8.18

8.18 A fluid flows through a horizontal 0.1-in.-diameter pipe. When the Reynolds number is 1500, the head loss over a 20-ft length of the pipe is 6.4 ft. Determine the fluid velocity.

$h_L = f\frac{\ell}{D}\frac{V^2}{2g}$, where since $Re = 1500 < 2100$ the flow is laminar.

Thus, $f = 64/Re = 64/1500 = 0.0427$ so that

$$6.4\,ft = 0.0427\,\frac{20\,ft}{(0.1/12\,ft)}\,\frac{V^2}{2(32.2\,ft/s^2)}$$

or

$$V = \underline{\underline{2.01\,\tfrac{ft}{s}}}$$

8.19

8.19 A viscous fluid flows in a 0.10-m-diameter pipe such that its velocity measured 0.012 m away from the pipe wall is 0.8 m/s. If the flow is laminar, determine the centerline velocity and the flowrate.

For laminar flow in a pipe

$u(r) = V_c\left[1 - \left(\frac{2r}{D}\right)^2\right]$, where $D = 0.1\,m$ and $u = 0.8\,\frac{m}{s}$ at $r = \frac{0.1m}{2} - 0.012m = 0.038m$

Thus,

$$0.8\,\tfrac{m}{s} = V_c\left[1 - \left(\frac{2(0.038m)}{0.10m}\right)^2\right] \quad \text{or} \quad V_c = \underline{\underline{1.89\,\tfrac{m}{s}}}$$

so that

$$Q = \tfrac{\pi}{4}D^2 V = \tfrac{\pi}{4}D^2(0.5V_c) = \tfrac{\pi}{4}(0.1m)^2(0.5)(1.89\,\tfrac{m}{s}) = \underline{\underline{7.42\times10^{-3}\,\tfrac{m^3}{s}}}$$