TRIBHUVAN UNIVERSITY

Institute of Engineering,

Pulchowk Campus

A LAB REPORT

ON

FLUID MECHANICS

A

LAB NO: 1, 2, 3, 4, 5, 6

EXPERIMENTS DATE: 2080

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[HYDRAULICS LAB]

TITLE: VERIFICATION OF BERNOULLI'S THEOREM

OBJECTIVE:

To compute total heads at different point in a venturimeter and verify Bernoulli's theorem.

SCOPE:

Bernoulli's theorem is one of the fundamental principles of fluid flow. As verification leads to better understanding of fluid flow circumstances through various devices.

APPARATUS:

(a) Hydraulic bench

(b) Orifice tank

(c) Stop watch

THEORY:

(a) For a horizontal pipe the total head

$$H = \frac{P_1}{\gamma} + \frac{v_1^2}{2g} = \frac{P_2}{\gamma} + \frac{v_2^2}{2g}$$

where, $\frac{P_1}{\gamma}, \frac{P_2}{\gamma}$ = Pressure head

v_1, v_2 = velocity of flow

(b) Actual discharge $(Q_a) = \frac{V}{T}$

EXPERIMENTAL PROCEDURE

(a) Connect the venturimeter with the hydraulics bench.

(b) Close the main delivery valve and start the pump.

(c) Allow sufficient flow to pass through the venturimeter by gradually operating the valve so that a head different of about 200mm is obtained. Allow the condition to settle

(d) Note the piezometer reading H_a, H_b, H_c and H_d.

(e) Determine the actual flow rate by timing the mass of water collected in the measuring tank

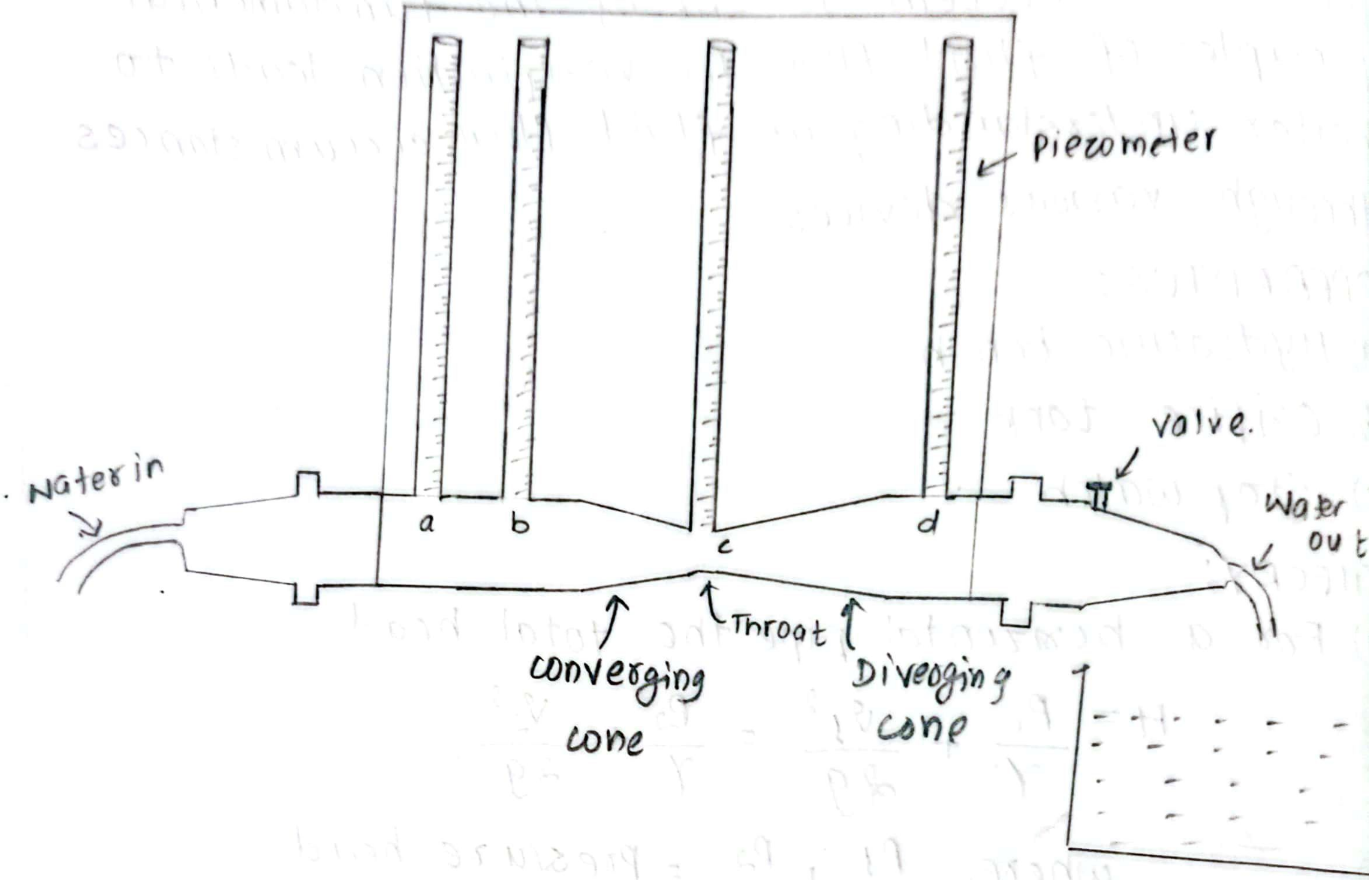


Fig: Experimental setup for Bernoulli's experiment.

(f) Repeat for few more observations.

(g) Show figure of apparatus.

OBSERVATION

Inlet diameter = 20mm

Pipe diameter = 20mm

Throat diameter = 10mm

OBSERVATION Table

No. of Obs.	Piezometric Reading h_a (cm)	h_b (cm)	h_c (cm)	h_d (cm)	Mass of water collected (kg)	Time (s)
1.	19.4	19.4	10.4	16.9	5	43
2.	24	23.8	13	21.8	5	38
3.	28.8	28.8	14.8	25.7	5	34
4.	36.6	36.4	19.3	32.4	5	31
5.	41.6	41.5	21.8	31.9	5	28

Sample Calculation

For observation 1: Point (a)

Mass of water collected (m) = 5kg

time (t) = 43sec

Actual discharge $(Q_a) = \frac{V}{t} = \frac{5/1000}{43} = 1.163 \times 10^{-4} m^3/s.$

Area of inlet $(A_a) = \pi \times R_{inlet}^2 = \pi \times 0.01^2$

$= 3.14 \times 10^{-4} m^2$

velocity of inlet $(V_a) = \frac{Q_a}{A_a} = \frac{1.163 \times 10^{-4}}{3.14 \times 10^{-4}} = 0.37 m/s$

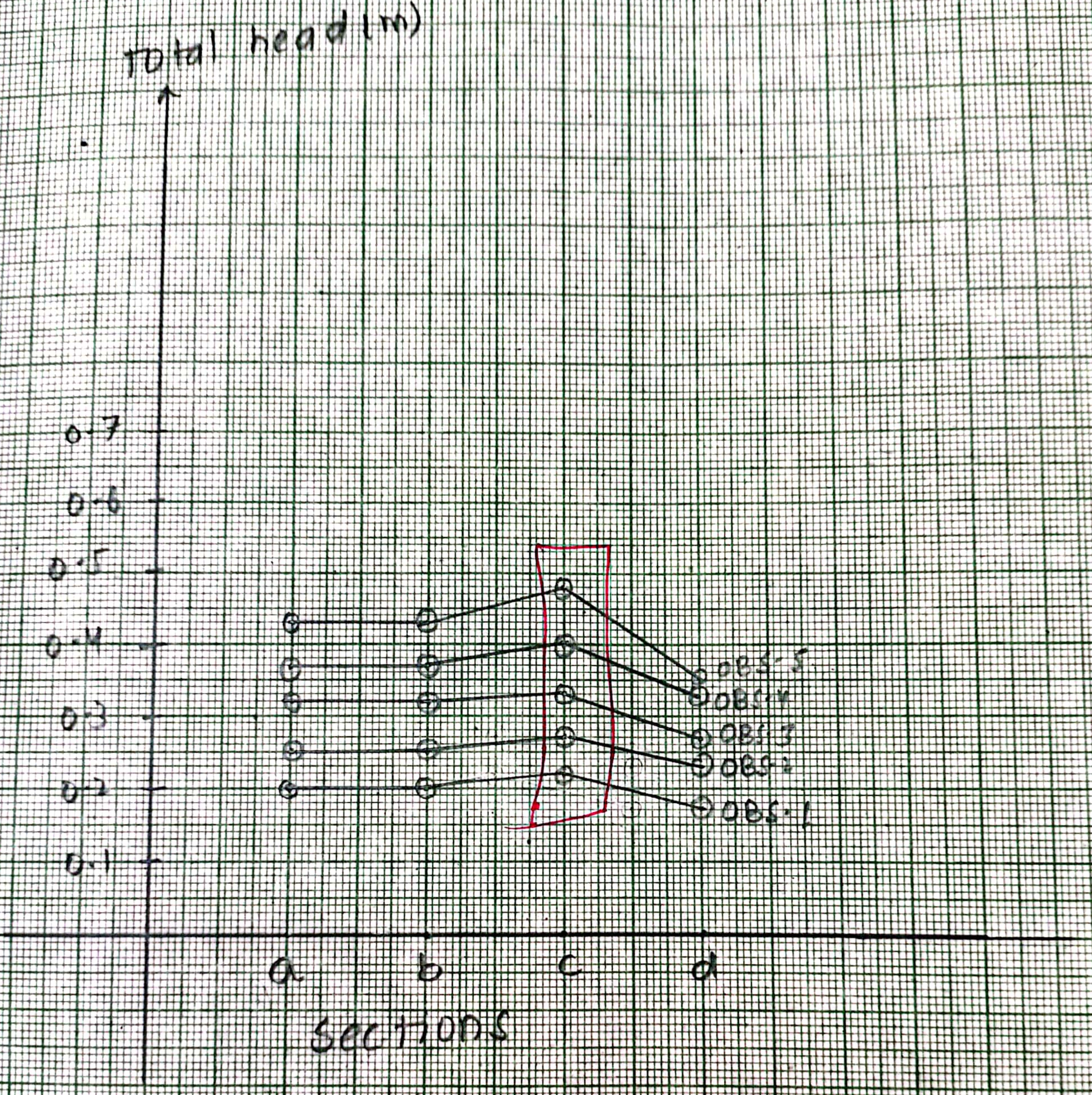
velocity head, $\frac{V_a^2}{2g} = \frac{0.37^2}{2 \times 9.81} = 6.99 \times 10^{-3} m$

