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.

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

Thus, \( f = \frac{64}{Re} = \frac{64}{1500} = 0.0427 \) so that

\[ 6.4 \text{ ft} = 0.0427 \frac{20 \text{ ft}}{(0.1/12 \text{ ft})} \frac{V^2}{2(32.2 \text{ ft/s}/5^2)} \]

or

\[ V = \frac{2.01 \text{ ft}}{5} \]

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

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

Thus,

\[ 0.8 \frac{m}{s} = V_c \left[ 1 - \left( \frac{2(0.03 \text{ m})}{0.1 \text{ m}} \right)^2 \right] \text{ or } V_c = 1.89 \frac{m}{s} \]

so that

\[ Q = \frac{\pi}{4} D^2 V = \frac{\pi}{4} D^2 (0.5 V_c) = \frac{\pi}{4} (0.1 \text{ m})^2 (0.5)(1.89 \frac{m}{s}) = 7.42 \times 10^{-3} \frac{m^3}{s} \]