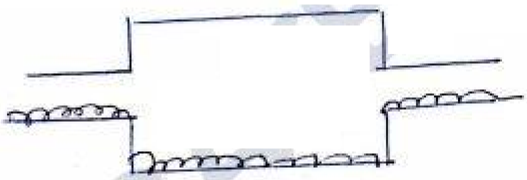
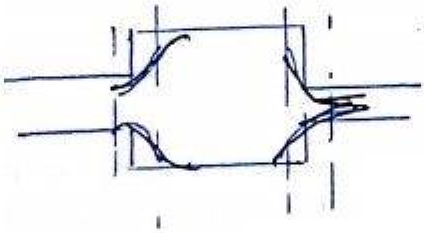
Flow through Pipe

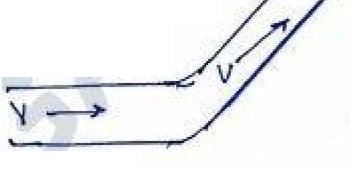
A flow is said to be pipe flow if flow of the
fluid in close ~~in~~ conduit under depth.
There are diff. types of losses flow through pipes

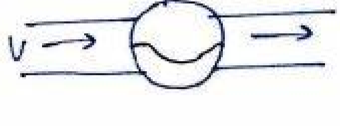
1) Major loss :- These losses are also known as
frictional losses. These losses are due to viscosity
of fluid their mag. is high as well as
occurance is more. It occurs over the entire
length.



2) Minor losses : These are due to change of momentum
of fluid their mag. is less as well as occurance
is less These are also known as variable velocity
loss eg. sudden expansion loss, exit loss,
sudden contraction loss, entrence loss, bend
loss & pipe filling losses etc.







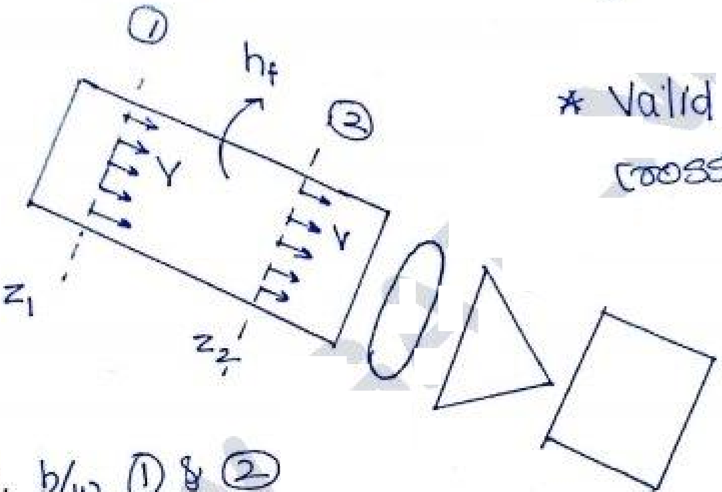
Major losses:- → Darcy's weishbac eqⁿ (pipe flow)
→ chezy's eqⁿ (for open chennel flow)

Darcy's Weishbach eqⁿ:-

Assumption:- (i) Steady flow

(ii) Uniform flow

(iii) Mean Velocity



* Valid for any prismatic cross section

B.E. b/w 1 & 2

$$\frac{P_1}{\omega} + \cancel{\frac{V_1^2}{2g}} + z_1 = \frac{P_2}{\omega} + \cancel{\frac{V_2^2}{2g}} + z_2 + h_f \qquad (V_1 = V_2 = V)$$

$$\left(\frac{P_1}{\omega} + z_1\right) - \left(\frac{P_2}{\omega} + z_2\right) = h_f = \frac{4f'LV^2}{2gD_h}$$

$$\boxed{\left(\frac{P_1}{\omega} + z_1\right) - \left(\frac{P_2}{\omega} + z_2\right) = \frac{fLV^2}{2gD_h}}$$

f' = darcy's friction coefficient

f - friction factor

f' = Fanning friction factor

$$D_h = \frac{4A_{cs}}{P}$$

$$h_f = \frac{fLV^2}{2gD_h} \qquad V = \frac{Q}{\frac{\pi}{4}d^2}$$

$$h_f = \frac{fLQ^2}{\left(2\times 9.81\times\frac{\pi^2}{16}\right)d^4 d}$$

$$\boxed{h_f = \frac{fLQ^2}{12.1d^5}}$$

→ laminar
→ turbulant

Chezy's equation:-

steady flow : Frictional losses

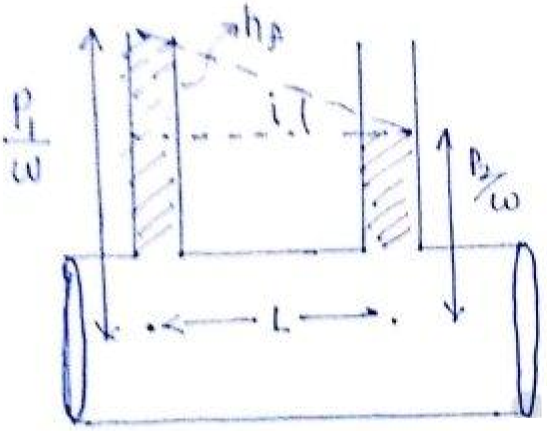
$$\boxed{V = C\sqrt{mi}}$$

C = chezy's coefficient

m = hydraulic mean depth

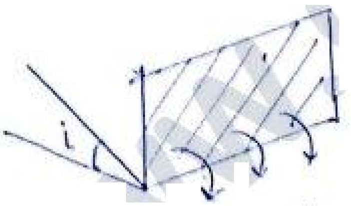
$m = \frac{A_{cs}}{P}$ ← perimeter

i = hydraulic slope.



$$\tan i = \frac{h_f}{L}$$

$$i = \frac{h_f}{L} \quad \text{small angle.}$$



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

$$L_c = \frac{A_{cs}}{P}$$

Q.1
pg 37
WB

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

$$V^2 = C^2 \left(\frac{A_{cs}}{P}\right)\left(\frac{h_f}{L}\right)$$

$$\cancel{V}^2 = C^2 \left(\frac{\cancel{A_{cs}}}{\cancel{P}}\right)\left[\frac{FL\cancel{V}^2}{2g\left(\frac{4A_{cs}}{P}\right) \times L}\right]$$

$$C^2 = \frac{8g}{f} \qquad C = \sqrt{\frac{8g}{F}}$$

Que Find the relationship b/w head loss due to friction and dia. of the pipe for constant discharge through the pipe. if the flow is laminar.

$$h_f = \frac{fLV^2}{2gd} = \frac{fLQ^2}{12.1d^5}$$

laminar $f = \frac{64}{Re} = \frac{64}{\frac{\rho V d}{\mu}} = \frac{64}{\frac{\rho Q \cdot d}{\mu\left(\frac{\pi d^2}{4}\right)}}$

$$f \propto d$$

$$h_f \propto \frac{d}{d^5} \qquad \boxed{h_f \propto \frac{1}{d^4}}$$

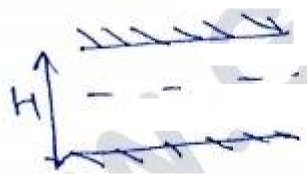
or laminar

$$h_f = \frac{fLV^2}{2gd} \qquad f = \frac{64}{Re}$$

$$h_f = \frac{32\mu VL}{\omega d^2} \qquad V = \frac{Q}{\frac{\pi}{4}d^2}$$

$$h_f = \frac{32\mu Q^2}{\omega d^2\left(\frac{\pi}{4}d\right)^2} = h \propto \frac{1}{d^4}$$

