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PHY250
HW2

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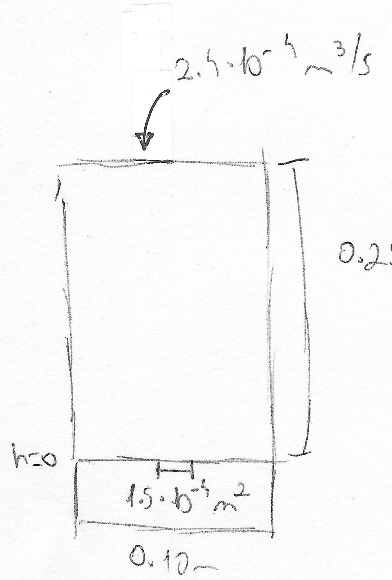
10/10/2021

1)



$\underbrace{A_1 \cdot V_1}_{} = A_2 \cdot V_2 \Rightarrow$

$2.4 \cdot 10^{-4} = 1.5 \cdot 10^{-4} \cdot V_2$

V_2. We know the Bernoulli's equation, so

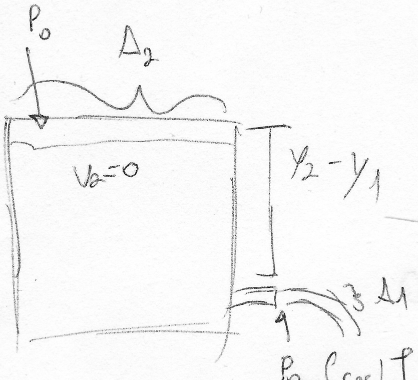
$\underset{\text{at wanted height}}{E_1} = \underset{\text{after end}}{E_2} \Rightarrow \rho \cdot g \cdot h = \frac{1}{2} \cdot \rho \cdot V_2^2 \Rightarrow \sqrt{2 \cdot g \cdot h} = V_2$

$2.4 \cdot 10^{-4} = 1.5 \cdot 10^{-4} \cdot \sqrt{2 \cdot 9.8 \cdot h} \Rightarrow$

$\left(\frac{2.4 \cdot 10^{-4}}{1.5 \cdot 10^{-4}}\right)^2 = 2 \cdot 9.8 \cdot h \Rightarrow$

$h = \left(\frac{2.4 \cdot 10^{-4}}{1.5 \cdot 10^{-4}}\right)^2 : (2 \cdot 9.8) \Rightarrow \boxed{h = 0.13 m}$

2)



P_0 Caught before leaving

$h = y_2 - y_1 \qquad A_2 >> A_1$

The only force that affects is the gravity, so we know that (Bernoulli's equation)

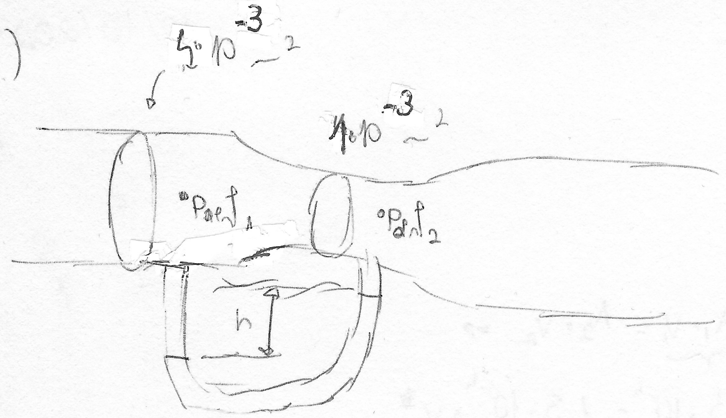
$\frac{1}{2} \cdot \rho \cdot V_2^2 + P_0 + \rho \cdot g \cdot y_2 = \frac{1}{2} \cdot \rho \cdot V_1^2 + P_0 + \rho \cdot g \cdot y_1 \Rightarrow$

$\rho \cdot g \cdot y_2 = \frac{1}{2} \cdot \rho \cdot V_1^2 + \rho \cdot g \cdot y_1 \Rightarrow g \cdot y_2 = \frac{1}{2} V_1^2 + g \cdot y_1 \Rightarrow$

$\sqrt{2 \cdot g \cdot (y_2 - y_1)} = V_1 \Rightarrow \boxed{\sqrt{2 \cdot 9.8 \cdot (y_2 - y_1)} = V_1}$

3)

