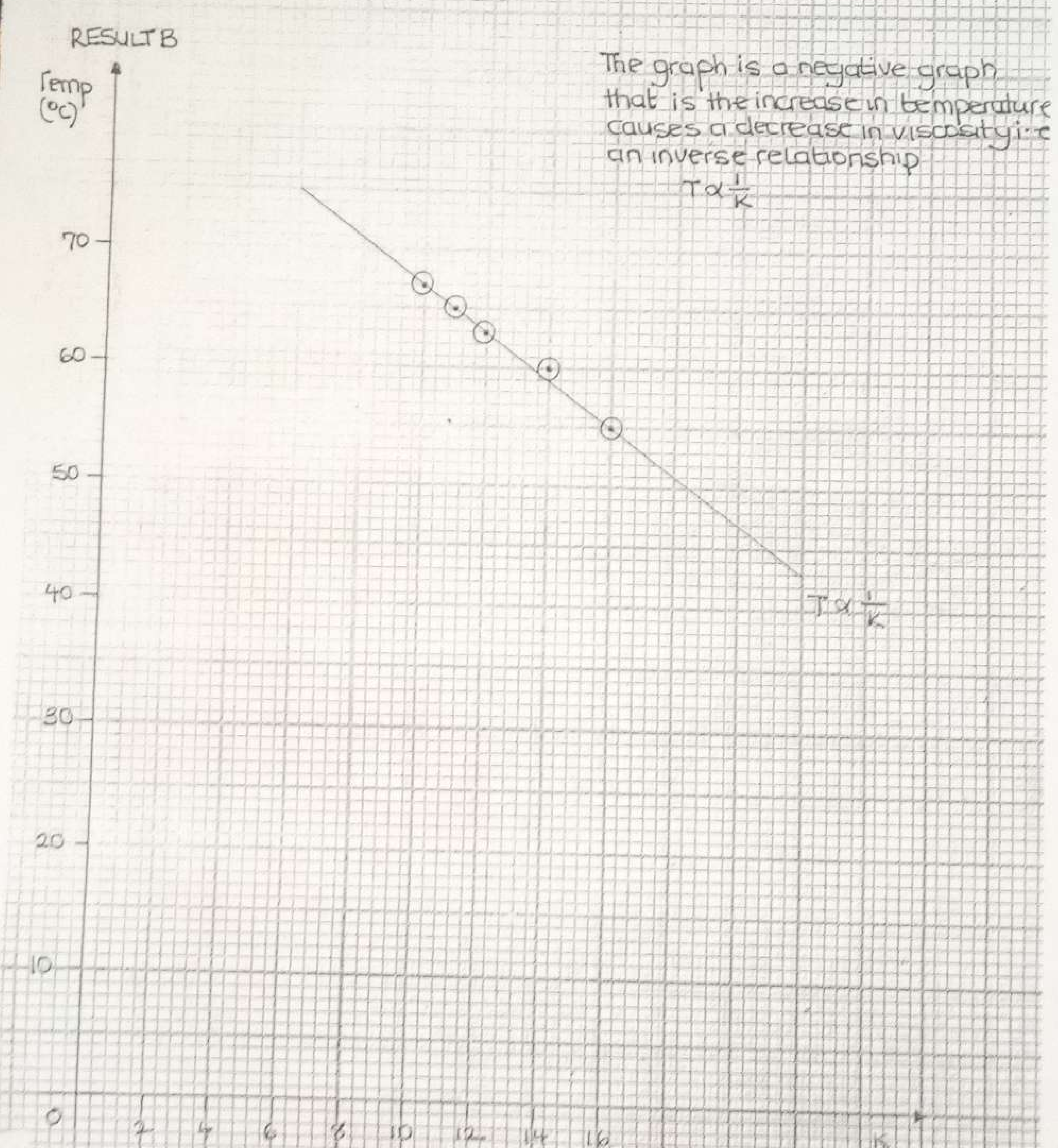
Graph of temperature against K

Scale: 2cm to rep 10 unit on Temp

1cm to rep 2 unit on K

RESULT B

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## OBSERVATIONS

1. from the table of results of A and B, I observed that as temperature increased, the kinematic viscosity reduced i.e they have an inverse relationship.
2. The - time varies directly with viscosity
3. The capillary constant (K=2). This is due to a specific capillary tube used in the experiment.
4. Observed that kinematic viscosity is measured with respect to time.

## CONCLUSION

Hence from the experiments performed it shows that temperature has effect on viscosity i.e the higher the temperature, the lesser the viscosity and vice versa. And that is an inverse relationship.