Q.2
Pg 42
WB



$$h_f = \frac{12\mu VL}{\omega H^2}$$

$$V = \frac{Q}{(2h \times 1)}$$

$$h_f = \frac{12\mu VL}{\omega(2h)^2}$$

$$h_f \propto \frac{V}{h^2} \qquad h_f \propto \frac{Q}{h^3}$$

$$\boxed{h_\alpha \propto \frac{1}{h^3}}$$

Imp Relationship b/w shear stress at the wall & friction factor :-

C_{fn} $$\boxed{f' = \frac{\tau_w}{\frac{1}{2}\rho V^2}}$$

$$f = 4f'$$

$$f' = \frac{f}{4}$$

$$\tau_w = \frac{f}{4} \times \frac{1}{2}\rho V^2 \qquad \tau_{wall} = C_{fn} \times \frac{1}{2}\rho U_\infty^2$$

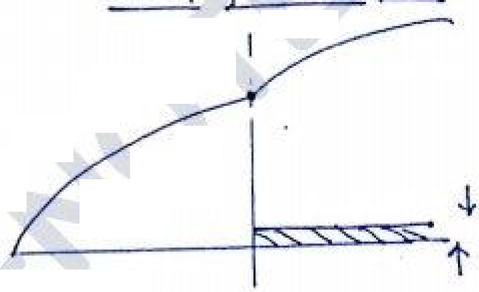
$$\tau_w = \frac{f\rho V^2}{8}$$

$$\frac{\tau_w}{\rho} = \frac{f}{8} \cdot V^2$$

$$\sqrt{\frac{\tau_w}{\rho}} = \sqrt{\frac{f}{8}} \cdot V$$ → mean velocity (m/s)

$$\boxed{V_* = \sqrt{\frac{f}{8}} \cdot V}$$

in pipe flow



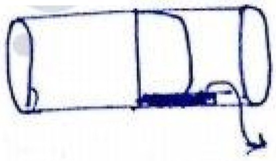
$$\delta' = \frac{11.6\,\nu}{\sqrt{\frac{\tau_0}{\rho}}}$$

* Shear Velocity $\boxed{V_* = \sqrt{\frac{f}{8}} \cdot V}$

or

Friction Velocity.

$$\left(\delta' = \frac{11.6\,\nu}{V_*}\right)$$



$$\delta' = \frac{11.6\,\nu}{V_*}$$

it is a fictitious quantity Representation of variables

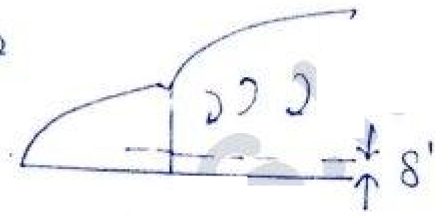
Hydrodynamically smooth and rough surface

Re↓↓

$\downarrow Re = \frac{\rho V L_c}{\mu}$ laminar

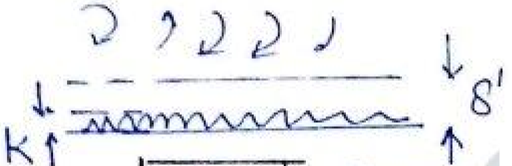
In fully developed turb.

Turb



k = avg. height of roughness.

Smooth



$\boxed{k < \delta'}$ Smooth

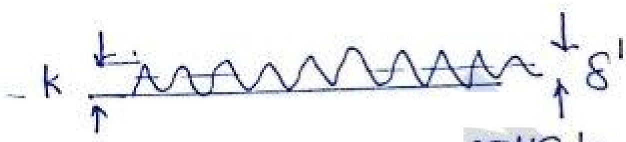
$\frac{k}{\delta'} < \frac{1}{4}$

$\frac{k}{\frac{11.6\nu}{V_*}} < 0.25$

$\boxed{\frac{V_* k}{\nu} < 3}$

Roughness Number

Rough



rough

$|\delta' < k|$

$6 < \frac{k}{\delta'}$

$6 < \frac{k}{\frac{11.6\nu}{V_*}}$

$\boxed{70 < \frac{V_* k}{\nu}}$

* In laminar flow, friction factor doesn't depend on surface roughness.
* In turbulent flow, friction factor depend on surface roughness

Calculation of friction factor (F)

Calculated by 2 Methods.

1. Correlations
2. Experimental charts. (Stanton – Moody chart)

Correlations:-

laminar $\quad Re \leq 2000$

$$\boxed{F = \frac{64}{Re}}$$

Turbulant $\quad 4000 \leq Re$

$F = \phi[Re, K]$

⇒ Smooth $\quad 4000 \leq Re \leq 10^5$

$F = \phi[Re]$

$$\boxed{F = \frac{0.316}{(Re)^{1/4}}}$$

⇒ Rough

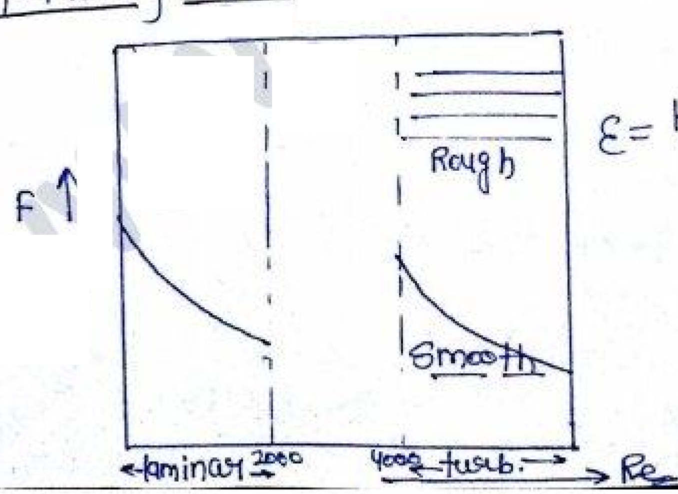
$F = \phi[K]$

$$\boxed{\frac{1}{\sqrt{F}} = 1.74 + 2\log_{10}\left(\frac{R}{K}\right)}$$

R = Radius of pipe

K = avg. height of roughness.

Stanton-Moody Chart:-



$\varepsilon = K/D$ Relative roughness.

Q. 26

$$\delta' = \frac{11.6\,\nu}{\sqrt{\frac{\tau_w}{\rho}}}$$

$$\delta' = \frac{11.6 \times 10^{-6}}{\sqrt{\frac{600}{1000}}}$$

$K_s = 0.12$ mm

$k_s = 0.12 \times 10^{-3}$ m

~~$\delta' = 14.96$~~

$$\frac{k_s}{\delta'} = \frac{0.12 \times 10^{-3}}{\frac{11.6 \times 10^{-6}}{\sqrt{\frac{600}{1000}}}} \approx 8$$

$6 < \frac{k_s}{\delta'}$ Rough surface.

