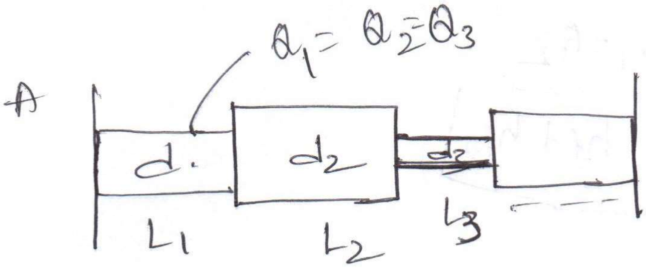
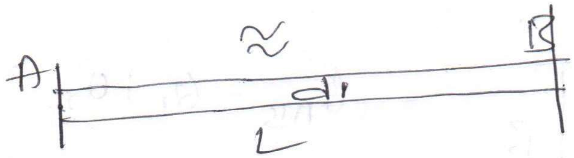
Dupit's Equation:-





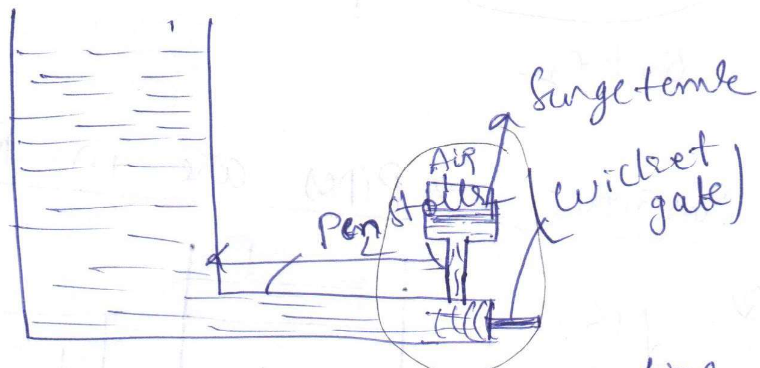
$$h_{f\,AB\,I^{st}} = h_{f\,AB\,II^{nd}}$$

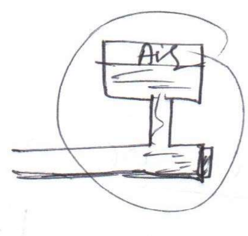
$$h_f + h_{f_2} + h_{f_3} = h_f$$

$$\frac{f L_1 Q_1^2}{12.1 d_1^5} + \frac{f \cdot L_2 Q^2}{12.1 d_2^5} + \cdots = \frac{f \cdot L Q^2}{12.1 d^5}$$

$$\boxed{\frac{L}{d^5} = \frac{L_1}{d_1^5} + \frac{L_2}{d_2^5} + \cdots}$$

Hammering effect :- → closure value Surge Tank





acoustic = sound velocity in fluid

→ In flow through a pipe line whenever value is closed because of the disturbance momentum of flow fluid. a pressure wave will be generated and travels in opposite direction with (acoustic speed) by hitting ~~the~~ walls known as hammering effect