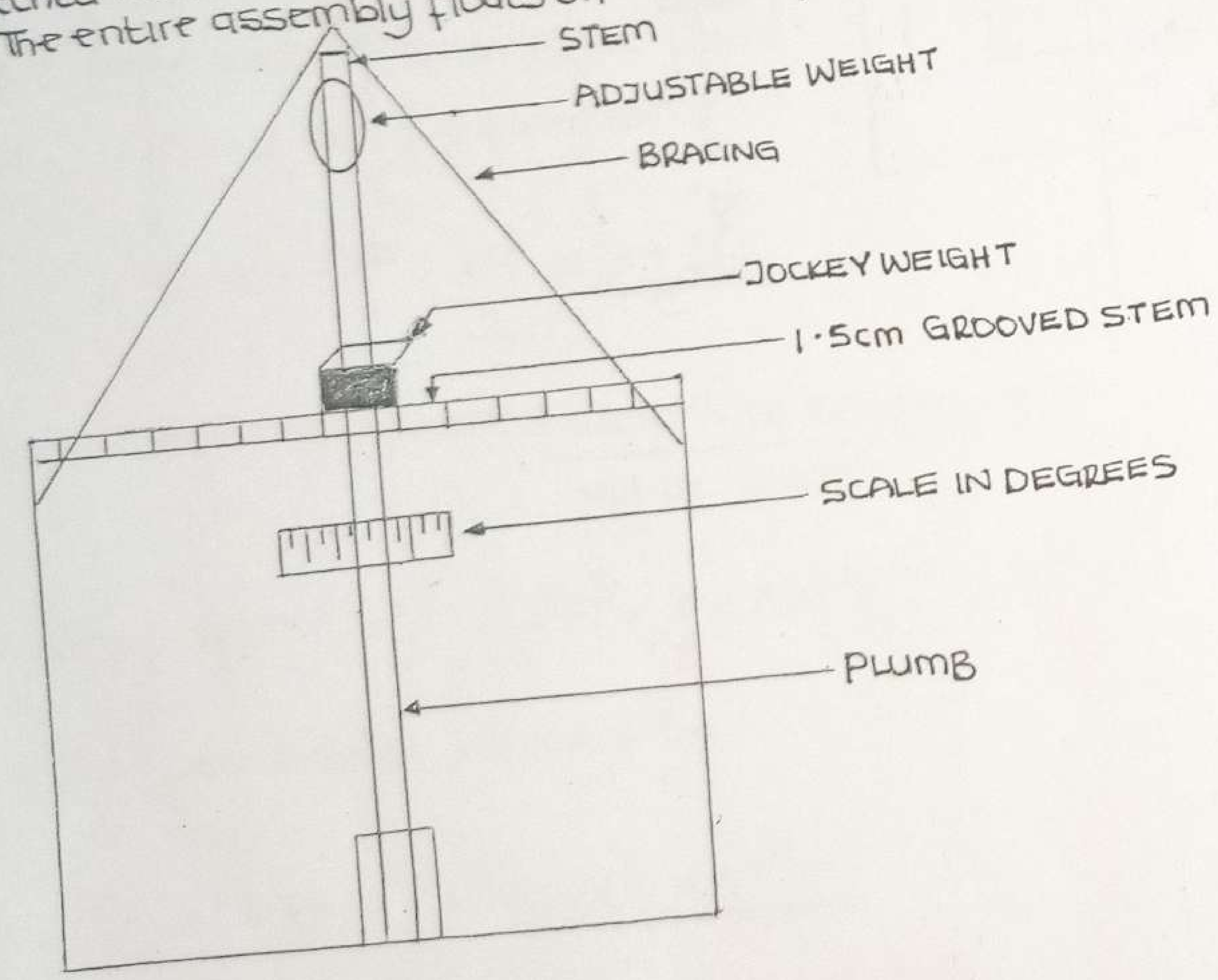
### EXPERIMENT THREE

**TITLE : STABILITY OF FLOATING PONTOON**

**Aim:** To verify the variation of the stability of a floating pontoon with variation in its centre of gravity

**APPARATUS:**

A similated pontoon which is rectangular in shape and made from a metal sheet of thickness 1millimeter. Mounted vertically on the pontoon is a stem which is braced on both sides with plastic cords, suspended from the stem is a plumb-bob so that the angle of tilt can be read off from a scale marked in degrees. An adjustable weight which slides up and down the stem is carried by the stem. Fitted across the breadth of the pontoon is a circular bar, with etched marks at 1·5cm interval, along which a jockey weight slides. The entire assembly floats on a bowl of water (see diagram)








**PROCEDURE**

The weight of the various components of the floating assembly was noted The length, width and depth of the pontoon were carefully taken and measured with a steel bar. The pontoon was turned on its side and was carefully supported with a steel rule to obtain the point unto which it balances with the base of the pontoon vertically. The point of balance was marked to get the point G (centre of gravity). The distance from G to the outer surface of the base was measured to get the height of C·G of the pontoon from the base. for various C·Gs of the pontoon was then calculated for various positions of the adjustable weight.

The pontoon was allowed to float in water and the jockey weight was centralized so that the angle of tilt is zero. At the position, the depth of immersion of pontoon was measured. Then the jockey weight were moved at a distance of 1·5cm from the center line of the stem towards the right and the angular displacement and the angular displacement as indicated by the plumbob over the scale graduated in degrees was recovered. Then the jockey weight was moved a further distance of 1·5cm to the right and the angular displacement was recorded.

This step was continued in step of 1·5cm to 6·0cm from the centralize position of the stem. Then the jockey weight was returned to the central position at the stem. The left of the stem was moved towards the left at the same equal interval of 1·5cm to 6cm each line corresponding to angular displacement was recorded.

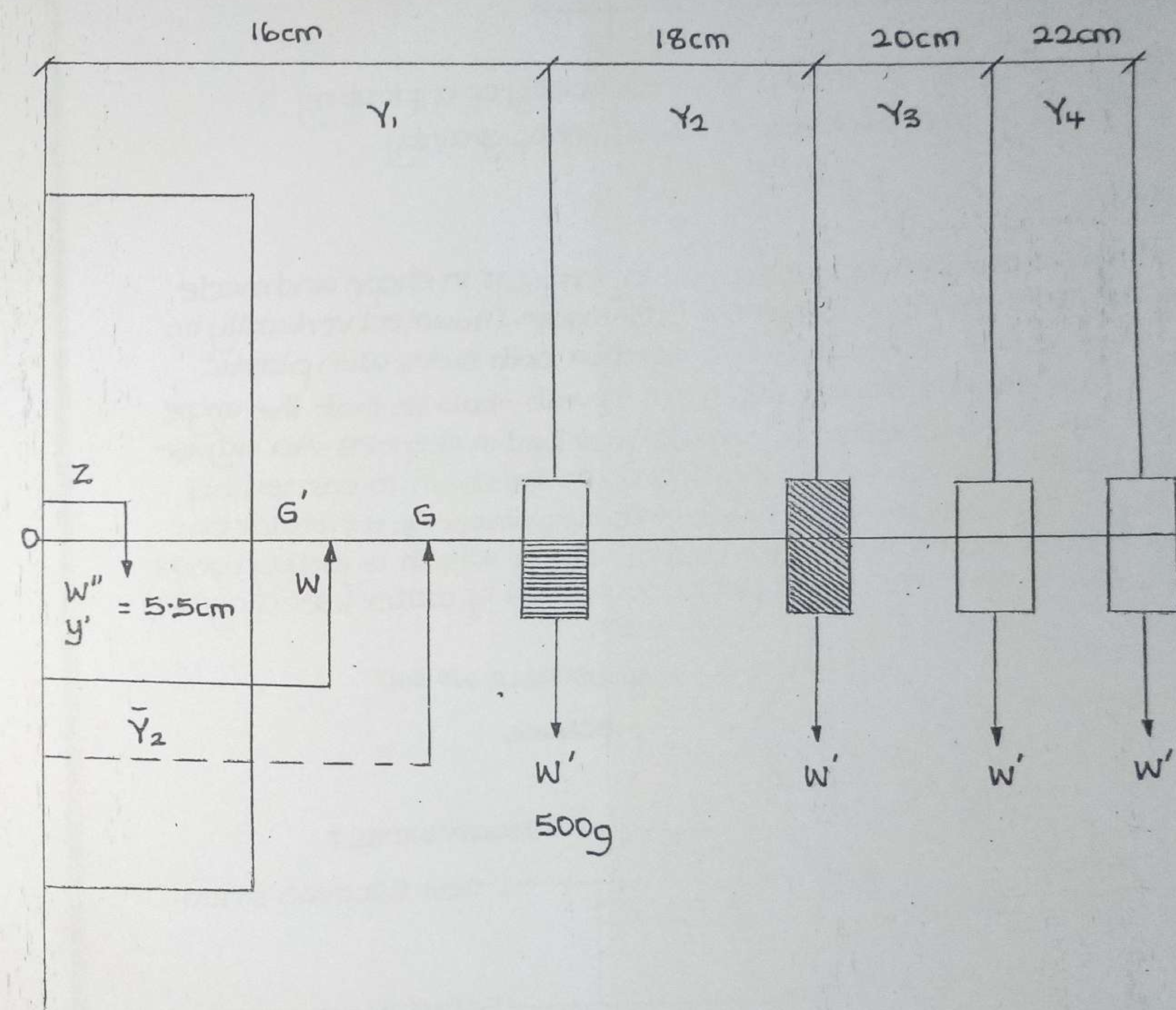
Finally, the height of the adjustable from the base of the pontoon was increased and the above process was repeated for at least five other positions of the adjustable weight.

