* Dynamics *

Bernoulli's equation :- Conservation of energy

$$z + \frac{P}{\rho g} + \frac{V^2}{2g} = C$$

z = Datum (or) potential energy head.

$P/\rho g$ = pressure energy head

$V^2/2g$ = velocity (or) kinetic energy head

$(z + P/\rho g)$ = piezometric energy head

Dynamics : The branch of mechanics that is concerned with the effects of forces on the motion of objects

GPVTSC

F_G = Gravity force

F_P = pressure force

F_V = Viscous force

F_T = Turbulence

F_S = surface tension force

F_C = Compressible force

$F = m\alpha_x = F_G + F_P + F_V + F_T + F_S + F_C$ — Neglected
└ Newton's equation

$F = m\alpha_x = F_G + F_P + F_V + F_T$ → Reynolds equation (Neglected)

$F = m \cdot \alpha_x = F_G + F_P + F_V$ → Navier Stokes equation (Neglected)

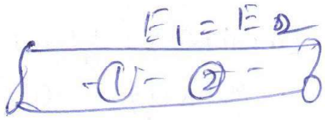
$F = m \cdot \alpha_x = F_G + F_P$ → Euler equation

Ideal fluid : static Incompressible Inviscid fluid

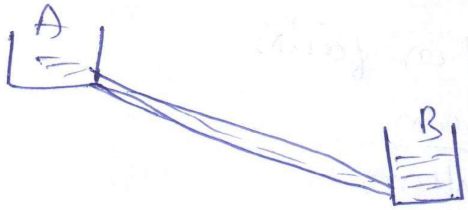
Euler → B eq is derived from here

→ $z_1 + \frac{P}{\rho g} + \frac{V^2}{2g} = C$ per unit weight in terms of meter of flowing fluid

→ $zg + \int \frac{dP}{\rho} + \frac{V^2}{2}$ unit mass

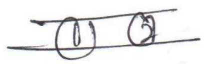


Ideal condition losses is neglected



$E_1 = E_2 + h_{loss}$

Energy eq'n for Real fluid flow [liquid → I.C]



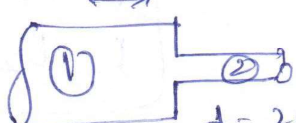
$E_1 = E_2 + h_{loss}$

$$\boxed{z_1 + \frac{P_1}{\rho g} + \alpha_1 \frac{v^2}{2g} = z_2 + \frac{P_2}{\rho g} + \alpha_2 \frac{v_2^2}{2g} + h_{loss}}$$

α = K.E correction factor

$$\boxed{\alpha = \frac{K.E_{Act}}{K.E_{mean}}}$$

(1) problems



$d = 2m$

$d = 4m$

$V_1 = 4 m/s$ $\quad V_2 = 16 m/s$

$A_1 V_1 = A_2 V_2$

$\rightarrow \frac{\pi}{4} \times (4)^2 \times 4 = \frac{\pi}{4} \times 2^2 \cdot V_2$

$V_2 = 16 m/s$

→ V_{act}

V_{act} $\quad V_{mean}$

V_{act}

$V_{min} = 0$

$V_{max} = V_0$

V_{mean}

$Q = \int v \cdot dA$

$V_{mean} = Q/A$

$$\boxed{V_{mean} = \frac{1}{A} \int v \cdot dA}$$

→ K.E / unit time

$K.E = \frac{1}{2} \frac{m}{t} v^2 = \frac{1}{2} \rho A v^3$ ($\frac{m}{t} = \rho A v$; K.E → time)

$$\alpha = \frac{K.E_{act}}{K.E_{mean}} = \frac{\frac{1}{2} \rho \int v^3 \cdot dA}{\frac{1}{2} \rho \cdot A \, V_{mean}^3}$$

$$\boxed{\alpha = \frac{\int v^3 \, dA}{A \cdot V_{mean}^3}}$$

$$\boxed{\alpha = \frac{\int v^3 \cdot dA}{A \cdot V_{mean}^3} = 2.0} \rightarrow \text{laminar flow through circular pipe}$$

β = Momentum correction factor

$$= \frac{\text{Actual momentum}}{\text{Mean momentum}}$$

$$\boxed{\beta = \frac{\int v^2 \cdot dA}{A \cdot V_{mean}^2}}$$

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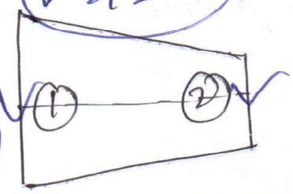
(1) At two points (1) & (2) in a horizontal pipe line where velocity are V & 2V. The pressure diff b/w two points considering an ideal flow

