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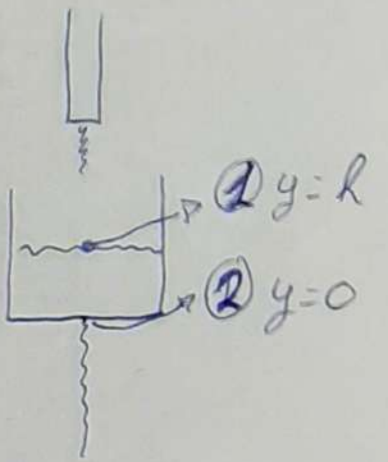
PHY250

Homework 2:

1). Since we are dealing with the flow of ided fluids we will be using two equations:

- Equation of continuity: $R_V = Av = \text{constant}$
- Bernoulli's equation: $P + \frac{1}{2}\rho v^2 + \rho g y = \text{constant}$



Velocity at point 1:

$$R_V = A_1 v_1$$
$$v_1 = \frac{R_V}{A_1}$$
$$v_1 = \frac{2{,}4 \cdot 10^{-4}}{\pi \cdot 0{,}1^2}$$
$$\underline{v_1 = 7{,}63 \cdot 10^{-3}\,m/s}$$

Velocity at point 2:

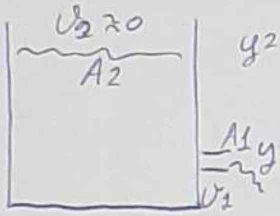
$$R_V = A_2 v_2$$
$$v_2 = \frac{R_V}{A_2}$$
$$v_2 = \frac{2{,}4 \cdot 10^{-4}}{1{,}5 \cdot 10^{-4}}$$
$$\underline{v_2 = 1{,}6\,m/s}$$

By Bernoulli's equation:

$$P_1 + \rho \cdot g \cdot y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho \cdot g \cdot y_2 + \frac{1}{2}\rho v_2^2$$
$$P_1 = P_2 = P_{atm}\ ;\ y_1 = h,\ y_2 = 0$$
$$\rho \cdot g \cdot h + \frac{1}{2}\rho v_1^2 = \frac{1}{2}\rho \cdot v_2^2$$
$$h = \frac{1}{2g} \cdot (v_2^2 - v_1^2)$$
$$\underline{h = 13\,cm}$$

2). For this we are going to use the Bernoulli's equation:

$$P + \frac{1}{2}\rho \cdot v^2 + \rho \cdot g \cdot h = \text{constant}$$



$y_2 = h \qquad A_1 << A_2$

$$\cancel{P_0} + \frac{1}{2}\rho \cdot v_2^2 + \rho \cdot g(y_2 - y_1) = \cancel{P_0} + \frac{1}{2} \cdot \rho \cdot v_1^2 + \cancel{\rho \cdot g \cdot (0)}$$

$$\frac{1}{2} v_2^2 + g \cdot (y_2 - y_1) = \frac{1}{2} \cdot v_1^2$$

$$v_1^2 = 2g \cdot h + v_2^2$$

$$v_1 = \sqrt{2g \cdot h + v_2^2 \approx 0} \rightarrow \underline{v_1 = \sqrt{2 \cdot g \cdot h}}$$

3).

a). Equation of continuity: $R_V = Av$

$$6 \cdot 10^{-3} = 4 \cdot 10^{-3} \cdot v_1 \rightarrow \underline{v_1 = 1{,}5\ m/s}$$

b). Equation of continuity: $R_V = Av$

$$6 \cdot 10^{-3} = 10^{-3}\, v_2 \rightarrow \underline{v_2 = 6\ m/s}$$

c). By Bernoulli's equation:

$$P_1 + \frac{1}{2}\rho v_1^2 + \cancel{\rho \cdot g \cdot y_1} = P_2 + \frac{1}{2}\rho \cdot v_2^2 + \cancel{\rho \cdot g \cdot y_2}$$

$$P_1 - P_2 = \frac{1}{2}\rho \cdot (v_1^2 - v_2^2) \rightarrow \underline{\Delta P = 16{,}8\ Pa}$$

d). $\Delta P = \rho \cdot g \cdot \Delta h$

$16{,}8 = 13{,}6 \cdot 9{,}8 \cdot \Delta h$

$\Delta h = 0{,}127\,m$

4). We assume have v_0, r_0 and h_0 the starting velocity, radius and height. And we have v_1, r_1 and h_1 for any velocity, radius and height at any time.

By the conservation law of energy:

$$v_1^2 = v_0^2 + 2gh_1 \Rightarrow v_1 = \sqrt{v_0^2 + 2gh_1} \quad (1)$$

By continuity equation:

$$v_0 A_0 = v_1 A_1 \Rightarrow v_0 \pi r_0^2 = v_1 \pi r_1^2$$

$$r_1 = r_0 \sqrt{\frac{v_0}{v_1}} \quad (2)$$

Joining 1 and 2 we get:

$$r_1 = r_0 \sqrt{\frac{v_0}{\sqrt{v_0^2 + 2gh_1}}}$$

b). Now we want $v_0/v_1 = 2$ with $v_0 = 1{,}2\ m/s$

$$2 = \frac{1}{\sqrt{\frac{1{,}2}{\sqrt{1{,}2^2 + 2 \cdot 9{,}8 \cdot h_1}}}} \rightarrow \underline{h_1 = 1{,}1\ m}$$