6.93

6.93 A liquid (viscosity = 0.002 N·s/m²; density = 1000 kg/m³) 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?

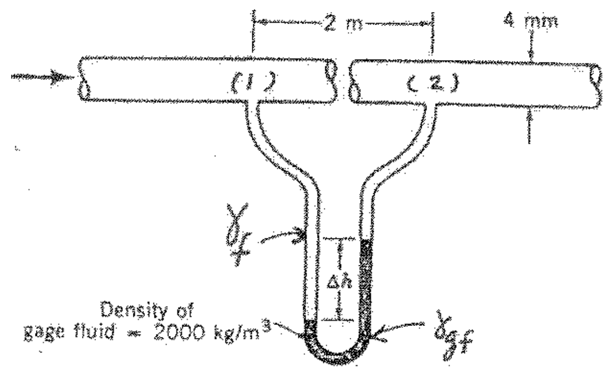

FIGURE P6.107

Assume laminar flow so that

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

For manometer (see figure),

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

or

$$p_1 - p_2 = \Delta p = \Delta h\,(\gamma_{gf} - \gamma) = \Delta h\,(g)(\rho_{gf} - \rho_f)$$

$$= (0.009\,m)\left(9.81\,\frac{m}{s^2}\right)\left(2000\,\frac{kg}{m^3} - 1000\,\frac{kg}{m^3}\right)$$

$$= 88.3\,\frac{N}{m^2}$$

Thus,

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

Check Reynolds number to confirm that flow is laminar:

$$R_e = \frac{\rho V(2R)}{\mu} = \frac{\left(10^3\,\frac{kg}{m^3}\right)\left(1.10\times10^{-2}\,\frac{m}{s}\right)(0.004\,m)}{0.002\,\frac{N\cdot s}{m^2}}$$

$$= 22.0 < 2100$$

Since $R_e < 2100$ flow is laminar.