Total head = pressure head + velocity head

$= 0.194 + 6.99 \times 10^{-3}$

$= 0.201 m.$

Scale:
Along Y-axis 10 division = 0.1



CALCULATION TABLE

No. of Obs.	Point	Pressure head (m)	Actual discharge Q_A (m^3/s)	Area (A) $\times 10^{-4}$ m^2	Velocity $\underline{V}$ (m/s)	Velocity head (m) $V^2/2g$	Total head (m)
1	a	0.194	1.163×10^{-4}	3.14	0.37	0.0069	0.201
	b	0.194		3.14	0.37	0.0069	0.201
	c	0.104		$(\pi \times 0.005^2)$ = 0.785	1.48	0.116	0.215
	d	0.169		3.14	0.37	0.0069	0.176
2	a	0.240	1.316×10^{-4}	3.14	0.42	0.0089	0.2489
	b	0.238		3.14	0.42	0.0089	0.2469
	c	0.130		0.785	1.67	0.142	0.272
	d	0.218		3.14	0.42	0.0089	0.2269
3	a	0.288	1.47×10^{-4}	3.14	0.47	0.011	0.3168
	b	0.288		3.14	0.47	0.011	0.3168
	c	0.148		0.785	1.87	0.178	0.326
	d	0.257		3.14	0.47	0.011	0.268
4.	a	0.360	1.613×10^{-4}	3.14	0.51	0.013	0.373
	b	0.364		3.14	0.51	0.013	0.377
	c	0.193		0.785	2.05	0.214	0.407
	d	0.324		3.14	0.51	0.013	0.337
5	a	0.416	1.786×10^{-4}	3.14	0.57	0.0165	0.433
	b	0.415		3.14	0.57	0.0165	0.432
	c	0.218		0.785	2.27	0.263	0.481
	d	0.319		3.14	0.57	0.0165	0.336

CONCLUSION

Hence, the total head at different point in venturi-meter was calculated and was found to be almost constant every time which verifies Bernoullis Theorem. There is slight variation in total head which may be due to human error in reading pressure head, some instrumental error. Also, there are some losses which doesn't make all the total head constant. This is seen increment in total head from B to C which is due to instrumental error which might have occured due to capillary action due to blunt faces.

HYDROSTATIC FORCE ON A SUBMERGED SURFACE

OBJECTIVE

To measure the moment, about a knife edge of the hydrostatic force on a fully immersed plane vertical surface and to compare this moment with that derived from theory.

SCOPE:

- All surfaces that are in contact with water experience force.
- All water retaining structures must be designed to withstand water pressure. This experiment helps to determine the hydrostatic force on a plane surface.

APPARATUS

(a) centre of pressure apparatus with weights
(b) water
(c) scale

THEORY:

(a) The moment about the pivot of the water pressure on the fully immersed plane vertical face is

$$M_{th} = \underbrace{\rho g \bar{y}}_{F} \underbrace{bd}_{A} \left(a + \frac{d}{2} + \frac{d^2}{12\bar{y}}\right)$$

$$\bar{y} = y - d/2$$

where, M = Moment due to force
b = Breadth of the plane face of a guard
d = Depth of plane face
a = Distance of edge of plane face from knife edge
y = Bottom edge of the plane below water surface

(b) Moment is also measured experimentally by putting a mass at a distance 'l' from the knife edge.

$$M_E = mgl$$

equating

$$mgl = \rho g \bar{y}\, bd\left(a + \frac{d}{2} + \frac{d^2}{12y}\right)$$

EXPERIMENTAL PROCEDURE

The apparatus was placed on a level table. Then distance l, b, a and d were measured. At first with no water in the apparatus, the plane face was checked if it was vertical and a preliminary balance was made by using the empty mass longer and adjustable screw at the end. In the balanced position the beam just lifted off its underside present stop. Then water was added to the perspex quadrant until the level of water was just above the top edge of the plane under test. Now, masses were added in the mass area until the balance was restored. y_1 and w_1 were noted. After it additional mass was added on it and water was added carefully to restore the balance. and reading y_2 was noted. The procedure was repeated few more times.

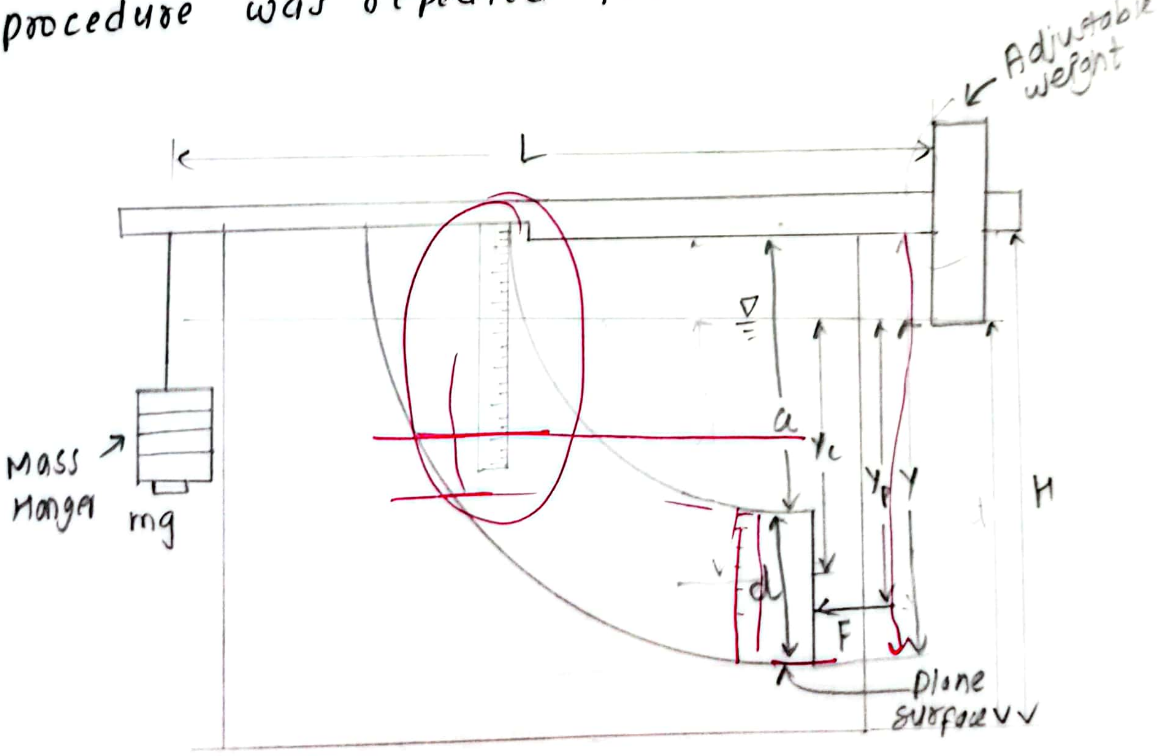


Fig: Fully submerged Quadrant

OBSERVATION

Moment arm (l) = 275mm

Breadth of plane face (b) = 75mm

Depth of plane face (d) = 100mm

Distance of top edge of the face from knife edge (a) = 100mm

OBSERVATION TABLE

No. of Observations	Depth of water, y (mm)	Mass added, (g)
1	107	250
2	122	300
3	134	350
4	147	400
5	152	420
6	157	440
7	158	450

Sample Calculation.

For 1st observation:

@ Theoretical moment,

$$M_{Th} = \rho g \bar{y}\, bd\left(a + \frac{d}{2} + \frac{d^2}{12\bar{y}}\right)$$

