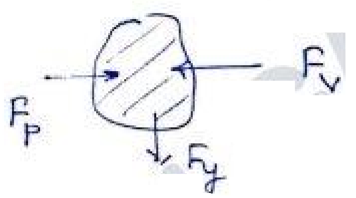
* Fluid Dynamics *

→ study of motion of fluid ~~w.r.t. force~~ with refrence of forces and moment.

→ In fluid dynamics motion there are diff types of force like viscous forces, pressure force, Gravitational force, surface tension force, elastic force, turbulant forces (Reynolds stresses) etc.



$\Sigma F_{net} = ma$ Newton's eq^n

momentum eq^n

$\{ F_p + F_g + \underset{\downarrow \text{Viscous force}}{F_v} = F_i \}$ Navier stokes eq^n (laminar)

$F_v = 0$

$\{ \underset{\downarrow \text{pressure}}{F_p} + \underset{\downarrow \text{Grav.}}{F_g} = \underset{\downarrow \text{inertia}}{F_i} \}$ Euler's — Integral form

↓

Bernoulli eq^n.

energy eq^n.

* $Re = \dfrac{F_i}{F_v}$ * $Eu = \sqrt{\dfrac{F_i}{F_p}}$ * $We = \sqrt{\dfrac{F_i}{F_s}}$

* $Fr = \sqrt{\dfrac{F_i}{F_g}}$ * $Ma = \sqrt{\dfrac{F_i}{F_e}}$

$\Rightarrow \quad Re = \dfrac{\rho(Vol)(V/t)}{\tau \times A} \Rightarrow X$

Vol $= L_c^3$

Area $= L_c^2$

length / Dia, height $= L_c$

$F_i = \rho \, Vol \, \dfrac{V}{t}$

$= \rho L_c^3 \dfrac{V}{t}$

$\boxed{F_i = \rho L_c^2 V^2}$

$F_v = \mu \cdot \dfrac{V}{h} A$

$F_v = \mu \dfrac{V}{L_c} \cdot L_c^2 = \mu$

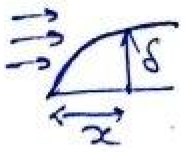
$\boxed{F_v = \mu V L_c}$

$Re = \dfrac{\rho V^2 L_c^2}{\mu V L_c}$ $\quad Re = \dfrac{\rho V L_c}{\mu}$

$\underline{\underline{x}}$

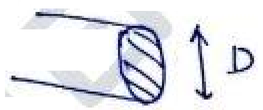
L_c

internal flow (pipe flow)



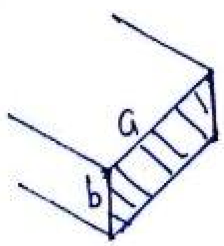
$L_c = x$

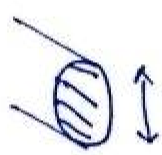
$Re_x = \dfrac{\rho U_\infty x}{\mu}$



$L_c = D$

$Re = \dfrac{\rho V D}{\mu}$ $\quad$ V = mean Velocity





$D_h = \dfrac{4A_s}{P}$

$D_h = \dfrac{2ab}{(a+b)}$

$Re \leq 2000$ laminar

$Re \geq 4000$ turbu.

* $F_r = \sqrt{\dfrac{F_i}{F_g}}$

$$F_r = \sqrt{\frac{\rho V^2 L_c^2}{\rho L_c^3 g}}$$

$$F_r = \frac{V}{\sqrt{L_c g}}$$

$M_a = \sqrt{\dfrac{F_i}{F_e}}$ ← elastic

$$K = \frac{dp}{\left(\frac{-dV}{V}\right)} \quad N/m^2$$

$$F_e = KA$$

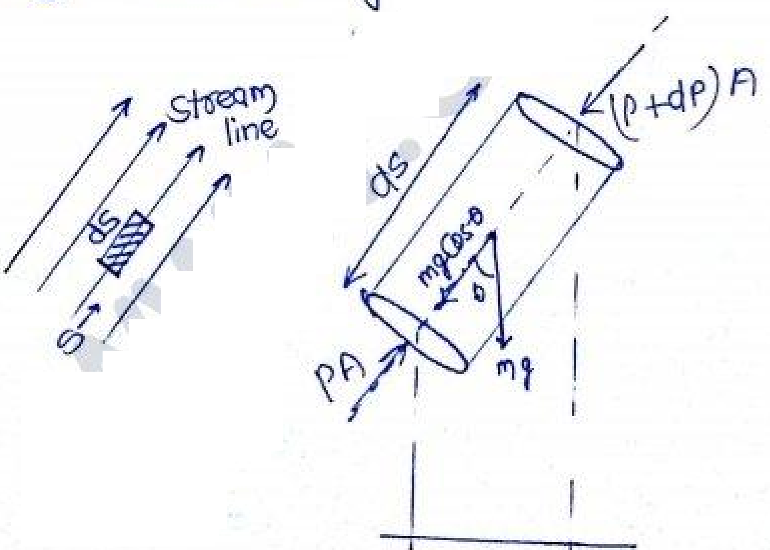
$$M_a = \sqrt{\frac{\rho V^2 L_c^2}{K L_c^2}}$$

$$M_a = \frac{V}{\sqrt{K/\rho}} = \frac{V}{C}$$

Bernoulies eqn:

Assumption :-

1. steady flow
2. Incompressible flow
3. Non viscous flow.
4. Irrotational flow
5. Flow along the stream line.



$$P = f(s)$$

$$dP = \frac{\partial P}{\partial s} ds$$

$$z = f(s)$$

$$dz = \frac{\partial z}{\partial s} ds$$

Euler's eqⁿ

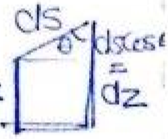
$$F_p + F_g = m\left[v\frac{\partial v}{\partial s} + \frac{\partial v}{\partial t}\right]$$ Non-viscous flow

Along stream line

$$\left(pA - (p+dp)A\right) - mg\cos\theta = m\left[v\frac{\partial v}{\partial s} + \frac{\partial v}{\partial t}\right]$$

$$\cancel{pA} - \cancel{pA} - \rho g A ds\cos\theta = \rho \cdot A ds \cdot \left[v\frac{\partial v}{\partial s} + \frac{\partial v}{\partial t}\right]$$

$-dpA$



$$\boxed{-dp - \rho g\,dz = \rho\,ds\left[v\frac{\partial v}{\partial s} + \frac{\partial v}{\partial t}\right]}$$ Unsteady Euler's eqⁿ.

Steady flow. $\frac{\partial v}{\partial t} = 0$

$$-dp - \rho g dz - \rho ds\left(v\frac{\partial v}{\partial s}\right) = 0$$

irrotational flow

$$v\frac{\partial v}{\partial s} = \frac{1}{2}\frac{\partial v^2}{\partial s} \quad ?$$

$$-\frac{\partial p}{\partial s}ds - \rho g\frac{\partial z}{\partial s}ds - \rho\frac{1}{2}\frac{\partial v^2}{\partial s}ds = 0$$

$$\frac{1}{\rho}\left[\int\frac{\partial p}{\partial s}ds + \frac{1}{2}\int\frac{\partial v^2}{\partial s}ds + g\int\frac{\partial z}{\partial s}ds = 0\right.$$

$$\boxed{\frac{p}{\rho} + \frac{v^2}{2} + gz = 0}$$ incompressible flow

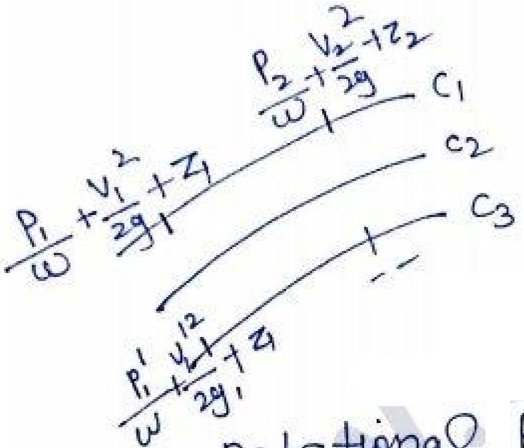
C - stream line
Const.

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

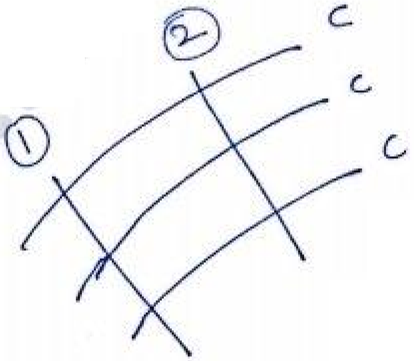
Along stream line for steady, incomp non-viscous & irrotational flow.