Q. A roughpipe of Dia 0.1m carries water at 20°C at the rate of 50 lit/s if the avg heigh of roughness projection is 0.15 mm Determine. (i) friction factor

(ii) shear stress at the surface

(iii) sheal velocity

(iv) max velocity

take water at 20°C $\nu = 10^{-6}$ m²/s

$\rho = 1000$ kg/m³

Soln $K = 0.15$ mm $Q = \dot{m} = 50 \times 10^{-3}$ m³/s.

$Q = AV$

$50 \times 10^{-3} = \frac{\pi}{4}(0.1)^2 \times v$. $V = 6.36$ m/s

$$Re = \frac{\rho V D}{\mu} \qquad Re = \frac{\rho V D}{\mu} = \frac{VD}{\upsilon}$$

$$\cancel{Re = \frac{VD}{\upsilon}}$$

$$\cancel{Re = \frac{50\times10^{-3}}{\frac{\pi}{4}(0.1)^2}\times\frac{0.1}{10^{-6}}}$$

$$Re = \frac{50\times10^{-3}}{\frac{\pi}{4}(0.1)^2}\times\frac{0.1}{10^{-6}}$$

$$Re = 6.36\times10^{5}$$

flow is turbulant ≥ 4000

$$\cancel{f = \frac{64}{}}$$

$$\frac{1}{\sqrt{F}} = 1.74 + 2\log_{10}\left(\frac{R}{K}\right)$$

$$= 1.74 + 2\log_{10}\left(\frac{0.1\times1000}{2\times0.45}\right)$$

$$\cancel{\frac{1}{\sqrt{F}} = 0.46.0046} \qquad \cancel{F = 0.02100}$$

$$\cancel{F = 0.0036} \qquad \frac{1}{\sqrt{F}} =$$

(i) $F = 0.0217$

(ii) $\tau_{wall} = ?$ $\quad F' = \frac{\tau_w}{\frac{1}{2}\rho V^2}$

$$\tau_w = \frac{F}{8}\rho V^2 = \frac{0.0217\times1000\times6.36^2}{8}$$

$$\tau_w = 109.9\ N/m^2$$

(iii) $= V_f^{+} = \sqrt{\frac{\tau_w}{\rho}} = \sqrt{\frac{109.9}{1000}} = 0.3315\ m/s^2$

(iv) For turbulant Pipe flow.

~~Imp~~

$$\boxed{\frac{U_{max}}{U_{mean}} = 1 + 1.33\sqrt{F}}$$ → For turbulant ~~and laminar~~ Valid for Rough and smooth.

$$\frac{U_{max}}{6.36} = 1 + 1.33\sqrt{0.0217}$$

$$U_{max} = 7.6 \text{ m/s}$$

or $U_{max} = 0.82\, U_{mean}$ in turbulant

$$U_{mean} = \frac{6.36}{0.82} = 7.7 \text{ m/s}$$

Q.23 / Pg.45 / WB

$$V_{mean} = 2.6 \text{ m/s.}$$

$$V_{max} = 3.17 \text{ m/s.}$$

For laminar

$$U_m = \frac{U_{max}}{2} = \frac{3.1\cancel{7}}{2} = 1.52 \text{ m/s}$$

So flow is turbulant

For turb.

$$U_{\cancel{max}\ mean} = 0.82 \times 3.17$$

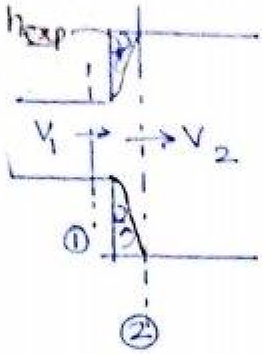
$$U_{\cancel{max}\ mea} = 2.6$$

$$\frac{3.17}{2.6} = 1 + 1.33\sqrt{F}$$

$$F = 0.027$$

Minor losses:

① sudden expansion losse :-



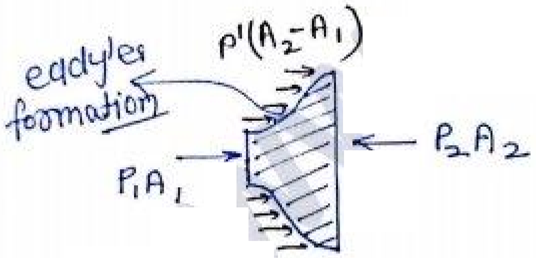
B.E. ① & ②

energy eqⁿ → $\frac{P_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + z_2 + h_{exp.}$

$\{z_1 = z_2\}$ in any orientation

$$h_{exp.} = \left(\frac{P_1}{w} - \frac{P_2}{w}\right) + \left[\frac{V_1^2 - V_2^2}{2g}\right] \quad -(i)$$

momentum eqⁿ



Assumption

$P_1 \simeq P'$ ⇒ experimently.

$P_1A_1 + P'(A_2 - A_1) - P_2A_2 = -\dot{m}V_2 + \dot{m}V_1$

$\cancel{P_1A_1} + P_1A_2 - \cancel{P_1A_1} - P_2A_2 = \dot{m}(V_1 - V_2)$

$$(P_1 - P_2)A_2 = -\rho A_2V_2^2 + \rho A_1V_1^2$$

$\dot{m} = \rho AV$

$$P_1 - P_2 = \rho \frac{A_1}{A_2}V_1^2 - \rho V_2^2$$

$A_1V_1 = A_2V_2$

$\frac{A_1}{A_2} = \frac{V_2}{V_1}$

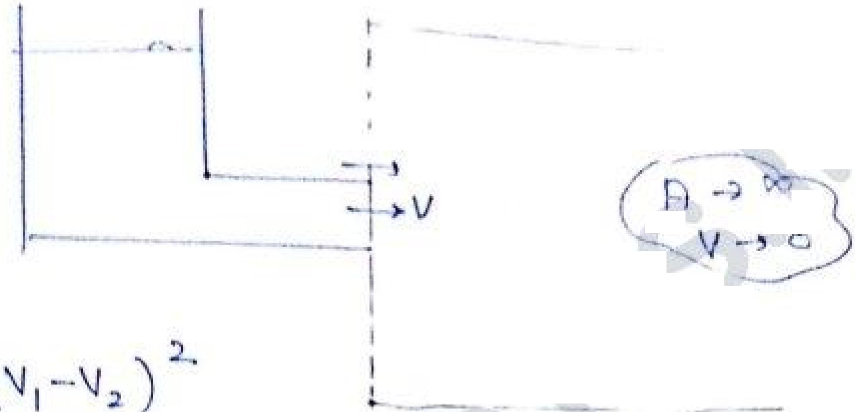
$$\frac{P_1}{w} - \frac{P_2}{w} = \rho\frac{V_2V_1 - V_2^2}{g} \quad -(ii)$$

(i) & ②

$$h_{exp} = \frac{2(V_2V_1 - V_2^2)}{2g} + \frac{V_1^2 - V_2^2}{2g}$$

$$\boxed{h_{exp} = \frac{(V_1 - V_2)^2}{2g}}$$

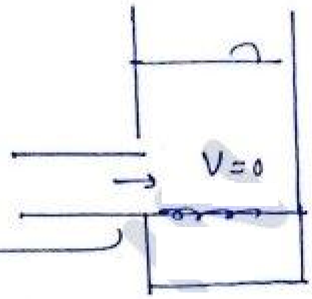
② Exit loss:-



$$h_{exit} = \frac{(V_1 - V_2)^2}{2g}$$

$V_2 \to 0$

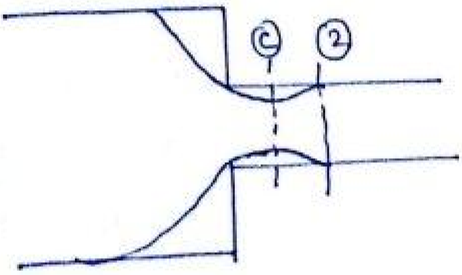
$$\boxed{h_{exit} = \frac{V^2}{2g}}$$



$$h_{exit} = \frac{V^2}{2g}.$$

Fluid Coming in reservoir.