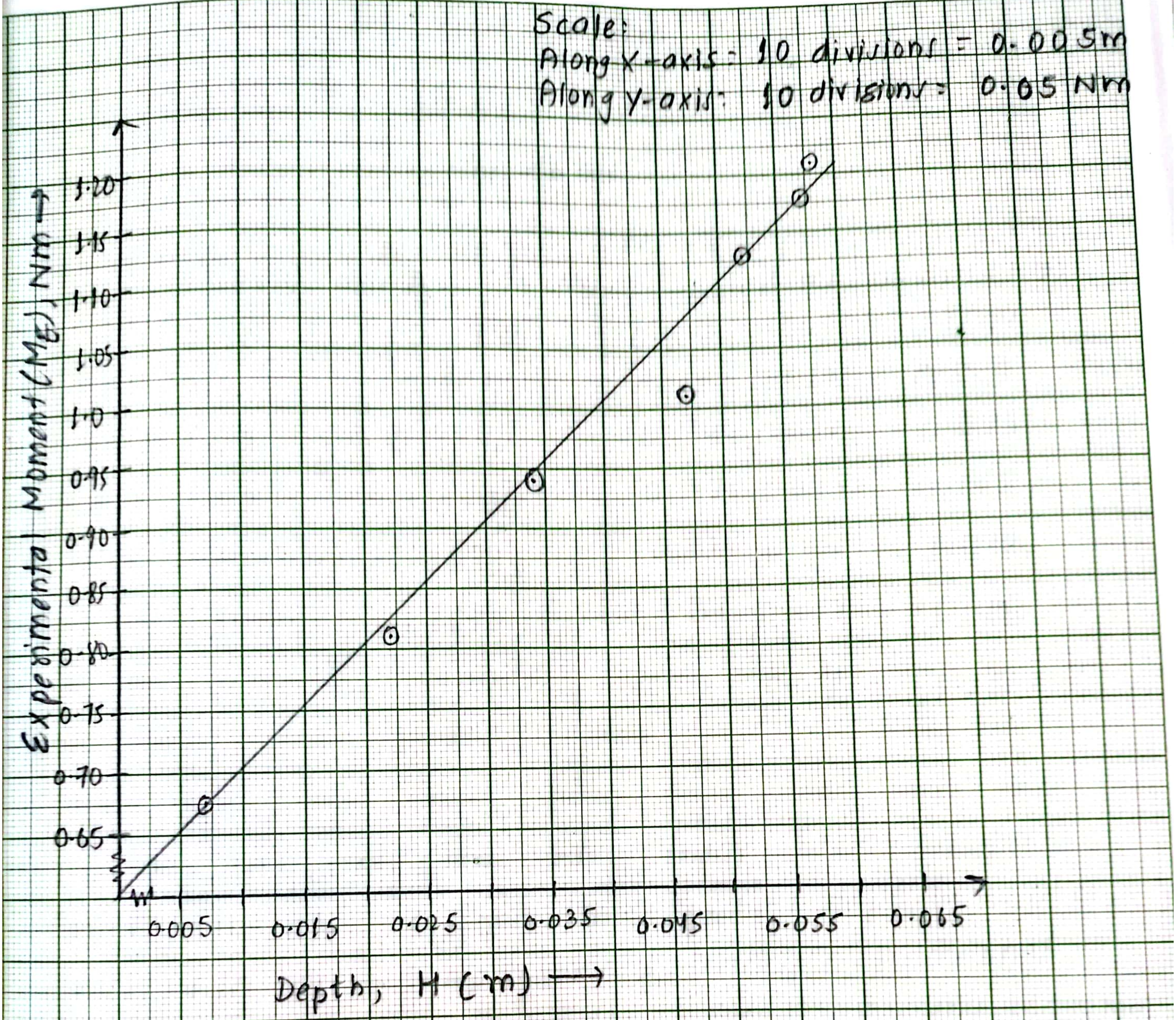
$$\bar{y} = y - d/2$$

$$= 107 - 100/2 = 57mm = 0.057m$$

$$So,\ M_{Th} = 1000 \times 9.81 \times 0.057 \times 0.075 \times 0.1 \left(0.1 + \frac{0.1}{2} + \frac{0.1^2}{12 \times 0.057}\right)$$

$$= 0.6904Nm.$$

Experimental Moment (M_E) V/S H



(b) Experimental moments

$$M_E = mgl$$
$$= 0.25 \times 9.81 \times 0.275$$
$$= 0.6744 \text{ Nm}$$

(c) Depth, $H = y - d = 0.107 - 0.1 = 0.007$ m.

Calculation table

No. of obs.	Weight added (N)	Experimental moment, M_E (Nm)	Depth of water, y (cm)	Depth, H (cm)	Theoretical moment arm (Nm)
1	2.45	0.6744	0.107	0.007	0.6904
2	2.94	0.8093	0.122	0.022	0.8559
3	3.43	0.9442	0.134	0.034	0.9883
4	3.92	1.0791	0.147	0.047	1.1318
5	4.12	1.1330	0.152	0.052	1.1870
6	4.31	1.1870	0.157	0.057	1.2422
7	4.41	1.2140	0.158	0.058	1.2532

Comments

The M~H graph showcases a linear behaviour for for hydrostatic force with respect to dept of water which is in accordance with the principle. Addition of mass and water has to be done simultaneously. Marginal errors have been encountered due to humane factors such as reading approximation due to least count limitations of scale, non-horizontal scale sighting, temperature, impurities in water can be other factors.

FLOW THROUGH SHARP EDGED ORIFICE

OBJECTIVE:

(a) To determine the coefficient of discharge of the sharp edged orifice.

(b) To measure the trajectory of a jet emerging from the orifice and determine coefficient of velocity and coefficient of contraction for the orifice.

(c) To measure time to lower the water level in the tank drained by the orifice and compare the value with that obtained from theory.

SCOPE:

An orifice is used to discharge liquid into the atmosphere from reservoirs, tanks and conducts. Orifice are fitted into storage tanks also. In such example, it is essential to know the actual discharge flowing through orifice. They are determined by knowing the jet characteristics and hydraulic constants of the orifice. C_d, C_v and C_c are three orifice constants. 'C_d' enables us to calculate actual flow rate through the orifice. 'C_v' helps to calculate actual velocity of flow. 'C_d' and 'C_v' enable indirect calculation of the 'C_d'.

APPARATUS

(a) Hydraulic bench

(b) Orifice tank

(c) Stopwatch

(d) Scale

THEORY

(a) Theoretical discharge through orifice

$$q_{Th} = A_1 \sqrt{2gH}$$

A_1 = Area of orifice

H = Height above orifice

g = acceleration due to gravity.

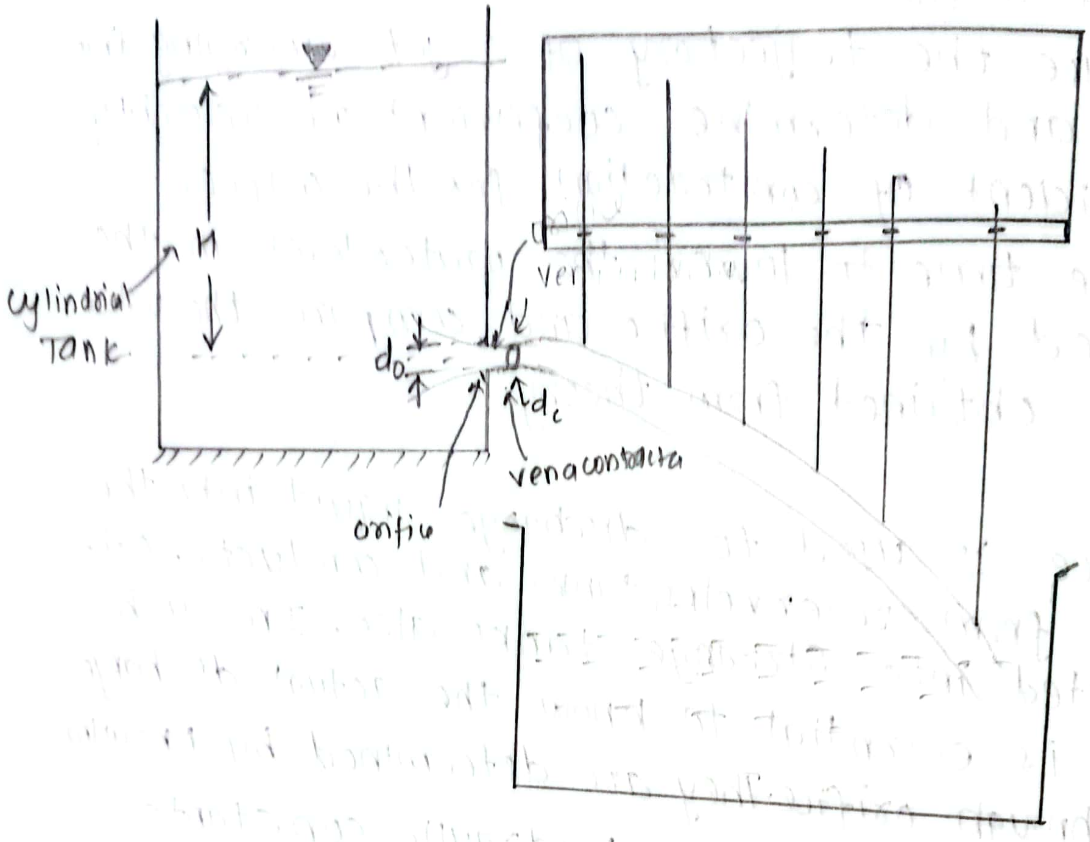


Fig: Sharp edged orifice Experimental Arrangement

(b) Actual discharge $(Q_a) = V/T$

(c) coefficient of discharge $(C_d) = \frac{Q_a}{Q_{Th}}$

(d) coefficient of velocity $(C_v) = \frac{X}{2}\sqrt{\frac{1}{YH}}$

where, X = Distance from orifice to a point in jet trajectory

Y = Drop from orifice at a point where X measured.

(e) Coefficient of contraction $(C_c) = \frac{C_d}{C_v}$

(f) Time required to lower the water level from H_1 to H_2 in the tank.

~~(g) Show the~~

$$T = \frac{2A_T}{C_d A_1 \sqrt{2g}} \left(\sqrt{H_1} - \sqrt{H_2}\right)$$

where, A_T = Area of the tank

EXPERIMENTAL PROCEDURE

(a) Connect the hydraulic bench supply to the orifice tank.
(b) Close the main delivery valve and start the pump.
(c) Open the valve and allow water level in the cylinder to settle at around 500mm. Check constant level.
(d) Determine the discharge by timing the mass of water collected.
(e) Note H and continue to determine average H.
(f) Repeat five more times by reducing flow and at each stage measure the flow rate and head.
(g) At three values of H, measure trajectory by taking reading X against vertical drop Y. At orifice X=0, Y=0.
(h) Restore the head to a convenient value in cylinder and close the supply. Note time taken from 450mm to 200. Repeat two further times.

OBSERVATION

Diameter of cylinder = 90mm

Diameter of orifice = 8mm

OBSERVATION Table:

No. of observation	Head H (cm)	mass of water collected (kg)	Time (sec.)
1.	30	5	79
2.	35	5	76
3.	40	5	72
4	45	5	64
5	50	5	72
6	55	5	56

OBSERVATION TABLE

No. of Obs.	X (cm)	0	5	10	15	20	25	30	
1	Y(cm)	~~3.2~~	3.2	4.3	6.25	8.25	11.5	15	
2	Y(cm)		2.95	3.95	5.55	7.8	10.2	12.7	
3	Y(cm)		2.7	3.6	5.2	6.9	9.2	11.6	

OBSERVATION TABLE

No. of observation	Head (cm)		Time (sec)	Average time (sec)
	H_1	H_2		
1	50	20	22.36	22.33
2	50	20	22.32	
3	50	20	22.31	

Sample calculation:

For Head (H) = 55cm = 0.55m

mass of water collected (m) = 5 kg

time taken = ~~76~~ 56 sec.

