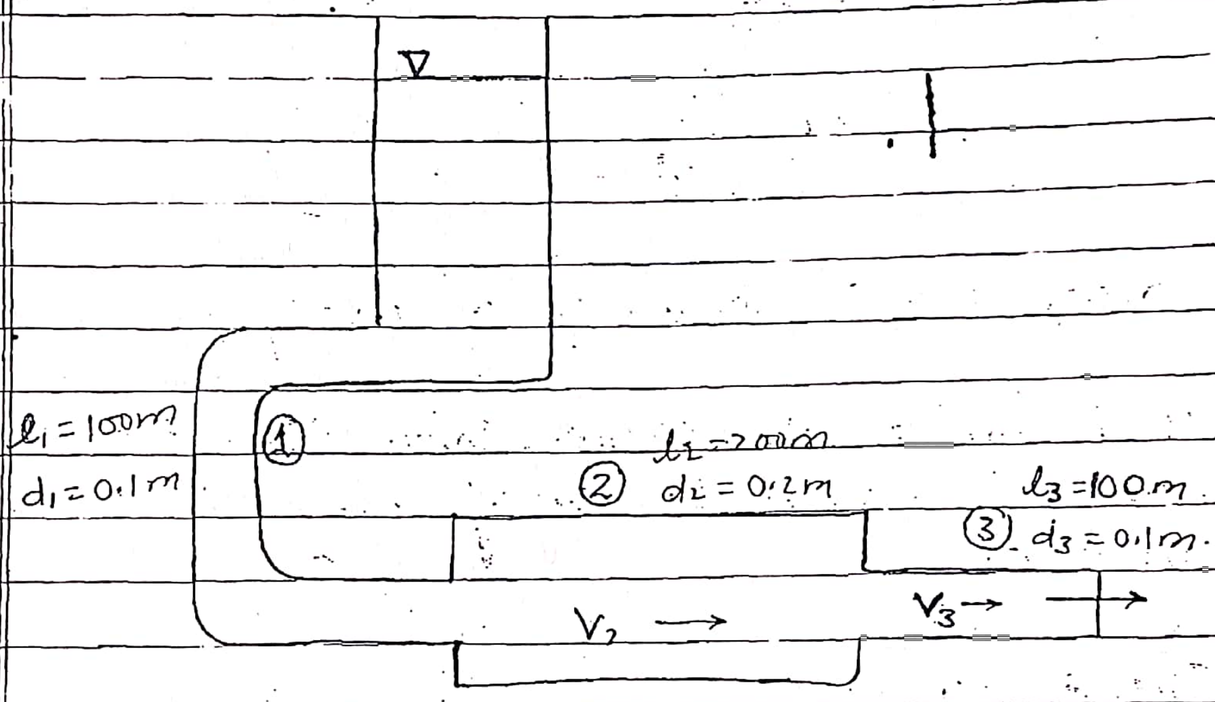
Prob-97 Water flows from a reservoir through a series of pipe joint as shown in fig. Find the percentage error in discharge if minor losses are neglected. assume $K=1$ for bends & friction factor $f=0.02$ for all pipes & the available head of 20m. is used to overcoming losses.



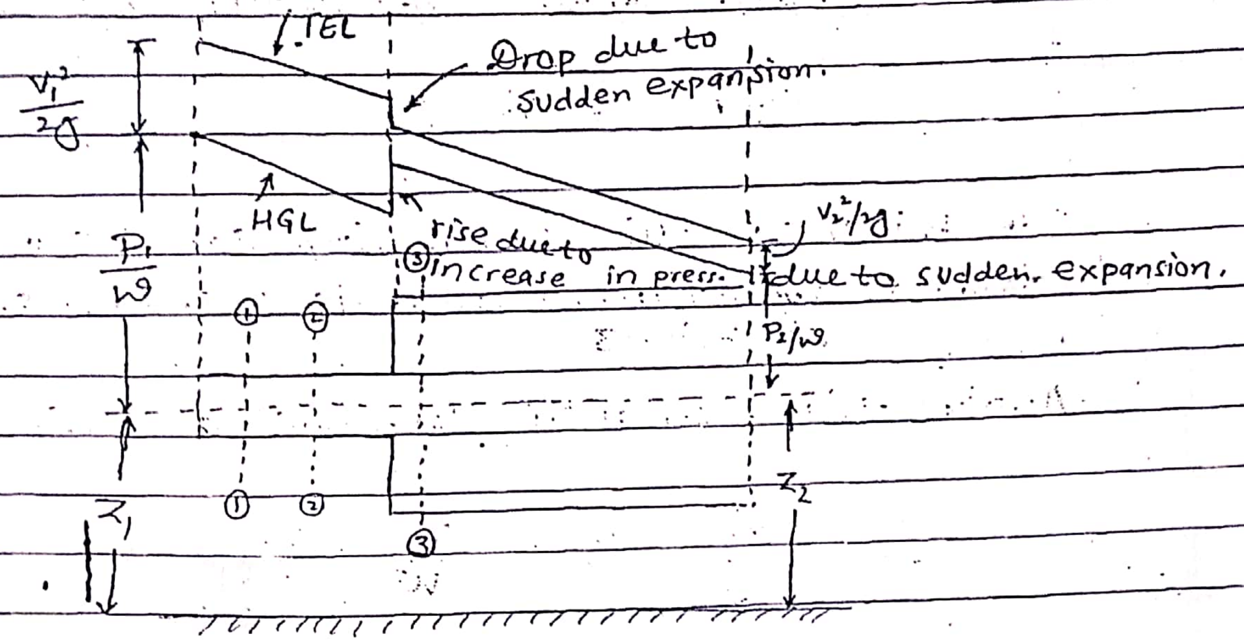
Soln:- Case-I: Discharge when all losses are taken into account