③ sudden contraction loss.



$$h_{cont} = \frac{(V_c - V_2)^2}{2g}$$

$$h_{cond} = \frac{V_2^2}{2g}\left[\frac{A_2}{A_c} - 1\right]$$

$$\boxed{C_c = \frac{A_c}{A_2}}$$

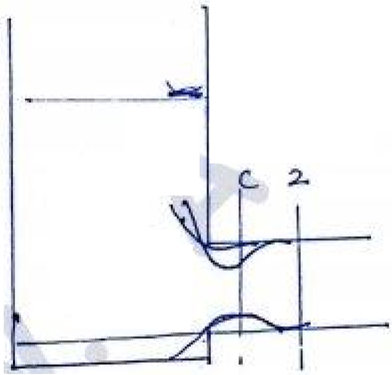
$$h_{cont} = \frac{V_2^2}{2g}\left[\frac{1}{C_c} - 1\right]^2$$

C_c not Given.

$$\left[\frac{1}{C_c}-1\right]^2 \simeq 0.5$$

$$\boxed{h_{cont} = 0.5\frac{V_2^2}{2g}}$$

(4) Entrance loss

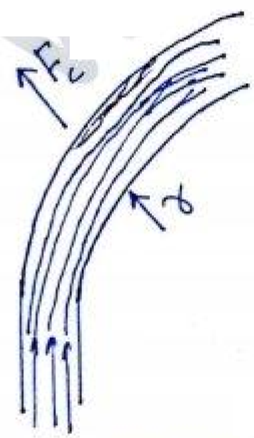


$$\boxed{h_{ent} = \frac{0.5V^2}{2g}}$$

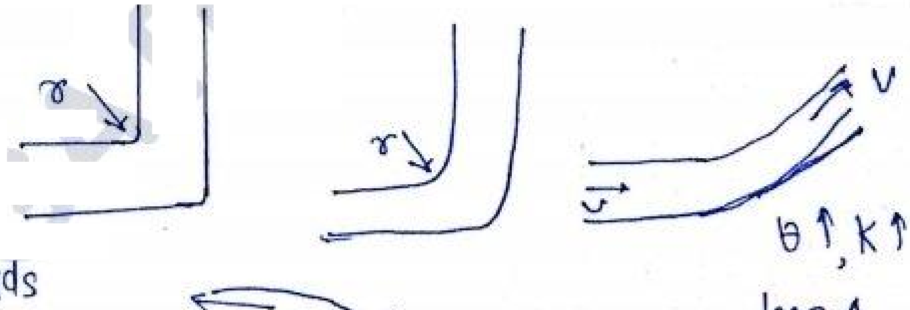
(5) Bend loss :-

$$\boxed{h_{bend} = \frac{kV^2}{2g}}$$

k = bend Coefficient.



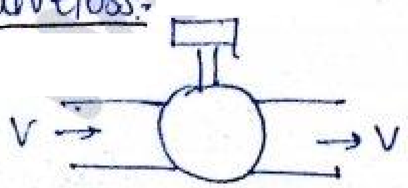
* streamline Converge towards centre on bend



θ↑, k↑

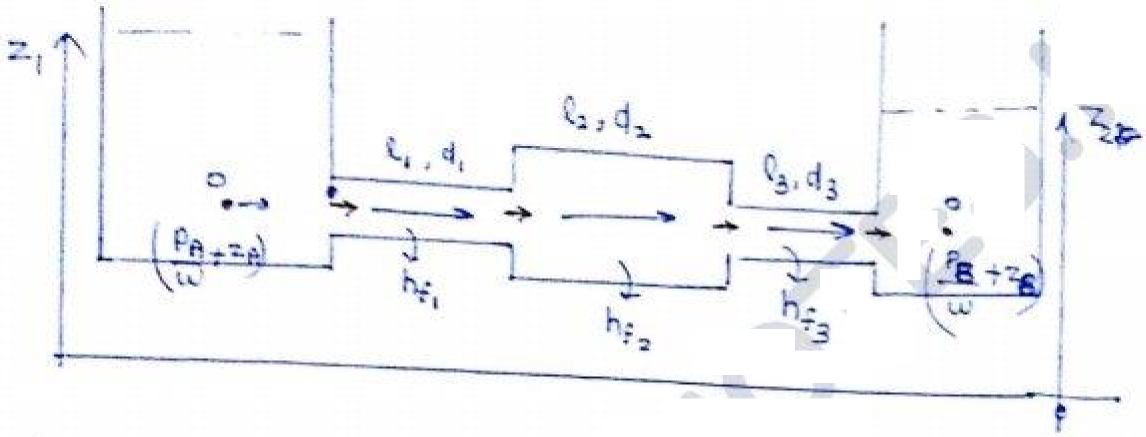
loss ↑

(6) Valveloss:-



$$\boxed{h_{valve} = \frac{kV^2}{2g}}$$

* losses



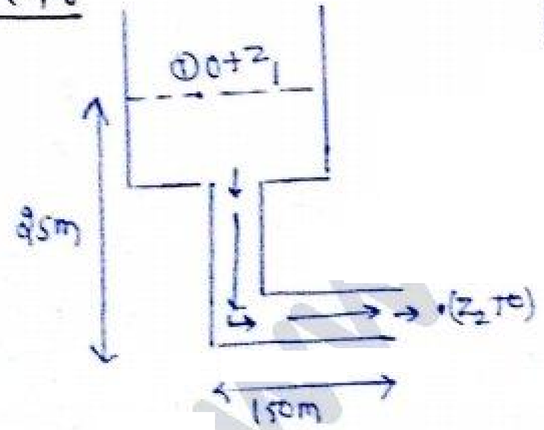
$$\left(\frac{P_A}{w}+z_A\right)-\left(\frac{P_B}{w}+z_B\right) = \text{loss.}$$

$$= \frac{0.5V_1^2}{2g} + h_{f_1} + \frac{(V_1-V_2)^2}{2g} + h_{f_2} + \frac{0.5V_3^2}{2g} + h_{f_3} + \frac{V_3^2}{2g}$$

$$\left(\frac{P_A}{w}+z_A\right)-\left(\frac{P_B}{w}+z_B\right) = h_{f_1}+h_{f_2}+h_{f_3}$$ if minor loss neglected.

