Pb5# On Bernoulli's Equation.

Pb#01

Given data.

$\rho = 960 kg/m^3$.

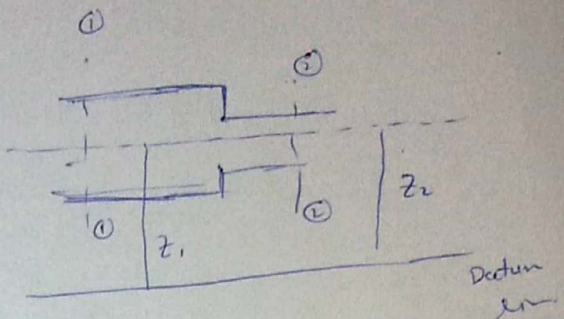
$d_1 = 100mm = 0.1m$.

$d_2 = 80mm = 0.08m$

$P_1 = 200 kN/m^2$

$V_1 = 5 m/s$.

Tube is horizontal.



$z_1 = z_2$.

So $z_1 = z_2 = 0$.

Find the value of $V_2 = ?$

also find $P_2 = ?$ (Required)

Solution:- As from Bernoulli's equation;

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2.$$

As $h_1 = h_2$.

So;

$$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2 \longrightarrow (1).$$

Since V_2 also unknown.

So from equation of Continuity,

$$A_1 V_1 = A_2 V_2.$$

$\because A = \pi/4\, d^2$.

$$\pi/4 (0.1)^2 (5) = \pi/4 (0.08)^2 V_2$$

$$\boxed{V_2 = 7.81 m/s}$$

$\&(1) \Rightarrow$ $P_2 = P_1 + 1/2 \rho V_1^2 - 1/2 \rho V_2^2$.

By putting values. $\rho_w = 1000\ kg/m^3$

$$P_2 = 200 kN/m^2 + \frac{1}{2}(5)^2 \times 1000 - \frac{1}{2} \times 1000 \times (7.8125)^2$$

$$P_2 = 181982.42\ N/m^2.$$

or

$$\boxed{P_2 = 181.9\ kN/m^2}$$

Pb #02 Water is flowing through a pipe of 5cm diameter under a pressure of $29.43\ N/cm^2$ (gauge) & with mean velocity of 2m/s. Find the total head or total energy per unit weight of the water at a cross section, which is 5m above datum line.

Given data:

$d = 5cm = 5 \times 10^{-2} m.$

$p = 29.43\ N/cm^2 = 29.43 \times 10^4\ N/m^2.$

$V = 2m/s.$

$h = z = 5m.$

Required data Total head = ?

Solution:-

As total head is

$H =$ Kinetic head + Potential head + Pressure head

$$= \frac{V^2}{2g} + \frac{p}{\rho g} + z. \longrightarrow (1).$$

$$\frac{V^2}{2g} = \frac{(2)^2}{2\times 9.81} = 0.204\,m.$$

$$\frac{P}{\rho g} = \frac{29.43\times 10^4}{1000\times 9.81}$$

$\rho_w = 1000\ kg/m^3$

$$= 30\,m.$$

$\because\ z = 5\,m.$

So eq① ⇒

Total head = $0.204 + 30 + 5$

$= 35.204\,m.$

Problem #03

The water is flowing through a pipe having diameters 20cm & 10cm at section 1 & 2. respectively. The rate of flow through a pipe is 35 litre/sec. The section 1 is 6m above datum and section 2 is 4m above datum. If the pressure at section 1 is 39.24 N/cm². Find P_2.

Given data:-

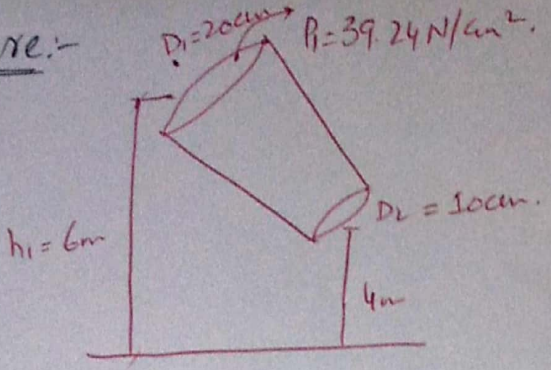
$D_1 = 20cm$

$D_2 = 10cm$

$Q = 35$ litre/sec.