## RESULTS AND CALCULATIONS

- Total weight of floating assembly W = 2600 gm
- Jockey weight W″ = 200 gm
- Adjustable weight W′ = 500 gm
- Length of pontoon L = 36 cm
- Width of pontoon D = 20 cm
- Depth of pontoon R = 7.0cm
- Second moment of inertia $I = \frac{LD^3}{12}$ = 24000cm$^4$
- Volume of displaced water V = 2600cm$^3$
- Depth of immersion of ponton $= \frac{V}{LD}$ $= \frac{2600}{36 \times 20} = \underline{3.61cm}$
- Metacentric height from center of buoyancy $= \frac{I}{V} = \frac{2400}{2600} = \underline{9.23cm}$
- Measured depth of immersion = 3.61cm



## EXPERIMENTAL DETERMINATION OF CENTER OF GRAVITY



## READINGS

### TABLE 1: READINGS FROM EXPERIMENT

| Height of adjustable weight from base of pontoon | Angular displacement for various (deg) positions of the jockey weight (cm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | -6.0 | -4.5 | -3.0 | -1.5 | 0 | 1.5 | 3.0 | 4.5 | 6.0 |
| 16cm | -5.5 | -4.5 | -2.4 | -1.4 | 0 | 1.4 | 2.5 | 4.0 | 5.5 |
| 18cm | -5.6 | -4.3 | -2.8 | -1.5 | 0 | 1.5 | 2.8 | 4.4 | 5.6 |
| 20cm | -6.0 | -4.6 | -3.0 | -1.6 | 0 | 1.8 | 3.0 | 4.6 | 6.0 |
| 22cm | -6.7 | -5.0 | -3.4 | -1.8 | 0 | 1.8 | 3.6 | 5.2 | 6.7 |
| 24cm | -7.0 | -6.5 | -4.5 | -3.2 | 0 | 3.3 | 4.6 | 6.2 | 7.0 |

### TABLE II: READINGS FROM GRAPHS

| | Pos. adju. weight ($Z_1$) | $X_0$ cm deg, dx dθ | $X_0 \times 57.3$ in radians dx/dθ |
|---|---|---|---|
| 1 | 31.50 | 1.10 | 63.03 |
| 2 | 31.70 | 1.04 | 59.59 |
| 3 | 31.51 | 1.00 | 57.30 |
| 4 | 31.45 | 0.55 | 48.71 |
| 5 | 31.51 | 0.69 | 39.54 |

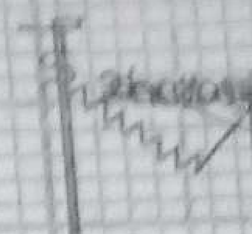
NOTE: Position of adjustable weight at Z

i.e $\bar{y} = y_1' \frac{W'}{W} + \frac{W''}{W} Z$, etc to $Z_5$

CETE

Graph of θ(°C) against Jockey position

Scale: 2cm to rep 2unit at θ°C
2cm to rep 2unit at Xcm



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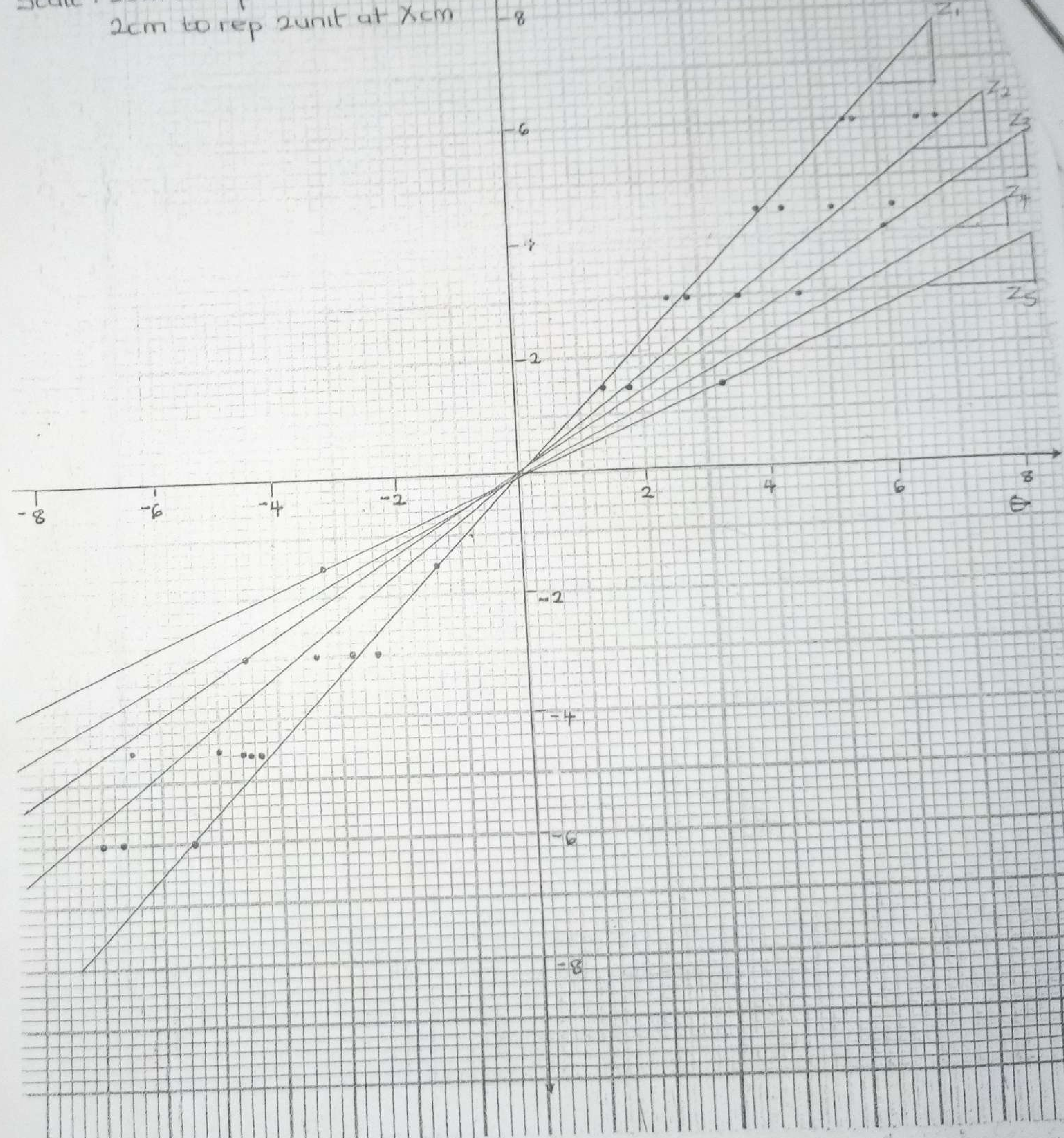



