

6.107

6.107 A liquid (viscosity = $0.002 \text{ N}\cdot\text{s}/\text{m}^2$; density = $1000 \text{ kg}/\text{m}^3$) is forced through the circular tube shown in Fig. P6.107. A differential manometer is connected to the tube as shown to measure the pressure drop along the tube. When the differential reading, Δh , is 9 mm , what is the mean velocity in the tube?

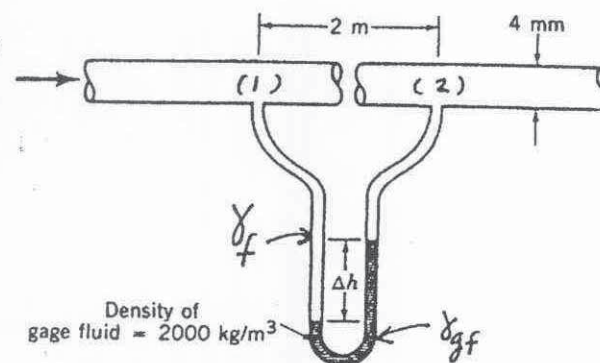


FIGURE P6.107

Assume laminar flow so that

$$V = \frac{R^2}{8\mu} \frac{\Delta p}{L} \quad (\text{Eq. 6.145})$$

For manometer (see figure),

$$p_1 + \gamma \Delta h - \gamma_{gf} \Delta h = p_2$$

or

$$\begin{aligned} p_1 - p_2 = \Delta p &= \Delta h (\gamma_{gf} - \gamma) = \Delta h (g)(\rho_{gf} - \rho_f) \\ &= (0.009 \text{ m})(9.81 \frac{\text{m}}{\text{s}^2})(2000 \frac{\text{kg}}{\text{m}^3} - 1000 \frac{\text{kg}}{\text{m}^3}) \\ &= 88.3 \frac{\text{N}}{\text{m}^2} \end{aligned}$$

Thus,

$$V = \frac{(\frac{0.004}{2} \text{ m})^2 (88.3 \frac{\text{N}}{\text{m}^2})}{8 (0.002 \frac{\text{N}\cdot\text{s}}{\text{m}^2}) (2 \text{ m})} = \underline{\underline{1.10 \times 10^{-2} \frac{\text{m}}{\text{s}}}}$$

Check Reynolds number to confirm that flow is laminar:

$$Re = \frac{\rho V (2R)}{\mu} = \frac{(10^3 \frac{\text{kg}}{\text{m}^3})(1.10 \times 10^{-2} \frac{\text{m}}{\text{s}})(0.004 \text{ m})}{0.002 \frac{\text{N}\cdot\text{s}}{\text{m}^2}}$$

$$= 22.0 < 2100$$

Since $Re < 2100$ flow is laminar.