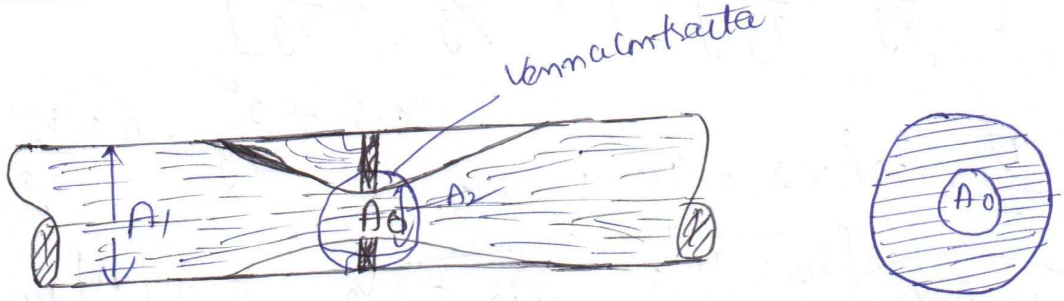
ORIFICE METER :- (to measure flow Rate)



Coefficient discharge $C_D = \underline{0.63}$ $\quad \frac{\pi}{\pi+2}$

→ A_1 = Area of Main pipe

→ A_0 = Area of orifice

→ A_2 = The Minimum Area at Vennacontracta

C_c = Coefficient of Contraction

$$C_c = \frac{A_2}{A_0}$$

$$\boxed{A_2 = A_0 \times C_c}$$

Venturimeter

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

Gate 14 1) The measurement of water flow using a venturimeter with a coefficient of 0.98 and a constant of $0.3\,\frac{m^{2.5}}{sec}$ using mercury as manometric fluid. The difference in pressure head across venturi is estimated as 50 cm of Hg. That the approximate flow rate will be ______

Sol.

$$\boxed{Q = C_d K \sqrt{H}}$$

$C_d = 0.98$

$K = 0.3\,\frac{m^{2.5}}{sec}$

H = pressure head difference = 50 cm of Hg

$g = 9.81$

H = 50 cm of Hg = 0.5 m

(13.6) Specific gravity

$Q = C_d \times K \times \sqrt{h}$

$Q = 0.98 \times 0.3 \times \sqrt{13.6 \times 0.5}$

$= 0.98 \times 0.3 \times 2.607$

$= 0.76\ m^3/sec$

(2) Flow of water through circular pipe measured by using venturimeter with $C_d = 0.98$ it replace an orifice meter with $C_d = 0.63$ for the same flow parameters the ratio of pressure drop across venturi to orifice

$C = \boxed{Q = C_d \cdot K \cdot \sqrt{H}} \rightarrow \Delta p$

Sol: $\rightarrow C_d\,(\text{vent}) = 0.98$

$C_d\,(\text{orifice}) = 0.63$

$\boxed{\dfrac{\Delta p\ \text{vent}}{\Delta p\ \text{orifice}} = ?}$

$\rightarrow \Delta p = \sqrt{H} \rightarrow$ pressure head drop difference

$\rightarrow \sqrt{\Delta p} \propto \dfrac{1}{C_d} \Rightarrow \sqrt{\Delta p} \propto \dfrac{1}{C_d}$

$\Rightarrow \Delta p \propto \dfrac{1}{C_d^2}$

$$\rightarrow \frac{\Delta p\ \text{vent}}{\Delta p\ \text{orifice}} = \frac{\frac{1}{C_d^2}}{\frac{1}{C_d^2}} = \frac{1}{C_{d\,\text{ventur}}^2} \times \frac{C_{d\,\text{orific}}^2}{1} = \frac{(0.63)^2}{(0.98)^2}$$

(3) For flow of water through an inclined pipe (30° inclination with horizontal) of 30 cm dia. was connected by a venturi of 15 cm dia using mercury was manometric fluid with deflection of 50 cm calculate the approximate flow rate considering venturi as 20% of the losses according its kinetic energy.

