

Name : _____

Quiz: No. 9

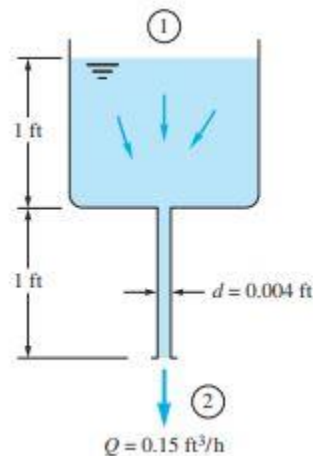
Time: 15 minutes

Student ID# : _____

Course: ME 5160, Fall 2022

The exam is closed book and closed notes.

A liquid of density $\rho=1.803 \text{ slugs/ft}^3$ ($g=32.17 \text{ ft/s}^2$) flows by gravity through a 1-ft tank and a 1-ft capillary tube at a rate of $0.15 \text{ ft}^3/\text{h}$, 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:**

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

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:

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

(b) Energy equation between Section 1 and 2:

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

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

(c) Use laminar formula for viscosity:

$$h_f = 1.829 ft = \frac{32\mu LV}{(\rho g)d^2} \quad (+1.5)$$

Solve for μ :

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

(d) Verify laminar assumption:

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

The flow is laminar.

(e) Impose $Re_d = 2000$

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

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

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