Apply continuity eqn. b/w ①, ② & ③.

$$A_1 V_1 = A_2 V_2 = A_3 V_3$$

$$\frac{\pi}{4} d_1^2 V_1 = \frac{\pi}{4} d_2^2 V_2 = \frac{\pi}{4} d_3^2 V_3$$

Draw HGL & TEL Line for Sudden expansion case –



$$HGL = \frac{P}{w} + Z$$

but in horizontal pipe $Z_1 = Z_2$ then P/w decide the HGL line.

At section ① & ② from continuity eqn.

$$A_1 V_1 = A_2 V_2$$

$$V_1 = V_2 \quad [\because A_1 = A_2]$$

Then Apply bernoulli's eqn. b/w 1 & 2

$$\frac{P_1}{w} + \cancel{\frac{V_1^2}{2g}} + \cancel{Z_1} = \frac{P_2}{w} + \cancel{\frac{V_2^2}{2g}} + \cancel{Z_2} + h_L$$

$$\frac{P_1}{w} = \frac{P_2}{w} + h_L$$

To overcome the losses pressure decreases from section 1 to section 2.

At section 2 & 3 Area are increases from 2 to 3. Apply continuity equation b/w 2 & 3.

$$A_2 V_2 = A_3 V_3$$

To balanced the continuity eqn. Velocity decreases at section 3 because area is increases.

Apply the bernoullis eqn. b/w ② & ③.

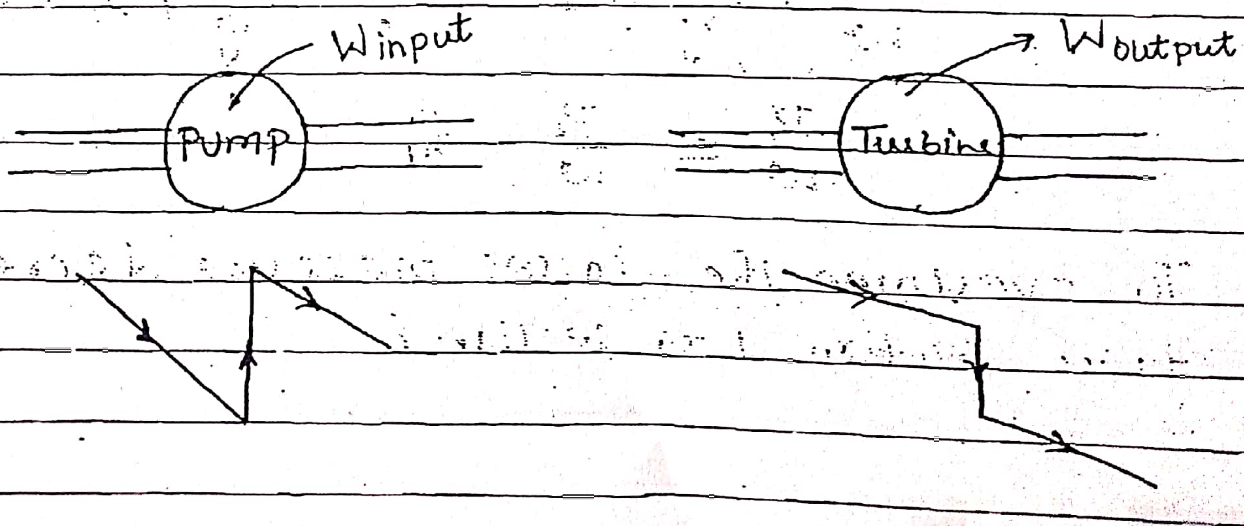
$$\frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2 = \frac{P_3}{w} + \frac{V_3^2}{2g} + Z_3$$

$Z_2 = Z_3$ As horizontal pipe.

$$\frac{P_2}{w} + \frac{V_2^2}{2g} = \frac{P_3}{w} + \frac{V_3^2}{2g}$$

∵ At section 3 the velocity decreases mean's kinetic energy decreases then the pressure energy increases.