Sol:

$A_1 = 30\text{ cm dia}$

$A_2 = 15\text{ cm dia}$

30° inclination

$S_m = S_{Hg} = 13.6$

$\rightarrow y = 50\text{ cm}$

$h_l = 20\%$ of K.E of inlet

$0.2 \dfrac{V_1^2}{2g}$

$A_1 = \dfrac{\pi}{4}(30)^2 = \cancel{706.8\ \text{cm}} \Rightarrow \cancel{7.06}\ \text{m}$

$A_2 = \dfrac{\pi}{4}(15)^2 = 1.76\ \text{m}$

Sol:

$$Q = C_d \cdot \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \sqrt{2g\, y\left(\frac{S_m}{S_0} - 1\right)}$$

$d_1 = 30\,CM \rightarrow S_m = S_g = 13.6$ $h_L = 20\%\ 1s.\ E\ 4f$ inlet

$d_2 = 15\,CM \rightarrow y = 50\,CM$ $-\ 0.2\ V^2/2g$

$$A_1 = \frac{\pi \times (0.3)^2}{4} = 0.0707\ m^2$$

$$A_2 = \frac{A_1}{4} = 0.01767\ m^2$$

Take $C_d = 1.0$ (approx) $A_{ct} = 0.96$

$$Q = 1 \times \frac{0.0707 \times 0.01767}{\sqrt{(0.0707)^2 - (0.01767)^2}} \times \sqrt{2 \times 9.81 \times 0.5\left[\frac{13.6}{1.0} - 1\right]}$$

S_0 = water

$\rightarrow Q =$ ~~0.0612 m³/sec~~ $0.202\ m^3/sec$

$$\boxed{E_1 = E_2 + h_{loss}}$$

h_{loss}

$$\left[z_1 + \frac{P}{\rho g} + \frac{V^2}{2g}\right]_1 = \left[z_2 + \frac{P}{\rho g} + \frac{V_2^2}{2g}\right]_2 + 0.2\frac{V_1^2}{2g}$$

$$= \left[z_1 + \frac{P}{\rho g}\right]_1 - \left[z_2 + \frac{P}{\rho g}\right]_2 = \frac{V_2^2}{2g} + 0.2\frac{V_1^2}{2g} - \frac{V_1^2}{2g}$$

Venturi head $= y\left(\frac{S_M}{S_0} - 1\right)$

$$= \underbrace{\left[z_1 + \cancel{\frac{P}{\rho g}}\right] - \left[z_2 + \cancel{\frac{P}{\rho g}}\right]_2}_{H} = \frac{V_2^2}{2g} + 0.2\frac{V_1^2}{2g} - \frac{V_1^2}{2g} = y\left[\frac{S_m}{S_0} - 1\right]$$

$$\frac{V_1^2}{2g}[0.2 - 1]$$

0.8

$$V_2^2 - 0.8V_1^2 = 2gy\left(\frac{S_M}{S_0} - 1\right)$$

$$\left(\frac{Q}{A_2}\right)^2 - \frac{0.8\,Q}{(A_1)^2} = 2gy\left(\frac{S_M}{S_0} - 1\right)$$

$$\sqrt{\frac{2g.y\left[\frac{S_M}{S_0} - 1\right)}{\frac{1}{(A_2^2)} - \frac{0.8}{A_1^2}}} \Rightarrow \sqrt{\frac{0.5\left[\frac{13.6}{1.0} - 1\right]}{\frac{1}{0.01767} - \frac{0.8}{0.0707}}}$$

$$Q = 0.201\ m^3/sec$$

Pitot tube :- (To measure velocity)

Pitot tube measures ?

