apply Bernoulli's eqn b/w section (1) & (2)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 \quad \text{[ignore losses]}$$

The velocity at section 1 can be ignored due to the fact that tank area is large in comparison to the cross-sectional area of the pipe.

$$P_1 = P_2 = P_{atm}$$

$$V_2 = \sqrt{2g(Z_1 - Z_2)}$$

Applying bernoulli's eqn b/w section (1) & (3)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_3}{\rho g} + \frac{V_3^2}{2g} + Z_3$$

$P_1 = P_{atm}$, $V_3 = V_2$, $V_1 \simeq 0$

$$\frac{P_3}{\rho g} = \frac{P_{atm}}{\rho g} - \left[\frac{V_2^2}{2g} + (Z_3 - Z_1)\right]$$

$$P_3 = P_{atm} - \rho g\left[\frac{V_2^2}{2g} + (Z_3 - Z_1)\right]$$

The pressure inside the pipe at section 3 is less than the atmospheric pressure.

The pressure at summit can be reduced theoretically to −10.3 meter of water [redacted], But in actual pressure is only −7.6m of water.

Q – Two pipe lines of equal length are connected in series. The diameter of end pipe (second) is two times that of the first pipe. Then find the ratio of friction head loss between 1 & 2 pipe.

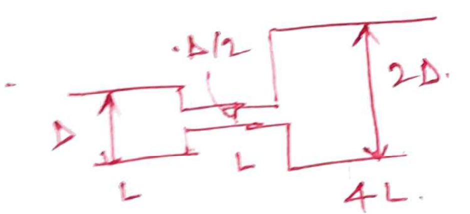
Sol^n

$Q_1 = Q_2 = Q, \qquad d_2 = 2d_1$

$$\frac{h_{L1}}{h_{L2}} = \frac{\frac{f l_1 Q_1^2}{12 d_1^5}}{\frac{f l_2 Q_2^2}{12 d_2^5}} = \frac{h_{L1}}{h_{L2}} = \left(\frac{d_2}{d_1}\right)^5$$

$$\Rightarrow \left(\frac{2d_1}{d_1}\right)^5 = \boxed{\frac{h_{L1}}{h_{L2}} = 32}$$

Q – A compound pipe is shown in fig. Find the equivalent length if the diameter of equivalent pipe is D.



Sol^n

$$h_L = h_{L1} + h_{L2} + h_{L3} \quad \Big| \quad \frac{l_1}{d_1^5} + \frac{l_2}{d_2^5} + \frac{l_3}{d_3^5} = \frac{l_e}{d_e^5}$$

$$\frac{L}{D^5} + \frac{L}{\left(\frac{D}{2}\right)^5} + \frac{l_3 = 4L}{(2D)^5} = \frac{Le}{D^5}$$

$$L\left(1 + 32 + \frac{1}{8}\right) = Le \Rightarrow 33.125L$$

$$\boxed{Le = 33.125L}$$

Q:- Two water carrying pipe are connected in parallel. The length l_1, diameter d_1 & friction factor f_1 for the first pipe are 200m, 0.5 m, .025 respectively. while $l_2 = 100$ m, $d_2 = 1$m, $f_2 = .02$.

Find the $\frac{V_2}{V_1} = ?$

Solⁿ

$$\frac{f_1 l_1 Q_1^2}{12 d_1^5} = \frac{f_2 l_2 Q_2^2}{12 d_2^5} \qquad Q = A_1 V_1$$

$$\frac{.025 \times 200 \times Q_1^2}{12 \times (.5)^2} = \frac{.02 \times 100 \times (Q_2)^2}{12 \times (1)^5}$$

Solⁿ.

$$\frac{f_1 l_1 v_1^2}{2g D_1} = \frac{f_2 l_2 v_2^2}{2g D_2}$$

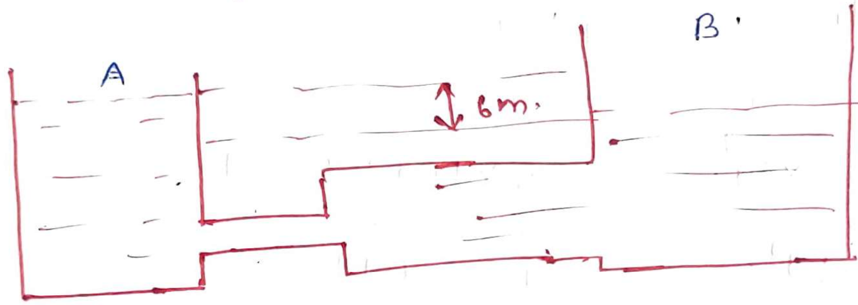
$$\frac{.025 \times 200 \times v_1^2}{2 \times .5} = \frac{.02 \times 100 \times v_2^2}{1}$$

$$\frac{v_2^2}{v_1^2} = 5.$$ (*)

$$\boxed{\frac{v_2}{v_1} = \sqrt{5}}$$

Q- Two reservoirs are connected by a pipe line consisting of two pipes, one of 15cm diameter and length 6m and the other of diameter 22.5cm. and 16m Length. If the difference of water level in two reservoir is 6m, calculate the discharge and draw the energy gradient line.

friction - co-efficient = 0.04



Soln

$d_1 = 15\,cm = 0.15\,m$, $l_1 = 6\,m$, $d_2 = 22.5\,cm = .225\,m$.