Taking m

Taking moment about O: $WY_1 = y'_{1ow} W' + W_2''$

$$\bar{Y}_1 = Y_1' \frac{W'}{W} + \frac{W''}{W} Z_1$$

$$\therefore \bar{y}_1 = y_1' \frac{W'}{W} + c$$

$$\therefore c = \bar{y}_1 - y_1' \frac{W'}{W} = 5.5 - \frac{16 \times 500}{2600} = \underline{\underline{2.42}}$$

∴ for any other position the same equation must be used and the value of c is the same

1. $\bar{y}_1 = \bar{y}_1' \frac{W_1}{W} + c = 16 \frac{500}{2600} + 2.42 = \underline{\underline{5.497cm}}$

2. $\bar{y}_2 = \bar{y}_2' \frac{W'}{W} + c = 18 \frac{500}{2600} + 2.42 = \underline{\underline{5.88cm}}$

3. $\bar{y}_3 = y_3' \frac{W'}{W} + c = 20 \frac{500}{2600} + 2.42 = \underline{\underline{6.26cm}}$

4. $\bar{y}_4 = y_4' \frac{W'}{W} + c = 22 \frac{500}{2600} + 2.42 = \underline{\underline{6.65cm}}$

5. $\bar{y}_5 = y_5' \frac{W'}{W} + c = 24 \frac{500}{2600} + 2.42 = \underline{\underline{7.04cm}}$

## CALCULATION OF META-CENTRIC HEIGHT

Meta centric height Gm can be calculated using the formular

$$G_m = \frac{W'd \times 57.3}{W d\theta}$$

where $\frac{dx}{d\theta}$ = slope

W' = adjustable weight

W = total weight of fluid displaced

1. $Gm_1 = \frac{500 \times 57.3}{2600}\left(\frac{dx}{d\theta}\right)$ where $\frac{dx}{d\theta} = 1.1$

$= \underline{12.12cm}$

2. $Gm_2 = \frac{500 \times 57.3}{2600}\left(\frac{dx}{d\theta}\right) = \underline{11.46cm}$

3. $Gm_3 = \frac{500 \times 57.3}{2600}\left(\frac{dx}{d\theta}\right) = \underline{11.02cm}$

4. $GM_4 = \frac{500 \times 57.3}{2600}\left(\frac{dx}{d\theta}\right) = \underline{9.37cm}$

5. $Gm_5 = \frac{500 \times 57.3}{2600}\left(\frac{dx}{d\theta}\right) = \underline{7.6cm}$

Height of G above water surface is determined by substituting $\bar{y}$ from the depth of immersion of pontoon (cm) which has been given as 3·61 Hence

at $y_1' = 6{\cdot}5$ Height of $G = 5{\cdot}5 - 3{\cdot}61 = \underline{1{\cdot}89\text{cm}}$

at $y_2' = 5{\cdot}88$ Height of $G = 5{\cdot}88 - 3{\cdot}61 = \underline{2{\cdot}27\text{cm}}$

at $y_3' = 6{\cdot}27$ Height of $G = 6{\cdot}27 - 3{\cdot}61 = \underline{2{\cdot}66\text{cm}}$

at $y_4' = 6{\cdot}65$ Height of $G = 6{\cdot}65 - 3{\cdot}61 = \underline{3{\cdot}04\text{cm}}$

at $y_5' = 7{\cdot}04$ Height of $G = 7{\cdot}04 - 3{\cdot}61 = \underline{3{\cdot}43\text{cm}}$

Height of M in above water surface (cm)

Height of M = Gm, Depth of Immersion of pontoon (cm)

at $G_m = 12{\cdot}12$, $m' = 12{\cdot}12 - 3{\cdot}61 = \underline{8{\cdot}6\text{cm}}$

$G_m = 11{\cdot}46$, $m = 11{\cdot}46 - 3{\cdot}61 = \underline{7{\cdot}85\text{cm}}$

$G_m = 11{\cdot}02$, $m = 11{\cdot}02 - 3{\cdot}61 = \underline{7{\cdot}41\text{cm}}$

$G_m = 9{\cdot}37$, $m = 9{\cdot}37 - 3{\cdot}61 = \underline{5{\cdot}76\text{cm}}$

$G_m = 7{\cdot}60$, $m = 7{\cdot}60 - 3{\cdot}61 = \underline{3{\cdot}99\text{cm}}$





Calculations of $(dx/d\theta)$ from the graph the values can be deducted.

$$Z_1 = \left(\frac{dx}{d\theta}\right)_1 = \frac{-1{\cdot}3 - (-3{\cdot}3)}{-1{\cdot}2 - (-3{\cdot}2)} = 1{\cdot}10$$

$$Z_2 = \left(\frac{dx}{d\theta}\right)_2 = \frac{-2{\cdot}5 - (-5)}{-2{\cdot}4 - (-4{\cdot}3)} = 1{\cdot}04$$

$$Z_3 = \left(\frac{dx}{d\theta}\right)_3 = \frac{-4 - (-6{\cdot}0)}{-4 - (-6)} = 1{\cdot}00$$

$$Z_4 = \left(\frac{dx}{d\theta}\right)_4 = \frac{4{\cdot}7 - 3{\cdot}6}{5{\cdot}6 - 3{\cdot}6} = 0{\cdot}55$$

$$Z_5 = \left(\frac{dx}{d\theta}\right)_5 = \frac{5{\cdot}3 - 3{\cdot}5}{8 - 5{\cdot}4} = 0{\cdot}69$$

To find z (position of adjustable weight at $Z_1$)