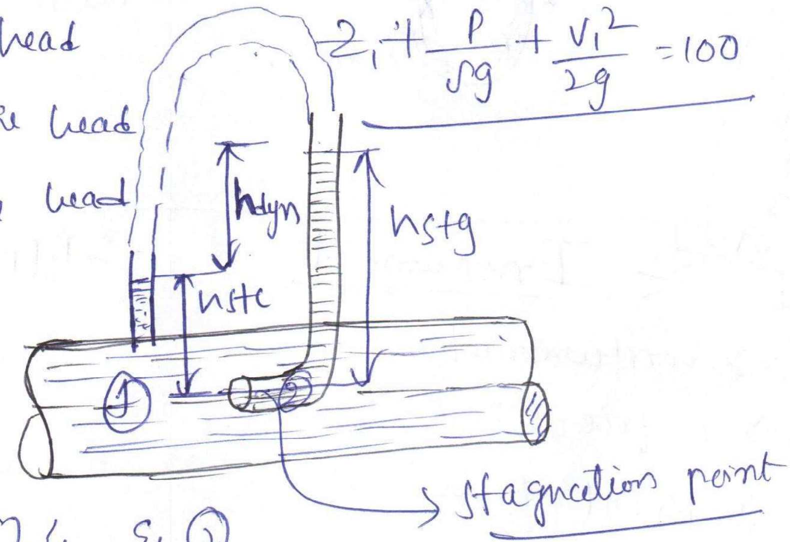
(a) velocity

(b) static pressure head

(c) dynamic pressure head

(d) stagnation pressure head

$$z_1 + \frac{P}{\rho g} + \frac{V_1^2}{2g} = 100$$



→ Apply Ber Eq (1) & Eq (2)

$$\left[z_1 + \frac{P}{\rho g} + \frac{V_1^2}{2g}\right] = \left[z + \frac{P}{\rho g} + \frac{V_2^2}{2g}\right]$$

$$\underbrace{\left[z_1 + \frac{P}{\rho g}\right]}_{h_{static}} + \left[\frac{V_1^2}{2g}\right] = \underbrace{\left[\cancel{z} + \frac{P}{\rho g}\right]}_{h_{stg}} + \cancel{\frac{V_2^2}{2g}} \rightarrow 0\ (stg)$$

$$\frac{V_1^2}{2g} = h_{stg} - h_{stc} = h_{dyn}$$

C_c = Coefficient of Contraction

$$\boxed{V_{1_{Th}} = \sqrt{2g\,h_{dyn}}}$$

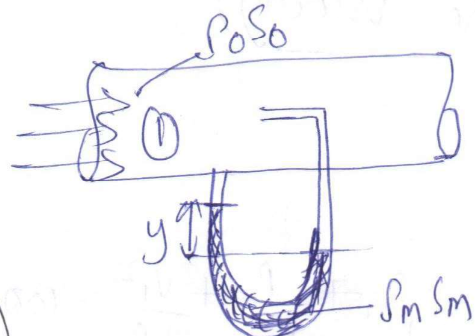
$\rightarrow C_v$ = Coefficient of velocity $= \frac{V_{act}}{V_{the}}$

$\rightarrow V_{act} = C_v \cdot \sqrt{2g\,H_{dyn}}$

$$\boxed{C_D = C_c \times C_v}$$

$$\boxed{h_{dyn} = h_{stg} - h_{stc}}$$

Pitot static tube :- To measure gas velocity — I.C flow $[M < 0.4]$



$$\boxed{V_{act} = C_v\sqrt{2 \cdot g \cdot h_{dyn}} = \sqrt{2g \cdot y\left[\frac{\rho_m}{\rho_0} - 1\right]}}$$

$$h_{dyn} = y\left[\frac{S_m}{S_0} - 1\right] \quad \left(\frac{\rho_m}{\rho_0}\right)$$

$$S = \frac{\rho_{Any}}{\rho^0_{w}}$$

$V = IR$
$R = \frac{\rho L}{A}$
$P = VI$
$H = I^2RT$

→ Instrument	→ Application (To measure)
→ Venturimeter, → Orifice meter	→ Flow Rate ← (ΔP)
→ pitot tube →	→ velocity ← h_{dyn} ← h_{stg}
→ Current meter →	→ velocity
→ Rotameter →	→ Flow Rate
→ Hot wire Anemometer →	Turbulent vel. fluctuations (unsteady flow)
→ Hydrometer →	Relative density [(sp. gravity)] Buoyancy
→ Hygrometer →	Humidity (moisture)

1) For measurement of velocity of air by using pitot static tube with coefficient 0.98. The stagnation pressure head was estimated as 3M at the static pressure 0.5M and then approximate velocity V = ?