Flow rate $6 \cdot 10^{-3}\ m^3/s$



a) V_1 V_2

$A_1 \cdot V_1 = 6 \cdot 10^{-3} \Rightarrow V_1 = \boxed{1{,}5\ m/s}$

$A_2 \cdot V_2 = 6 \cdot 10^{-3} \Rightarrow V_2 = \boxed{6\ m/s}$

b) Bernoulli's equation

$$\underbrace{\frac{1}{2} \cdot p \cdot V_1^2 + P_1 + p \cdot g \cdot h}_{\text{Point 1}} = \underbrace{\frac{1}{2} \cdot p \cdot V_2^2 + P_2 + p \cdot g \cdot h}_{\text{Point 2}}$$

Same height so

$$\Rightarrow \frac{1}{2} p \cdot V_1^2 + P_1 = \frac{1}{2} \cdot p \cdot V_2^2 + P_2 \Rightarrow$$

$$P_1 - P_2 = \frac{1}{2} p \cdot V_2^2 - \frac{1}{2} \cdot p \cdot V_1^2 \Rightarrow$$

$$P_1 - P_2 = \frac{1}{2} \cdot p \cdot (V_2^2 - V_1^2) = \boxed{16875\ Pa}$$

c) The mercury will have a velocity of 0

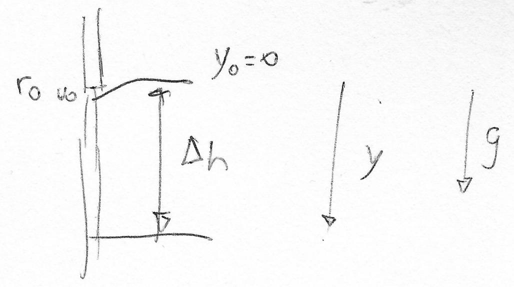
Column 1: $P_1 = p_m \cdot g \cdot h_1$

Column 2: $P_2 = p_m \cdot g \cdot h_2$

Bernoulli eq.

$$P_1 - P_2 = p \cdot g \cdot \Delta h \Rightarrow \Delta h = \frac{16875}{13{,}6 \cdot 10^3 \cdot 9{,}8} = \boxed{0{,}127\ m}$$

4) Equations of motion



a)

$$y = y_0 + v_0 t + \frac{1}{2} \cdot g \cdot t^2$$

$$v = v_0 + g \cdot t$$

$$\Rightarrow \frac{v - v_0}{g} = t$$

$$y = v_0 \cdot \left(\frac{v - v_0}{g}\right) + \frac{1}{2} \cdot g \cdot \left(\frac{v - v_0}{g}\right)^2 \Rightarrow$$

$$y = \frac{v v_0 - v_0^2}{g} + \frac{1}{2} \cdot \frac{v^2 + v_0^2 - 2 v v_0}{g} \Rightarrow$$

$$g \cdot y = \frac{2 v v_0 - 2 v_0^2 + v^2 + v_0^2 - 2 v v_0}{2} \Rightarrow$$

$$2 g \cdot y = v^2 - v_0^2 \Rightarrow \boxed{v = \sqrt{2gy + v_0^2}}$$

$$A_1 \cdot v_1 = A_2 \cdot v_2 \Rightarrow \quad v_1 = v_0 \quad v_2 \quad A_2 = r^2 \cdot \pi \quad A_1 = r_0^2 \cdot \pi$$

$$\Downarrow$$

$$\pi \cdot r_0^2 \cdot v_0 = \pi \cdot r^2 \cdot \sqrt{2g \cdot y + v_0^2} \Rightarrow$$

$$r^2 = \frac{\pi \cdot r_0^2 \cdot v_0}{\pi \cdot \sqrt{2gy + v_0^2}} \Rightarrow \boxed{r = \frac{r_0 \sqrt{v_0}}{\sqrt[4]{2gy + v_0^2}}}$$

b) $v_0 = 1.2 \, m/s \qquad r = \frac{1}{2} r_0$

$$\frac{1}{2} r_0 = \frac{r_0 \sqrt{1.2}}{\sqrt[4]{2 \cdot 9.8 \cdot y + 1.2^2}} \Rightarrow \sqrt[4]{2 \cdot 9.8 \cdot y + 1.44} = 2 \cdot \sqrt{1.2} \Rightarrow$$

(to the power of 4)

$$2 \cdot 9.8 \cdot y + 1.44 = 23.04 \Rightarrow y = \boxed{1.1 \, m}$$