$KE = \frac{1}{2} m V^2$

$$\frac{KE}{mg} = \frac{V^2}{2g} = \frac{\text{energy}}{\text{wt}}$$



Rotational flow.
(non viscous)
(Along stream line)



irrotational flow
(can applie on section)

Note:

* In rotational flow the energy constant C is differenct for diff stream lines So B.E. $\left(\frac{P}{\omega} + \frac{V^2}{2g} + z\right)$ - is applicable only along the stream line.
* In irrotational flow the energy constant C is same for all stream lines so B.E. is applicable over the entire section in irrotational flow.

Note:

$$\frac{p}{w}+\frac{V^2}{2g}+z=c$$ m of liquid column $\left(\frac{\text{Energy}}{\text{weight}}\right)$

$$\frac{K.E.}{m}=\frac{V^2}{2}\ \frac{\text{energy}}{\text{mass}}$$

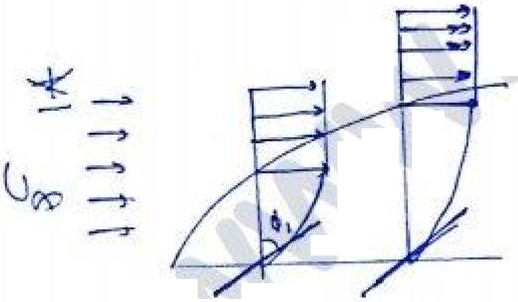
$$\frac{p}{\rho}+\frac{V^2}{2}+gz=c$$ $\left.\frac{\text{Energy}}{\text{mass}}\right\}$

$$\underbrace{\frac{K.E.}{\rho\cdot Vol.}}_{\text{mass}}=\frac{V^2}{2}$$

(N/m^2)

$$\underbrace{p}_{\text{Static pressure}}+\underbrace{\frac{\rho V^2}{2}}_{\text{Dynamic pressure}}+\rho g z=c$$ $\left.\frac{\text{energy}}{\text{Vol.}}\right\}$

$$\underbrace{\frac{K.E.}{Vol.}}_{\text{Volume}}=\frac{\rho V^2}{2}$$



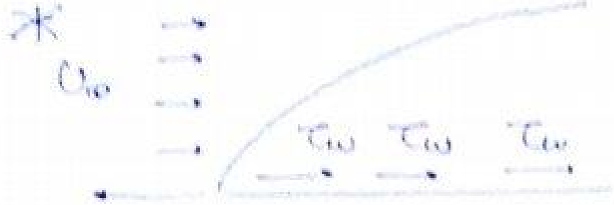
$$\left(\frac{d\phi_1}{dt}\right)>\left(\frac{d\phi_2}{dt}\right)$$

$$\mu\frac{du}{dy}\bigg|_{y=0}>\mu\frac{du}{dy}\bigg|_{y=0}$$

$$\tau_{w_1}>\tau_{w_2}$$

$$x\uparrow\ \rightarrow\ \tau_w\downarrow\ \rightarrow\ C_{fx}\downarrow$$

*



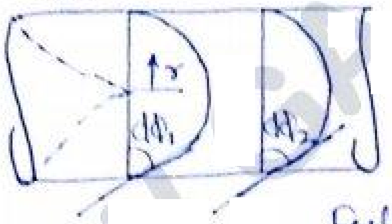
$P + \frac{\rho U_\infty^2}{2} + \rho g z = C \rightarrow \frac{\rho U_\infty^2}{2} \rightarrow \frac{\rho U_\infty^2}{2} \rightarrow \frac{\rho U_\infty^2}{2}$

Const $\quad$ Const

$$C_f = \frac{\tau_w}{\frac{\rho U_\infty^2}{2}}$$ Skin friction coefficient.

$$\boxed{C_D = \frac{1}{L}\int_0^L C_{fx}\,dx}$$ Avg drag coeff

* τ_w = Const. $U \neq f(x)$ $u = f(r)$



$A_1 V_1 = A_2 V_2$

$V_1 = V_2$

Fully develope

$$\left.\frac{d\phi}{dr}\right)_1 = \left.\frac{d\phi}{dr}\right)_2$$

$$\tau_{w_1} = \tau_{w_2}$$

$$\boxed{f' = \frac{\tau_w}{\frac{1}{2}\rho V^2}}$$ Darcy's friction coeff.

friction factor

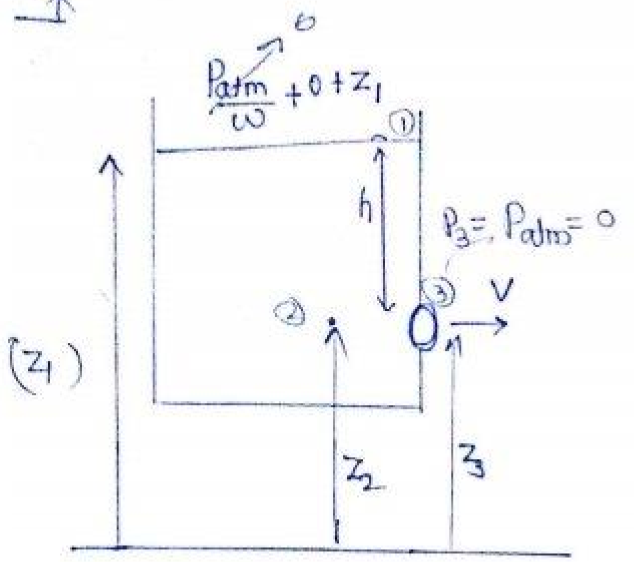
$F = 4f'$

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

$f' =$ Const.

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

$S_x = \frac{F'}{2}$



B.E.

at ① $\quad 0 + 0 + z_1 = C \quad$ — ①

at ② $\quad \frac{P_2}{w} + 0 + z_2 = C \quad$ — ②

① & ②

$$0 + 0 + z_1 = \frac{P_2}{w} + z_2$$

$$\frac{P_2}{w} = z_1 - z_2 = h$$

$$\frac{P_2}{w} = h$$

$$\boxed{\text{energy at ① = energy at ②}}$$

B.E. at ② & ③

$$\frac{P_2}{w} + 0 + \cancel{z_2} = 0 + \frac{V_3^2}{2g} + \cancel{z_3}$$

$$\frac{V^2}{2g} = \frac{P_2}{w} = h$$

$$V = \sqrt{2gh}$$

at ① & ③

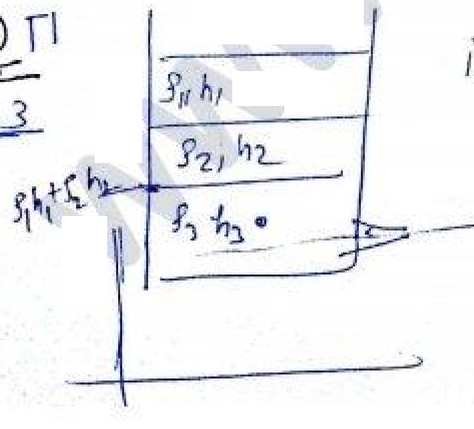
$$\cancel{\frac{P_{atm}}{w}} + 0 + z_1 = \cancel{\frac{P_{atm}}{w}} + \frac{V^2}{2g} + z_3$$

$$\frac{V^2}{2g} = z_1 - z_3 = h$$

$$V = \sqrt{2gh}$$

Q 11

p.g 3



if fluid change NOTE

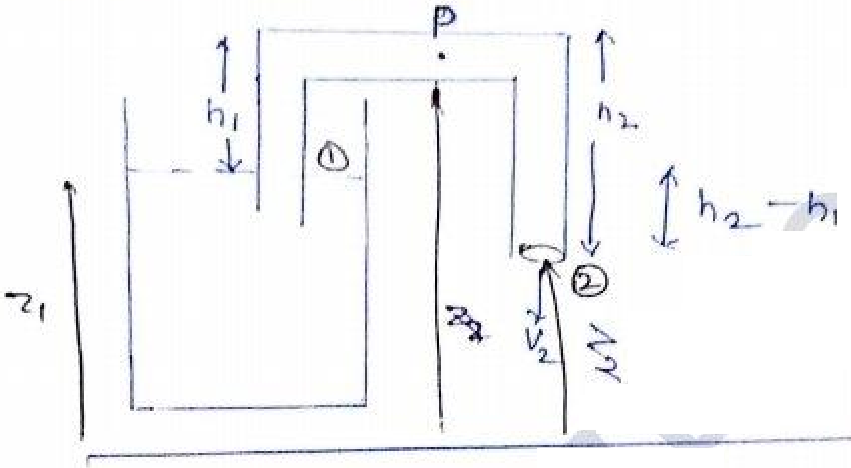
$$\frac{P}{\rho g} + \frac{V^2}{2g} + z = C$$

$$\frac{\rho_1 h_1 + \rho_2 h_2 + \rho_3 h_3}{\rho_3 g} + 0 + 0 = \frac{V^2}{2g}$$

$$V = \sqrt{2gh_3\left(\frac{\rho_1 h_1}{\rho_3 h_3} + \frac{\rho_2 h_2}{\rho_3 h_3} + 1\right)}$$