Actual discharge $(Q_a) = \frac{V}{T} = \frac{5\times10^{-3}}{56} = 8.93\times10^{-5}\ m^3/sec.$

Area of cylindrical tank $(A_T) = \frac{\pi \times 0.09^2}{4} = 6.36 \times 10^{-3} m^2$

Area of orifice $(A_0) = \frac{\pi \times 0.008^2}{4} = 5.026 \times 10^{-5} m^2$

Theoretical discharge $= A_0 \sqrt{2gH}$

$Q_{Th} = 5.026 \times 10^{-5} \sqrt{2 \times 9.81 \times 0.55}$

$= 1.651 \times 10^{-4} \; m^3/sec.$

coefficient of discharge, $C_d = \frac{Q_a}{Q_{Th}} = \frac{0.893}{1.1651} = 0.77$

Again,

Time required to lower the water level from H_2 to H_1

$H_2 = 50 cm, \quad H_1 = 20 cm$

Actual time $\doteq 22.33$ sec.

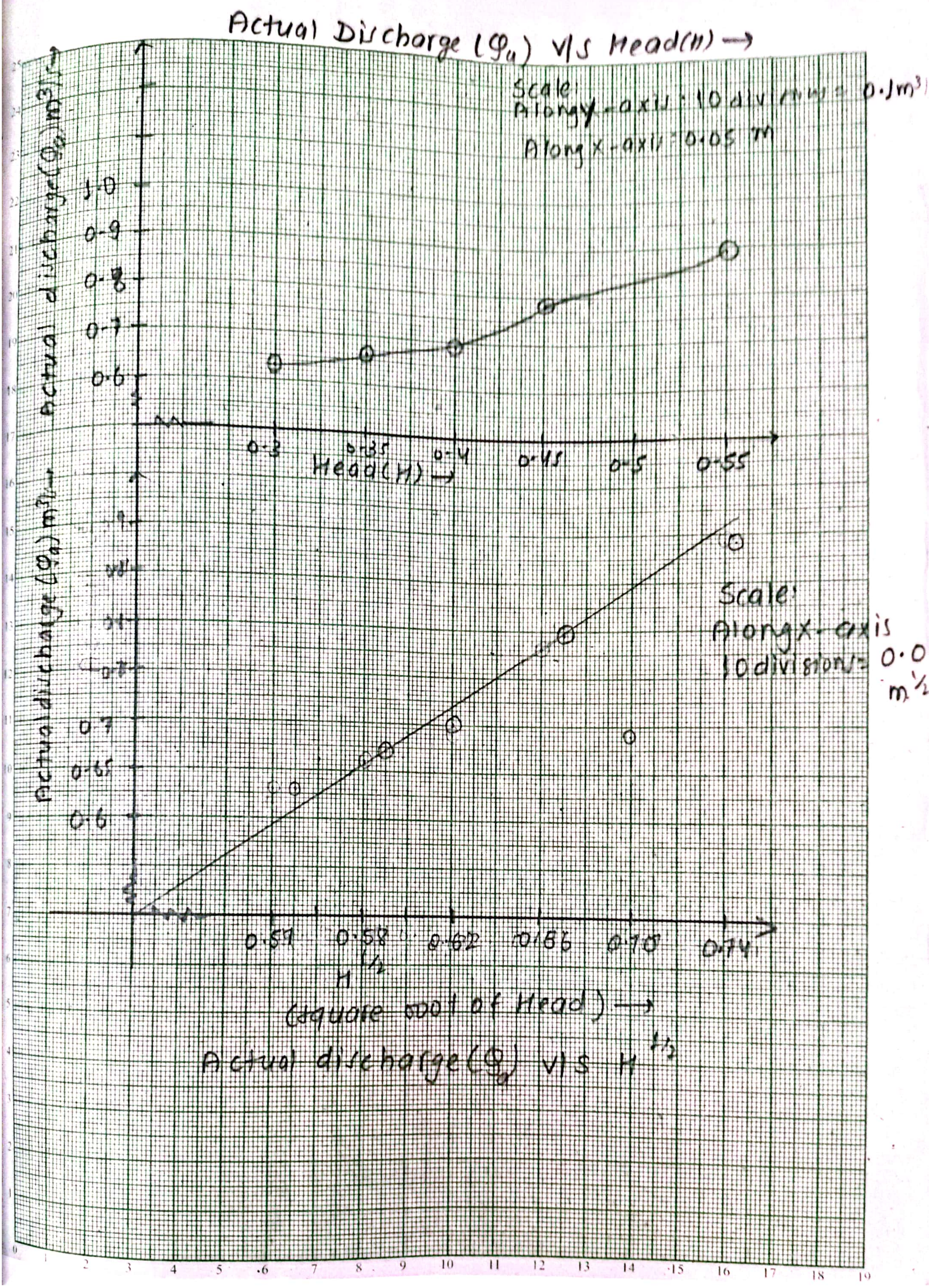
Theoritical time $(T_{Th}) = \frac{2 A_T}{C_d A_0 \sqrt{2g}} (\sqrt{H_2} - \sqrt{H_1})$

$= \frac{2 \times 6.36 \times 10^{-3}}{0.77 \times 5.026 \times 10^{-5} \times \sqrt{2 \times 9.81}} (\sqrt{0.5} - \sqrt{0.2})$

$= 19.28$ sec.

Calculation of Cd

No. of Obs.	Head H (m)	Theoretical discharge Q_{th} (m^3/s)	Actual discharge, Q_A (m^3/s)	Coefficient of discharge $C_d = (Q_a/Q_{th})$	Mean Cd
1	0.3	1.22×10^{-4}	0.63×10^{-4}	0.516	
2	0.35	1.32×10^{-4}	0.66×10^{-4}	0.5	
3	0.40	1.41×10^{-4}	0.69×10^{-4}	0.489	0.501
4	0.45	1.49×10^{-4}	0.78×10^{-4}	0.523	
5	0.50	1.57×10^{-4}	0.69×10^{-4}	0.44	
6	0.55	1.65×10^{-4}	0.89×10^{-4}	0.54	



Actual Discharge (Qa) V/S Head(H) →
Scale:
Along y-axis: 10 division = 0.1 m³
Along x-axis: 0.05 m
Actual discharge (Qa) m³ →
1.0
0.9
0.8
0.7
0.6
0.3
0.35
0.4
0.45
0.5
0.55
Head (H) →
Actual discharge (Qa) m³ →
0.6
0.65
0.7
Scale:
Along x-axis
10 division = 0.0 m½
0.57
0.58
0.62
0.66
0.70
0.74
H½
(square root of Head) →
Actual discharge (Qa) V/S H½

Calculation of C_v

$$C_v = \frac{x}{2}\sqrt{\frac{1}{yH}}$$

No. of obs.	Head H, (cm)	X (cm)	Y (cm)	Coefficient of Velocity (C_v)	Mean (C_v)
1	55	5	3.2	0.1884	
		10	4.3	0.325	
		15	6.25	0.405	
		20	8.25	0.469	
		25	11.5	0.497	
		30	15	0.522	
2	50	5	2.95	0.206	$\frac{8.0194}{18} = 0.446$
		10	3.95	0.356	
		15	5.55	0.450	
		20	7.8	0.506	
		25	10.2	0.553	
		30	12.7	0.595	
3	45	5	2.7	0.227	
		10	3.6	0.393	
		15	5.2	0.490	
		20	6.9	0.567	
		25	9.2	0.614	
		30	11.6	0.656	

Coefficient of contraction (C_c) $= \frac{C_d}{C_v} = \frac{0.501}{0.446} = 1.123$

Conclusion

We found the coefficient of contraction with help of coefficient of velocity and coefficient of discharge but did not got satisfactory result as our C_c was greater than 1. Theoretically, it is not possible as Area of jet at venacontracta is always less than area of orifice. It might be due to inappropriate handling of instrument, errors in taking reading or there might be turbulence effect in jet. ~~as~~

TITLE: Stability of Floating body

OBJECTIVE:

- To determine the metacentric height of a simple floating body and to investigate how metacentric height varies with change in the position of centre of gravity.

SCOPE:

Metacentric height of a floating object determine its stability. The study of various variation of metacentric height with position of centre of gravity enables us to analyze the stability of floating bodies.

APPARATUS REQUIRED:

(a) Pontoon

(b) Trough

THEORY:-

The point through buoyancy force act on the floating body is known as centre of Buoyancy, B.

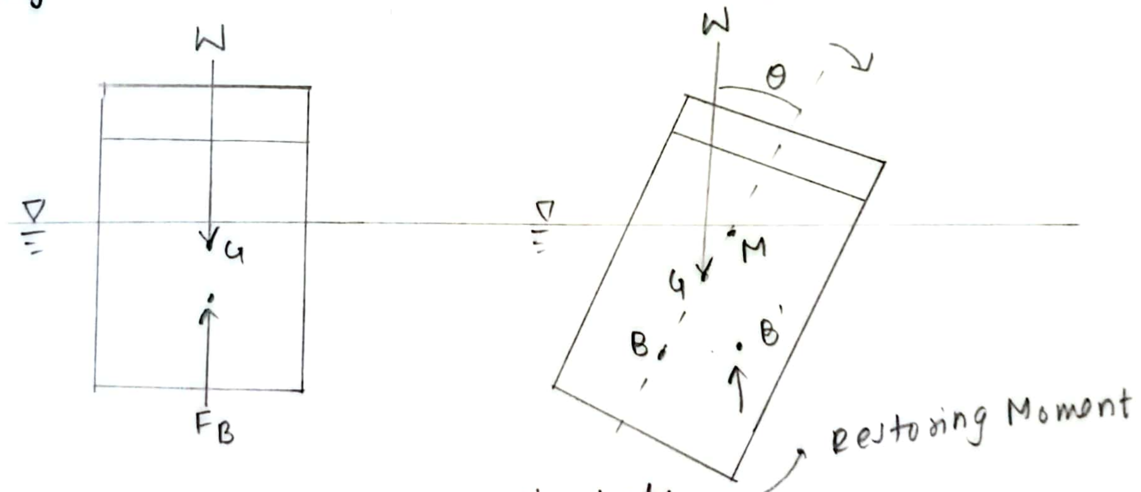


Fig: Oscillation of floating body.

