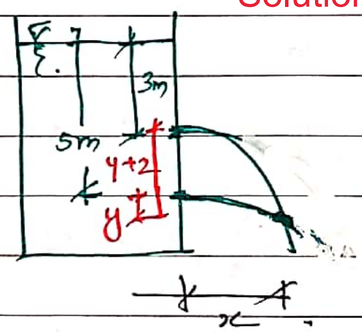
1) An internal mouthpiece is said to be running free if the length of the mouthpiece is less than three times the diameter of the orifice (1)

2) A tank has two identical orifices in one of its vertical sides. The upper orifice is 3.0 m below the water surface and lower orifice is 5.0 m below the water surface. If the value of coefficient of velocity for each orifice is 0.96, find the point of intersection of the jets.

Sketch - 2
Equations -2
Solutions -4

x remains the same.
y only changes.

$$C_v = \frac{x}{\sqrt{4yh}}$$



$$\frac{x}{\sqrt{4y \times 5}} = \frac{x}{\sqrt{4 \times (y+2) \times 3}}$$

or $$\frac{\sqrt{3y+6}}{\sqrt{5y}} = 1$$

$3y + 6 = 5y$ or $2y = 6$

or $y = \underline{\underline{3}}$

$$0.96 = \frac{x}{\sqrt{12 \times 5}}$$

$x = 0.96 \times \sqrt{60}$

$x = \underline{\underline{7.436\,m}}$

Point of intersection $\underline{\underline{(7.44 ; 3)}}$

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3. A 25 mm diameter orifice discharges 0.22 m^3 of water/minute when the head is 6m. The diameter of the jet at vena contracta is 22.5 mm. Determine Cd, Cv, and Cc.

$d = 0.025m$

$d_a = 0.0225m$.

$H = 6m$.

$Q = 0.22/60 = \underline{3.67 \times 10^{-3} m^3/s}$

$C_c = \frac{0.0225^2}{0.025^2} = 0.81.$

$V_{th} = \sqrt{2gH}$

$= \sqrt{19.62 \times 6} = \underline{10.85 m/s}$

$V_{actual} = \frac{3.67 \times 10^{-3}}{\pi/4 \times 0.0225^2} = \underline{9.23 \cancel{\times 10^{-3}}\ m/s}$.

Q and vth - 2 marks
Cd, Cv and Cc each 2 marks

$C_v = \frac{V_{ac}}{V_{th}} = \frac{9.23}{10.85} = \underline{0.85}$.

$C_d = C_v \times C_c = \underline{\cancel{0.??}}\ \underline{0.69}$

$C_d = \frac{Q_{act}}{Q_{th}} = \frac{0.0225^2 \times 9.23}{0.025^2 \times 10.85} = \underline{0.69}$

4 Define hydraulic coeffecients. The head of water over an orifice of diameter 100 mm is 10m. The water coming out from orifice is collected in a circular tank of diameter 1.5m. The rise of water level in this tank is 1m in 25 seconds. Also the coordinates of the a point on the jet, measured from vena contracta are 4.3m horizontal and 0.5m vertical. Find the hydraulic coeffecient of orifice.

Definition-2
Each coeffecient determination 2 mark each

Hydraulic coeffecients refers to Cd, Cv and Ce

C_c - is the actual area of the jet to the theoretical area of the jet -

actual area refers to the area of vena contracta

C_v is the ratio of the actual velocity to theoretical velocity.

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Cd is the ratio of actual discharge to theoretical discharge.

$$C_d = \frac{Q_{act}}{Q_{th}} = \frac{V_{act} \cdot A_{act}}{V_{th} \times A_{th}} = C_v \times C_c.$$

$$\boxed{C_d = C_c \times C_v}.$$

$$C_v = \frac{x}{\sqrt{4yH}} = \frac{4.3}{\sqrt{4 \times 0.5 \times 10}}$$

$$C_v = \underline{0.96}$$

$$Q_{act} = \frac{\pi/4 \times 1.5^2 \times 1}{25}$$

$$Q_{act} = \underline{70.69 \times 10^{-3}\ m^3/s}.$$

$$V_{th} = \sqrt{2gH} = \sqrt{19.62 \times 10}$$
$$= \underline{14\ m/s}.$$

$$Q_{th} = \pi/4 \times 0.1^2 \times V_{th}$$
$$= \underline{109.96 \times 10^{-3}\ m^3/s}.$$

$$C_d = C_c \times C_v.$$
$$0.64 = C_c \times 0.96$$
$$C_c = \underline{0.67}$$

$$C_d = \frac{Q_{act}}{Q_{th}} = \frac{70.69}{109.96}$$

$$C_v = 0.96$$

$$C_d = \underline{0.64}.$$

$$C_d = 0.64.$$

5. The ratio of % error in the discharge and percentage error in the measurement of head, over triangular notch is $\underline{5/2}$.