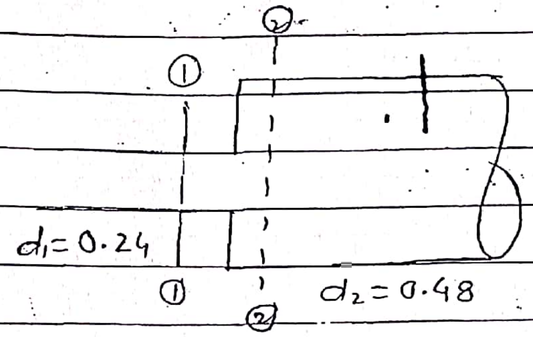
& then pressure head decreases due to friction.



Hydraulic gradient line may rise or fall but the total energy line rises only when there is external energy input as in the case of pump's & compressor.

prob-98- At a sudden ~~eta~~ enlargement of a water pipeline from a dia. of 0.24m to 0.48m. the hydraulic gradient line rises by 10mm. then find the discharge.

Soln:-



Apply bernoullis eqn. b/w ① & ②.

$$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2 + h_L$$

$$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2 + \frac{(V_1 - V_2)^2}{2g}$$

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

$$\frac{V_1^2 - V_2^2 - (V_1^2 + V_2^2 - 2V_1V_2)}{2g} = \frac{10}{1000}$$

where $\left(\frac{P_2}{w} + Z_2\right) - \left(\frac{P_1}{w} + Z_1\right)$ = rise of HGL = 0.01

$$\frac{2V_1V_2 - 2V_2^2}{2g} = 0.01$$

$$V_1V_2 - V_2^2 = 0.01 \times g$$

Apply continuity eqn. b/w ① & ②

$$A_1V_1 = A_2V_2$$

$$\frac{\pi}{4} \times d_1^2 \times V_1 = \frac{\pi}{4} \times d_2^2 \times V_2$$

$$0.24V_1 = 0.48V_2$$

$$V_1 = 4V_2$$

then $4V_2 \times V_2 - V_2^2 = 0.01 \times 9.81$

$$3V_2^2 = 0.01 \times 9.81$$

$$V_2 = 0.18 \text{ m/s.}$$

discharge;

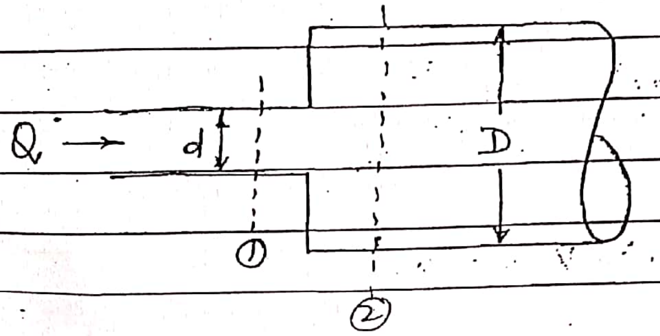
$$Q = A_2V_2 = \frac{\pi}{4} d_2^2 V_2$$

$$= \frac{\pi}{4} \times (0.48)^2 \times 0.18$$

$$= 0.0327 \text{ m}^3\text{/sec. Ans.}$$

prob-9 :- A horizontal pipe of a given dia. d suddenly enlarge's to dia D find the ratio D/d such that the rise in press. for a given discharge past the enlargement shall be maximum.

Soln:-



let $d_1 = d$ (given)
& $d_2 = D$.

Apply continuity eqn. b/w. 1 & 2.

$$A_1 V_1 = A_2 V_2$$

$$\frac{\pi}{4} d_1^2 V_1 = \frac{\pi}{4} d_2^2 V_2$$

$$\boxed{d_1^2 V_1 = d_2^2 V_2}$$

Apply bernoulli's eqn. b/w 1 & 2.