$l_2 = 16\,m$, Total head loss $= 6\,m$, $f = 0.04$.

$A_1V_1 = A_2V_2 \Rightarrow \frac{\pi}{4} \times (.15)^2 \times V_1 = \frac{\pi}{4} \times (.225)^2 \times V_2$

$V_1 = 2.25\,V_2$ —— (1).

Apply Bernoulli's eqn to free water surface in the two tank

$$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B + \text{losses}.$$

$P_A = P_B$, $V_A = V_B \approx 0$, $Z_A - Z_B = 6$.

$6 = h_{entry} + h_{f_1} + h_{exp.} + h_{f_2} + h_{exit}$

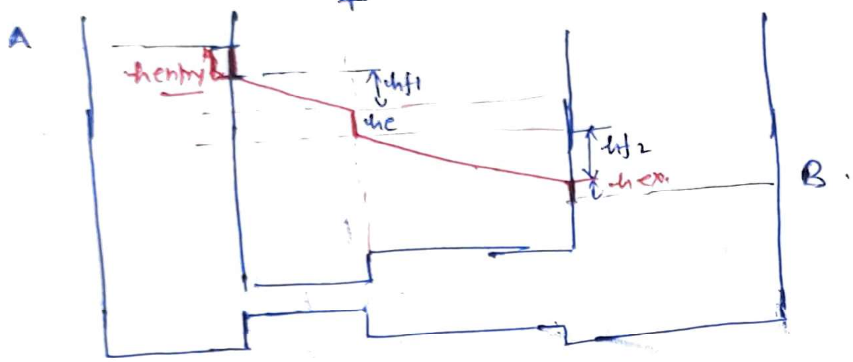
$$6 = \frac{.5V_1^2}{2g} + \frac{4fl_1V_1^2}{2gd_1} + \frac{(V_1 - V_2)^2}{2g} + \frac{4fl_2V_2^2}{2gd_2} + \frac{V_2^2}{2g}$$

$$6 = \frac{.5V_1^2}{2g} + \frac{4 \times .04 \times 6 \times V_1^2}{2g \times .15} + \frac{\left(V_1 - \frac{V_1}{2.25}\right)^2}{2g} + \frac{4 \times .04 \times 16 \times \left(\frac{V_1}{2.25}\right)^2}{2 \times g \times .225} + \frac{(V_1/2.25)^2}{2g}$$

$$6 = \frac{.5 V_1^2}{2g} + \frac{6.4 V_1^2}{2g} + \frac{.308 \times V_1^2}{2g} + \frac{2.25 V_1^2}{2g} + \frac{.197 V_1^2}{2g}.$$

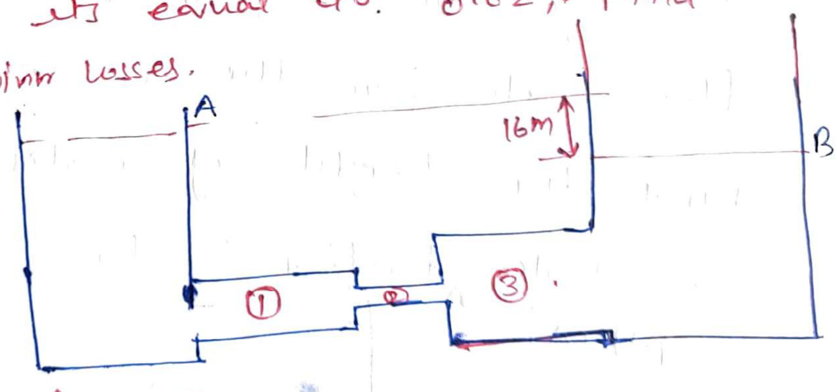
$V_1 = 3.49$ m/s.

$$Q = A_1 V_1 = \frac{\pi}{4} \times (0.15)^2 \times 3.49 = 0.0617 m^3/s.$$



$h_i = .31m$ $h_{f1} = 3.97m$, $h_e = 0.19m$ $h_{f2} = 1.397m$, $h_{exit} = 0.122m$.

Q- Three pipes are connected in a series as shown in fig. The difference in water level between two tank is 16m. If the friction factor for all the pipe is same and its equal to 0.02, find the discharge. neglect minor losses.



$l_1 = 400m$
$d_1 = 400mm$

$l_2 = 200m$

$d_2 = 200mm$

$l_3 = 300m$
$d_3 = 300mm.$

Bernoulli's eqn b/w A and B.

$$\frac{P_A}{\rho g} + \frac{V_a^2}{2g} + Z_a = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B + h_L.$$

$V_a \simeq V_b = 0$ (almost zero).

$P_A = P_B$

$16 = h_L.$

$$\frac{f l_1 Q_1^2}{12 d_1^5} + \frac{f l_2 Q_2^2}{12 d_2^5} + \frac{f l_3 Q_3^2}{12 d_3^5} = 16.$$

$Q_1 = Q_2 = Q_3,$

$$\boxed{Q = .1104 \ m^3/s.}$$

Q. Three reservoir A, B, and C are connected by a pipe system as shown in fig. Find the discharge into or from the reservoirs B and C. The flow rate from the reservoir A is 60 lits/sec. Find the height of water level in the reservoir C. take friction factor = 0.024 for all the pipe.