Que

Pipe draws water from reservoir. Assuming the ideal fluid the velocity of the flow at the point P is



Assume datum

at P $E_p = \frac{P_p}{w} + \frac{V_p^2}{2g} + z_p$

at ① $E_1 = \frac{P_{atm}}{w} + 0 + z_1$

at ② $E_2 = \frac{P_{atm}}{w} + \frac{V_2^2}{2g} + z_2$

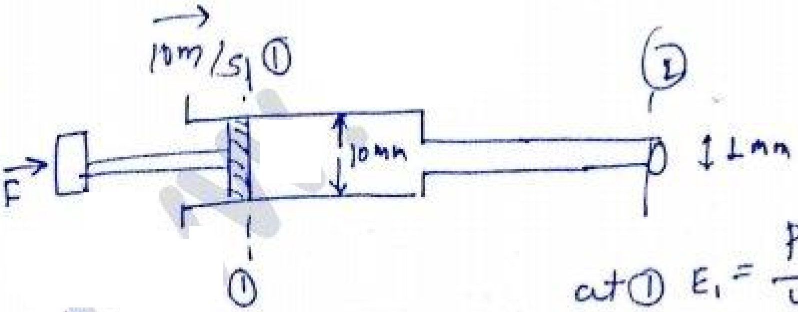
① & ② $\frac{P_{atm}}{w} + z_1 = \frac{P_{atm}}{w} + \frac{V_2^2}{2g} + z_2$

$$V_2 = \sqrt{2g(z_1 - z_2)}$$

$$A_p V_p = A_2 V_2$$

$$V_p = \sqrt{2g(h_2 - h_1)} \quad \text{Ans}$$

Q. 16
P.g 44
WB



at ① $E_1 = \frac{P_1}{w} + \frac{V_1^2}{2g} + z_1$

at ② $E_2 = \frac{P_{atm}}{w} + \frac{V_2^2}{2g} + z_2$

$P_1 = \frac{F}{A}$

$F = P_1 \times A$

$A_1 V_1 = A_2 V_2$

$\pi(10)^2 \times 10 = \pi(1)^2 \times V_2 \Rightarrow V_2 = 1000$ m/s

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + z_1 = \frac{\cancelto{0}{P_{atm}}}{\omega} + \frac{V_2^2}{2g} + z_2$$

$z_1 = z_2$

$$\frac{P_1}{\omega} = \frac{V_2^2 - V_1^2}{2g}$$

$$P_1 = \frac{(1010)(990)}{2 \times 10} \times \rho \times g$$

$$P_1 = \frac{1010 \times 990 \times 1000}{2}$$

$$F = \frac{1010 \times 990 \times 1000}{2} \times \pi (10)^2 \times 10^{-6}$$

$$F = 0.$$

$$P_1 = \frac{\rho V_1^2}{2} \left(\frac{V_2^2}{V_1^2} - 1 \right)$$

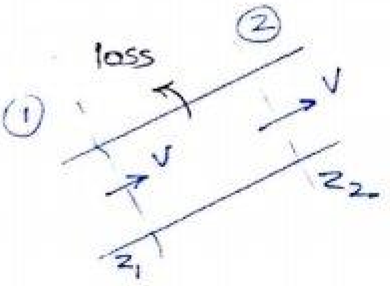
$A_1 V_1 = A_2 V_2$

$$P_1 = \frac{\rho V_1^2}{2} \left[\frac{d_2^4}{d_1^4} - 1 \right]$$

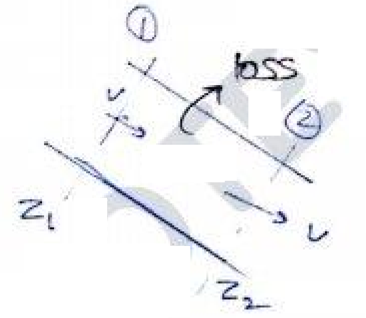
$$P = \frac{1000 \times (10)^2}{2} \left[\frac{10^4}{1^4} - 1 \right)$$

$$F = 0.04 \ \underline{\underline{N}}$$

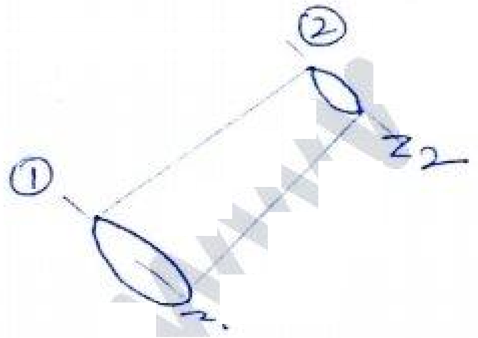
Note: If the expressions (conversing & uniform section pipe) are in piezometric head then expression are independent of orientation of pipe.



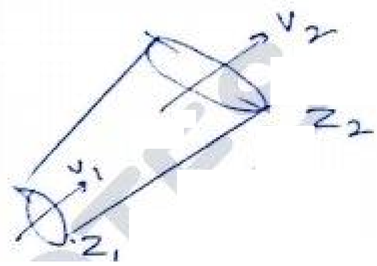
$$\left(\frac{p}{w} + \overset{\uparrow\uparrow}{z}\right) + \frac{v^2}{2g} + \text{loss}^{\uparrow\uparrow}$$



$$\left(\frac{p}{w} + \overset{\downarrow\downarrow}{z}\right) + \frac{v^2}{2g} + \text{loss}\uparrow\uparrow$$

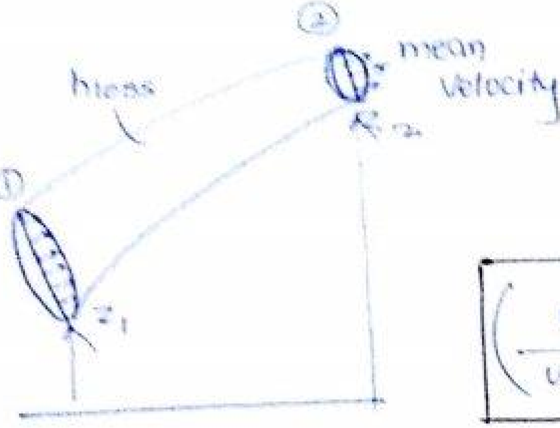


$$\left(\frac{p}{w} + \overset{\uparrow}{z}\right) + \frac{\overset{\uparrow}{v}^2}{2g} + \overset{\uparrow}{\text{loss}}(\uparrow)$$



$$\left(\frac{p}{w} + \overset{\uparrow\uparrow}{\cancel{z}}\right) + \frac{\overset{(\downarrow)}{v}^2}{2g} + \text{loss}(\uparrow)$$

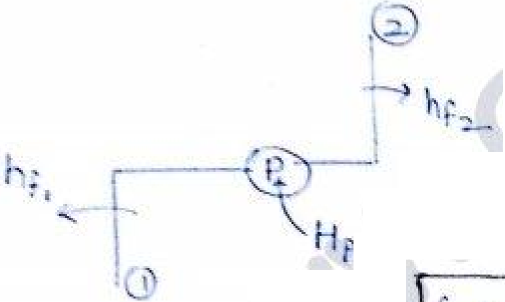
Application of B.E. equation:-



$$\left(\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1\right) - \left(\frac{P_2}{w} + \frac{V_2^2}{2g} + z_2\right) = h_L$$

$$\boxed{\left(\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1\right) = \left(\frac{P_2}{w} + \frac{V_2^2}{2g} + z_2 + h\right)}$$

This is the Modified form of B.E.



$$\left(\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1\right) + H_p - \left(\frac{P_2}{w} + \frac{V_2^2}{2g} + z_2\right) = h_{f_1} + h_{f_2}$$

$$\boxed{\left(\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1\right) + H_p = \left(\frac{P_2}{w} + \frac{V_2^2}{2g} + z_2\right) + h_{eq.}}$$

$\Downarrow$

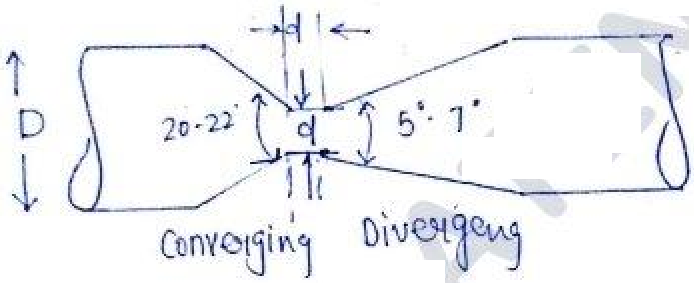
Modified B.E.