$h_1 = 6m$ & $h_2 = 4m$, $P_1 = 39.24\ N/cm^2$.

Figure:-



Solution:-

As $D_1 = 20cm = 20 \times 10^{-2} m$.

$D_2 = 10cm = 10 \times 10^{-2} m$.

As we know from Bernoulli's equation.

$$P_1 + \frac{1}{2}\rho V_1 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2 + \rho g h_2. \longrightarrow (1)$$

To find value of V_1 & V_2.

As $Q = AV = ?$

$Q = 35 l/sec.$

$Q = 35 * \frac{1}{1000} m^3/sec$

$Q = 0.035 m^3/s.$

$Q = A_1 V_1 \Rightarrow V_1 = \frac{Q}{A_1}$.

$$V_1 = \frac{Q}{\pi/4 D_1^2} = \frac{0.035}{\pi/4 * (20 \times 10^{-2})^2}$$

$$\boxed{V_1 = 1.1146 m/s}$$

$$V_2 = \frac{Q}{A_2} = \frac{Q}{\pi/4 D_2^2} = \frac{0.035}{\pi/4 (10 \times 10^{-2})^2}.$$

$$\boxed{V_2 = 4.46 m/s}$$

By putting values in eq ①.

$$39.24\times10^4 + \frac{1}{2}\times1000\times1.1146 + 1000\times9.81\times6 = P_2 + \frac{1}{2}\times1000\times4.46 + 1000\times9.81\times4.$$

$P_1 = 39.24\ N/cm^2.$

$P_1 = 39.24\times10^4\ N/m^2$

$P_2 = 410347.3\ N/m^2.$

or

$$\boxed{P_2 = 41.03\ N/cm^2}$$

Pb # 04

Water is flowing through a pipe having diameter 300mm & 200mm at bottom & upper end respectively. The intensity of pressure at bottom is $24.525\ N/cm^2$ and the pressure at upper end is $9.81\ N/cm^2$. Determine the difference in datum head if rate of flow through the pipe is 40 lit/sec.

Given data.

$d_1 = 300mm.$

$d_2 = 200mm.$

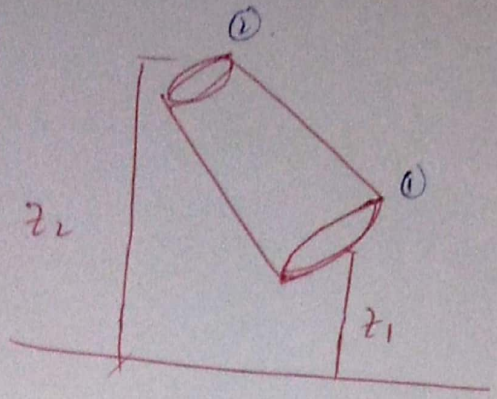
$P_1 = 24.525\ N/cm^2.$

$= 24.525\times10^4\ N/m^2.$

$P_2 = 9.81\ N/cm^2 = 9.81\times10^4\ N/m^2.$

$Q = 40\ litre/sec = 0.04\ m^3/sec.$

Figure:-



Required data

Difference in datum head = $z_2 - z_1 = ?$

Solution:- As we know that;

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$z_2 - z_1 = \frac{P_1}{\rho g} + \frac{V_1^2}{2g} - \frac{P_2}{\rho g} - \frac{V_2^2}{2g} \longrightarrow (1)$$

To find V_1 & V_2.

$$Q = AV$$

$$Q = A_1 V_1$$

$$V_1 = \frac{Q}{A_1} = \frac{0.04}{\pi/4 (300\times10^{-3})}$$

$$\boxed{V_1 = 0.5658 \text{ m/s}}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.04}{\pi/4 (200\times10^{-2})^2} = 1.274 \text{ m/s}$$

By Putting values in eq (1).

eq(1) ⇒

$$z_2 - z_1 = \frac{24.575\times10^4}{1000\times9.81} + \frac{(0.5658)^2}{2\times9.81} - \frac{9.81\times10^4}{1000\times9.81} - \frac{(1.274)^2}{2\times9.81}$$

$z_2 - z_1 = 25.0163 - 10.05$.

$\boxed{z_2 - z_1 = 14.93 \text{ m}}$ Ans