$$\boxed{z_1 - z_2 = h_{f_1}+h_{f_2}+h_{f_3}}$$

Q.18



$$(0+z_1)-(0+z_2) = \text{loss}$$

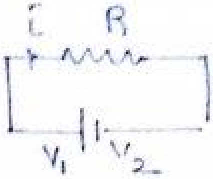
$$= \cancel{\frac{0.5v^2}{2g}} + \frac{fL_1Q^2}{12.1d^5} + \cancel{\frac{kv^2}{2g}} + \frac{fL_2Q^2}{12.1d^5} + \cancel{\frac{v^2}{2g}}$$

$$z_1 - z_2 = \frac{f(L_1+L_2)Q^2}{12.1d^5}$$

$$25 = \frac{0.03(175)Q^2}{12.5(0.100)^5}$$

$$Q = 24 \text{ lit/sec.}$$

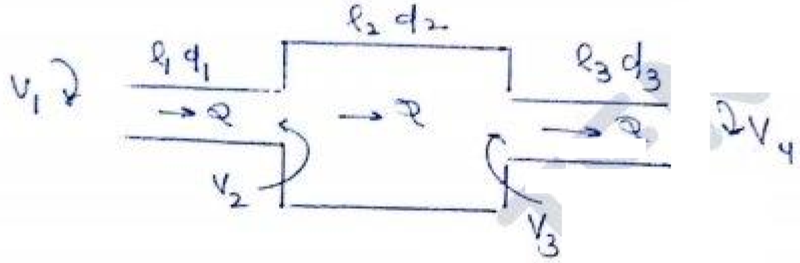
Compound pipes :-



$$V_1 - V_2 = iR$$

$$\left(\frac{P_A}{w} + Z_A\right) - \left(\frac{P_B}{\rho w} + Z_B\right) = h_f$$

① Series connection :-



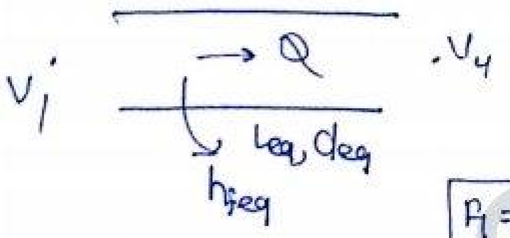
Assume : minor losses are neglected.

$$Q_1 = Q_2 = Q_3 = Q \quad \text{—(i)}$$

$$(V_1 - V_4) = (V_1 - V_2) + (V_2 - V_3) + (V_3 - V_4) \quad \{\text{potential diff}\}$$

$$h_{feq} = h_{f_1} + h_{f_2} + h_{f_3} \quad \text{— ②}$$

by solving ① & ②



$$V_1 - V_4 = h_{feq}.$$

$$= \frac{f L_{eq} Q^2}{12.1\, d_{eq}^5}$$

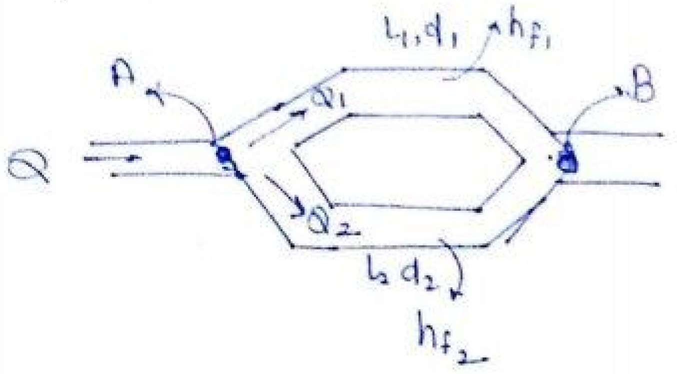
$\boxed{f_1 = f_2 - - = f_n}$

Assume

$$\Rightarrow \frac{f L_{eq} Q^2}{12.1\, d_{eq}^5} = \frac{f_1 L_1 Q^2}{12.1\, d_1^5} + \frac{f_2 L_2 Q^2}{12.1\, d_2^5} + \cdots$$

$$\boxed{\frac{L_{eq}}{d_{eq}^5} = \frac{L_1}{d_1^5} + \frac{L_2}{d_2^5} \cdots}$$ Dupuit's equation

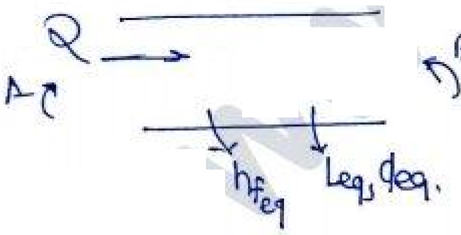
② parallel Connection:-



$$Q = Q_1 + Q_2 \quad -①$$

pipe ① $\left(\frac{P_A}{w} + z_A\right) - \left(\frac{P_B}{\rho w} + z_B\right) = h_{f_1}$

pipe ② $\left(\frac{P_A}{w} + z_A\right) - \left(\frac{P_B}{w} + z_B\right) = h_{f_2}$



$\left(\frac{P_A}{w} + z_A\right) - \left(\frac{P_B}{w} + z_B\right) = h_{f_{eq}}$

$$h_{eq} = h_{f_1} + h_{f_2} \quad -②$$

$$\frac{f L_{eq} Q^2}{12.1 d_{eq}^5} = \frac{f L_1 Q_1^2}{12.1 d_1^5} + \frac{f L_2 Q_2^2}{12.1 d_2^5} - - -$$

$$\boxed{\frac{d_{eq}^{5/2}}{L_{eq}^{1/2}} = \frac{d_1^{5/2}}{L_1^{1/2}} + \frac{d_2^{5/2}}{L_2^{1/2}} + - - -}$$

if $L_{eq} = L_1 = L_2 = L_3$ - - -

$d_1 = d_2 = d_3$ - - -

$$\frac{d_{eq}^{5/2}}{L_{eq}^{1/2}} = n \frac{d^{5/2}}{L^{1/2}}$$

$$\boxed{d_{eq} = (n)^{2/5} d}$$

eg

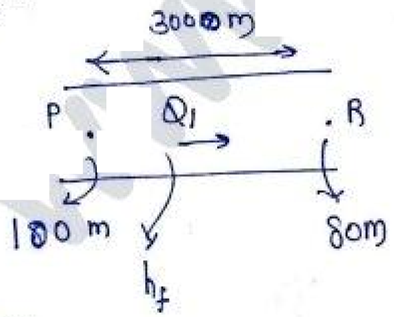
$n=3$

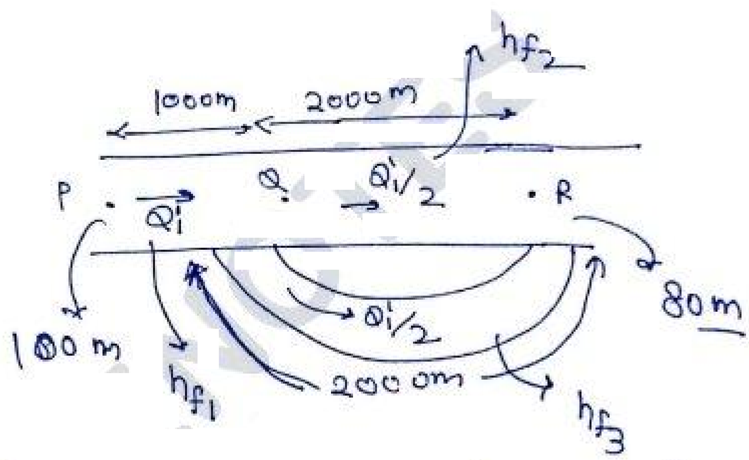
$d_{eq} = (9)^{1/5} d$

$d_{eq} = 1.55\, d$

Note:-

Q.19
P.9.39
WB





$F = 0.04$

$$100 - 80 = \frac{0.04 \times 3000 \times Q_1^2}{12.1 \times 0.3^5}$$

$Q_1 = 0.0700$

$100 - 80 = h_{f_1} + (h_{f_3} = h_{f_2})$

$$100 - 80 = \frac{0.04(1000)Q_1'^2}{12.1(0.3)^5} + \frac{0.04(2000)(\frac{Q_1'}{2})^2}{12.1(0.3)^5}$$