Application of B.E.

Application
- Discharge measurment
  - Venturimeter
  - Orificemeter
  - Flow Nozzle
- Velocity measurment
  - pitot tube.
- Pipe flow
- Free Vortex

Venturimeter:-

- It is highly accurate discharge measurement ~~device~~ instrument of incompressible fluid flow.
- It consist of Converging section, Diverging section and minimum area known as throat.
- The angle of divergence of Venturimeter is small to avoid the sepration of flow

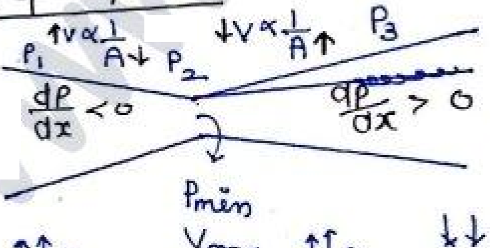


$$\frac{D}{3} \le d \le \frac{3}{4} D$$

Design

$$d \le \frac{D}{2}$$

Flow separation:-



$$P_1 > P_2 < P_3$$

→ Adverse pressure Gradient

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

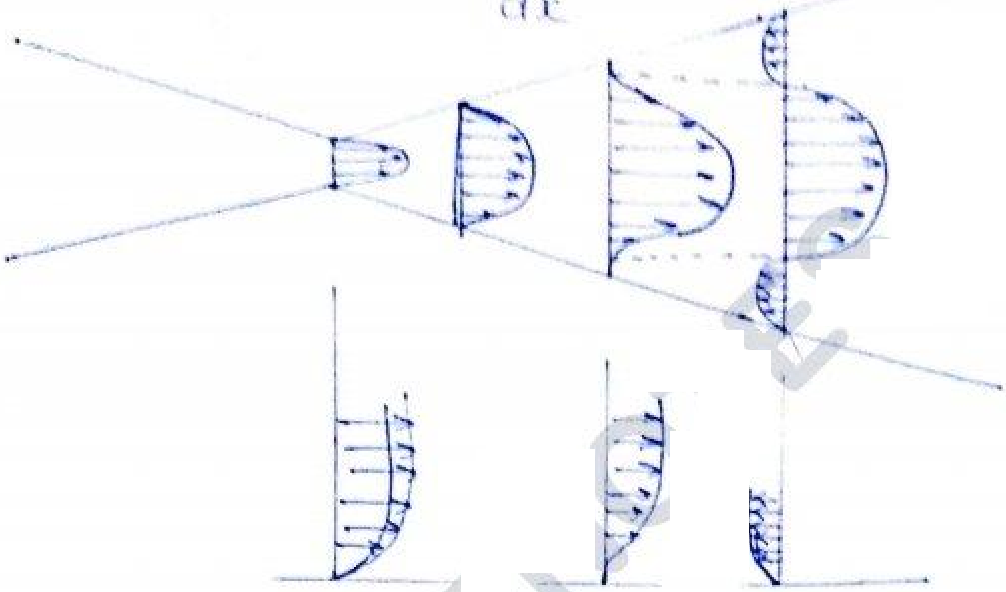
$$dP = P_2 - P_1 \qquad dP = P_3 - P_2$$

$$dP < 0 \qquad dP > 0$$

$$\frac{dP}{dx} < 0 \qquad \frac{dP}{dx} > 0$$

↳ Adverse pressure Gradient

$\frac{dp}{dx} > 0$



$\left.\frac{du}{dy}\right|_{y=0} > 0$ $\quad$ $\left.\frac{du}{dy}\right|_{y=0} = 0$ $\quad$ $\left.\frac{du}{dy}\right|_{y=0} < 0$

$\left.\mu\frac{du}{dy}\right|_{y=0} > 0$ $\quad$ $\left.\mu\frac{du}{dy}\right|_{y=0} = 0$ $\quad$ $\left.\mu\frac{du}{dy}\right|_{y=0} < 0$

$\tau_w > 0$ $\quad$ $\tau_w = 0$ $\quad$ $\tau_w < 0$

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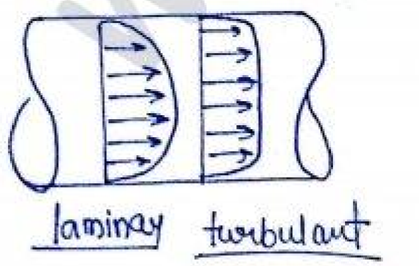

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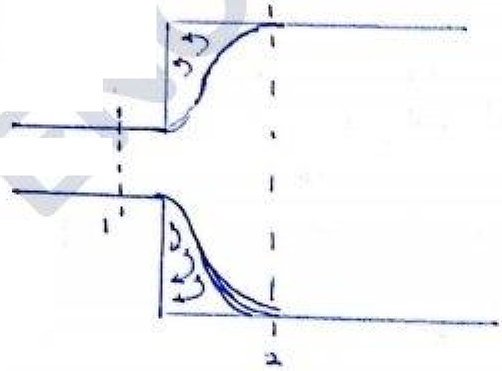

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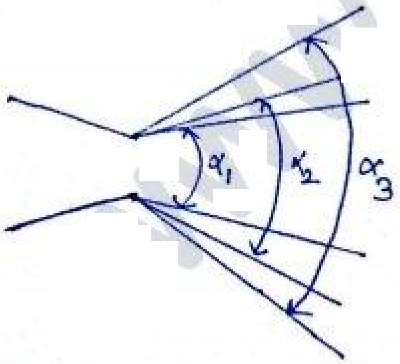
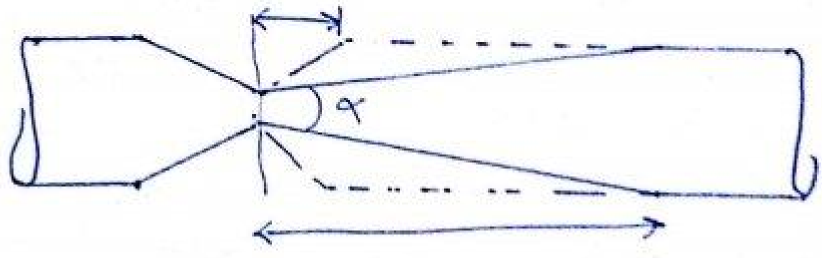
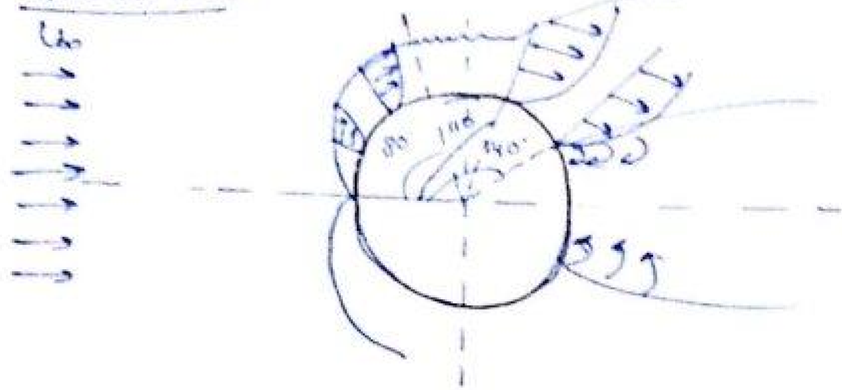