V & 2V



17-07

$$E_1 = E_2 + h_{loss}$$
$$E_1 - E_2 = h_{loss}$$

diff

$$\left[\cancel{z} + \frac{P}{\rho g} + \frac{v^2}{2g}\right] = \left[\cancel{z} + \frac{P}{\rho g} + \frac{v^2}{2g}\right]$$

$$\frac{P_1 - P_2}{\rho \cancel{g}} = \frac{V_2^{\,2V} - V_1^{\,V}}{2\cancel{g}} = \frac{(2v)^2 - v^2}{2} = 1.5v^2$$

$$\underline{P_1 - P_2 = 1.5 \rho v^2}$$

Hints (1) Horizontal pipe line

$$\boxed{z_1 = z_2}$$

(2) → uniform dia bore / c/s ---

Area = C ⇒ Q = AV → $V_1 = V_2$

** (3) Given head difference

$$h_{f\,I^{st}} = h_{f\,II^{nd}}$$

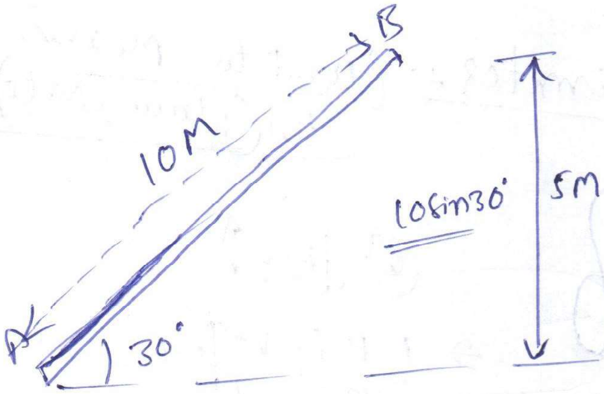
G-09

(7) water flows through 'AB' of 10 m length at ~~[illegible]~~ of uniform diameter end B is above end A and the pipe makes an angle of 30° with horizontal and the corresponding for pressure of 12 kN/m² at the end B the corresponding pressure at A neglecting losses.

$P_B = 12\,kN/m^2$

$P_A = ?$

Sol.



$E_A = E_B$ $\boxed{V_A = V_B}$

$$\left[z + \frac{P}{\rho g} + \cancel{\frac{V^2}{2g}}\right]_A = \left[z + \frac{P}{\rho g} + \cancel{\frac{V^2}{2g}}\right]_B$$

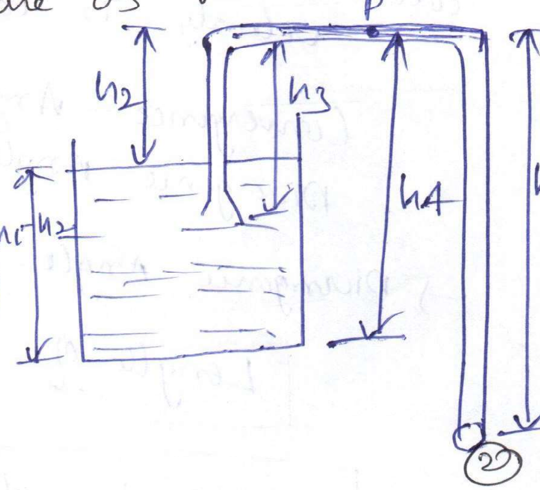
$$0 + \frac{P_A}{\rho g} = \left(\frac{12\times10^3}{10^3\times g} + 5\right)$$

$$P_A = \left(\frac{12}{9.81} + 5\right)10^3 \times 9.81$$

$$P_A = 61.4\,kpa$$

(8) Gate-06

Siphon draws water from large reservoir and releases in to atmosphere as shown. Find the velocity at point 'P'.



Sol. (a) $\sqrt{2g(h_1-h_2)}$ (b) $\sqrt{2g(h_1-h_4)}$

(c) $\sqrt{2g(h_1+h_4)}$ (d) $\sqrt{2g(h_4-h_3)}$

Find velocity of point 'P'

Sol.

