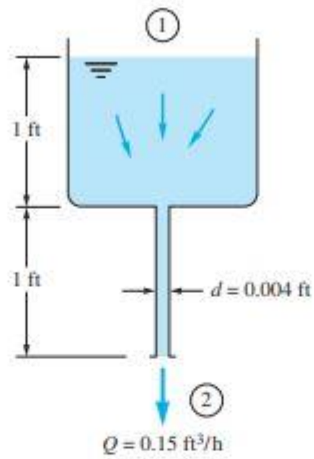
Name :__________________ **Quiz: No. 9** **Time: 15 minutes**

Course: ME 5160, Fall 2024

The exam is closed book and closed notes.

A liquid of density ρ=1.803 slugs/ft^3 (g=32.17 ft/s^2) flows by gravity through a 1-ft tank and a 1-ft capillary tube at a rate of $0.15 ft^3/h$, as shown in the figure. Sections 1 and 2 are at atmospheric pressure. Neglecting entrance effects and friction in the large tank, compute (a) the velocity at section 2, (b) the head loss h_f, (c) the viscosity of the flow μ, (d) and verify the laminar flow assumption. (e) What would be the value of the volumetric flowrate in ft^3/h such that $Re_d = 2000$? (Use the viscosity you found in (c)).



Hint:

$$h_f = f\frac{LV^2}{2dg}\ ; \qquad f = \frac{64}{Re_d}(for\ laminar); \qquad Re_d = \frac{\rho V d}{\mu}$$

Energy equation:

$$\left(\frac{p}{\rho g} + \frac{\alpha V^2}{2g} + z\right)_1 = \left(\frac{p}{\rho g} + \frac{\alpha V^2}{2g} + z\right)_2 + h_f$$

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Solution

(a) Velocity at section 2:

$$V_2 = \frac{Q}{A_2} = \frac{Q}{(\pi/4)d^2} = \frac{(0.15/3600)ft^3/s}{(\pi/4)(0.004\ ft)^2} = 3.32\ ft/s \qquad \text{(+3)}$$

(b) Energy equation between Section 1 and 2:

$$\left(\frac{\mathrm{p}}{\rho \mathrm{g}} + \frac{\alpha \mathrm{V}^2}{2\mathrm{g}} + \mathrm{z}\right)_1 = \left(\frac{\mathrm{p}}{\rho \mathrm{g}} + \frac{\alpha \mathrm{V}^2}{2\mathrm{g}} + \mathrm{z}\right)_2 + h_f \qquad \text{(+1)}$$

$$h_f = z_1 - z_2 - \frac{{V_2}^2}{2g} = 1.829ft \qquad \text{(+1)}$$

(c) Use laminar formula for viscosity:

$$h_f = 1.829ft = \frac{32\mu L V}{(\rho g)d^2} \qquad \text{(+1.5)}$$

Solve for μ:

$$\mu = \frac{(\rho g)d^2 h_f}{32LV} = 1.6E-5\frac{slug}{ft-s} \qquad \text{(+0.5)}$$

(d) Verify laminar assumption:

$$Re_d = \frac{\rho V d}{\mu} = 1495 \qquad \text{(+2)}$$

The flow is laminar.

(e) Impose $Re_d = 2000$

$$Re_d = \frac{\rho V d}{\mu} = 2000 \qquad \text{(+0.5)}$$

$$V = \frac{2000\mu}{\rho d} = 4.44\ ft/s$$

$$Q = VA = 4.44\frac{ft}{s} \cdot \left(\frac{\pi}{4}\right)(0.004\ ft)^2 = 0.201 ft^3/h \qquad \text{(+0.5)}$$