angle less

length more

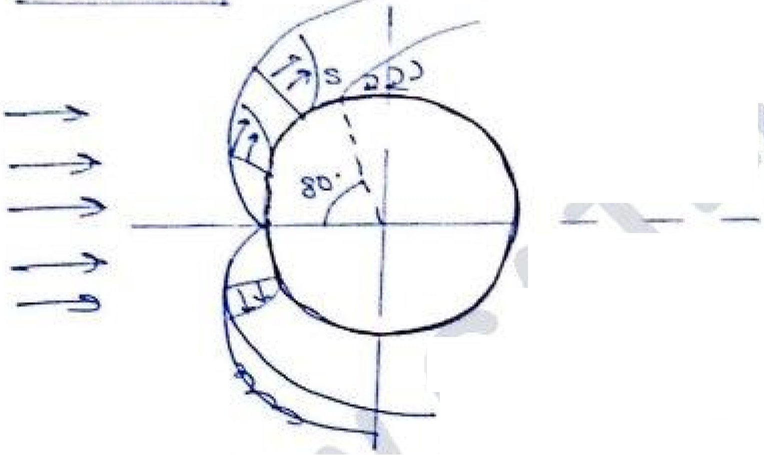
Turbulant



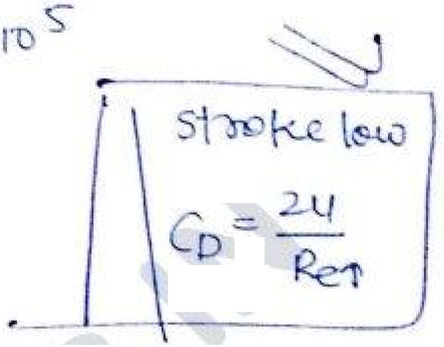
$Re > 2 \times 10^5$

theory book

in laminar



$Re < 2 \times 10^5$



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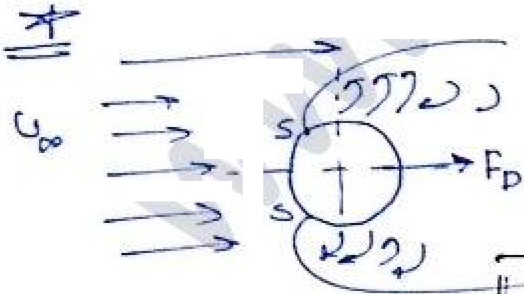
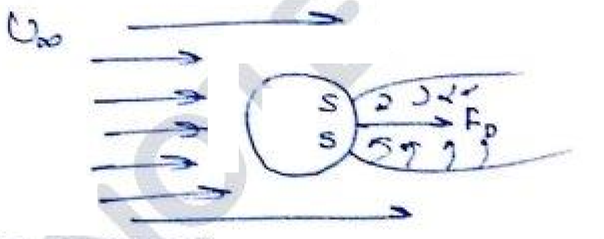


laminar



turbulant

Coeff of drag $\boxed{C_D = \dfrac{F_D}{\frac{1}{2}\rho U_\infty^2 A}}$

* C_D will be more in case of laminar flows.

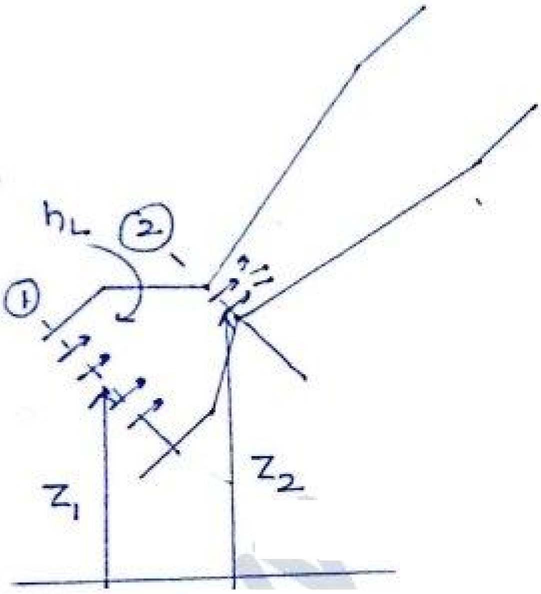
* When fluid flow under adverse condition the momentum of fluid reduces near the surface the reduction rate is more and the particles near the surface looses their momentum first and after that the flow of fluid near the surface is in reverse direction that

point is known as point of sepration.

* At sepration point

$$\Rightarrow \frac{dP}{dx} > 0 \;,\; \left.\frac{du}{dy}\right|_{y=0} = 0 \;,\; \tau_\omega = 0$$

<u>Discharge equation for Venturimeter</u>:-



BE. b/w ① & ②

$$\left(\frac{P_1}{\omega} + Z_1\right) + \frac{V_1^2}{2g} = \left(\frac{P_2}{\omega} + Z_2\right) + \frac{V_2^2}{2g} + h_L$$

$$A_1V_1 = A_2V_2 \Rightarrow V_2 = \frac{A_1V_1}{A_2}$$

$$\frac{V_2^2}{2g} - \frac{V_1^2}{2g} = \underbrace{\left(\frac{P_1}{\omega} + Z_1\right) - \left(\frac{P_2}{\omega} + Z_2\right)}_{h} - h_L$$

$$\frac{V_1^2}{2g}\left(\frac{A_1^2}{A_2^2} - 1\right) = h - h_L$$

h = Piezometric head ~~loss~~. difference.

$$V_1 = \frac{A_2\sqrt{2g(h-h_L)}}{\sqrt{A_1^2 - A_2^2}}$$

$$Q_{act} = A_1V_1 = \frac{A_1A_2\sqrt{2g(h-h_L)}}{\sqrt{A_1^2 - A_2^2}}$$

$$\boxed{Q_{act} = \frac{A_1 A_2 \sqrt{2g(h-h_L)}}{\sqrt{A_1^2 - A_2^2}}}$$ Actual

theoritically $h_L = 0$

$$Q_{th} = \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$C_d = \frac{Q_{act}}{Q_{th}} < 1$$

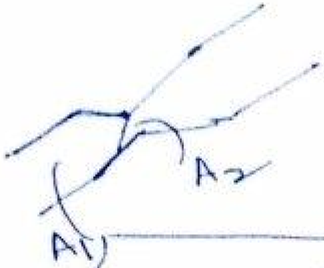
$$Q_{th} > Q_{act}.$$

$$Q_{act} = C_d Q_{th}.$$

$$Q_{act} = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$\Rightarrow \quad \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}} = \frac{A_1 A_2 \sqrt{2g(h-h_L)}}{\sqrt{A_1^2 - A_2^2}}$$

$$C_d = \sqrt{\frac{h-h_L}{h}}$$



$$\boxed{Q_{th} = \frac{A_1 A_2 \sqrt{2g}\,\sqrt{h}}{\sqrt{A_1^2 - A_2^2}}}$$

$$C = \frac{A_1 A_2 \sqrt{2g}}{\sqrt{A_1^2 - A_2^2}}$$

C = Venturi Constant

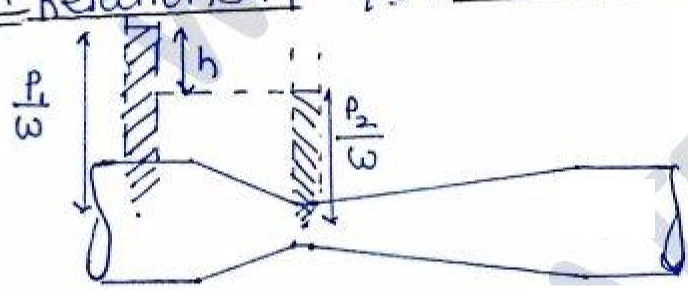
$$Q_{th} = C\sqrt{h}$$

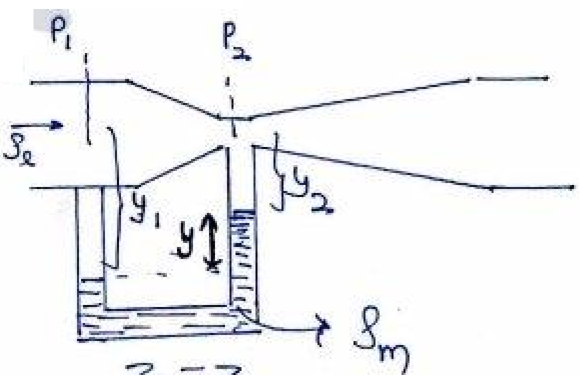
$$\boxed{Q_{act} = C_d\, C\sqrt{h}}$$

* The expression of (Q for) Venturimeter is independent of orientation of pipe.

Imp

* Relationship b/w piezometric head diff. and manometric deflection





$$z_1 = z_2$$

$$h = \left(\frac{P_1}{\omega} + z_1\right) - \left(\frac{P_2}{\omega} + z_2\right)$$

$$Q = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$P_1 + \rho_e g y_1 - \rho_m g y - \rho_e g y_2 = P_2$$

$$P_1 - P_2 = \rho_m g y - \rho_e g (y_1 - y_2)$$

$$y_1 - y_2 = y$$

$$P_1 - P_2 = \rho_m g y - \rho_l g y$$

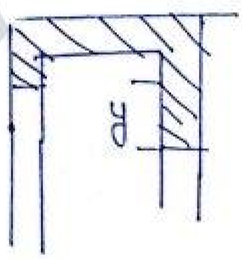
$$\frac{P_1}{\rho_l g} - \frac{P_2}{\rho_l g} = \left(\frac{\rho_m}{\rho_l} - 1\right) y$$

$$\frac{P_1}{\rho_l g} + z_1 - \frac{P_2}{\rho_l g} - z_2 = \left(\frac{\rho_m}{\rho_l} - 1\right) y$$

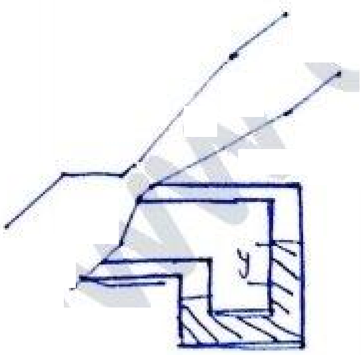
Piezomentric head diff. $\boxed{h = \left(\frac{\rho_m}{\rho_l} - 1\right) y}$ → manometric deflection

* $\boxed{h = \left(\frac{\omega_m}{\omega_l} - 1\right) y}$ * $\boxed{h = \left(\frac{S_m}{S_l} - 1\right) y}$

* For inverted manometer.