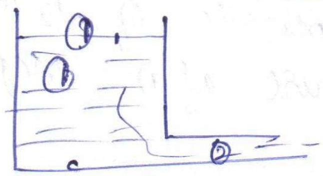
$E_1 = E_2 \Rightarrow \left[z + \frac{P}{\rho g} + \frac{V^2}{2g}\right]_1 = \left[z + \frac{P}{\rho g} + \frac{V^2}{2g}\right]_2$ velocity at point 1 = 0

$$(h_1 - h_2) + \frac{P_{atm}}{\rho g} + 0 = 0 + \frac{P_{atm}}{\rho g} + \frac{V^2}{2g}$$

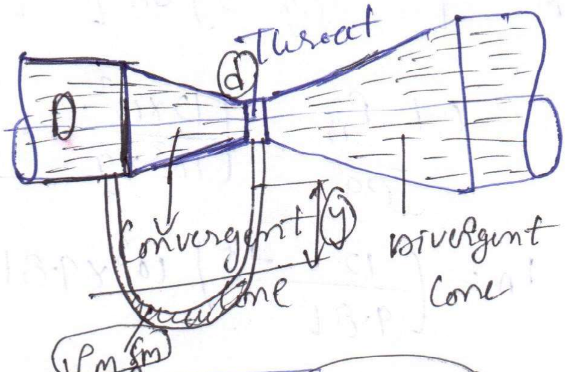
$\boxed{V_{approach\ velocity} = 0}$

$$V^2 = 2g(h_1 - h_2)$$

$$V = \sqrt{2g(h_1 - h_2)}$$



Venturimeter (used to measure the flow rate)



$Q = AV \uparrow$

$z + \frac{P}{\rho g} \downarrow + \frac{V^2}{2g} \uparrow = C$

$\boxed{\frac{Q_{Act}}{Q_{the}} = C_D = 0.98}$ → Coefficient of discharge through nozzle

$C_D = 0.98$ (pressure minimum)

→ By varying area of flow pressure difference will be created by applying bernoulli's equation velocity is calculated

Convergence Angle $= 20 \pm 2^\circ$

Divergence Angle $= 5$ to 7°

→ Divergence Angle is low

$\boxed{\text{Length of Div.} > \text{Length Convergent}}$

$\boxed{\text{Dia of throat } d = \frac{D}{2} \text{ to } \frac{D}{3}}$

Note:-

1) pressure at throat is minimum and it should not fall below vapour pressure to avoid ~~Cavitation~~ cavitation

2) Divergence angle is limited to ensure smooth flow (to avoid flow separation)

→ Applying Bernoulli's equation 1 & 2

$$\left[z + \frac{P}{\rho g} + \frac{V^2}{2g}\right]_1 = \left[z + \frac{P}{\rho g} + \frac{V^2}{2g}\right]_2$$

$$\left[z + \frac{P}{\rho g}\right]_1 - \left[z + \frac{P}{\rho g}\right]_2 = \frac{V_2^2 - V_1^2}{2g} = H$$

venturi head = H

$Q = A_1 V_1$
$Q = A_2 V_2$

$$\rightarrow V_2^2 - V_1^2 = 2gH = \left(\frac{Q}{A_2}\right)^2 - \left(\frac{Q}{A_1}\right)^2$$

$A_2 V_2$ $A_1 V_1$

$$\rightarrow \frac{Q^2}{A_2^2} - \frac{Q_1^2}{A_1^2} = 2gh$$

$$\rightarrow Q_{th} = \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}}\sqrt{2gH} \Rightarrow C_d = \frac{Q_{act}}{Q_{the}}$$

C_d = Coefficient of discharge

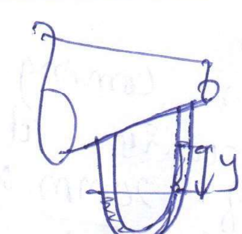
$$\boxed{Q_{act} = C_d \cdot Q_{th}}$$

$$H \rightarrow \left[z + \frac{P}{\rho g}\right] = \left[z_1 + \frac{P}{\rho g_2}\right]$$

$$= y\left[\frac{S_M}{S_0} - 1\right] \quad (S_M > S_0)$$

$$= y\left[1 - \frac{S_M}{S_0}\right] \quad (S_M < S_0)$$

flowing fluid.