$\Rightarrow V = C_v \sqrt{2g\,h_{dyn}}$

Sol Given: $C_v = 0.98$

$h_{stg} = 3.0\,M$

$h_{stc} = 0.5\,M$

$V = ?$

$= 0.98 \sqrt{2 \times 9.81 \times 2.5}$

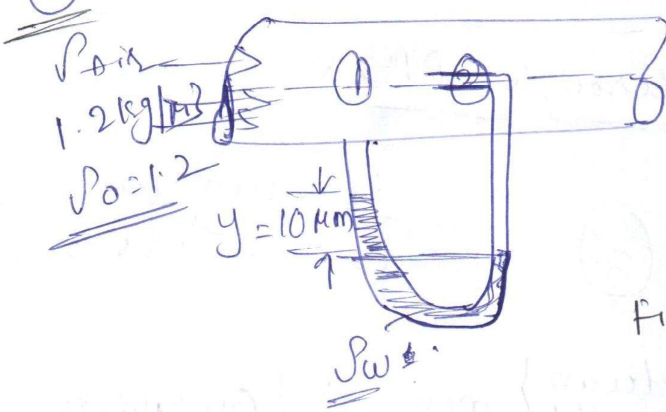
$= 6.8\,m/s$ Ans ✓

$\rightarrow h_{dyn} = h_{stg} - h_{stc}$

$= 3.0 - 0.5$

$= 2.5\,m$ — (h_{dyn}) ✓

2)



V = ?

$$\boxed{V = C_v \sqrt{2g\,h_{dyn}}}$$

Then $C_v = 1.0$

Find $V = C_v \sqrt{2 g y \left(\frac{\rho_M}{\rho_0} - 1\right)}$

$= 1.0 \sqrt{2 \times 9.81 \times 10 \times 10^{-3} \left[\frac{1000}{1.2} - 1\right]}$

$Vel = 12.8\,M/sec$

3) For measurement velocity of Air is density of air 1.2 kg/m³ using pitot static tube with manometric fluid with density 800 m/ static & stagnation estimated the difference 380 pas then the approximate velocity of flow?

$\rho_{air} = 1.2\ kg/m^3$ ✓

$\rho_m = 800\ kg/m^3$

$P_{static} - P_{stg} = \cancel{h_{dyn}} \Rightarrow P_{dyn} = 380\ Pa \cdot N/m^2 \Rightarrow \underline{P_{dyn} = 380\ Pa \cdot N/m^2}$

$\underline{P_{static} - P_{stg} = P_{dyn}}$ $\longrightarrow$ $\underline{Vel = ?}$

$$\boxed{h_{dyn} = \frac{P_{dyn}}{\rho \times g}}$$

$$V = C_V \times \sqrt{2 g\, h_{dyn}}$$

$$V = 1.0 \sqrt{2 \times 9.81 \times \frac{380}{\rho \times g}}$$

$$\boxed{h_{dyn} = \frac{P_{dyn}}{\rho \cdot g}}$$

$$\cancel{h_{dyn}}\quad V = 1.0 \sqrt{2 \times 9.81 \times \frac{380}{\rho_{Air} \times g}}$$

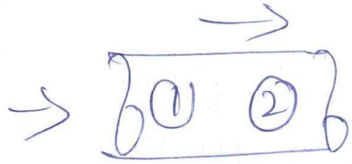
$$V = 1.0 \sqrt{2 \times 9.81 \times \frac{380}{9.81 \times 1.2}} \Rightarrow \underline{V = 26\ m/sec}$$

Flow through pipes

$$\boxed{Re = \frac{F_i}{F_V} = \frac{\rho V L}{\mu}}$$ ... d

$\frac{F_i}{F_V} = \frac{\text{inertia force}}{\text{viscous force}}$

	Circular pipe	Between parallel plates	open channel	Over a sphere / Through soil / Earth
Laminar L	$Re < 2000$ (2300)	$Re < 1000$	$Re < 500$	$Re < 1$
Critical	Re critical			
Transitional	$2000 < Re < 4000$; $2000 < Re < 4000$	$1000 < Re < 2000$	$500 < Re < 1000$	$1 < Re < 2$
Turbulent T	$Re > 4000$	$R > 2000$	$Re > 1000$	$Re > 2$

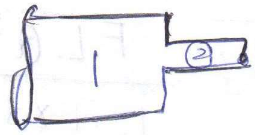


$E_1 = E_2 + h_{loss}$

- → major loss [80–90%] [$h_{friction}$]
- → Minor loss [10–20%] pipe c/s variation, External fitting