$$y = y_1' \frac{W''}{W} + \frac{W''}{W} Z_1$$

For $Z_1$

$$5.5 = 16 \times \frac{500}{2600} + \frac{200}{2600} \times Z_1$$

$$Z_1 = \underline{31.5}$$

For $Z_2$

$$5.88 = 18 \times \frac{500}{2600} + \frac{200}{2600} \times Z_2$$

$$Z_2 = \underline{31.44}$$

For $Z_3$

$$6.25 = 20 \times \frac{500}{2600} + \frac{200}{2600} \times Z_3$$

$$Z_3 = \underline{31.25}$$

For $Z_4$

$$6.65 = 22 \times \frac{500}{2600} + \frac{200}{2600} \times Z_4$$

$$Z_4 = \underline{31.43}$$

For $Z_5$

$$7.04 = 24 \times \frac{500}{2600} + \frac{200}{2600} \times Z_5$$

$$Z_5 = \underline{31.52}$$



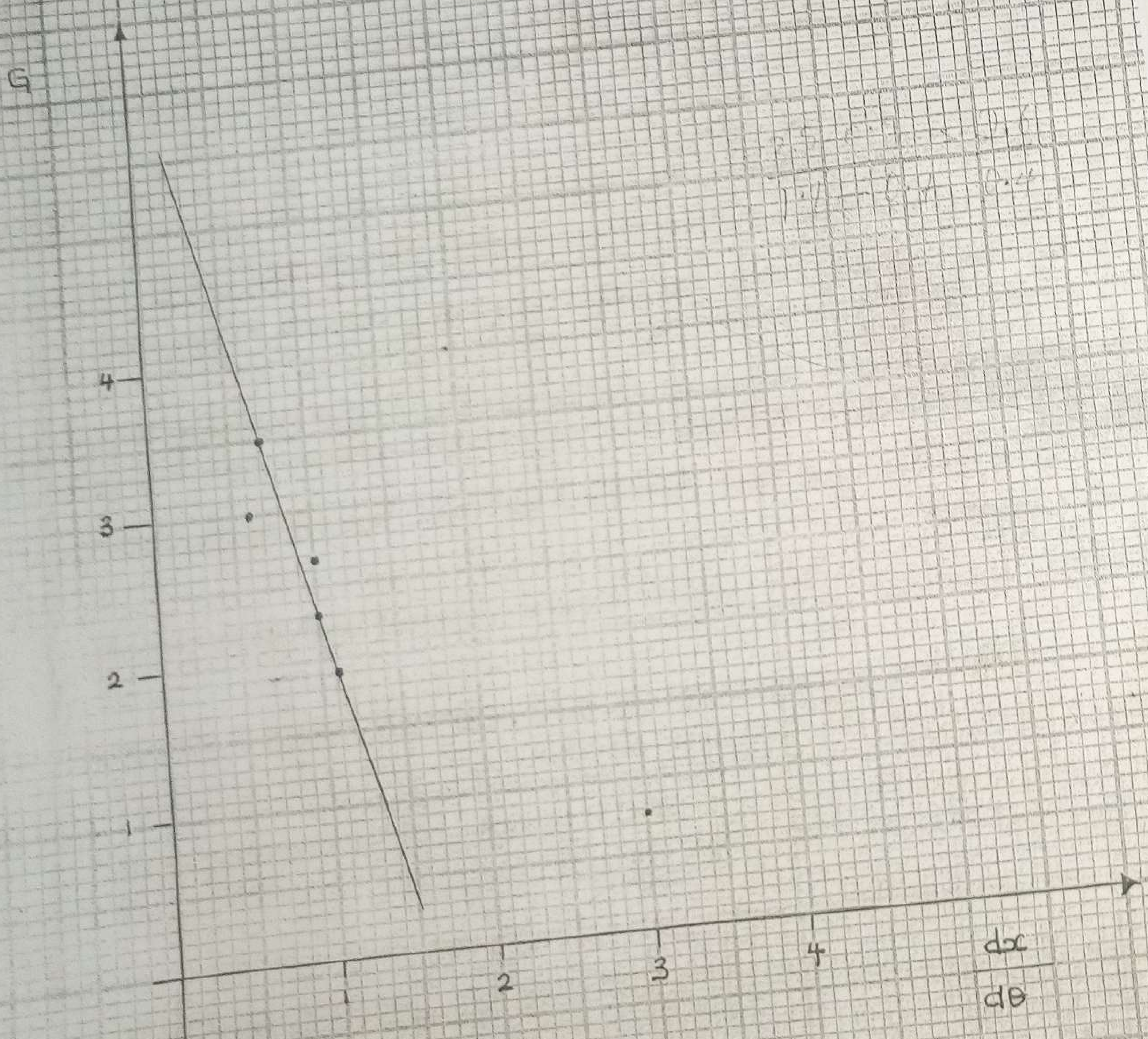


TABLE III: RESULTS FROM GRAPHS AND CALCULATION

| S/NO | Ht of adj weight $y_1'$ (cm) | Dept of imm of pontoon (cm) | Dist $\bar{y}_1$ from bottom (cm) | Ht of G above water surf (cm) | $dx/d\theta$ (cm/deg) | Metacentre Ht $Gm = \frac{W'd \times 57.3}{W d\theta}$ | Ht of M above water surf (cm) |
|---|---|---|---|---|---|---|---|
| 1 | 16cm | 3.6 | 5.50 | 1.89 | 1.10 | 12.12 | 8.6 |
| 2 | 18cm | 3.6 | 5.88 | 2.27 | 1.04 | 11.46 | 7.85 |
| 3 | 20cm | 3.6 | 6.27 | 2.66 | 1.00 | 11.02 | 7.41 |
| 4 | 22cm | 3.6 | 6.65 | 3.04 | 0.55 | 9.37 | 5.76 |
| 5 | 24cm | 3.6 | 7.04 | 3.45 | 0.69 | 7.6 | 3.99 |