→ To avoid these effect surge tank will be used in the penstock

---

Hammering effect vel $= C = \sqrt{K/\rho}$ → liquids

$= \sqrt{\gamma R T}$ → Gases

→ Sudden closure $t < \frac{2L}{C}$

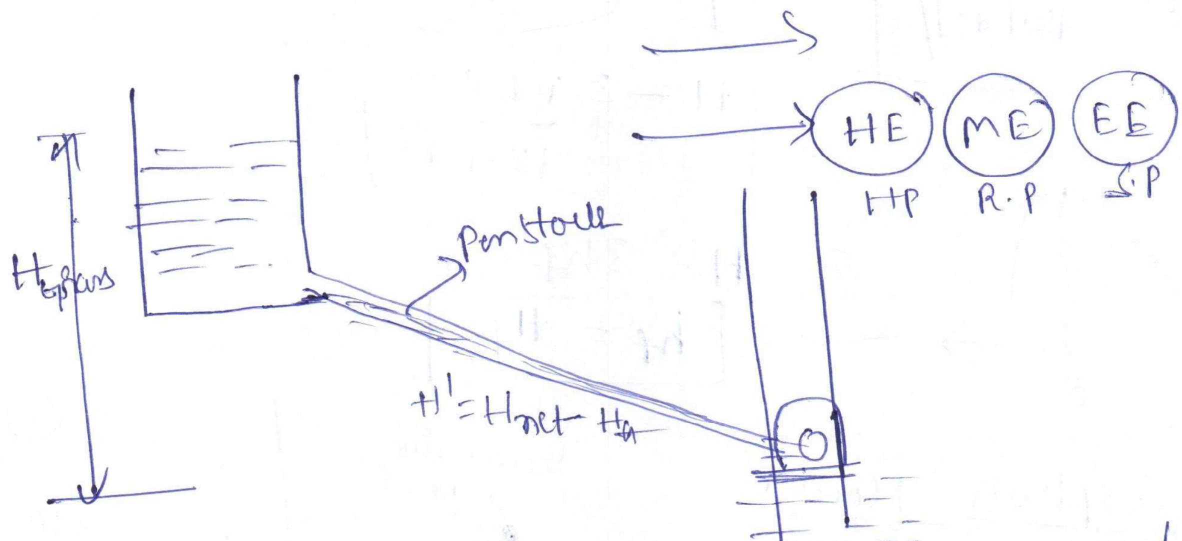
'T' → time of closure

→ Gradual closure $t > \frac{2L}{C}$

Allei's equation → $P = \rho C V$

→ **Power transmission** :-

→ Net hydraulic power / water power



→ Net available power (or) Hydraulic power / water power (P) = $\gamma Q (H - h_f)$

$W = \frac{N}{m^3} \cdot \frac{m^3}{sec} \cdot m = \frac{N \cdot m}{sec} = J/sec$

$P = \gamma Q (H - h_f)$

loss in power
Frictional
pumping } $= \gamma Q h_f$

$(\eta) = \frac{\gamma Q (H - h_f)}{\gamma Q H} = \left(\frac{H - h_f}{H}\right)$

$$\eta = \frac{\gamma Q (H - h_f)}{\gamma Q H} = \left(\frac{H - h_f}{H}\right)$$

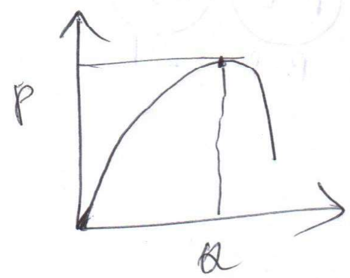
→ **Condition for maximum power :-** $h_f = \frac{H}{3}$

$$P_t = \gamma Q_T (H - h_{fT}) = \gamma_T Q \left[H - \frac{f L Q_T^2}{12.1 d^5}\right]$$

$$\frac{dP}{dQ} = 0 \Rightarrow \frac{d}{dQ}\left[\gamma \left[HQ - \frac{f L Q^3}{12.1 d^5}\right]\right] = 0$$

$$\Rightarrow \frac{d}{dQ}\left[\gamma\left[HQ - \frac{f L Q^3}{12.1 d^5}\right]\right] = 0 = \gamma\left[H - 3\frac{f L Q^2}{12.1 d^5}\right] = 0$$