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

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

$$\frac{V_1^2 - V_2^2 - (V_1^2 + V_2^2 - 2V_1V_2)}{2g} = \frac{P_2 - P_1}{w}$$

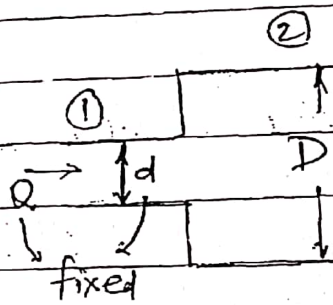
$$\frac{V_1^2 - V_2^2 - (V_1^2 + V_2^2 - 2V_1V_2)}{2g} = \frac{P_2 - P_1}{\rho g}$$

$$\frac{2V_1V_2 - 2V_2^2}{2} = \frac{\Delta P}{\rho}$$

$$V_1V_2 - V_2^2 = \frac{\Delta P}{\rho}$$

$$\Delta P = \rho (V_1V_2 - V_2^2)$$

For max. press. rise.



$$\frac{d(\Delta P)}{dV_2} = 0.$$

$Q = A_1V_1$ & $Q = A_2V_2$

$$\frac{d(\Delta P)}{dV_2} = \rho [V_1(1) - 2V_2] = 0.$$

$Q = \frac{\pi}{4} d^2 V_1$ & $Q = \frac{\pi}{4} D^2 \times V_2$

V_1 = fixed $\quad$ V_2 = variable

D = variable.

$$V_1 - 2V_2 = 0.$$

$$V_1 = 2V_2$$

then $\quad d_1^2 V_1 = D^2 V_2$

$$d^2 \times 2V_2 = D^2 V_2$$

$$\boxed{\frac{D}{d} = \sqrt{2}}$$ Ans.

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prob-100 - Two water carrying pipe's are connected in parallel the pipelength l_1 dia. d_1 friction factor f_1 for the first pipe are 200 m, 0.5 m, 0.025 m & for the second pipe are 100 m, 1 m, 0.02 m respectively then find V_2/V_1.

(a) 5 (b) 7 (c) $\sqrt{7}$ (d) $\sqrt{5}$.

soln:- The pipe's are in parallel, then

$$h_{L_1} = h_{L_2}$$

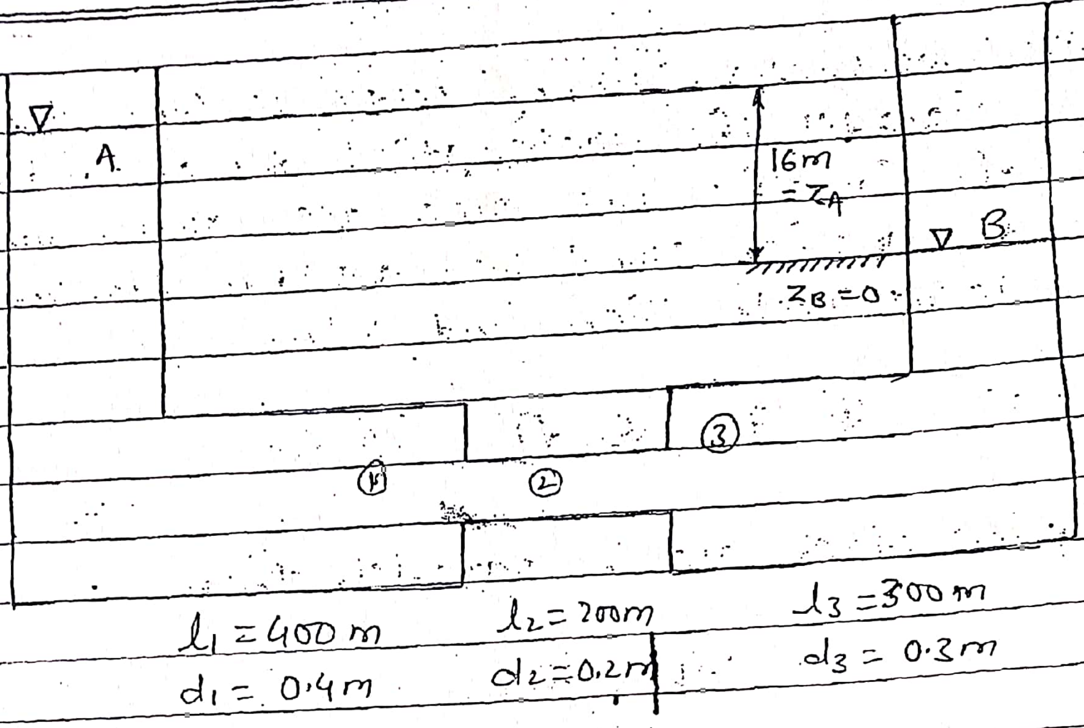
$$\frac{f_1 l_1 V_1^2}{2g \times d_1} = \frac{f_2 l_2 V_2^2}{2g \times d_2}$$

$$\frac{V_2^2}{V_1^2} = \frac{f_1 l_1 d_2}{f_2 l_2 d_1}$$

$$\frac{V_2}{V_1} = \sqrt{\frac{f_1 l_1 d_2}{f_2 l_2 d_1}}$$

$$\frac{V_2}{V_1} = \sqrt{5}$$ Ans.

prob-101 - Three pipe's are connected in serie's as shown in fig. The difference in water level b/w two tank's is 16. If the friction factor for all pipe's is same & is equal to 0.02 find the discharge (neglect minor losses).