$\boxed{h = \left(1 - \frac{\rho_m}{\rho_l}\right) y}$ → For light fluids



y will Remain same in all orientation for a given liquid (flowing fluid)

Note

Coefficient of discharge (C_d)

① Reynolds number (R_e)

② Area ratio ($A_1/A_2 > 1$)

③ surface ~~Surfa~~ roughness

④ C_d of venturimeter is high (0.96 − 0.98) because of no formation of venacontractal

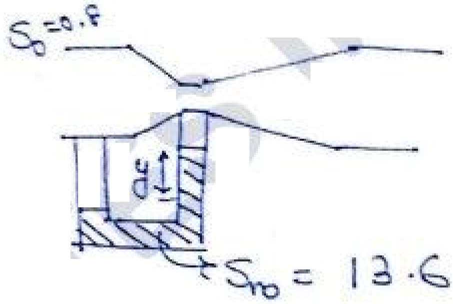
Que

$$Q = 0.16\ m^3/s \qquad y = 20\ cm$$

$$h_1 = \left(\frac{S_m}{S_o} - 1\right) y$$

$$h_1 = \left(\frac{13.6}{0.8} - 1\right) \times 20$$

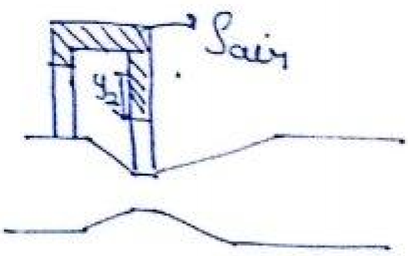
$$h_1 = 340\ cm$$



$$Q \propto \sqrt{h_1}$$

$$\frac{0.16^2}{0.08} = \frac{\sqrt{340}}{\sqrt{h_2}}$$

$$4 h_2 = 340 \Rightarrow h_2 = 85\ cm$$



$$h_2 = \left(1 - \frac{S_{air}}{S_{oil}}\right) y \Rightarrow 85 = \left(1 - \frac{1.2}{800}\right) y$$

$$85 = \left(1 - \frac{0.0012}{0.8}\right) y \qquad y = 80.12\ cm$$

$$Q_1 = 2Q_2$$

$$\frac{C_d A_1 A_2 \sqrt{2gh_1}}{\sqrt{A_1^2 - A_2^2}} = \frac{C_d A_1 A_2 \sqrt{2gh_2}}{\sqrt{A_1^2 - A_2^2}}$$

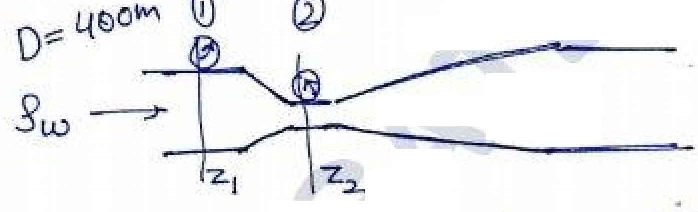
$$h_1 = 4h_2$$

$$\left(\frac{13.6}{0.8} - 1\right) \times 0.2 = 4 \times \left(1 - \frac{1.2}{800}\right) y_2$$

$$y = 80.12 \text{ cm.}$$

Ques Venturimeter is installed in a Hz pipe of 400 mm dia. The throat dia is 1/3rd of pipe dia Water flow through the pipe, pressure in pipe line is 1.405 kgf/cm² and the vaccume in the throat is 37.5 cm Hg if 4% of differential head is lost b/w gauges

Soln



$P_1 = 1.405 \text{ kgf/cm}^2$

$P_1 = 1.405 \times 10^4 \times 9.81$ Pa

$P_2 = 37.5$ cm vaccume.

$P_2 = -37.5 \times 10^{-2} \times 13.6 \times 9810$ Pa

$= -5003.1$ Pa

$$Q_{act} = \frac{A_1 A_2 \sqrt{2g(h - h_L)}}{\sqrt{A_1^2 - A_2^2}}$$

$$h = \left(\frac{P_1}{\omega} + z_1\right) - \left(\frac{P_2}{\omega} + z_2\right)$$

$$h = \frac{P_1 - P_2}{\omega} = \frac{\left(1.405 \times 9.81 \times 10^4 - \left(-37.5 \times 10^{-2} \times 13.6 \times 9810\right)\right)}{9810}$$

$$h_L = 0.04\,h \qquad h = 19.15\,m$$

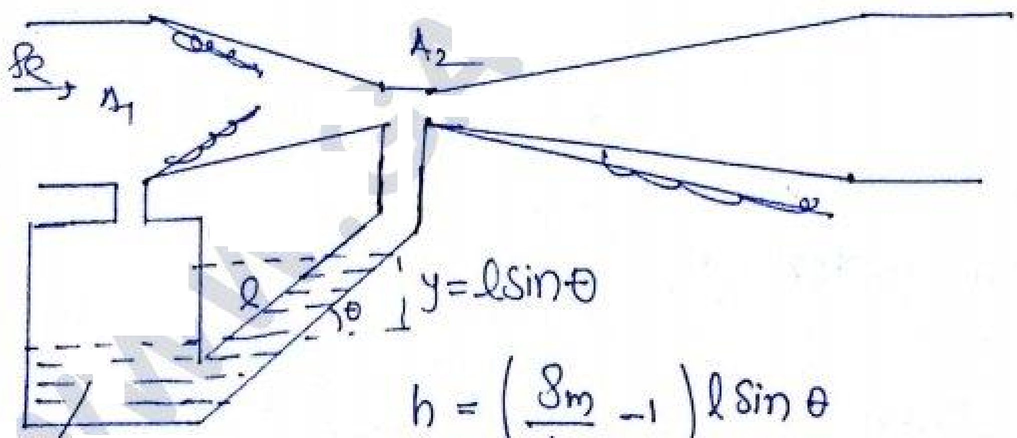
$$h_L = 0.766\,m$$

$$Q_{act} = \frac{d_1^2 d_2^2 \sqrt{2g(h - h_L)}}{\sqrt{d_1^4 - d_2^4}}$$

$$Q_{act} = \frac{(400)^2 \left(\frac{400}{3}\right)^2 \sqrt{2 \times 9.81 \times (19.15 - 0.766)}}{\sqrt{(400)^4 - \left(\frac{400}{3}\right)^4}}$$

$$Q_{act} = 0.268\ m^3/s.$$

<u>Note</u>



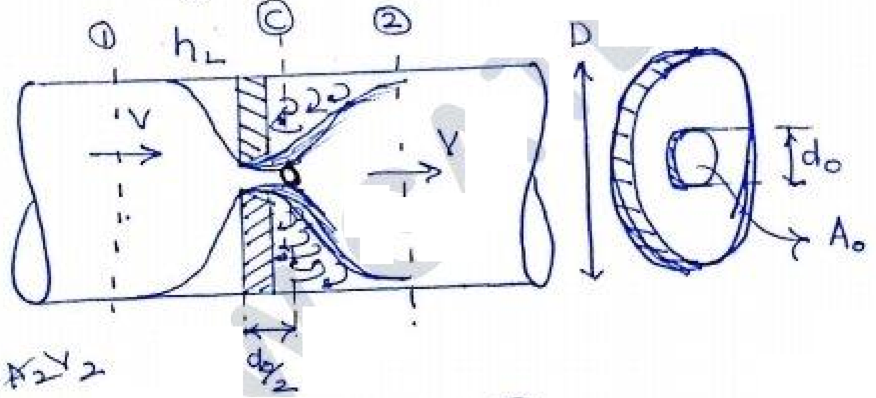
$$h = \left(\frac{\rho_m}{\rho_l} - 1\right) l \sin\theta$$

$$Q = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

Orificemeter :-

→ It is circular plate with sharp edge hole at the centre use to measure the discharge in pipe flow or tank openings.

→ Due to formation of venacontracta high losses takes place so it have low value of C_d (0.62 – 0.64)



h_L = head loss

h = piezometric head diff.