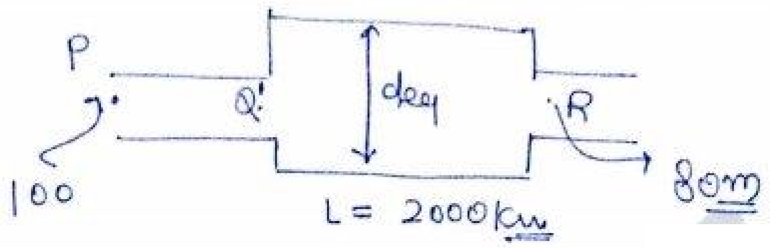
$Q_1 = 0.099$

$$\text{increase} = \frac{Q_1' - Q_1}{Q_1} \times 100$$

$$= \frac{0.099 - 0.700}{0.700} \times 100$$

$= 41\%$

or



$$d_{eq} = (n)^{2/5} d$$

$$d_{eq} = (2)^{2/5} \times 0.3$$

$$100 - 80 = \frac{0.04 \times 1000 \times (Q')^2}{12.1\,(0.3)^5} + \frac{0.04 \times 2000 \times (Q')^2}{12.1\,(2)^2 (0.3)^5}$$

$$\frac{20 \times 12.1 \times (0.3)^5}{0.04 \times 1000} = (Q_1')^2 + \frac{(Q')^2}{2} = \frac{3}{2} Q_1'^2$$

$$3Q^2 = \frac{3}{2} Q_1'^2$$

$$Q_1' = 0.099$$

$$\underline{\sqrt{2}\,Q = Q'}$$

Q.20

$$20 = \frac{f \times 1000 \times Q_1'^2}{(12.1)d^5} + \frac{f \times 2000 \times Q_1'^2}{12.1\,(n)^{2}\,d^5}$$

$$n \to \infty$$

$$20 = \frac{0.04 \times 1000 \times Q_1'^2}{12.1\,(0.3)^5}$$

$$Q_1' = 0.1212$$

$$\% = \frac{0.1212 - 0.0700}{0.0700} \times 100 = \simeq 73\%$$

$$100-80 = h_f = \frac{fLQ^2}{12.1 d^5}$$

$Q^2 L \rightarrow$ Const

$$Q_1^2 L_1 = Q_2^2 L_2$$

$L_1/L_2 = 3 = \frac{3\,\text{km}}{1\,\text{km}}$

$$Q_1^2 \times 3 = Q_2^2$$

$$\underline{\underline{Q_2 = \sqrt{3}\, Q_1}}$$

Q

Water Power or Power to overcome the friction loss:-

$$\text{Power} = F \times V$$

$$= P \times (A \times V)$$

$$= P \times Q$$

$$\text{Power} = wh \times Q$$

$$\boxed{\text{Power} = wQh}$$

Steady flow

$$\left(\frac{P_A}{w} + z_A\right) - \left(\frac{P_B}{w} + z_B\right) = h_f$$

$$H = h_f$$

$$\boxed{\text{Power} = wQh_f}$$

Q.14

P.943

WB

Q_1

$Q_2 = 1.2 Q_1$

$P \propto Q h_f$

$h_f = \frac{f L Q^2}{}$

$h_f = \frac{32 \mu Q L}{w\left(\frac{\pi}{4}d^2\right) \cdot d^2}$

$h_f \propto Q$

$\text{Power} \propto Q^2$

Q $\frac{P_2 - P_1}{P_1} \% = ?$

$\frac{1.44 Q_1^2 - Q_1^2}{Q^2} \times 100 = 44\ \%.$

Q.

Total Energy line / Hydraulic energy line :-

$$\text{Total energy line (T.E.L.)} = \left(\frac{P}{w} + Z\right) + \frac{V^2}{2g}$$ locus of total energy head along the flow.

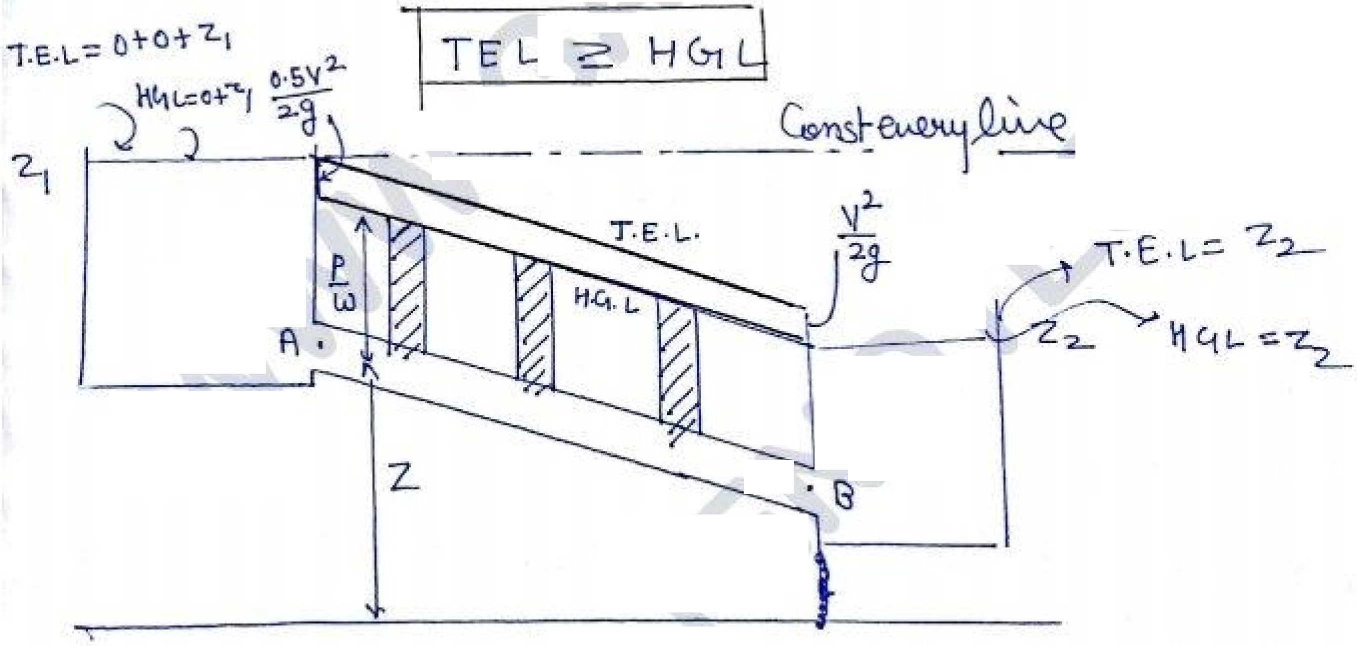
$$\text{Hydraulic energy line (HGL)} = \left(\frac{P}{w} + Z\right)$$ locus of piezometric head along the flow