If the metacentre M lies above G, the floating body will be in stable equilibrium i.e. for given small angular displacement to the equilibrium position produced a moment that tends to bring the body to the original position. If the metacentre M lies below the G the floating body will be in unstable equilibrium. If

M and G coincide the body is in neutral equilibrium.

(a) $BM = \frac{I}{V}$ — (I)

where, BM = distance between centre of buoyancy and metacentre

I = Moment of inertia

V = volume displaced

(b) Distance of centre of buoyancy from bottom of pontoon is given by, $OB = \frac{V}{2LB}$ — (II)

where, OB = Distance between base of pontoon and centre of buoyancy

V = Displaced volume

L = length of pontoon

B = Bredth of pontoon.

(c) Metacentric height is given by

$$GM = \frac{W_L}{W}\left(\frac{dx}{d\theta}\right) \quad \text{— (III)}$$

where, GM = Metacentric height

W = total weight of pontoon

dx = lateral displacement

dθ = Angle of tilt for the displacement dx.

W_L = weight of Lateral mass.

$\therefore OG = OB + BM - GM$ — (IV)

Experimental Procedure:

(a) Water was filled upto three fourth of water through.

(b) The pontoon was placed on the trough.

(c) The lateral weight was placed on the centre, of horizontal bar and the plumb was adjusted give zero reading on the scale.

(d) The mass weight was placed at its lowest position and its height above the base was noted.

(e) The lateral ~~height~~ weight was moved to a distance of x along the cross horizontal bar to give a tilt to the right.

(f) x and θ were noted at that position.

(g) Step (e) was repeated to get tilt to the left and x and θ were noted.

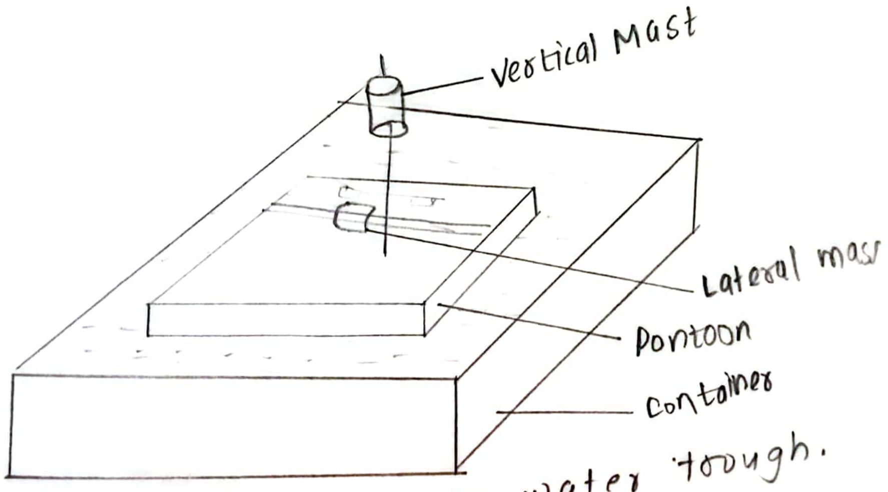


Fig: Pontoon in water trough.

OBSERVATION

Length of Pontoon, $L = 360mm$

Breadth of Pontoon, $B = 202mm$

weight of pontoon, $W = 2600gm$

Lateral weight, $w_L = 200gm$

Upper adjustable mass = 500gm

No. of obs	Position of Mass above base (mm)	Lateral wt shifted to			
		Left		Right	
		x mm	θ°	x mm	θ
1	140-17 = 123	101-60 = 41	3°	101-54 = 47	3°
2	170-17 = 153	101-45 = 56	4°	101-54 = 47	3.5°
3	185-17 = 168	101-45 = 56	5°	101-45 = 56	4.5°
4	220-17 = 203	101-55 = 46	5°	101-45 = 56	5.5°
5	286-17 = 269	101-55 = 46	6°	101-48 = 53	7°

Calculation

Sample No. 1

Position of mass above base (OG) = 123 mm

Angle of tilt toward left ($d\theta$) = 3° = 0.0524 rad

lateral weight displaced toward left (dx) = 41mm

$$\therefore \frac{dx}{d\theta} = \frac{41}{0.0524} = 782.44 \text{ mm/rad.}$$

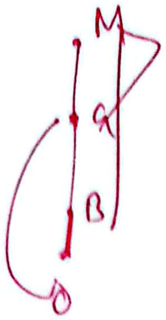
$$GM = \frac{W_L}{W} \times \frac{dx}{d\theta} = \frac{200}{2600} \times 782.44 = 60.18 \text{ mm.}$$

height of metacenter above base (OM)

$= OG + GM$

$= 123 + 60.18$

$= 183.19$ mm.



