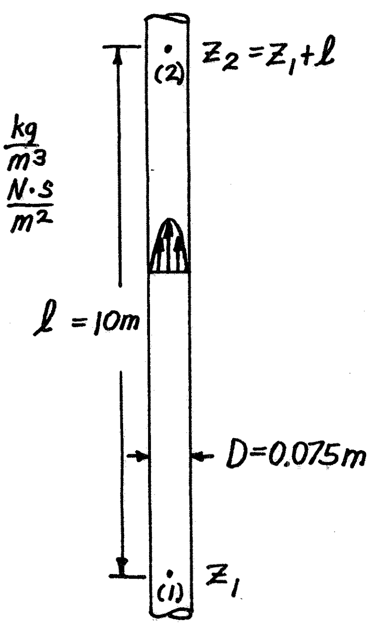
8.17

8.17 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.

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

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



For laminar flow in a pipe,

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

Thus,

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

The flow is laminar so that

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

Thus,

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

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

Also,

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

$p_1 = p_2 + \Delta p$ this gives

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