$$= \left[H - 3\frac{f L Q^2}{12.1 d^5}\right] \rightarrow h_f$$



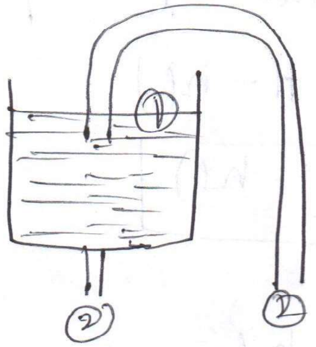
$$= H - 3h_f = 0$$

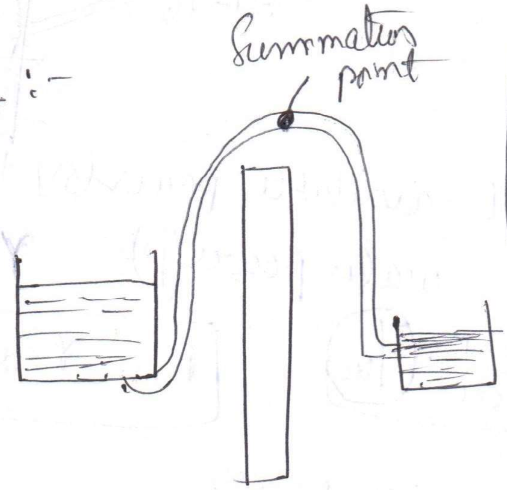
$$h_f = H/3$$

$$\eta_{max} = \left(\frac{H - H/3}{H}\right) = 2/3 \times 100$$

$$\eta = 66.7\%$$

→ **Syphon flow :-**





Summation pressure → $P_s = P_{atm} > P_{vap}$

$$P_s = P_{min} > P_{vap}$$

Q-13

1) A pipe line connecting two reservoirs 200 mm dia and 2 km length Friction factor = 0.04 with head diff of 8 m according for frictional entry and exit loss the approximate velocity flow through pipes

Sol:- 200 mm dia

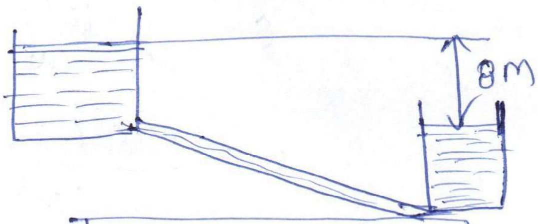
2 km length

F = 0.04 ✓

Z = 8 m ✓

Frictional, Entry & exit loss

Vel.?



$E_1 = E_2 + h_{loss}$

$$\left[Z_1 + \frac{P_1}{\rho g} + \frac{V_1^2}{2g}\right] = \left[Z_2 + \frac{P_2}{\rho g} + \frac{V_2^2}{2g}\right] + \left[h_f + h_{Ent} + h_{exit}\right]$$

$$Z_1 - Z_2 = \frac{FLV^2}{2gd} + 0.5\frac{V^2}{2g} + \frac{V^2}{2g} = 8 + 0.5\frac{V^2}{2g} + \frac{V^2}{2g} = 8$$

$$8 = \frac{V^2}{2g}\left[\frac{FL}{d} + 0.5 + 1.0\right]$$

$$V = \sqrt{\frac{2 \times 9.81 \times 8}{\left[\frac{0.04 \times 2000}{0.2} + 1.5\right]}} = 0.62 \text{ m/s}$$

---

2) water at

Q-09

25°C flowing through 1 km long GI pipe upto 200 mm dia at rate of 0.07 m³/sec

f = 0.02, and pumping power required = ?

Sol. → 1 km   Q = 0.07 m³/sec & 200 mm dia

→ f = 0.02

pumping power = ? $\gamma Q h_f$ $= \frac{9810 \times 0.07 \times 0.02 \times 10^3 \times 0.07^2}{12.1 \times (0.2)^5}$

where $h_f = \frac{FLV^2}{2gd}$ & $\frac{FLQ^2}{12.1 d^5}$

= 17.4 kW

(3) The Hammering velocity of flow water through Rigid pipe $K_w = 1.96$ GPa

Sol. $K_w = 1.96$ GPa

$c = \sqrt{K/\rho}$ ✓ Hammering effect $\boxed{c = \sqrt{K/\rho}}$

$= \sqrt{\dfrac{19.6 \times 10^9}{10^3}}$

$= 1400$ m/s

(4) The turbine ~~pipe~~ connected with penstock of travels in it 3 km length. the pressure wave with velocity 1500 m/sec. The turbine gates are closed uniformly and completely in a period 4.5 sec It is called ______ Gradual