$OB = \dfrac{V_a}{\frac{A}{2}}$

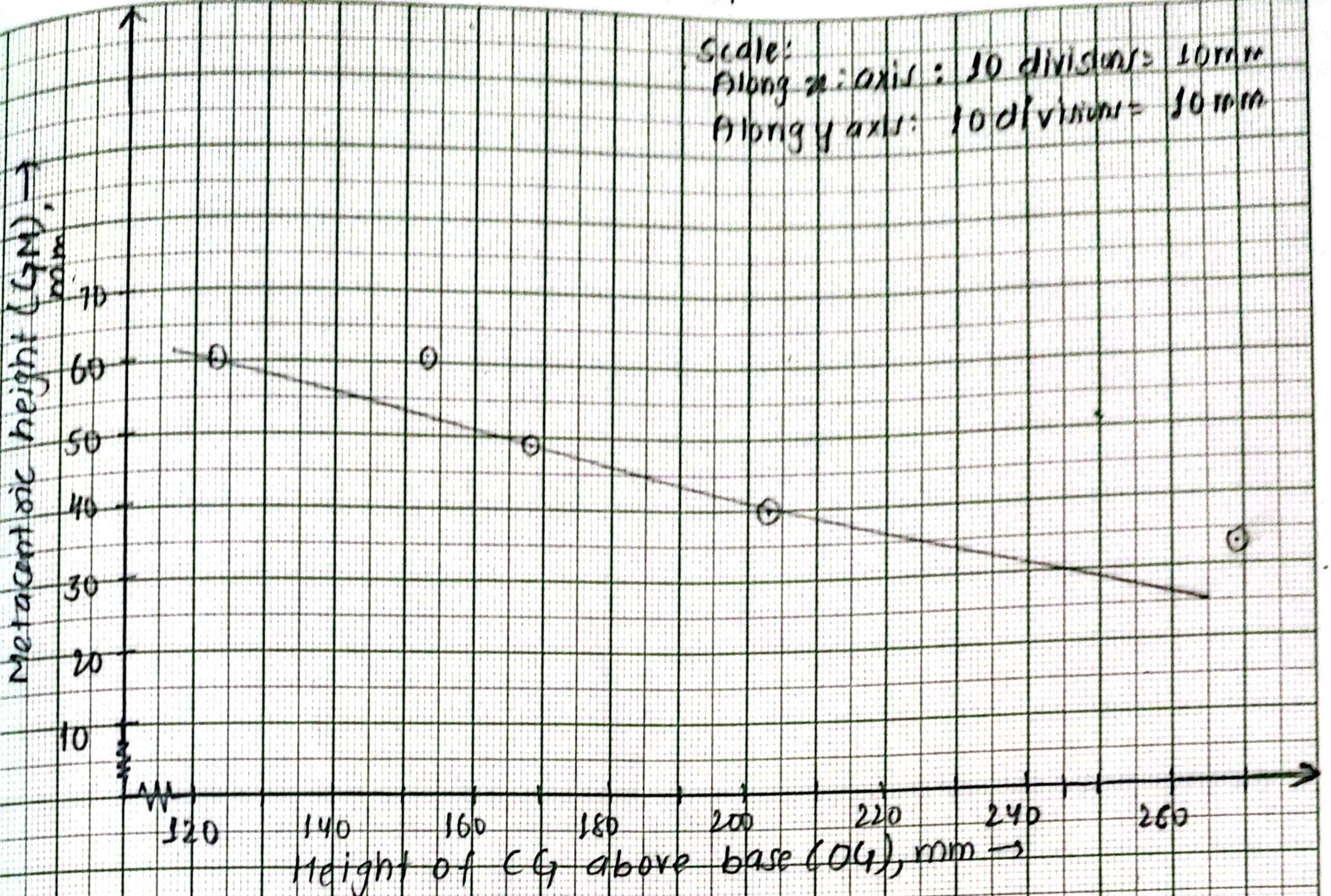
$BM = \dfrac{I}{V}$

$OM = OB + BM$

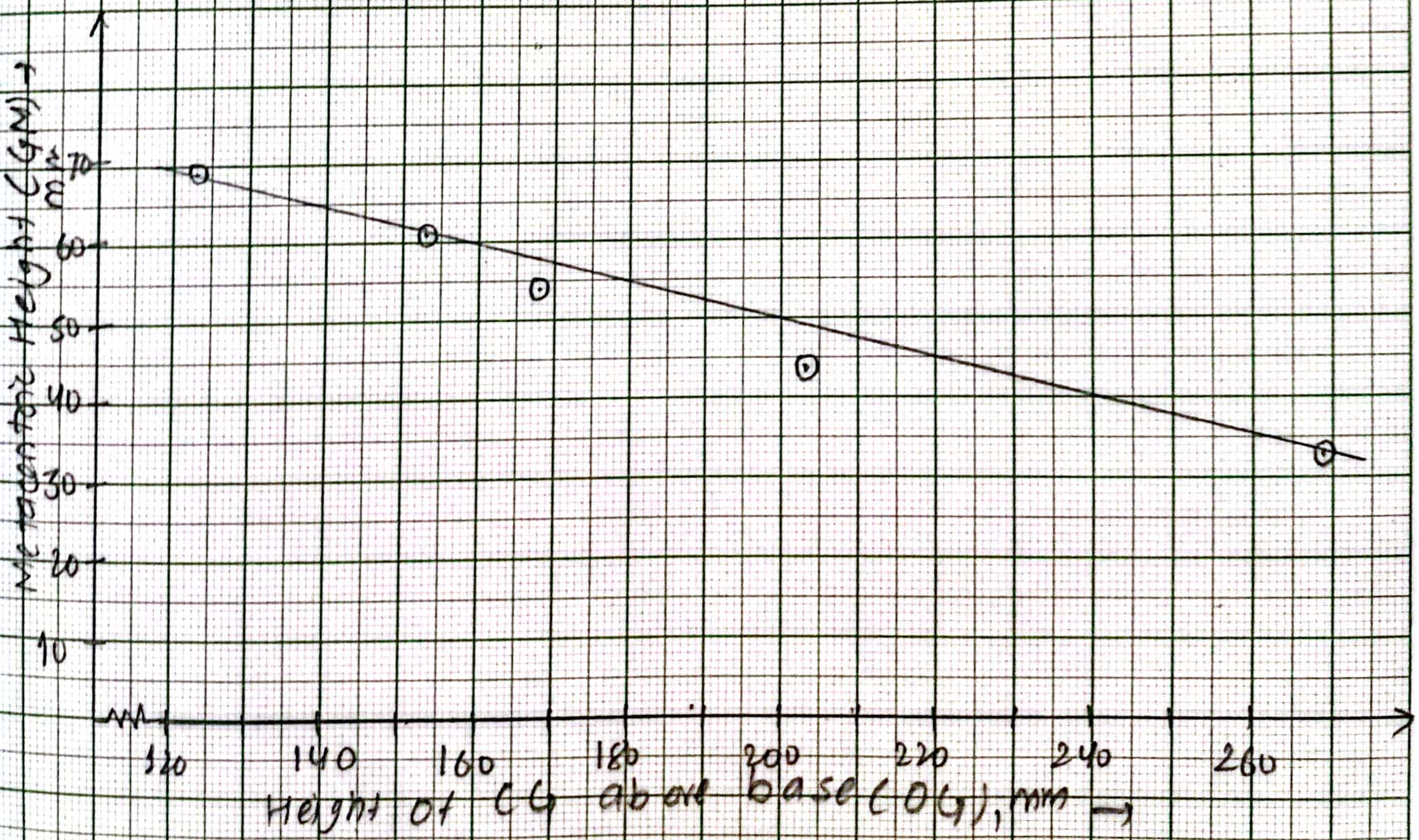
$F_b \times GM \times \cancel{\tan}\,\theta = w x$

$GM = \quad F_b \times \underline{GM} = \left(\dfrac{w}{W}\left(\dfrac{dx}{d\theta}\right)\right)$

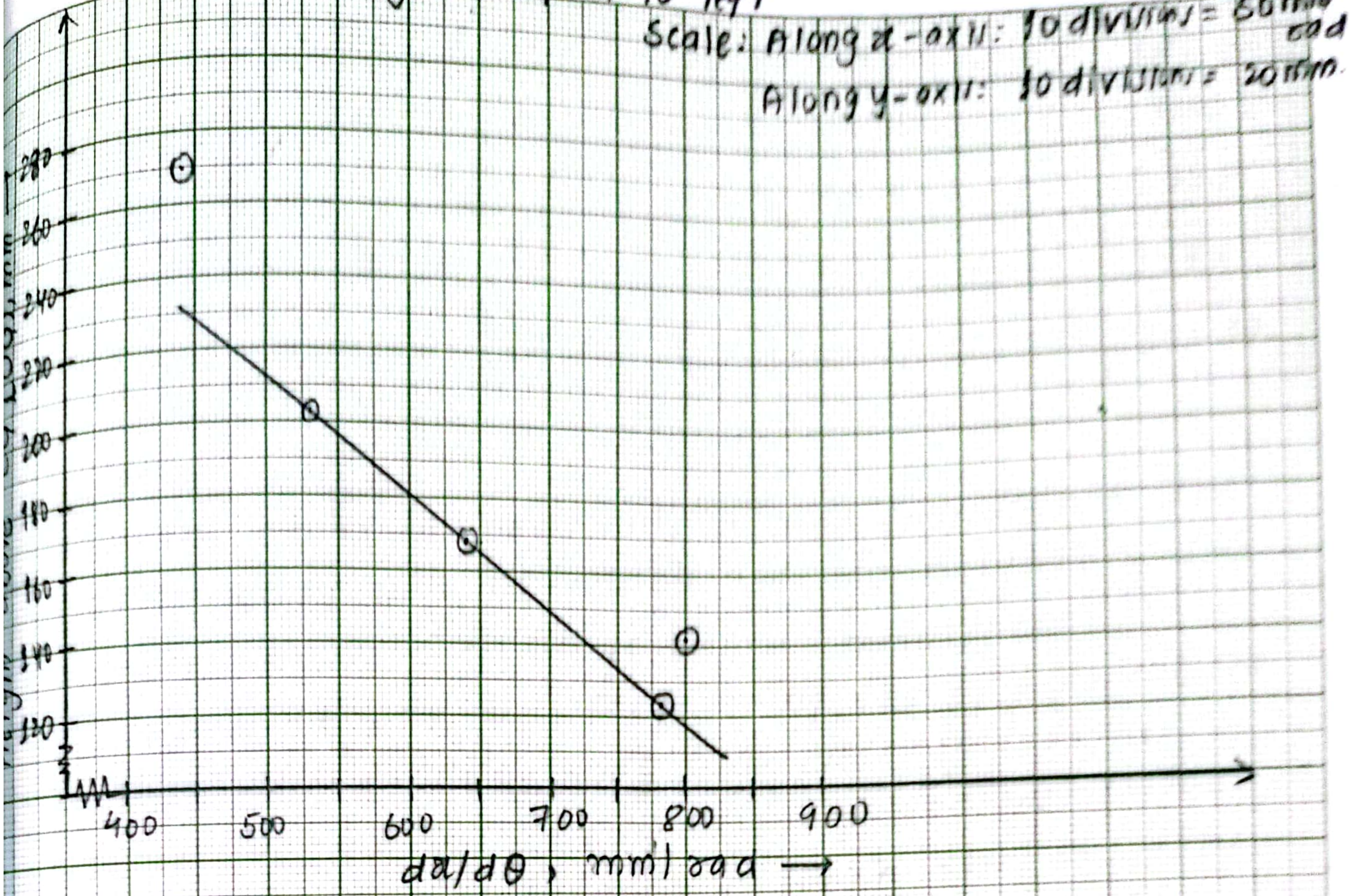
Lateral wt. shifted to left:



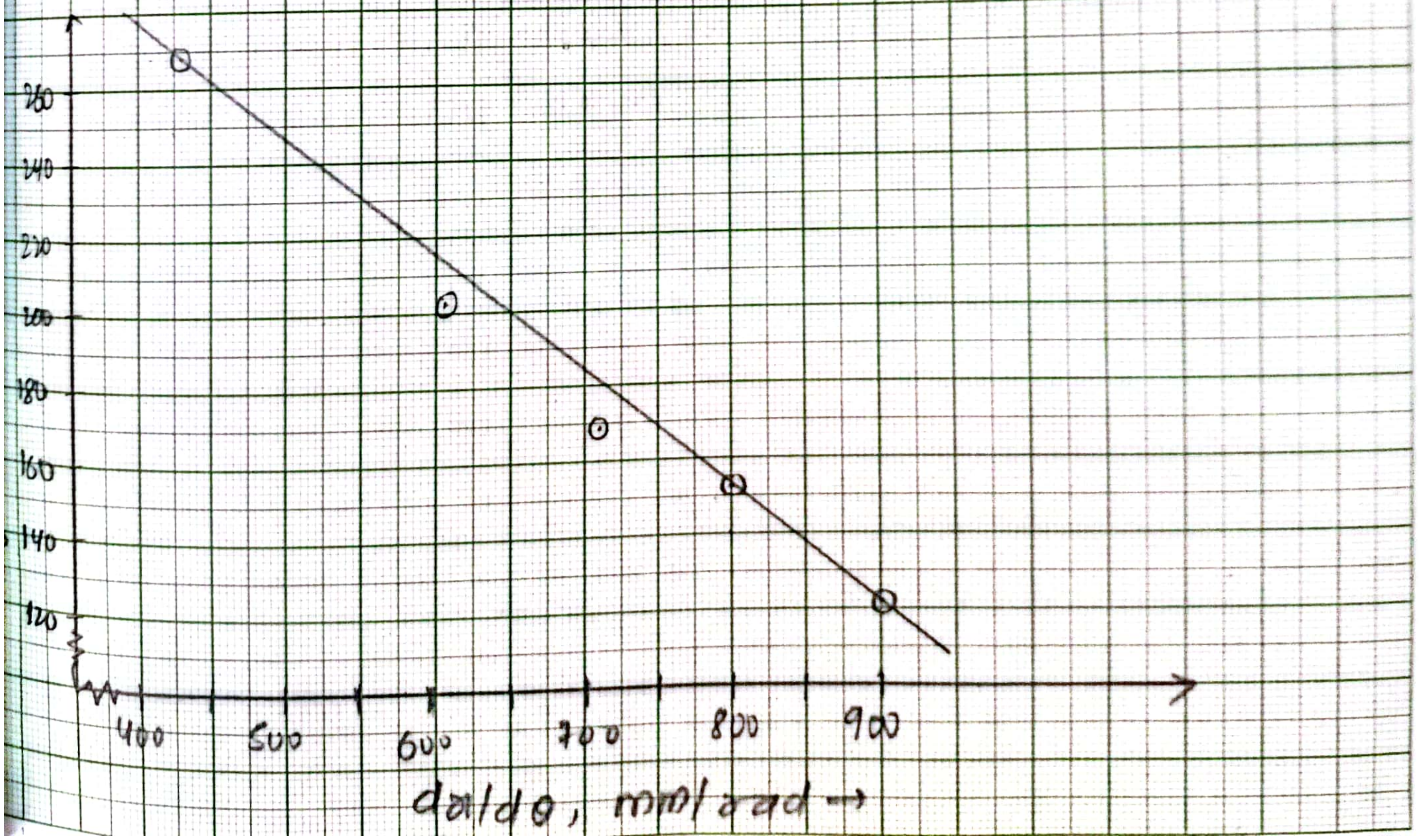
Lateral weight Shifted to Right



Lateral weight shifted to left



Lateral weight shifted to right.