Graph of $\frac{dx}{d\theta}$ against height G

Scale: 2cm to rep 1unit on G-axis
2cm to rep 1unit on $\frac{dx}{d\theta}$ axis

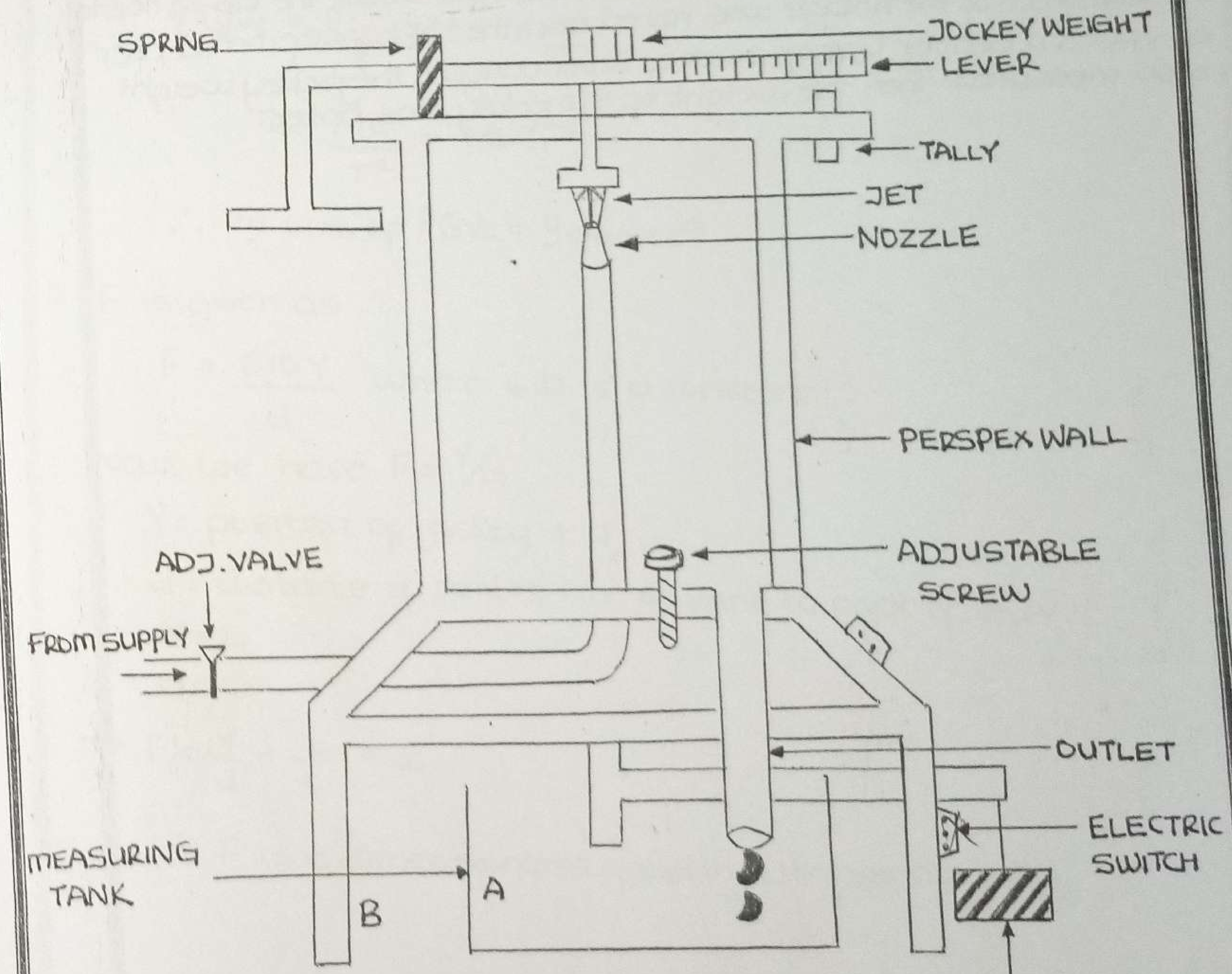





## EXPERIMENT FOUR

### TITLE: IMPACT OF JET

**AIM:** To compare the force generated by a jet of water as it strikes a flat plate or a hemispherical cup with the theoretical value given by the momentum equation.




HYDRAULIC BENCHE

## PRECAUTIONS

1. I ensured that the apparatus were in their good working condition before starting the experiment.
2. I ensured that the Laboratory table was not toyed
3. I avoided zero error when taking reading from the experiment
4. I avoided also the error due to parallax when taking reading from the angular scale and steel rule
5. I avoided side distraction from my mates

## OBSERVATION

1. The height of the adjustable weight was increased uniformly by 2cm
2. The depth of immersion of the pontoon was constant throughout the experiment
3. The distance Y from the bottom increased with the increase in the height of adjustable weight.
4. The adjustable weight also increased with the height of G above water surface
5. The height of adjustable weight was increased with decreased in dx/dθ
6. The height of M above the surface of water decreased with increase in the height of adjustable weight
7. The metacentric height indicated a corresponding decrease with the increase in the height of adjustable weight

## CONCLUSION

It can be concluded that the stability of a floating pontoon varies inversely with the height of G above the water surface.





## PROCEDURE

The apparatus was leveled and the lever was set to the balanced position (as indicated by the tally) when the jockey weight was at its zero position. The inlet valve was open and the jet was centrolised on the flat plate by adjusting the three screws at the base.

The jockey weight was placed at a distance of 1.0cm from the zero and the flow was adjusted by means of the inlet valve until the lever was restored to the balanced position. Then the discharging was measured by recording the time required to collect 1500 grams of water in the measuring tank (as indicated by the distance of the balancing lever of tank) This process was repeated with the jockey weight at distances of 2.0cm, 3.0 cm, 4.0cm, 5.0cm, 6.0cm and 7.0cm from the zero mark.

Finally, the height of the vane was measured above the tip of nozzle and the diameter of the nozzle was noted and the distance from center line of vane to center line of point of lever carrying the jockey weight was also measured. Then, the weight of the jockey was noted.

## DERIVATION OF THE UNIT FOR ρQVc AND F

using dimensional analysis

1. $\rho$ = density = $\frac{\text{mass}}{\text{Volume}} = \frac{M}{L^3}$

$Q$ = discharge = $\frac{\text{volume}}{\text{Time}} = \frac{L^3}{T}$

$V_c$ = velocity = $\frac{L}{T}$

Now

$$\rho Q V_c = \frac{m^3}{L^3} \times \frac{L^3}{T} \times \frac{L}{T}$$

$$= \frac{ML}{T^2} = MLT^{-2}$$

∴ The unit of $\rho Q V_c$ = $g\,cm/sec^2$

2. F is given as

$$F = \frac{610Y}{d}$$ where 610 is a constant

Now, we have $F = Y/d$

$Y$ = position of jockey + d

$d$ = distance of centre line of vane to pivot of lever

$Y = L$

$d = L$

$\Rightarrow F = \frac{Y}{d} = \frac{L}{L} = 1$

∴ F is a dimensionless quantity (it has no unit)





## CALCULATION OF ρQVc

ρQVc,
where $\rho$ = density = $1g/cm^3$
$Q$ = discharge
$V_c$ = velocity of the jet

1. $\rho Q V_c = 1 \times 208.91 \times 248.99$
$= \underline{52016.50N}$

2. $\rho Q V_c = 1 \times 246.71 \times 299.90$
$= \underline{73988.33N}$

3. $\rho Q V_c = 1 \times 267.38 \times 327.83$
$= \underline{87655.19N}$

4. $\rho Q V_c = 1 \times 284.09 \times 349.49$
$= \underline{99286.61N}$

5. $\rho Q V_c = 1 \times 320.51 \times 397.33$
$= \underline{127348.24N}$

6. $\rho Q V_c = 1 \times 313.81 \times 388.56$
$= \underline{121934.01N}$

7. $\rho Q V_c = 1 \times 325.58 \times 403.71$
$= \underline{131359.16N}$

96771.9874

### CALCULATIONS FOR FLAT PLATE

$V_c = (V_0^2 - 2gs)^{1/2}$

WHERE

$V_0 = Q/A$

S = distance from nozzle top to the plate

Q = Discharge

A = Area of Nozzle $= \frac{\pi d^2}{4} = \frac{\pi(1)^2}{4} = 0.785cm^2$

g = acceleration due to gravity ; $981 cm/sec^2$

1. $V_c = (V_0^2 - 2gs)^{1/2}$
$= [(266.13)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{248.99 cm/s}$

2. $V_c = [(314.28)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{299.90 cm/s}$

3. $V_c = [(341.03)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{327.83 cm/s}$

4. $V_c = [(361.90)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{349.49 cm/s}$

5. $V_c = [(408.29)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{397.33 cm/s}$

6. $V_c = [(399.76)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{388.56 cm/s}$

7. $V_c = [(414.56)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{403.71 cm/s}$



### CALCULATIONS FOR HEMISPHERICAL CUP

$V_c = (V_0^2 - 2gs)^{1/2}$

WHERE $V_0 = Q/A$

S = distance from nozzle up to the plate

Q = Discharge

A = Area of the nozzle $= \frac{\pi d^2}{4} = \frac{\pi(1)^2}{4} = 0.785cm^2$

g = acceleration due to gravity $= 981 cm/sec^2$

1. $V_c = (V_0 - 2gs)^{1/2}$
$= [(173.71)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{146.10 cm/s}$