→ Minor loss :-

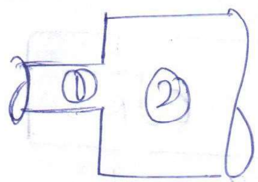
→ (1) h_L sudden contraction :-



If C_c is not given

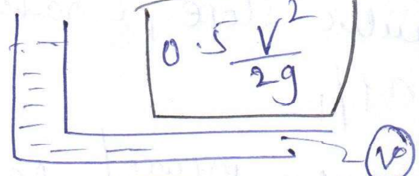
$$\boxed{h_L = \left[\frac{1}{C_c} - 1\right]^2 \frac{V_2^2}{2g}} \approx \frac{0.5 V_2^2}{2g}$$

→ (2) h_L sudden expansion :-



$$\boxed{h_L = \frac{[V_1 - V_2]^2}{2g}}$$

→ (3) h_L entry



$$\boxed{0.5 \frac{V^2}{2g}}$$

k = loss coefficient

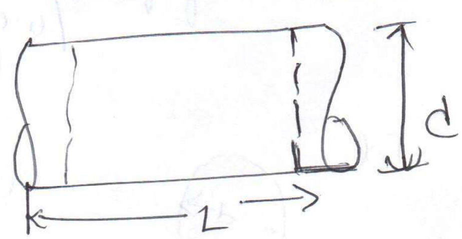
(4) h_L exit

$$\boxed{h_L = \frac{V^2}{2g}}$$

$$\boxed{h_L = k\left(\frac{V^2}{2g}\right)}$$

(1) Friction loss :- (h_f) :-

→ (1) Darcy weisbach's equation :-



$$\boxed{h_f = \frac{4 f L V^2}{2 g d}}$$

f = friction coefficient $= 0.005$ to 0.01

Modiefied Darcy weitchbaule

eq'n $\Rightarrow \boxed{\dfrac{FLV^2}{2gd}}$ $\rightarrow F = 4f =$ friction factor

0.02 to 0.04

$Q = A \cdot V$
$= \dfrac{\pi d^2}{4} \cdot V$

$\rightarrow h_f = \dfrac{F \cdot L \left(\dfrac{Q}{\frac{\pi d^2}{4}}\right)^2}{2 \cdot g d} \Rightarrow \dfrac{F \cdot L \left(\dfrac{Q}{\frac{\pi d^2}{4}}\right)^2}{2 \cdot g \cdot d}$

$\Rightarrow \boxed{\dfrac{FLQ^2}{12.1\, d^5}} \Rightarrow \boxed{h_f = \dfrac{FLQ^2}{12.1 \times d^5}}$

$\rightarrow f = \dfrac{64}{Re} \rightarrow$ laminar $\rightarrow f = \dfrac{0.316}{(Re)^{1/4}} \rightarrow$ turbulent

Chezy's equation:-

$\rightarrow \boxed{V = C\sqrt{mi} = C\sqrt{R \cdot S}}$

$\rightarrow$ where $\rightarrow$ $V =$ velocity [V_{mean}]

$\rightarrow C =$ chezy's Constant $= \sqrt{\dfrac{8g}{F}}$

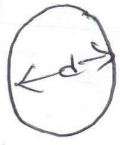
$\rightarrow i(\text{or}) S =$ Hydraulic slope / Gradient $= \dfrac{h_f}{L}$

h_f / L

$m(\text{or}) R -$ Hydraulic mean depth / Radius

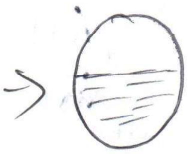
$= A / P$

Area of flow / wetted perimeter

Ex: 