to determine dirn of flow

$$T.E.L - HGL = \frac{V^2}{2g}$$

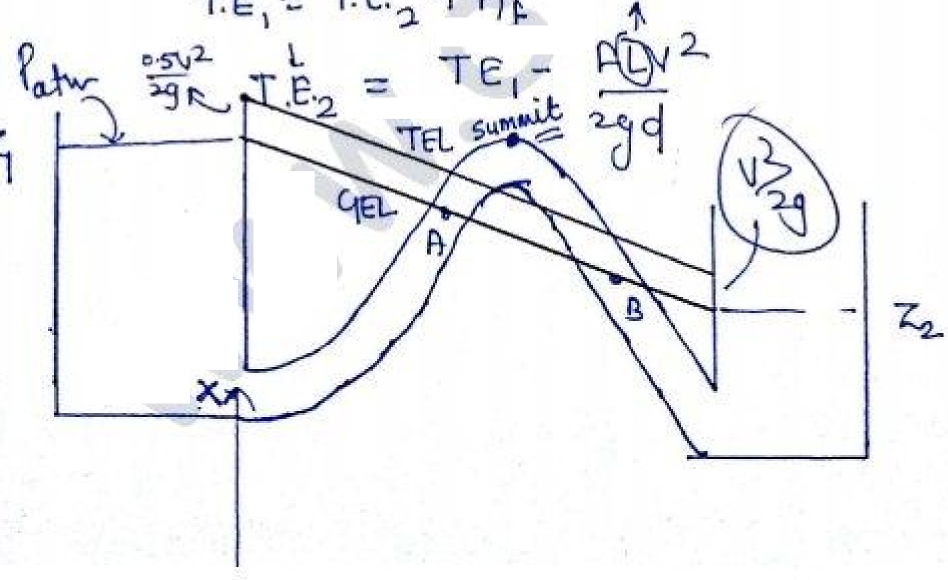
$$TEL - HGL \geq 0 \qquad V \geq 0$$

$$\boxed{TEL \geq HGL}$$

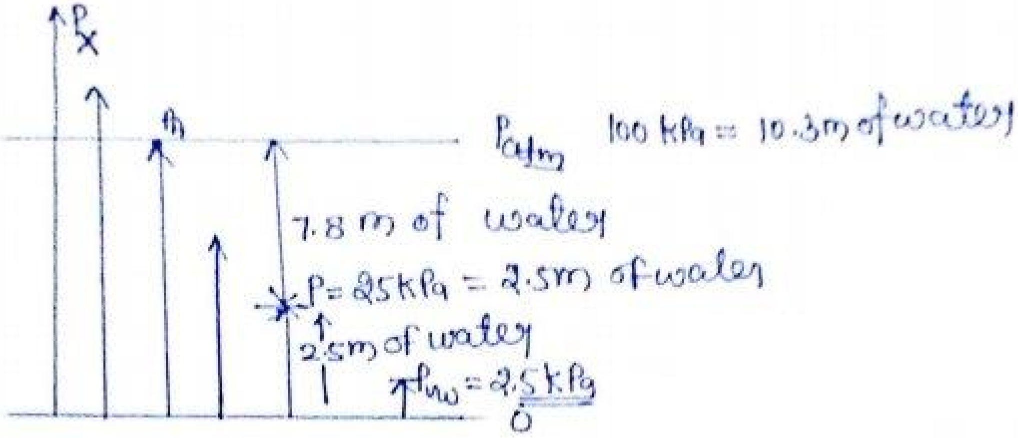


$$T.E_1 = T.E_2 + h_f$$

$$T.E_2 = TE_1 - \frac{fLV^2}{2gd}$$



$$P_A = P_B = P_{atm}$$



* if HGL coincides with pipe line ($P = P_{atm}$) then flow is called open chennel flow

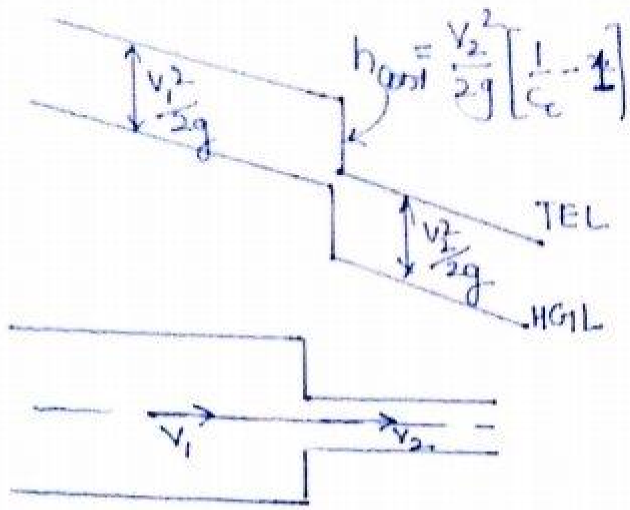
* Height of Summit from HGL can be max^m 7.8 m of water.

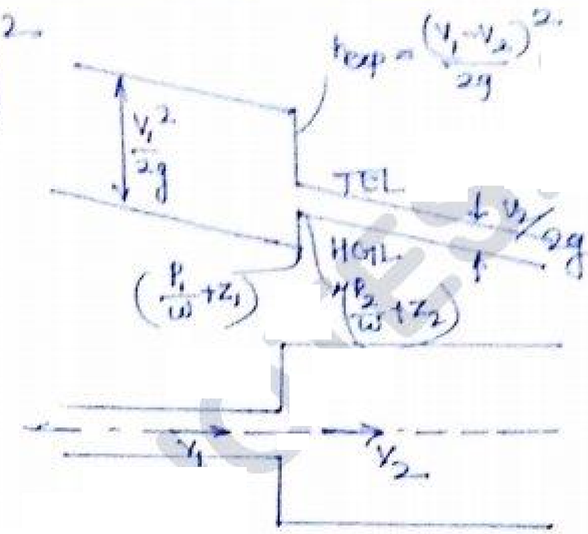
***Note**

* When HGL is above the pipe line, pipe is in positive gauge when concides, pipe is at atmospheric pressure when below pipe is in -ve gauge

* For uniform dia pipe the HGL and TEL are always parallel.

TEL and HGL for sudden Contraction and Sudden expn





$$TEL = \left(\frac{P}{w} + z\right) + \frac{V^2}{2g} + h_{const} \uparrow\uparrow \qquad TEL = \left(\frac{P}{w} + z\right) + \frac{V^2}{2g} + h_{exp} \uparrow$$

$$HGL = \left(\frac{P}{w} + z\right) \qquad HGL = \left(\frac{P}{w} + z\right)$$

$$\boxed{TEL - HGL = \frac{V^2}{2g}}$$

* HGL can rise or fall along the flow but TEL can not rise unless there is some external energy input.