$A_1V_1 = A_2V_2$

$V_1 = V_2$

$A_1V_1 = A_cV_c$

$\boxed{A_c = A_{min}}$

B.E. at ① & ©

$$\frac{V_c^2}{2g} - \frac{V_1^2}{2g} = h - h_L$$

A_c = area of vencontracta

$$\frac{V_1^2}{2g}\left(\frac{V_c^2}{V_1^2} - 1\right) = h - h_L$$

$$\frac{V_1^2}{2g}\left(\frac{A_1^2}{A_c^2} - 1\right) = (h - h_L)$$

$$\boxed{C_c = \frac{A_c}{A_o}}$$

coefficient of contraction

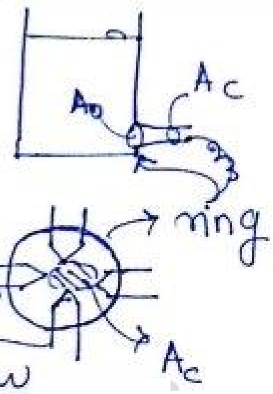
$$V_1 = \frac{A_o\sqrt{2g(h-h_L)}}{\sqrt{\frac{A_1^2}{C_c^2} - A_o^2}} \times \left(\frac{\sqrt{h}}{\sqrt{h}} \times \frac{\sqrt{A_1^2 - A_o^2}}{\sqrt{A_1^2 - A_2^2}}\right)$$

$$A_1 V_1 = \frac{A_1 A_0 \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}} \underbrace{\left(\frac{\sqrt{h-h_L}\,\sqrt{A_1^2 - A_0^2}}{\sqrt{h}\,\sqrt{\frac{A_1^2}{C_c^2} - A_0^2}} \right)}_{C = C_{d_0}}$$

Actual discharge

$$* \quad \boxed{Q_{act} = \frac{C_{d_0} A_1 A_0 \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}}$$

measurment of A_c



$$C_c = \frac{A_c}{A_0} = \frac{A_{min}}{A_0}$$

Q17

$$Q = \frac{C A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

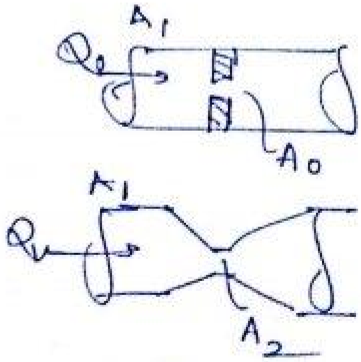
$C_{d_0} = 0.61$

$C_{d_v} = 0.98$

$Q_{ac} \propto C_{d_0} \sqrt{h}$

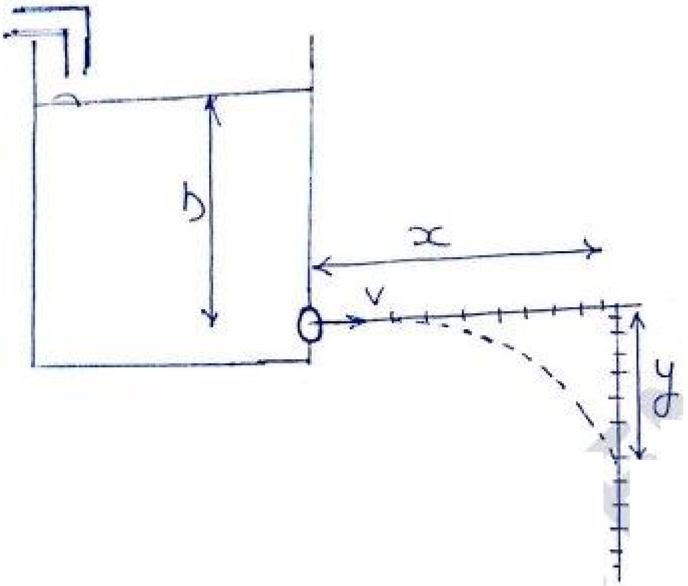
$$C_{d_0} \sqrt{h_0} = C_{d_v} \sqrt{h_v}$$

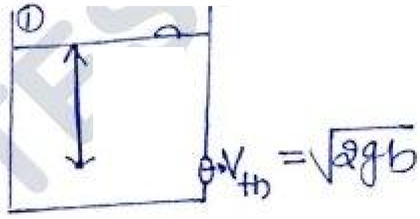
$$\left(\frac{0.61}{0.98}\right)^2 = \frac{h_v}{h_0}$$



$A_0 = A_2$

☆ Experimental measurement of coefficient of velocity of orifice meter :-





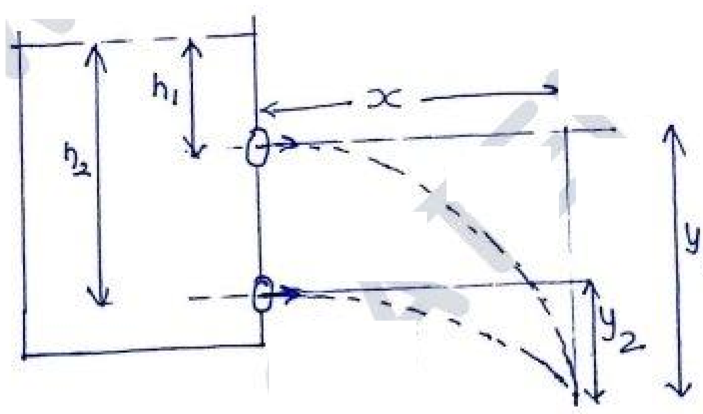
$C_v = \frac{x}{\sqrt{4yh}}$

$$V = V_{act} = C_v \times V_{th}$$

$$\boxed{C_v = \frac{V}{V_{th}}}$$

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

Case①



$$\boxed{y_1 - y_2 = h_2 - h_1}$$

$$C_{v_1} = \frac{x}{\sqrt{4y_1h_1}}$$

if $C_{v_1} = C_{v_2}$

$$C_{v_2} = \frac{x}{\sqrt{4y_2h_2}}$$

$$\frac{x}{\sqrt{4y_1h_1}} = \frac{x}{\sqrt{4y_2h_2}}$$

$$\boxed{y_1h_1 = y_2h_2}$$

Note:

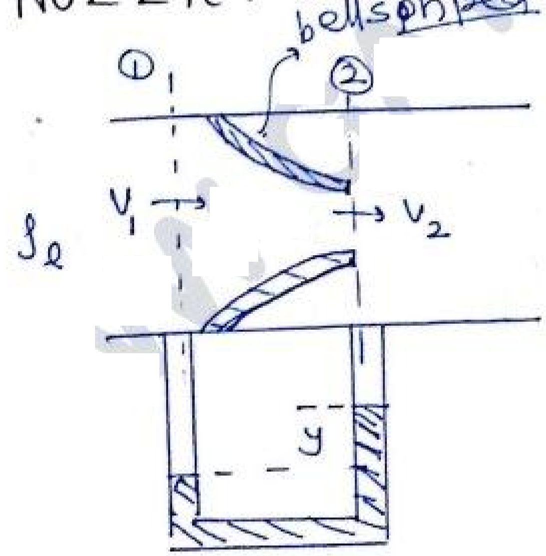
$$C_d = \frac{Q_{act}}{Q_{th}}$$

$$\boxed{C_c = \frac{A_c}{A_o}}$$

$$C_d = \frac{A_{act}}{A_{th}} \times \frac{V_{act}}{V_{th}}$$

$$\boxed{C_d = \underbrace{C_c}_{?} \times C_v} \qquad C_c = \frac{C_d}{C_v}$$

Flow Nozzle:-



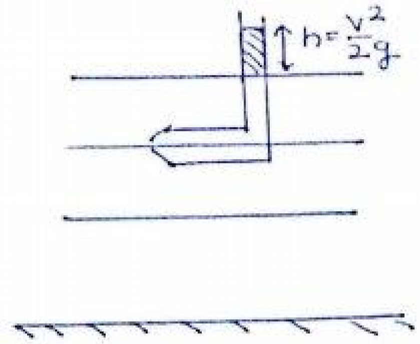
$$Q = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

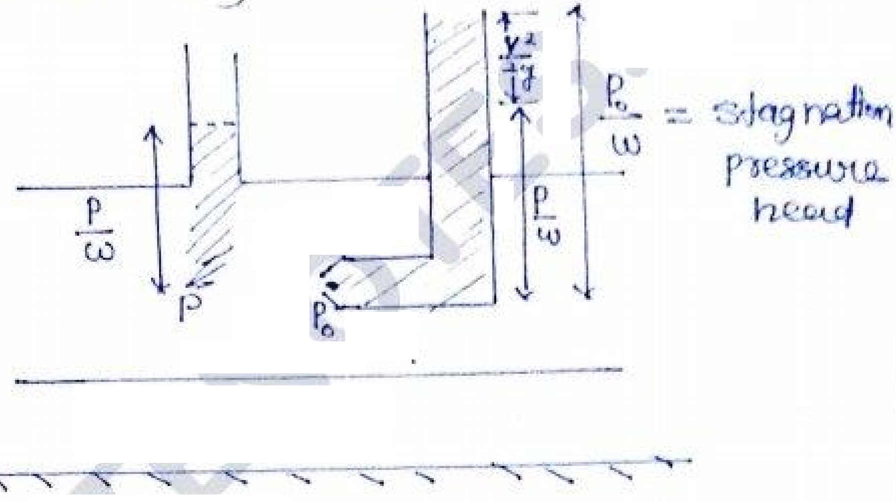
$$h = \left(\frac{\rho_m}{\rho_l} - 1\right) y$$