CALCULATION TABLE:

No. of obs.	Height of CG above the base, OG (mm)	Lateral weight shifted to Left			Right		
		$\frac{dx}{d\theta}$ (mm/rad)	GM (mm)	OM (mm)	$\frac{dx}{d\theta}$ (mm/rad)	GM (mm)	OM (mm)
1	123	782.44	60.18	183.19	897.63	69.05	192.05
2	153	802.14	61.70	214.70	796.40	61.26	214.26
3	168	641.71	49.36	217.36	713.01	54.85	222.85
4	203	527.12	40.55	243.55	583.37	44.87	247.87
5	269	439.27	33.79	302.79	433.81	33.37	302.37

Comments

From the above experiment, it was found that the floating body will be stable if its height of CG is above base i.e. OG is below metacentre.

In this ~~body~~ way, by performing the experiment, the stability of a floating body was determined. The relative factors i.e. position of CG and metacentre of the body ~~was~~ determined ~~which~~ the stability of body on water. The metacentric height GM of body decreases with increase in height of center of gravity above the base.

TITLE: IMPACT OF JET

OBJECTIVE:-

- To measure the force exerted by a jet on a fixed vane and compare the magnitude of this force with the force obtained by theorem.

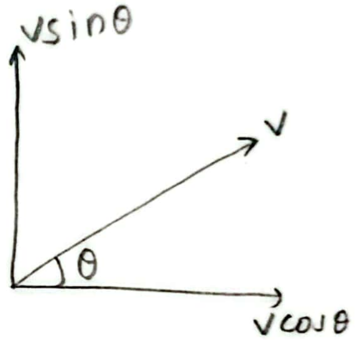
SCOPE:-

The momentum equation has wide application in many engineering system. like turbine, pumps and other rotational dynamics machines. Study of impact of jet on fixed vane enables one to calculate the force essential for the analysis of flow through machines.

APPARATUS:-

(a) Hydraulic bench (b) Jet impact Apparatus (c) stop watch

THEORY:



Let 2θ be angle between the two tangents drawn to the vane at its outlet, hence the jet after striking will be deflected on each side through the angle of (180° − θ). Component of velocity leaving in the direction of flow is $v\cos\theta$ as shown in figure. As per impulse momentum principle, the force exerted by the jet in normal direction of vane is

$$F_{m} = \rho Q(v_{2n} - v_{1n})$$

$$= \rho Q((-v\cos\theta) - v)$$

$$= \rho Q v(1 + \cos\theta)$$

$$\therefore F_{tn} = \rho A v^2 (1 + \cos\theta)$$

Force exerted by the jet on the plate is equal to the force exerted by the body of plate on jet. where,

A is the cross-section area of jet = 8mm φ

v is the velocity of jet (m/s)
ρ is density of water (100kg/m³)
F_{th} is the theoretical force on the vane.

If $F_{th} = K \rho A v^2$

Given the value of k differ from shape of vanes.
$K = 1.0$ for flat vane i.e. $\theta = 90°$
$K = 1.5$ for 120° vane
$K = 2$ for hemispherical vane i.e. $\theta = 0°$.

It indicates that force exerted by the jet on curved vane is always more than that of flat vane because $\rho A v^2 (1 + \cos\theta)$ always more than $\rho A v^2$. Similarly for $k = 2$ it indicates that force exerted by the jet on semicircular vane is twice the force exerted on flat plate in vertical direction. This is the reason to make bucket of pelton turbine close to semicircular in shape.

Here,
actual discharge $(Q_a) = \frac{V}{T}$

where, V = volume of water
T = time

EXPERIMENTAL PROCEDURE:

(a) The hydraulic bench supply was connected to orifice tank.
(b) The main delivery valve was closed and the pump was started.
(c) The valve was opened and water level in the cylinder was ~~set~~ allowed to settle at around 500mm above the orifice. ~~check~~ The level was checked constant. conditions were allowed to settle.
(d) The discharge was determined by timing the mass of water in the measuring tank.

(e) H was noted and continued to do so during the discharge measurement process and average H was determined.

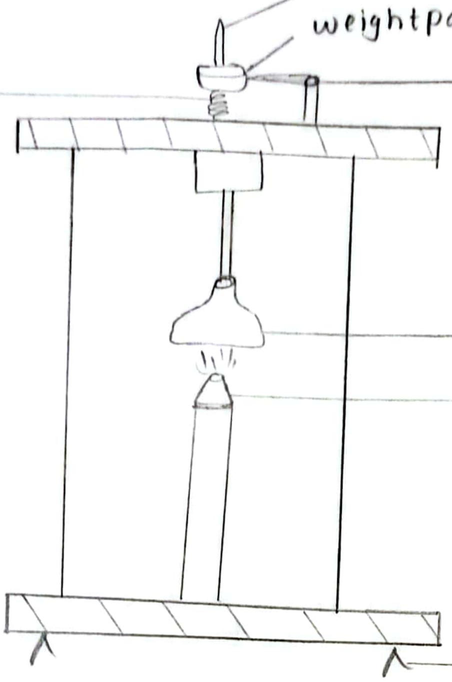


Fig: Jet impact Apparatus

OBSERVATION

Nozzle diameter = 8mm = 0.008m

Table:

S.N.	Mass of water collected (gram)			Time (in sec)		
	Flat	120°	Hemispherical	Flat	120°	Hemispherical
1	100	100	100	27	32	38
2	150	150	150	20	24	37
3	200	200	200	19	22	25
4	250	250	250	18	20	23
5	300	300	300	17	18	21.

SAMPLE CALCULATION:

For observation 1, flat plate:

Area (A) $= \frac{\pi d^2}{4} = \pi \times \frac{0.008^2}{4} = 5.0265 \times 10^{-5} m^2$

Actual discharge, $Q_A = \frac{V}{T} = \frac{6/1000}{27} = 2.22 \times 10^{-4} m^3/s$.

velocity of flow, $v = \frac{Q_A}{A} = 4.42 m/s$.

Theoretical force (F_{Th}) = $K \rho A V^2$

$= 1 \times 1000 \times 5.0265 \times 10^{-5} \times 4.42^2$

$= 0.982 N$

Actual force $= 0.1 \times 9.81$

$= 0.981 N.$

Calculation table

No of obs.	Vane Type	Discharge(q) m^3/s, (10^{-4})	Velocity (m/s)	Theoretical Force F_{Th} (N)	Actual Force F_a (N)
1	Flat vane K = 1	2.22	4.42	0.982	0.981
2		3.0	5.97	1.791	1.47
3		3.16	6.29	1.99	1.96
4		3.33	6.62	2.20	2.45
5		3.53	7.02	2.48	2.94
1	120°C vane K = 1.5	1.88	3.74	1.05	0.981
2		2.5	4.97	1.86	1.47
3		2.73	5.43	2.22	1.96
4		3.0	5.97	2.69	2.45
5		3.33	6.62	3.30	2.94
1	Hemispherical vane K = 2	1.58	3.14	0.99	0.981
2		1.62	3.22	1.04	1.47
3		2.40	4.77	2.28	1.96
4		2.61	5.19	2.71	2.45
5		2.86	5.69	3.25	2.94

CONCLUSION

Hence, from the above experiment, we measured the force exerted by a jet on a fixed vane and compared the magnitude of this force with the force obtained by theory. There was slight different in the actual and theoritical force which might be done due to error in handling the instument or observing the datas.

TITLE: OPEN CHANNEL FLOW – BROAD CRESTED WEIR

OBJECTIVE

- To determine the coefficient of discharge of a broad crested weir

SCOPE:

Broad crested weirs are used for measuring flow in open channels. Determination of discharge over the weir depends on its coefficient.

Apparatus

(i) Flume (ii) Weir (iii) stop watch (iv) Gauge

THEORY:-

$Q = AV$

where,

Q = Discharge

A = Area of orifice

V = velocity

and, diameter of orifice = 60mm

V determined by the head difference when water flow through the orifice the inlet and outlet of the manometer tubes are connected on the manometer. In the manometer shows the head difference which is important to note down.

$$H = h_1 - h_2 \text{ (mm)}.$$

Now, $$Q_{th} = 1.70\, B H^{3/2}$$

where, Q_{th} = Theoretical discharge

B = Breadth of flume

H = measurement of needle gauge

and depth of weir measured by the needle gauge after installed on the flume.