2. $V_c = [(214.70)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{193.05 cm/s}$

3. $V_c = [(235.90)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{216.38 cm/s}$

4. $V_c = [(248.17)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{229.69 cm/s}$

5. $V_c = [(281.01)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{264.84 cm/s}$

6. $V_c = [(328.87)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{309.94 cm/s}$

7. $V_c = [(341.22)^2 - (2 \times 981 \times 4.5)]^{1/2}$
$= \underline{328.03 cm/s}$

## CALCULATION OF PQVc

PQVc where P = density = 1g/cm²
Q = Discharge
Vc = Velocity of the jet

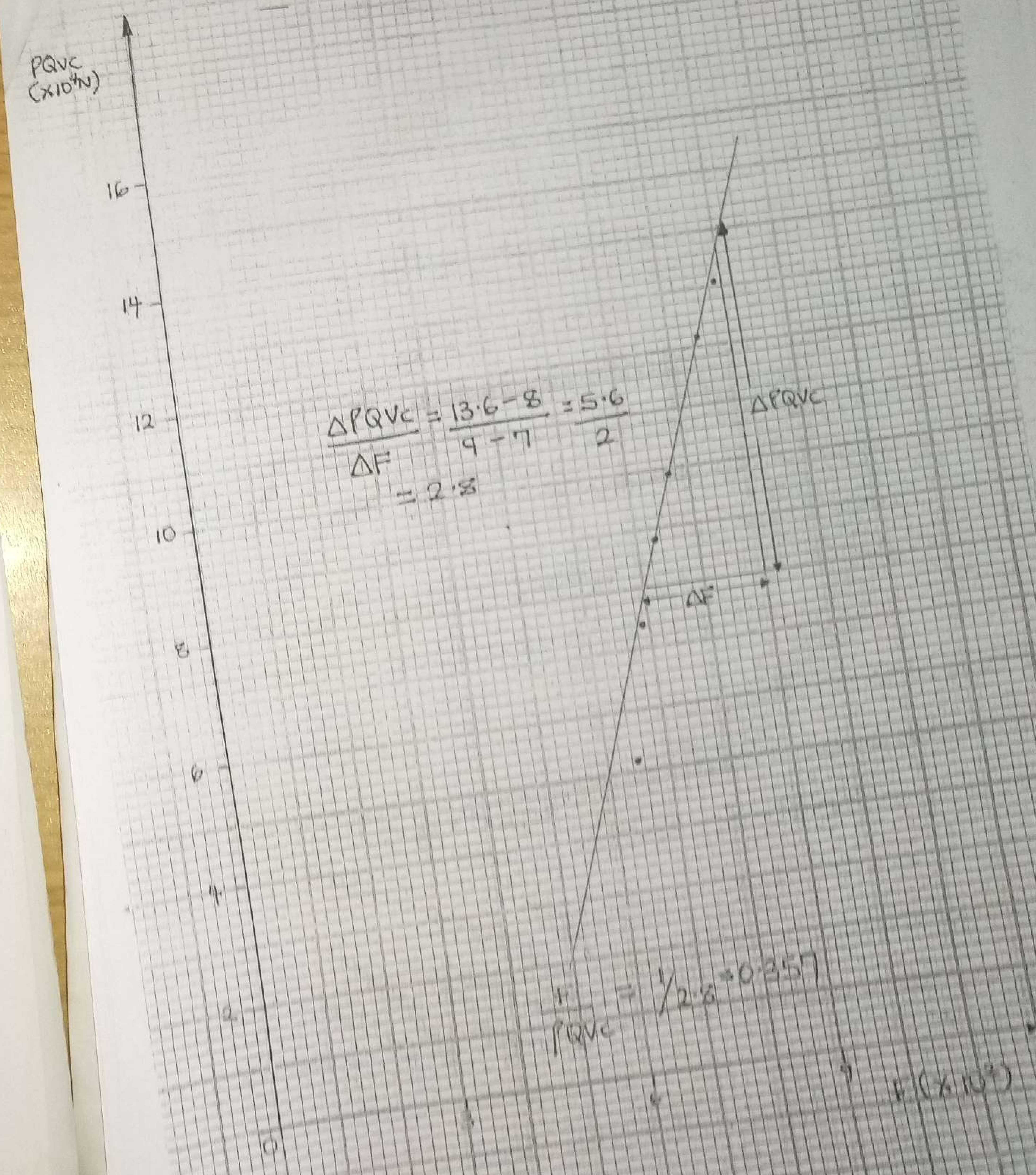
1. PQVc = 1 × 136·36 × 146·10 = 19922·20N
2. PQVc = 1 × 168·54 × 193·05 = 32536·65N
3. PQVc = 1 × 185·19 × 216·38 = 40071·41N
4. PQVc = 1 × 194·81 × 229·69 = 44745·91N
5. PQVc = 1 × 220·59 × 264·84 = 58421·06N
6. PQVc = 1 × 254·24 × 309·94 = 78799·15N
7. PQVc = 1 × 267·86 × 328·03 = 87866·12N





FOR FLAT PLATE

Graph of PQVc against F
Scale: 2cm to rep 2unit on PQVc axis
3cm to rep 3unit on F axis



## (I) FLAT PLATE

| Pos of jockey | Vol of water (cc) | time (sec) | discharge cc/sec | $V_o$ (cm/sec) | $V_c = (V_o^2 - 2gs)^{1/2}$ | $\rho QV_c$ | $F = \frac{610y}{d}$ |
|---|---|---|---|---|---|---|---|
| 1.0 | 15000 | 71.8 | 208.91 | 266.13 | 248.99 | 52016.50 | 649.4 |
| 2.0 | 15000 | 60.8 | 246.71 | 314.28 | 299.90 | 73988.33 | 688.7 |
| 3.0 | 15000 | 56.1 | 267.38 | 341.03 | 327.83 | 87655.19 | 728.1 |
| 4.0 | 15000 | 52.8 | 284.09 | 361.90 | 349.49 | 99286.61 | 767.4 |
| 5.0 | 15000 | 48.8 | 320.57 | 408.29 | 397.33 | 127348.24 | 806.8 |
| 6.0 | 15000 | 47.8 | 313.81 | 399.76 | 388.56 | 121934.01 | 846.1 |
| 7.0 | 15000 | 46.1 | 325.38 | 414.50 | 403.71 | 131359.16 | 885.5 |

