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

ME:5160 **Fall 2022**

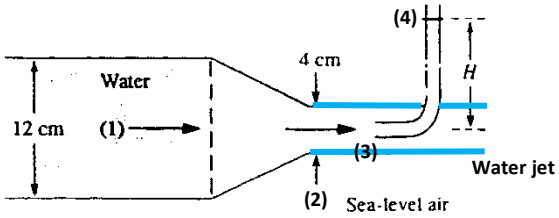
The exam is closed book and closed notes.

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 (2) to (3) and manometer equation from (3) to (4)



Solution:

Continuity:

$$V_1 A_1 = V_2 A_2 \qquad +2$$

$$V_1 \left(\frac{\pi}{4} D_1^2\right) = V_2 \left(\frac{\pi}{4} D_2^2\right) \qquad +1$$

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

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

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

$$solve \quad V_{jet} = \mathbf{4.19} \ \frac{\mathrm{m}}{\mathrm{s}} \qquad +1$$

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

(b) The water in the stagnation tube will rise above the jet surface by an amount equal to the stagnation pressure head of the jet:

$$p_a + \frac{\rho}{2} V_{jet}^2 = p_a + \rho g H$$

$$H = \frac{V_{jet}^2}{2g} = \frac{4.19^2}{2(9.81)} = \mathbf{0.89}\boldsymbol{m} \qquad Ans.\ (b) \qquad +1$$