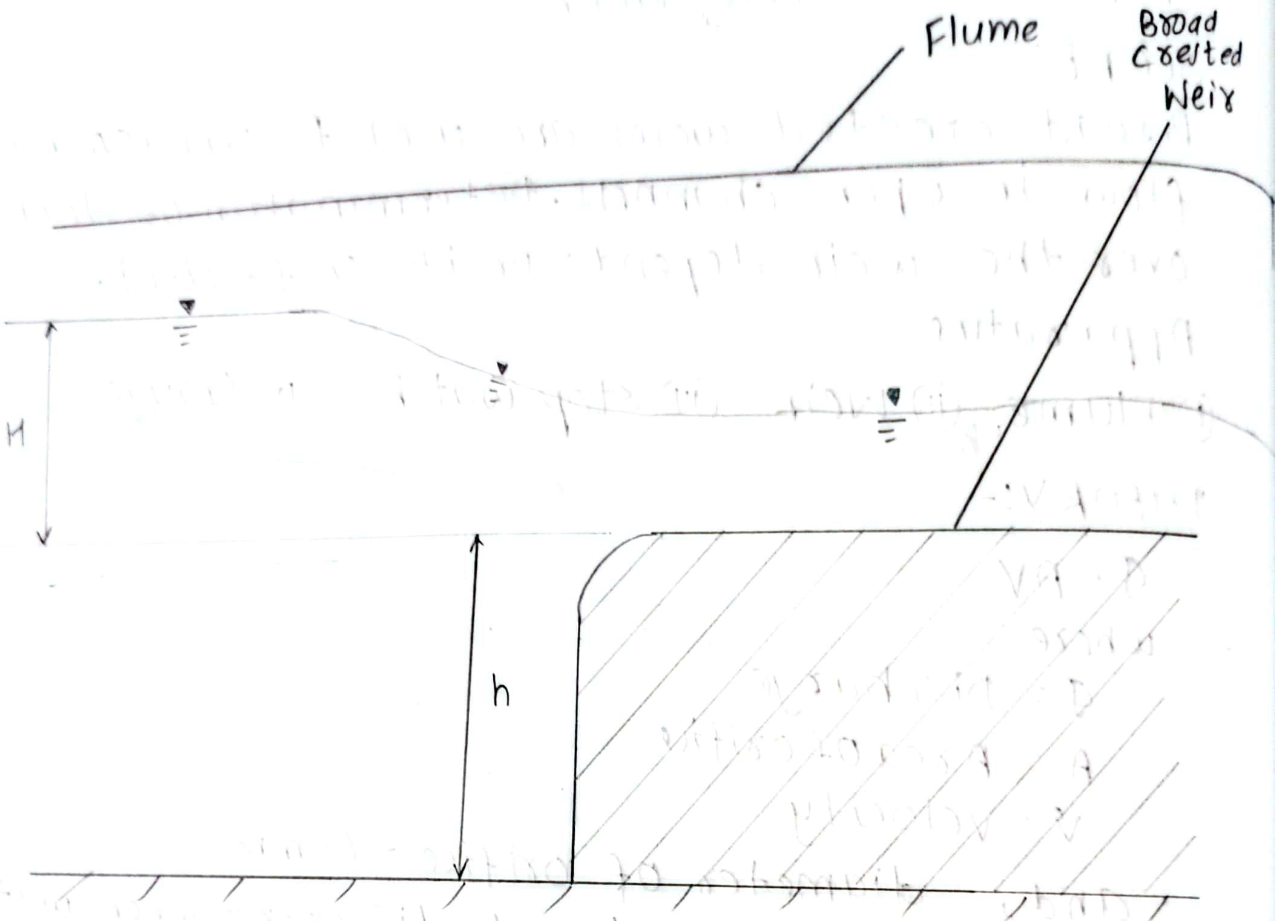


Fig: Flow through Broad crested weir.

We know,

$$Q_{th} = 1.7\, BH^{3/2}$$ while,

$$Q_{actual} = C_d\, 1.7\, BH^{3/2}$$

$$Q_{actual} = C_d\, Q_{th}$$

$$C_d = \frac{Q_{actual}}{Q_{theoritical}}$$

where, C_d = coefficient of discharge

PROCEDURE:

Initially broad crested weir was fixed in the frame. The height of broad crested weir was measured along the breadth of weir. The pump was started to let the water in and start the flow. The level of water upstream the weir was measured for each level of water. The time taken for flow of 0.1 m^3 of water was measured. The level was varied to obtain six set of reading.

OBSERVATION:

Breadth of weir (B) = 100 mm = 0.1 m

weir height (h) = 70.2 mm

No. of obser.	Head (H) (mm)	Volume (m^3)	time (sec)
1	104-70.2 = 33.8	0.1	144
2	118-70.2 = 47.8	0.1	81
3	132-70.2 = 61.8	0.1	39
4	150-70.2 = 79.8	0.1	25
5	160-70.2 = 89.8	0.1	24

Sample calculation:

For observation 1,

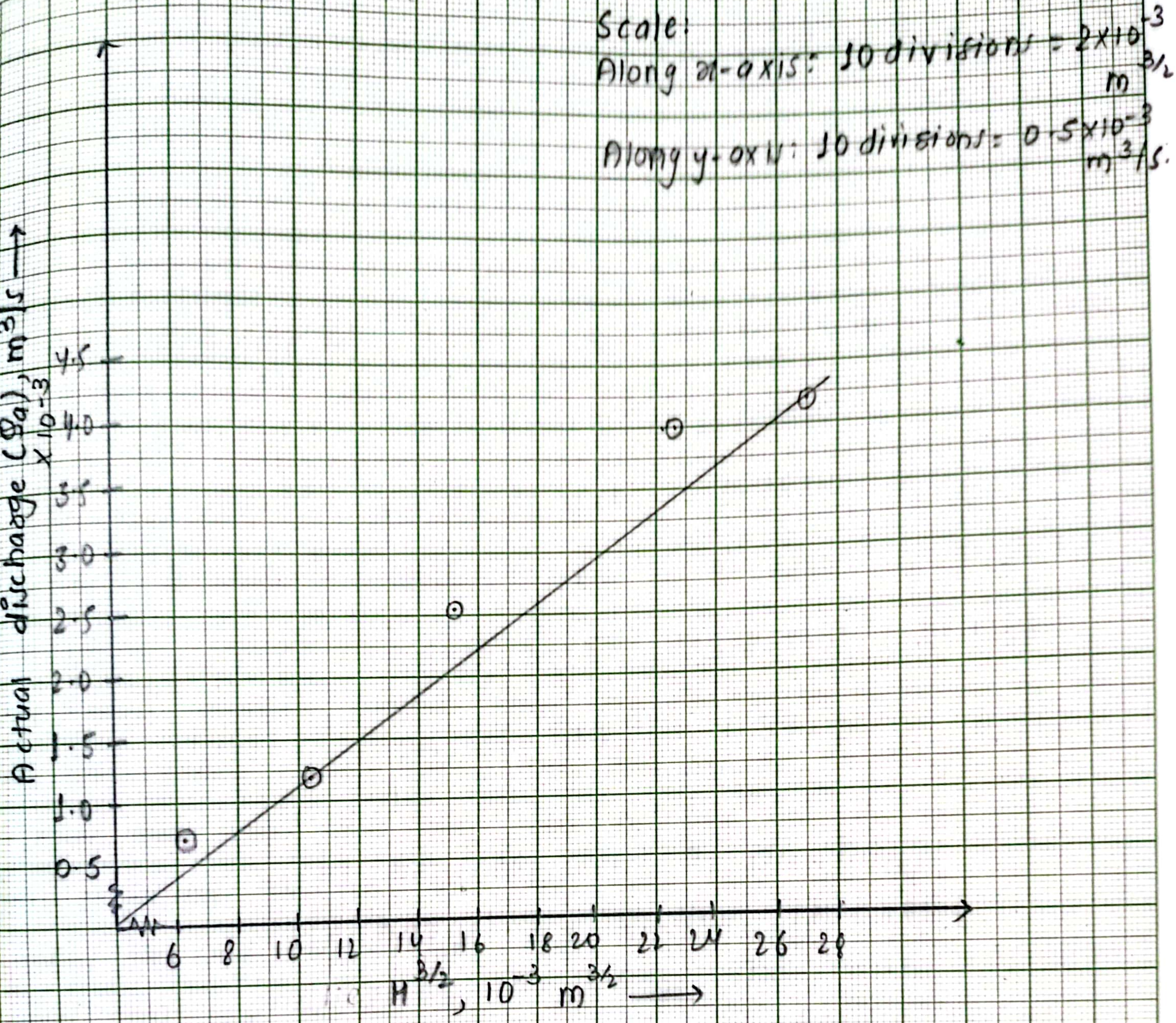
Head (H) = 104-70.2 = 33.8 mm = 0.0338 mm

Actual discharge (Q_a) = $\frac{\text{Volume}}{\text{time}} = \frac{0.1}{144} = 0.694 \times 10^{-3} m^3/s$

SUB/REF

Q_a v/s $H^{3/2}$

NO
DATE



Theoritical discharge (Q_{th}) = $1.7\,BH^{3/2}$

$$= 1.7 \times 0.1 \times (0.0338)^{3/2}$$

$$= 1.0564 \times 10^{-3}\ m^3/s$$

$\therefore$ coefficient of discharge (C_d) = $\frac{Q_{actual}}{Q_{theoritical}}$

$$= 0.657$$

RESULT:

No. of obs.	Actual discharge (Q_a) m^3/s	Head, H (m)	$H^{3/2}$ $m^{3/2}$	Theoretical discharge, Q_{th} m^3/s	Coefficient of discharge, C_d
1	6.94×10^{-4}	0.0338	6.21×10^{-3}	1.056×10^{-3}	0.657
2	1.23×10^{-3}	0.0478	10.45×10^{-3}	1.78×10^{-3}	0.695
3	2.56×10^{-3}	0.0618	15.36×10^{-3}	2.61×10^{-3}	0.981
4	4.0×10^{-3}	0.0798	22.54×10^{-3}	3.83×10^{-3}	1.044
5	4.167×10^{-3}	0.0898	26.91×10^{-3}	4.57×10^{-3}	0.912

Comments

We found out the coefficient of discharge (Cd) for varing discharge by finding theoretical discharge and actual discharge. The mean coefficient of discharge from experiment was found to be 0.858 which lies within range of actual value for broad crested weir which is in range 0.85 to 1.

Discussion

Some error might have occured in experiment, may be due to parallax in reading vernier scale and tank, the flow might not been fully stabilized and density of water can't be taken as of pure water as the water used in experiment was brownish indicating foreign substances.