Sol. $L = 3$ km length

$C = 1500$ m/s $\quad t > \left(\frac{2L}{c}\right)$

$t = 4.5$ sec $\quad 4.5 = \dfrac{2 \times 3000}{1500}$

$4.5 > 4$

(5) A piping system consist of 3 pipes arranged in series whose lengths are 1200 & 750, 600 M the corresponding dia 750, 600, 450 MM transform the system into an equally 450 MM dia of pipe ______ ? (equal length)

Sol. $L = 1200, 750, 600$

dia = 750, 600, 450

450.

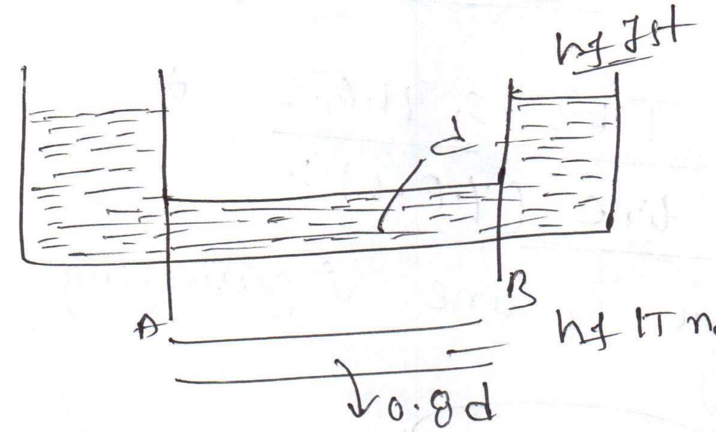
Sol. $\frac{L}{d^5} = \frac{L_1}{d_1^5} + \frac{L_2}{d_2^5} + \frac{L_3}{d_3^5}$

$$\frac{L_e}{(450)^5} = \frac{1200}{(750)^5} + \frac{750}{(600)^5} + \frac{600}{(450)^5}$$

$L_e = $ **871.3 M**

Q) A pipe line connecting b/w two reservoirs have its diameters reduced by 20% due to deposition chemicals with an alted (changed) friction factor this would cause a reduction in flow rate of ______?

Sol:-



Reduction in flow rate ?

$$\frac{(Q_1 - Q_2)}{Q_1} \times 100$$

Given head difference :-

$E_1 = E_2 + h_f = E_1 - E_2 = C$

$h_{f_{AB_1}} = h_{f_{AB_2}}$

$$\frac{FLQ_1^2}{12.1 d^5} = \frac{FLQ_2^2}{12.1\ d^5} \Rightarrow \frac{FLQ_1^2}{12.1\ d^5} = \frac{F \cdot L \cdot Q_2^2}{12.1\ (0.8d)^5}$$

$$Q_1^2 = \frac{Q_2^2}{(0.8)^5} \Rightarrow Q_2 = 0.8^{2.5}\ Q_1$$

$$Q_{reduction\%} = \left[\frac{Q_1 - 0.8^{2.5} Q_1}{Q_1}\right] \times 100 = \underline{42.8\%}$$

7) water flows through a circular pipe of 10CM dia at a velocity of 0.1m/s kinematic viscosity $\nu_w = 10^{-5} m^2/sec$ F = ? (Friction factor)

sol- d = 10CM dia

v = 0.1m/s

$\nu_w = 10^{-5} m^2/sec$

$$F = \frac{64}{Re} \Rightarrow F = \frac{64}{\frac{\rho V D}{\mu}}$$

$$F = \frac{64}{\frac{VD}{\nu}} = \frac{64}{\left(\frac{(0.1)\times(0.1)}{10^{-5}}\right)} = \frac{64}{1000}$$