6. Water flows over a rectangular weir 1.0m wide at a depth of 150mm and afterwards passes through a triangular right angled weir, taking coefficient of discharge for the rectangular and triangular weir as 0.62 and 0.59 respectively. Find the depth of water over the triangular weir.

$$0.62 \times \frac{2}{3} \times \sqrt{2g} \times 1 \times (0.15)^{3/2} = 0.59 \times \frac{8}{15} \times \sqrt{2g} \cdot (h)^{5/2}$$

$$24.07 \times 10^{-3} = 314.67 \times 10^{-3} \times h^{5/2}$$

$$h = \underline{0.357m}.$$

Equation for discharge for both - 4
H determination- 4

7. A rectangular weir of crest length 50 cm is used to measure the rate of flow of water in a rectangular channel of 80cm wide and 70 cm deep. Determine the discharge in the channel if the water level is 80mm above the crest of weir. Take velocity of approach into consideration. $C_d = 0.62$.

$$Q = \frac{2}{3} \times 0.62 \times \sqrt{19.62} \times 0.5 \times (0.08)^{3/2}$$

$$= 20.71 \times 10^{-3}\ m^3/s$$

$$V_a = \frac{20.71 \times 10^{-3}}{0.8 \times 0.7} = 36.98 \times 10^{-3}\ m/s$$

$$\frac{V_a^2}{2g} = \frac{(36.98 \times 10^{-3})^2}{19.62} = 6.97 \times 10^{-5}\ m$$

H+ha

$$= 80.0697 \times 10^{-3}\ m$$

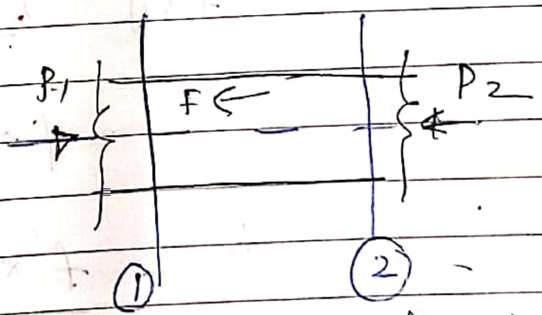
$$Q_{act} = \frac{2}{3} \times 0.62 \times \sqrt{19.62} \times 0.5 \left[(80.0697 \times 10^{-3})^{1.5} - (6.97 \times 10^{-5})^{1.5} \right]$$

$$= 20.74 \times 10^{-3}\ m^3/s.$$

Calculation of va-4
Calculation of Qact - 4

8. Derive Darcy Weisbach equation for head loss due to friction in a pipe.

Consider uniform horizontal pipe flow of uniform area.



Let (1) and (2) be the two sections with pressure p_1 and p_2 at both ends.

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + \text{loss}.$$

$Z_1 = Z_2 = 0$ since pipes are in the same level.

$V_1 = V_2 = V$ since area remains the same

$$\frac{p_1}{\rho g} + \frac{v^2}{2g} + 0 = \frac{p_2}{\rho g} + \frac{v^2}{2g} + 0 + \text{loss},$$

$$h_f = \text{loss} = \frac{p_1 - p_2}{\rho g} \quad \text{or} \quad p_1 - p_2 = h_f \rho g. \quad -(1).$$

According to Froude's expt,

Eqn 1 - 3
Calculation of F -2
Calculation of hf - 3

$$F = f' \times \pi d L \times v^2$$

f' - frictional force per unit wetted area per unit velocity.

$\pi d L$ - wetted area,

v - velocity

Considering the equilibrium of forces,

$$a(p_1 - p_2) - F = 0$$

$$a(p_1 - p_2) - f' \times \pi d L \times V^2 = 0,$$

$$h_f \rho g = \frac{f' \times \pi d L \times v^2}{a}. = \frac{f' \times P \times v^2}{a}$$

$$= f' \times \frac{4L}{d} \times v^2. \qquad \frac{P}{a} = \frac{\cancel{\pi} d L \times 4}{\cancel{\pi} d^2} = 4L.$$

$$h_f = \frac{f' \times 4L \times v^2}{\rho g d}.$$

Putting $\dfrac{f'}{\rho} = \dfrac{f}{2}$

$$\boxed{h_f = \frac{4 f L v^2}{2gd}}$$

$f = \dfrac{16}{Re}$ for $Re < 2000$

$f = \dfrac{0.079}{Re^{1/4}}$ for $Re > 4000$ to 10^6