

8.20

8.20 Glycerin at 20 °C flows upward in a vertical 75-mm-diameter pipe with a centerline velocity of 1.0 m/s. Determine the head loss and pressure drop in a 10-m length of the pipe.

$$\rho = 1260 \frac{\text{kg}}{\text{m}^3}$$

$$\mu = 1.50 \frac{\text{N}\cdot\text{s}}{\text{m}^2}$$

For laminar flow in a pipe,

$$V = \text{average velocity} = \frac{1}{2} V_{\text{max}} = \frac{1}{2} (1 \frac{\text{m}}{\text{s}}) = 0.5 \frac{\text{m}}{\text{s}}$$

Thus,

$$Re = \frac{\rho V D}{\mu} = \frac{(1260 \frac{\text{kg}}{\text{m}^3})(0.5 \frac{\text{m}}{\text{s}})(0.075 \text{ m})}{1.50 \frac{\text{N}\cdot\text{s}}{\text{m}^2}} = 31.5 < 2100$$

The flow is laminar so that

$$V = \frac{(\Delta p - \delta l \sin \theta) D^2}{32 \mu l}, \text{ where } \theta = 90^\circ$$

Thus,

$$\Delta p = \frac{32 \mu l V}{D^2} + \delta l = \frac{32 (1.50 \frac{\text{N}\cdot\text{s}}{\text{m}^2})(10 \text{ m})(0.5 \frac{\text{m}}{\text{s}})}{(0.075 \text{ m})^2} + (9.81 \frac{\text{m}}{\text{s}^2})(1260 \frac{\text{kg}}{\text{m}^3})(10 \text{ m})$$

$$= 1.66 \times 10^5 \frac{\text{N}}{\text{m}^2}, \text{ or } \Delta p = \underline{\underline{166 \text{ kPa}}}$$

Also,

$$\frac{p_1}{\rho} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{\rho} + z_2 + \frac{V_2^2}{2g} + h_L, \text{ or with } V_1 = V_2, z_2 - z_1 = l, \text{ and}$$

$p_1 = p_2 + \Delta p$ this gives

$$h_L = \frac{\Delta p}{\rho} - l = \frac{1.66 \times 10^5 \frac{\text{N}}{\text{m}^2}}{(9.81 \frac{\text{m}}{\text{s}^2})(1260 \frac{\text{kg}}{\text{m}^3})} - 10 \text{ m} = \underline{\underline{3.43 \text{ m}}}$$