F = 0.064 ✓

f = 0.005 to 0.01

F = 4f = 0.02 to 0.04

* T.E.L & H.G.L *

Total energy line (T.E.L) :-

→ T.E.L is line representing the total available energy

$$\to z + \frac{P}{\rho g} + \frac{v^2}{2g}$$

→ T.E.L will be horizontal for idle flow but it always slopes downwards for real fluid flow

Hydraulic gradient line :- (H.G.L) (or) Piezometric line :

→ Is line representing the available piezometric head

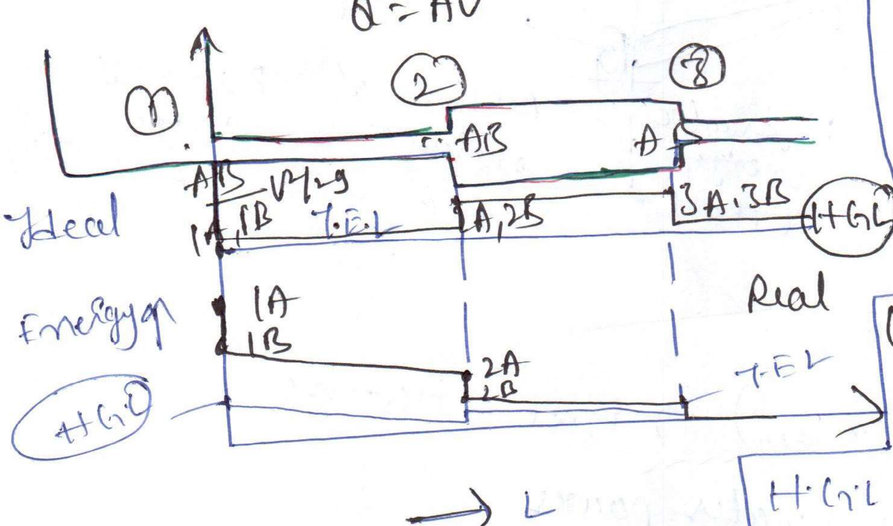
$$z + \frac{P}{\rho g}$$

$$T.E.L - H.G.L = \frac{v^2}{2g}$$

Note :- 1) H.G.L may rise or fall in the direction of flow

2) H.G.L represents atm. pressure condition for all the points about H.G.L. The pressure will be below atmospheric for all the points below H.G.L [Syphon flow]. The pressure will be above atmospheric

$Q = AV$



H.G.L ← $Z + \frac{P}{\rho g} + \frac{V^2}{2g} = 100$ T.E.L

Eg:

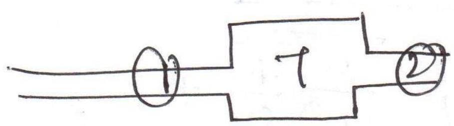
1A → $100 + 0 = 100$ (hf)

1B → $60 + 38 = 98$ hf2

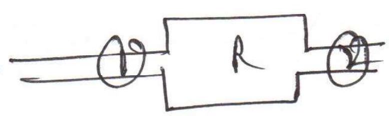
2A → $50 + 38 = 88$

(T.E.L horizontal)

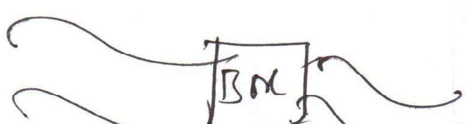
H.G.L → Rise or fall in direction of flow



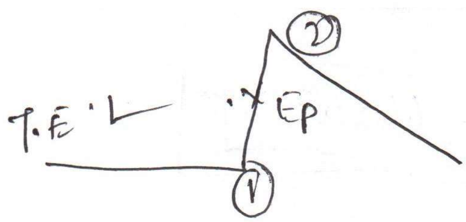
$E - E_T = E_2 + h_{loss}$



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



$P = \gamma Q H$



$E = ?$

Power $= P$

$= \frac{P}{\gamma Q}$