Que A a sudden expansion of a water pipe line from a dia of 0.24 m to 0.48 m the HGL rises by 10mm then find the discharge.

Sol^n

$$\frac{(V_1 - V_2)^2}{2g} = 10 \times 10^{-3}$$

$$(V_1 - V_2)^2 = 2 \times 9.81 \times 10 \times 10^{-3}$$

$$=$$

$A_1 V_1 = A_2 V_2$

$$\frac{(V_1-V_2)^2}{2g} = \underline{10\times10^{-3}}$$

$$A_1V_1 = A_2V_2$$

$$d_1^2 V_1 = d_2^2 V_2$$

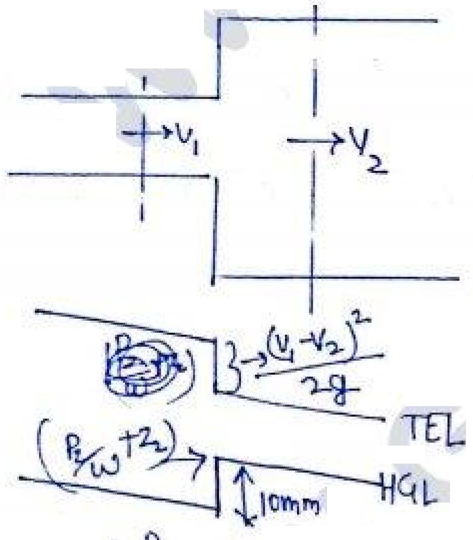
$$V_1 = 4V_2$$

$$\frac{(4V_2-V_2)^2}{2g} = 10\times10^{-3}$$

$$\frac{9V_2^2}{2g} = 10\times10^{-3}$$

$$V_2 = \sqrt{\frac{2g}{9}}\times\frac{1}{10}$$

$$Q = A_2V_2 = \frac{\pi}{4}(0.48)^2\sqrt{\frac{2\times9.81}{9}}\times\frac{1}{10}$$



~~B.E. (1) & (2)~~

$$\left(\frac{P_2}{w}+z_2\right)-\left(\frac{P_1}{w}+z_1\right) = 10 \text{ mm}$$

BE (1) & (2)

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

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

9

$$\frac{V_1^2}{2g}\left(1-\frac{V_2^2}{V_1^2}\right)-\frac{V_1^2}{2g}\left(1-\frac{V_2}{V_1}\right)^2 = 10\times10^{-3}$$

$$\frac{6 V_2^2}{2g} = 10 \times 10^{-3}$$

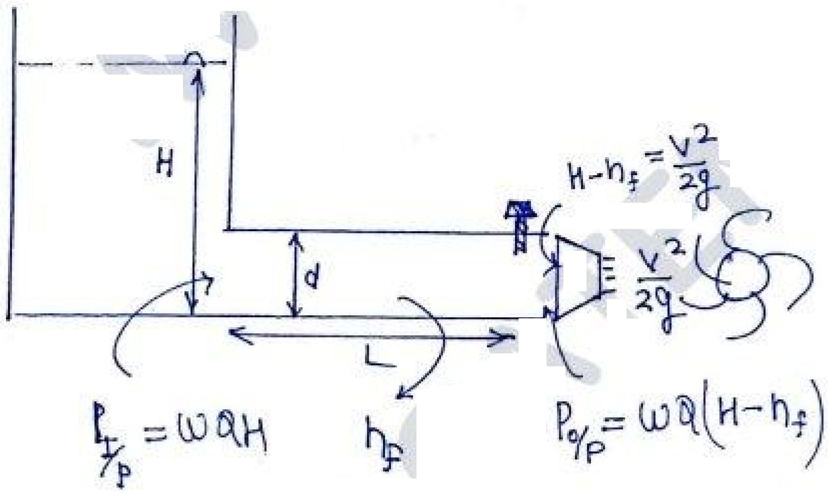
$$V_2 = \frac{1}{10}\sqrt{\frac{g}{3}}$$

$$Q = AV = \frac{\pi}{4}(0.48)^2 \times \frac{1}{10}\sqrt{g/3}$$

$$Q = 0.0327 \ m^3/s$$

Note When fluid flow in sudden expansion max^m pressure rise for given discharge is obtain by $\boxed{D = \sqrt{2}\,d}$

Power transmission through Pipe:-



$$\text{Power transmission} = wQ(H - h_f)$$

$$P = w\left[HQ - \frac{fLQ^3}{2gd}\right]$$

$$H = \text{Const}$$

Max power $\dfrac{dP}{dQ} = 0$

$$0 = w\left[H - \frac{3FLQ^2}{12.1d^5}\right]$$

$$H - 3h_f = 0$$

max power. $\boxed{h_f = \frac{H}{3}}$

$$P_{max} = wQ\left(H - \frac{H}{3}\right)$$

$$\boxed{P_{max} = \frac{2}{3}wQH}$$

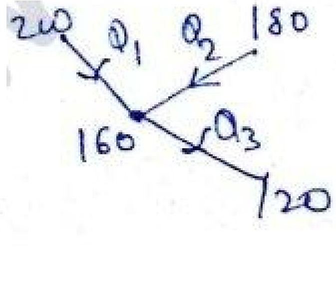
$$\eta = \frac{P_{o/p}}{P_{i/p}} = \frac{wQ(H-h_f)}{wQH}$$

$$\eta = \frac{H-h_f}{H} = \frac{H - H/3}{H}$$

$$\boxed{\eta_{max} = 66.66\%}$$

Chap 6 Pag Q.40 Q.6

Q.16 a Piezometer is decide at junction to decide dirn of flow



Flow → High to low

$$Q_3 = Q_1 + Q_2$$

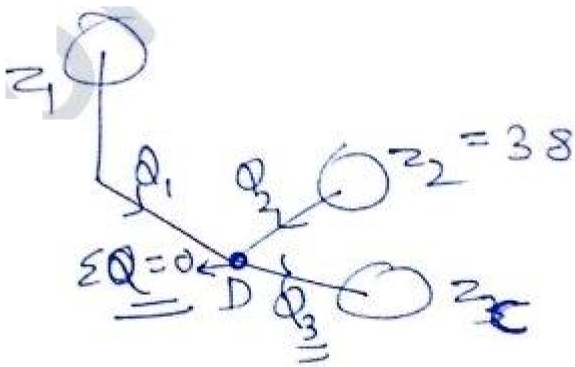
$\underline{Q. 29}$
$\frac{P.g.39}{41}$

Flow
$\underline{\text{High to low}}$

$$Z_D = Z_1 - h_{f_1}$$

$$= 40 - \frac{f \cdot 4 Q_1^2}{12.1 d_1^5}$$

$$Z_D = 36.4\ m$$



$$Z_2 - h_{f_2} \overset{?}{=} Z_D$$

$$Z_D - \frac{f L_3 Q_3^2}{12.1 d_3^5} = Z_3 = Z_C$$

$Q_2 = 0.0202\ m^3/s$

$Z_C = 32.288\ \underline{m}$