circular pipe running full

$= A/P = \dfrac{\pi d^2/4}{\pi d} = \dfrac{d}{4}$



Circular pipe - Running half full

$$m = A/P = \frac{(\pi d^2/4)/2}{(\pi d/2)} = d/4$$

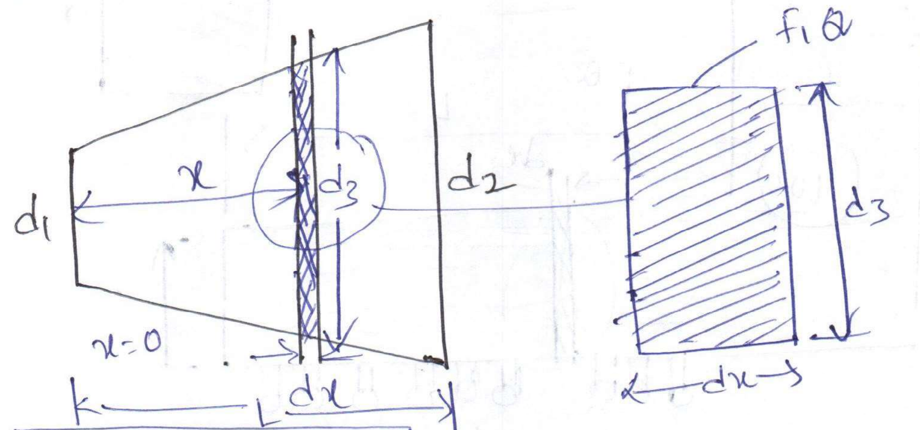
$$\rightarrow V = C\sqrt{mi}$$

$$V^2 = C^2 mi$$

$$V^2 = C^2 \cdot \frac{d}{4} \times \frac{h_f}{L} \Rightarrow \cancel{V^2} = C^2 \cdot \frac{d}{4} \times \frac{F L \cancel{V^2}}{2g \cdot d} \cdot \frac{1}{\cancel{L}}$$

$$\Rightarrow 1 = \frac{C^2 F}{8g} \Rightarrow \boxed{C = \sqrt{8g/F}}$$

Sp. case 1



$$\rightarrow \boxed{h_f = \frac{F L Q^2}{12.1 d^5}}$$

$$h_f = \int d h_f = \int \frac{F (dx) Q^2}{12.1 (d_3)^5}$$

$$\boxed{d_3 = d_1 + \left(\frac{d_2 - d_1}{L}\right) x}$$

$$= \frac{F Q^2}{12.1} \int_{x=0}^{L} \frac{dx}{\left(d_1 + \left(\frac{d_2 - d_0}{L}\right) x\right)}$$

$$h_f = \frac{F Q^2}{12.1 \left[\left(d_1 + \left(\frac{d_2 - d_0}{L}\right)\right)\right]^5} \int_0^L \frac{dx}{x^5}$$

$$h_f = \frac{fQ^2}{12.1\left[d_1 + \left(\frac{d_2 - d_1}{L}\right)\right]^5} \int_{x=0}^{L} \frac{dx}{x^5}$$

$\int x^n dx = \frac{x^{n+1}}{n+1}$

$\int_0^L x^{-5} dx$

$$h_f = \frac{fQ^2}{12.1\left[d_1 + \left(\frac{d_2 - d_1}{L}\right)\right]^5} \left[\frac{-x^{-4}}{4}\right]$$