Apply bernoulli's eqn. b/w A & B.

$$\frac{P_A}{w} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{w} + \frac{V_B^2}{2g} + Z_B + h_L$$

$$Z_A = Z_B + h_L$$

$$16 = 0 + h_L$$

$$h_L = 16$$

$$h_L = h_{L_1} + h_{L_2} + h_{L_3}$$

$$h_L = \frac{f l_1 Q^2}{12 d_1^5} + \frac{f l_2 Q^2}{12 d_2^5} + \frac{f l_3 Q^2}{12 d_3^5}$$

$$16 = \frac{f Q^2}{12}\left[\frac{l_1}{d_1^5} + \frac{l_2}{d_2^5} + \frac{l_3}{d_3^5}\right]$$

$Q = 0.11$ m³/se. Ans.

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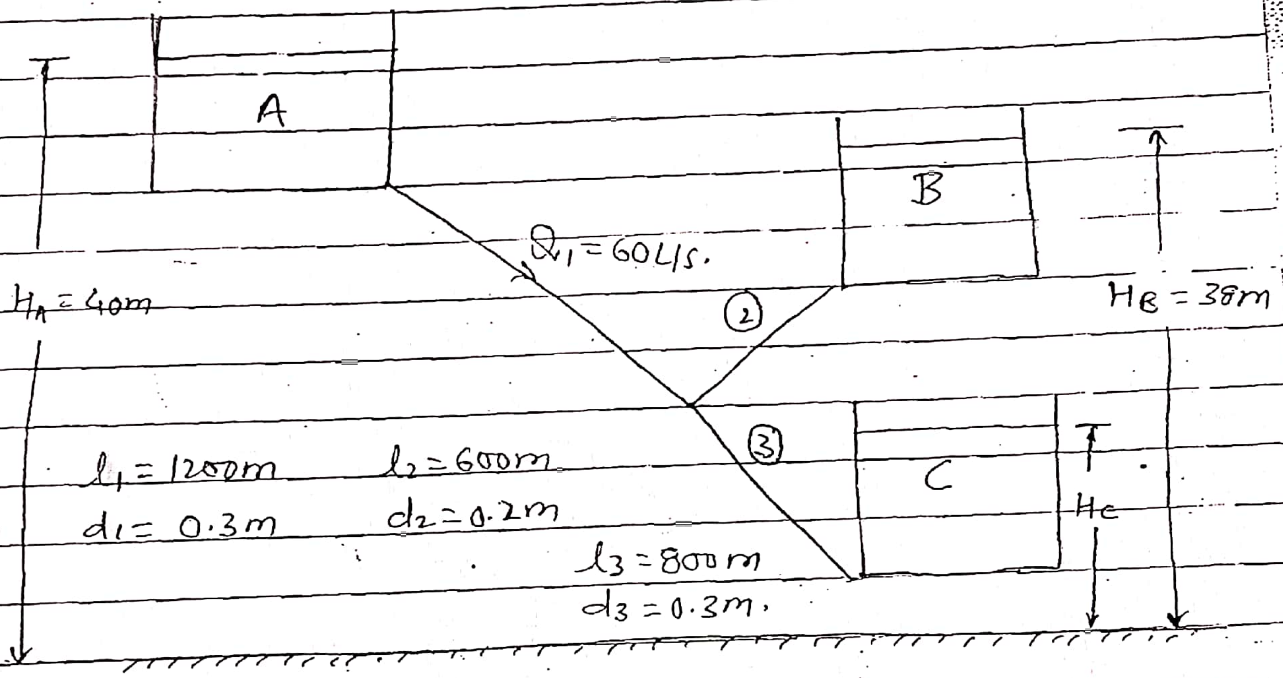
Prob-10:- Three reservoirs A, B, C are connected in a pipe system as shown in fig. find the discharge into or from reservoirs B & C the flow rate from reservoir A is 60 liter/sec. also find the height of water level in reservoir C take friction factor f = 0.024 for all pipe's.



Soln:- For Reservior A,

$$\frac{P_A}{w} + \frac{V_A^2}{2g} + Z_A = H_A$$

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