## (II) HEMISPHERICAL CUP

| Pos of jockey | Vol of water | time (sec) | discharge cc/sec | $V_o$ (cm/sec) | $V_c = (V_o^2 - 2gs)^{1/2}$ | $\rho QV_c$ | $F = \frac{610y}{d}$ |
|---|---|---|---|---|---|---|---|
| 1.0 | 15000 | 110.0 | 136.36 | 173.71 | 146.10 | 19922.20 | 649.4 |
| 2.0 | 15000 | 89.0 | 168.54 | 214.70 | 193.05 | 32536.65 | 688.7 |
| 3.0 | 15000 | 81.0 | 185.19 | 235.90 | 216.38 | 40071.41 | 728.1 |
| 4.0 | 15000 | 77.0 | 194.81 | 248.17 | 229.69 | 44745.91 | 767.4 |
| 5.0 | 15000 | 68.0 | 220.59 | 281.01 | 264.84 | 58421.06 | 806.8 |
| 6.0 | 15000 | 59.0 | 254.24 | 323.87 | 309.94 | 78799.15 | 846.1 |
| 7.0 | 15000 | 56.0 | 267.86 | 341.22 | 328.03 | 87866.12 | 885.5 |



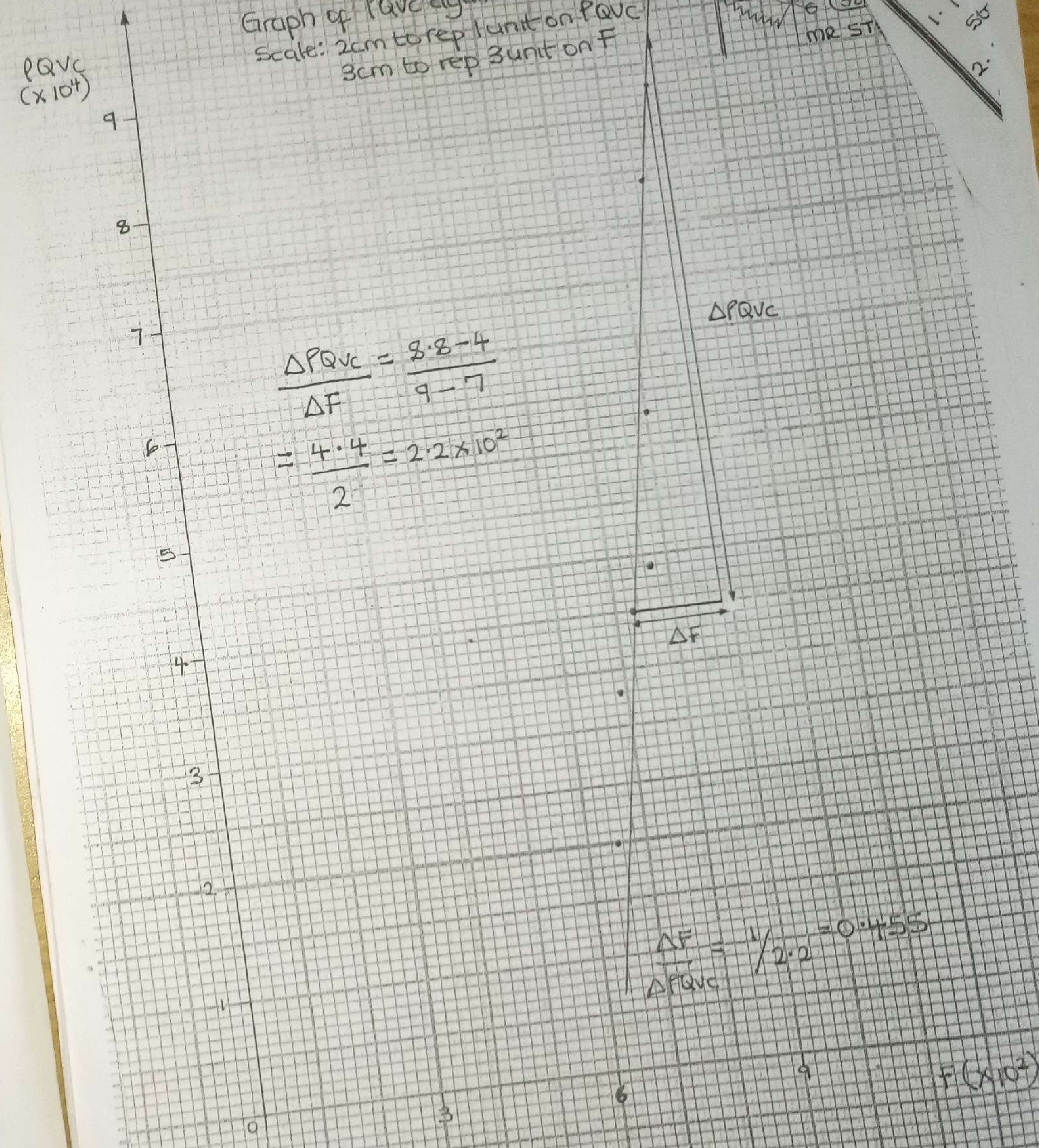


FOR HEMISPHERICAL CUP

Graph of $\rho QV_c$ against F

Scale: 2cm to rep 1 unit on $\rho QV_c$

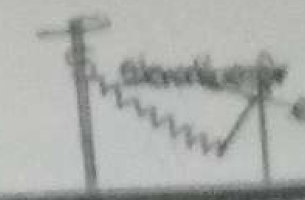
3cm to rep 3 unit on F




$$\frac{\Delta \rho QV_c}{\Delta F} = \frac{8.8 - 4}{9 - 7}$$

$$= \frac{4.4}{2} = 2.2 \times 10^2$$

$$\frac{\Delta F}{\Delta \rho QV_c} = \frac{1}{2.2} = 0.455$$





## PRECAUTION

1. I ensured that the instrument were in good working condition before starting the experiment
2. I avoided zero error from the lever scale
3. I ensured that I avoided error due to parallax from the lever scale
4. I also ensured that the hydraulic benche was not tapped
5. I avoided any side distraction from my mate in the course of the experiment

## OBSERVATION

1. The volume of Water was constant throughout the experiment for both tables.
2. There was a uniform increase in the position of jockey for both tables
3. The time required to collect the water decrease with increase in jockey position for both the flat plate and hemispherical cup
4. Discharge from both table increased as the time taken decreased
5. Both Vo and Vc increased with decrease in time
6. FQvc for both the flat plate and hemispherical cup table increased with increased in the jockey position

## CONCLUSION

It is obvious from the calculated slope of the graphs of FQvc against F for both tables that a close agreement exist between the two values i.e between experimental values and theoritical values, thus validating the momentum equation.

## EXPERIMENT FIVE

**TITLE: REYNOLDS DYE EXPERIMENT**

**AIM:** To determine the critical velocity for a flow of water through a glass tube of known diameter and to determine the Reynolds number at that velocity.

**APPARATUS:** (See diagram)

Water enters a header tank mounted on a vertical post via an inlet-pipe connected with the header tank, the flow enters a perpex tube from where it flows in reverse direction through a bell-mounted on vertical post. The dye container is connected to a bass nozzle by a rubber tube through which a stream of dye is introduced into the glass tube. A measuring tank used for measuring the discharge through the glass tube is connected at the end of the end of the apparatus for the discharge of both water and dye.