Name: ------------------ **Quiz 2** **Time: 20 minutes**

ME:5160 **Fall 2024**

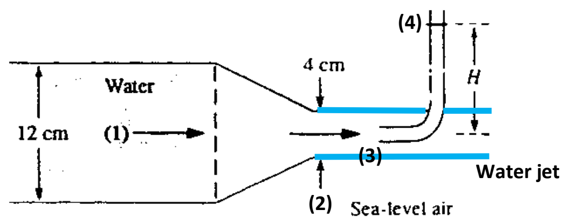
The exam is closed book and closed notes.

An open water jet exits from a nozzle into sea-level air, as shown, and strikes a stagnation tube (V=0). If the centerline pressure at section (1) is 110 kPa and losses are neglected, estimate (a) the mass flow in kg/s; and (b) the height *H* of the fluid in the tube.

Hint a): $V_1A_1 = V_2A_2$

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

Hint c): Use Bernoulli from (1) to (2) and manometer equation from (3) to (4)



Solution:

Continuity:

$$V_1 A_1 = V_2 A_2 \quad \textbf{+2}$$

$$V_1\left(\frac{\pi}{4}D_1^2\right) = V_2\left(\frac{\pi}{4}D_2^2\right)$$

$$V_2 = V_1\left(\frac{D_1}{D_2}\right)^2 \quad \textbf{+1}$$

Writing Bernoulli and continuity between pipe and jet yields jet velocity:

$$p_1 - p_a = \frac{\rho}{2}V_{jet}^2\left[1-\left(\frac{D_{jet}}{D_1}\right)^4\right] = 110000 - 101350 = \frac{998}{2}V_{jet}^2\left[1-\left(\frac{4}{12}\right)^4\right], \quad \textbf{+3}$$

$$\textit{solve} \quad V_{jet} = \mathbf{4.19}\ \frac{\text{m}}{\text{s}} \quad \textbf{+1}$$

$$\textit{Then the mass flow is} \quad \dot{m} = \rho A_{jet} V_{jet} = 998\frac{\pi}{4}(0.04)^2(4.19) = \mathbf{5.25}\ \frac{\textbf{kg}}{\textbf{s}} \quad \textit{Ans.}\text{ (a)} \quad \textbf{+1}$$

(b) Bernoulli between (2) and (3):

$$\frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2 = \frac{P_3}{\rho g} + \frac{V_3^2}{2g} + z_3$$

$$z2 = z3, P_2 = P_a, V_3 = 0, V_2 = V_{jet}$$

$$\frac{P_a}{\rho g} + \frac{V_{jet}^2}{2g} = \frac{P_3}{\rho g} \rightarrow P_3 = P_a + \frac{\rho V_{jet}^2}{2}$$

$$P_3 = 101350 + \frac{998(4.19)^2}{2} = 110110\ Pa \quad \textbf{+1}$$

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Bernoulli between (3) and (4):

$$\frac{P_3}{\rho g} + \frac{V_3^2}{2g} + z_3 = \frac{P_4}{\rho g} + \frac{V_4^2}{2g} + z_4$$

$$z_4 - z_3 = H, V_3 = 0, P_4 = P_a, V_4 = 0$$

$$H = \frac{P_3 - P_a}{\rho g} = \frac{110110 - 101350}{998 \cdot 9.81} = 0.894m$$ +1