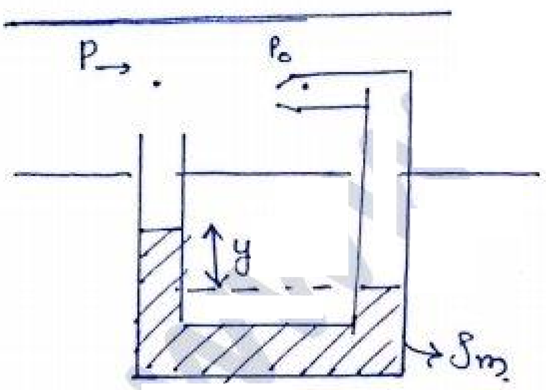
$C_d = 0.12$ to $.74$

Pitot tube:-

It measure local velocity in the flow.
The coefficient of velocity of pitot tube is 0.99.



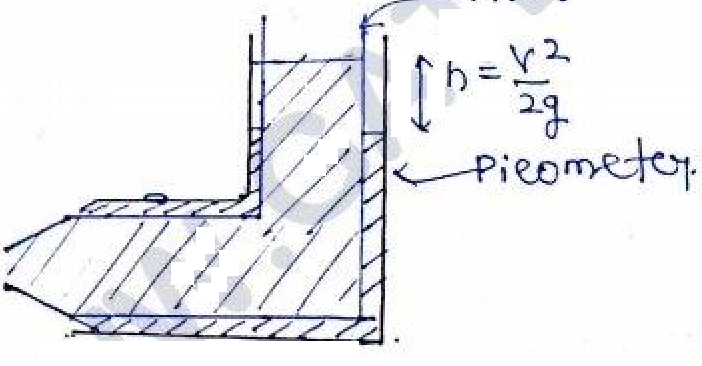




$$V_{th} = \sqrt{2gh}$$

$$V_{act} = C_v\sqrt{2gh}$$

$$h = \left(\frac{S_m}{S_l} - 1\right) y$$



Que When prandtl static tube move across flow the inner tube deflects but when it moves along the flow the outer tube deflects then the type of flow is

(a) U & R

(b) NU & R Ans B

(c) U & IR

(d) NU & IR

Q.16 WB 31

$$h = \left(\frac{\rho_m}{\rho_e} - 1\right) y$$

$$h = \frac{10}{1000}\left(\frac{1000}{1.2} - 1\right)$$

$$h = 8.32\ m$$

$$V = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 8.32}$$

$$V = 12.77\ m/s \text{ Ans}$$

Q.3B

$$h = (10 - 1) \times \frac{10}{1000}$$

$$V = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 0.09} = 1.328$$

Q.34

$C_d = 0.96$

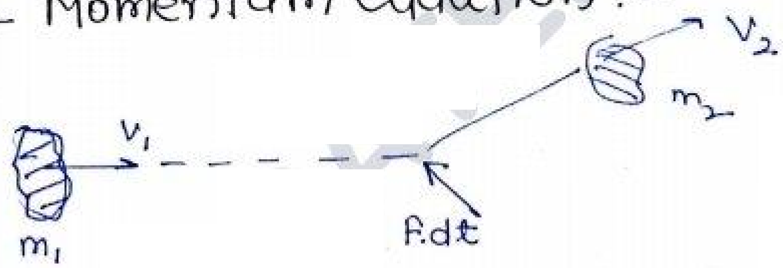
$C = 0.3$

$Q = C_d C \sqrt{h}$

$= 0.96 \times 0.3 \times \sqrt{0.2}$

$Q = 0.12 \ m^3/s$

Impulse- Momentum equation :-

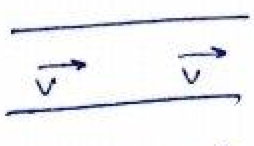


$$F.dt = m_f V_f - m_i V_i$$

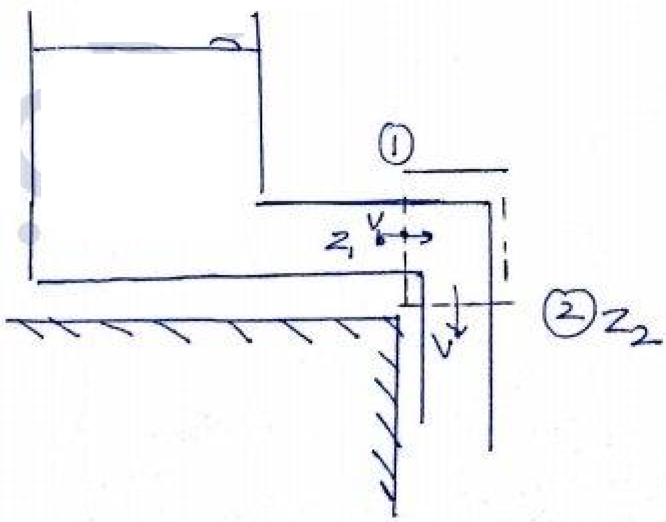
$$F = \frac{d}{dt}\left[m_f V_f - m_i V_i \right]$$

Net Force on body

$$F_{net} = \dot{m}_f V_f - \dot{m}_i V_i$$



V = mag. + dirn



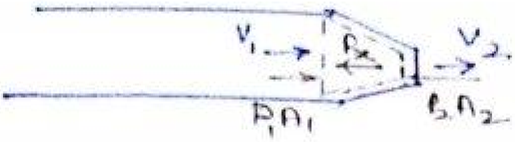
$z_1 = z_2$

$V_1 = V_2$

$P_1 = P_2$

$Q = AV$

*



$\dot{m} = \rho AV$

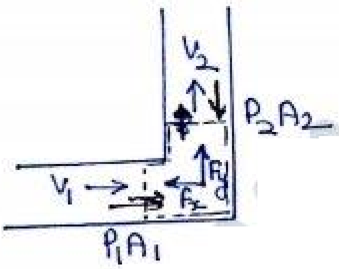
$\dot{m} = \rho Q$

$$\Sigma F_{net_x} = \dot{m}_f V_f - \dot{m}_i V_i$$

$$P_1A_1 - F_x - P_2A_2 = \rho Q V_2 - \rho Q V_1$$

force on the fluid by the bend $\rightarrow$ * $\boxed{F_x = P_1A_1 - P_2A_2 - \rho Q V_2 + \rho Q V_1}$

By the fluid $R = -F_x$



<u>x dirⁿ</u>

$$\Sigma F_{net} = \dot{m}_f V_f - \dot{m}_i V_i$$

$$P_1A_1 - F_x + 0 = \rho Q \times 0 - \rho Q V_1$$

<u>Y dirⁿ</u>

$$\Sigma F_{net} = \dot{m}_f V_f - \dot{m}_i V_i$$

$$F_y - P_2A_2 = \rho Q V_2 - \rho Q \times 0$$

force on the fluid by the bend in x-dirⁿ $\boxed{F_x = P_1A_1 + \rho Q V_1}$

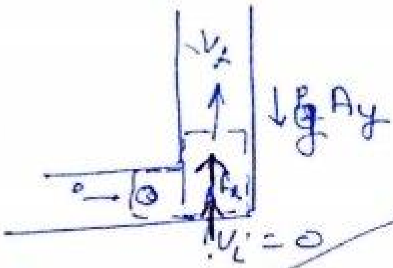
$\boxed{F_y = P_2A_2 + \rho Q V_2}$ in y dirⁿ

$$F_{net} = \sqrt{F_x^2 + F_y^2}$$

$Q = AV$

Q.23

$V = 5\,m/s$



in y dirn

$$F_y - P_y A_y = \rho Q V_2 - \rho Q \cancel{V_1}^{\,0}$$

$$(\Sigma F_{net})_y = \dot{m}_f V_f - \dot{m}_i V_i$$

$$F_y = 4 \times 10^3 \times \frac{\pi}{4}(0.30)^2 + \rho A V^2$$

$$F_y = \frac{\pi}{4}(0.30)^2 \left\{ 4 \times 10^3 + 1000 \times 25 \right\}$$

$$F_y = 2.048\ kN$$ Ans