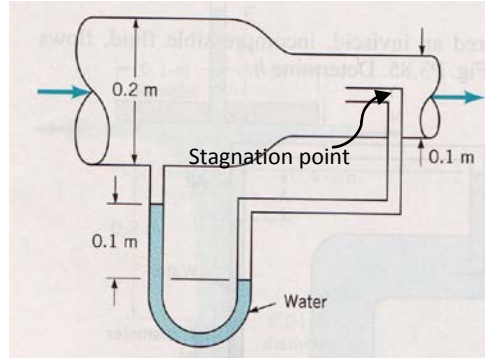


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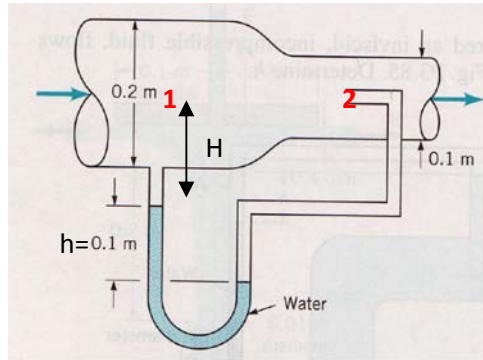
Quiz: No. 2
Course: 58:160, Fall 2009

Time: 15 minutes

Air flows steadily through the variable area pipe shown in the figure. Determine the flow rate Q if viscous and compressibility effects are negligible. ($\gamma_a=12 \text{ N/m}^3$; $\gamma_w=9800 \text{ N/m}^3$)



Solutions:



$$\left. \begin{aligned} \frac{p_1}{\gamma_a} + \frac{V_1^2}{2g} + z_1 &= \frac{p_2}{\gamma_a} + \frac{V_2^2}{2g} + z_2; z_1 = z_2; V_2 = 0 \\ Q &= A_1 V_1 \Rightarrow V_1 = Q/A_1 \end{aligned} \right\} \Rightarrow \frac{p_2 - p_1}{\gamma_a} = \frac{(Q/A_1)^2}{2g}$$

$$\Rightarrow Q^2 = \left(\frac{p_2 - p_1}{\gamma_a} \times 2g \right) / (4/\pi d_1^2)^2$$

$$\Rightarrow Q = \frac{\pi d_1^2}{4} \sqrt{\left(\frac{p_2 - p_1}{\gamma_a} \times 2g \right)}$$

$$p_1 + \rho_a g H + \rho_w g h = p_2 + \rho_a g (H + h) \Rightarrow p_2 - p_1 = h \times (\gamma_w - \gamma_a)$$

$$\Rightarrow Q = \frac{\pi d_1^2}{4} \sqrt{\left(\frac{h \times (\gamma_w - \gamma_a)}{\gamma_a} \times 2g \right)}$$

$$\Rightarrow Q = \frac{\pi \times 0.2^2}{4} \sqrt{\left(\frac{0.1 \times (9800 - 12)}{12} \times 2 \times 9.81 \right)} = 1.257 \text{ m}^3/\text{s}$$