$\gamma_w \cdot y(S_M - S_0)$ – n/m²

$y\,(S_M - S_0) \rightarrow$ m of water

$$\boxed{y\left[\frac{S_M}{S_0} - 1\right]} \rightarrow \text{m fluid of flow}$$

$$Q_{Act} = C_d \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}}\sqrt{2g}\sqrt{H}$$

$\boxed{K = \text{Venturi constant}}$

$$= \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}}\sqrt{2g} \quad \frac{m^{2.5}}{sec}$$

$$\boxed{Q_{Act} = C_d \cdot k \cdot \sqrt{H}}$$

$E_1 = E_2 + h_{loss}$

~~Sol~~ Act

$$\boxed{C_d = \sqrt{\frac{H - h_L}{H}}}$$

<u>Note</u> :- 1) If there is an x% error in the measurement venturihead when the corresponding error in determination flow rate will be x/2 %.

$\left(\frac{dQ}{Q}\right)$

$\rightarrow Q = C_d \cdot k \cdot \sqrt{H} \Rightarrow \boxed{Q \propto \sqrt{H}}$

$Q = C \cdot \sqrt{H}$ — (1)

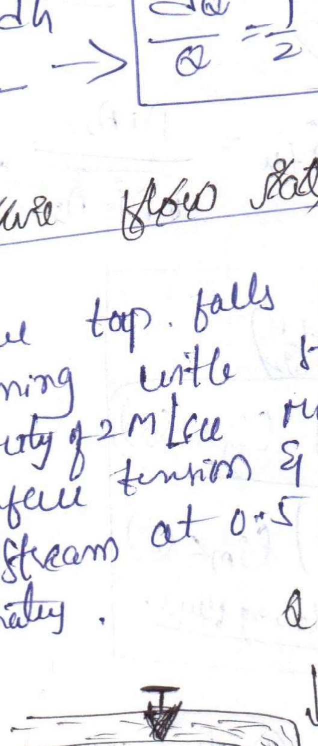
$dQ = C \cdot \frac{1}{2\sqrt{H}} dH$ — (2)

$$\frac{(2)}{(1)} = \frac{dQ}{Q} = \frac{\cancel{C} \cdot \frac{1}{2\sqrt{H}} \cdot dh}{C \cdot \sqrt{H}} \rightarrow \boxed{\frac{dQ}{Q} = \frac{1}{2}\left(\frac{dh}{H}\right)}$$

<u>ORIFICE METER</u> :- (To Measure flow rate)

(1) (7-13 problem) water coming out from the tap falls vertically downwards at the tap opening with stream dia of 20mm and with a velocity of 2 m/sec moving downwards $\boxed{\alpha_g = g}$ neglecting surface tension & curvature effects. the dia of the stream at 0.5 metres below the tap approximately.

$Q = \int A V \int$



$\downarrow Z + \frac{P}{\rho g} \uparrow + \frac{V^2}{2g} \uparrow$

Sol stream dia $\rightarrow d_1 \rightarrow 20mm$

V_1 2 m/s

$\alpha_g = g$

$$\left[z + \cancel{\frac{p}{\rho g}}^{0} + \frac{v^2}{2g}\right] = \left[z + \cancel{\frac{p}{\rho g}}^{0} + \frac{v^2}{2g}\right]$$

$$0.5 + \frac{2^2}{2 \times g} = 0 + \frac{v_2^2}{2g}$$

$$= \cancel{\frac{\pi}{4} \times (20)^2 \times 2 = \frac{\pi}{4} \frac{d^2}{2} \times 3.}$$

$\to$ $A_1 V_1 = A_2 V_2$ $\boxed{A_2 = \frac{\pi}{4} d^2 \quad d^2 = \frac{4 \times A_2}{\pi}}$ $\Rightarrow V_2 = 3.71 \, m/sec$

$$\to \frac{\pi}{4} \times (20)^2 \times 2 = \frac{\pi}{4} \frac{d^2}{\cancel{2}} \times 3.71$$

$$\to d_2 = 15 mm$$

$$\to \frac{\cancel{\pi}}{\cancel{4}} \times (20)^2 \times 2 = \frac{\cancel{\pi}}{\cancel{4}} d_2^2 \times 3.71$$

$$d_2 = 15 mm$$

$A_1 V_1 = A_2 V_2$

d_1

$v_2 = \_$

$A_1 v_1 = A_2 v_2$

$A_2 = \frac{A_1 v_1}{v_2}$

$A_2 = \_$

$A_2 = \frac{\pi}{4} d_2^2$

$* \frac{\times 4}{\pi}' = d_2^2$

8/7/17

ORIFICE METER :-

(To measure flow rate) :-