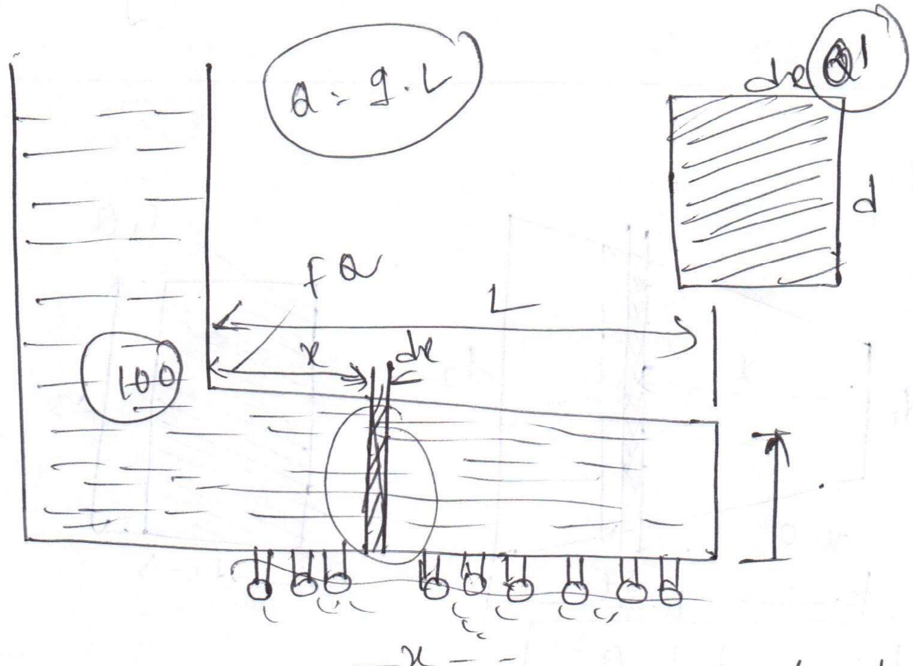
$-5x^{-5+1}$

$\frac{\cancel{-5}x^{-4}}{-\cancel{5}+1} = \frac{x^{-4}}{\cancel{4}}$

$\frac{x^{-5+1}}{-5+1}$

$\frac{x^{-4}}{-4}$

SP1-case 2



→ q = Lateral discharge per unit length

$$\boxed{h_f = \frac{1}{3}\left[\frac{f L Q^2}{12.1\, d^5}\right]}$$

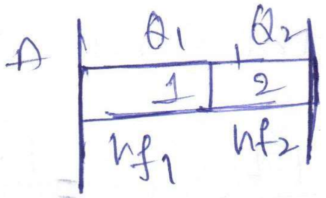
$Q' = Q - q \cdot x$

$Q' = q[L - x]$

$$h_f = \int dh_f = \int \frac{f \cdot (dx)\,(Q')^2}{12.1\; d}$$

$$= \frac{f}{12.1 d} \int_{x=0}^{L} [Q - qx]^2 dx$$

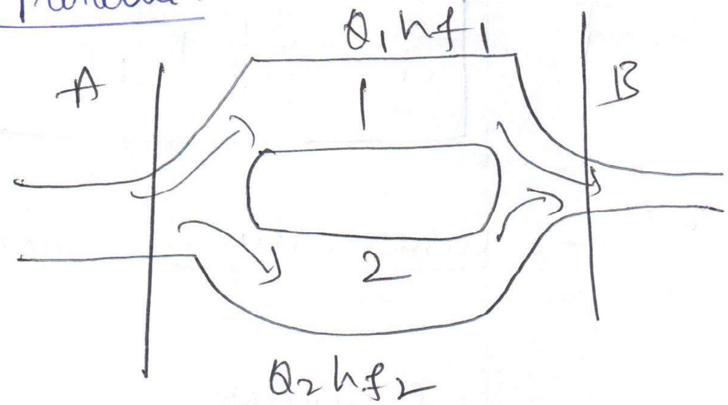
Pipe Connection Series :-



$Q_{AB} = Q_1 = Q_2$

$$\boxed{h_{f\,AB} = h_{f_1} + h_{f_2}}$$

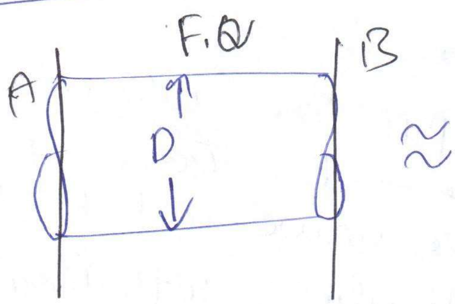
→ parallel :-



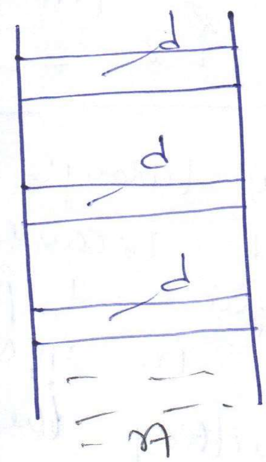
$Q_{AB} = Q_1 + Q_2$

$$h_{f\,AB} = h_{f_1} = h_{f_2}$$

pipes are in Reservoirs : → pipes are in Reservoirs :-



$\approx$



$$\boxed{d = \frac{D}{n^{2/5}}}$$

→ Given head difference

$h_{f\,AB\,Ist} = h_{f\,AB\,IInd}$ → $h_{f\,AB\,Ist} = h_{f\,AB\,IInd}$

$$\frac{\cancel{f} L \cancel{Q^2}}{\cancel{12}.1 D^5} = \frac{\cancel{f} \times L \times (\cancel{Q}/n)^2}{\cancel{12}.1 \times d^5}$$

$$\rightarrow \frac{1}{D^5} = \frac{1}{n^2 d^5} \Rightarrow \boxed{d = \frac{D}{n^{2/5}}}$$