33.48 A viscous fluid flows through a $0.025in$ I.D. tube at a flow rate of $3\frac{in^3}{min}$. The fluid has a specific weight of $100\frac{lb_f}{ft^3}$ and a kinematic viscosity of $1 \times 10^{-5}\frac{ft^2}{s}$. What is the pressure drop across a $1ft$ length of tube?

A. $7.5psi$

B. $8.4psi$

C. $13.5psi$

D. $19.4psi$

The Pressure Drop is given by the equation below.

$$\Delta p = \gamma h_f$$

Determine the head loss in ft by using the Darcy-Weisbach Equation.

$$h_f = \frac{fLv^2}{2Dg}$$

Start by calculating the velocity and converting to $\frac{ft}{s}$, then use the velocity with the diameter and kinematic viscosity to find the Reynolds Number.

$$Q = vA$$

$$v = \frac{Q}{A} = \frac{3\frac{in^3}{min}}{\frac{\pi}{4}(0.025in)^2} = 6112\frac{in}{min}\left(\frac{1min}{60s}\right)\left(\frac{1ft}{12in}\right) = 8.49\frac{ft}{s}$$

Convert the diameter from in to ft.

$$D = \frac{0.025in}{12\frac{in}{ft}} = 0.00208ft$$

Calculate the Reynolds Number.

$$Re = \frac{vD}{\nu}$$

$$Re = \frac{\left(8.49\frac{ft}{s}\right)(0.00208ft)}{1 \times 10^{-5}\frac{ft^2}{s}} = 1769 < 2000 \ (laminar)$$

Use the equation on the Moody Diagram to determine the friction factor for Laminar flow based on the Reynolds Number.

$$f = \frac{64}{Re} = \frac{64}{1769} = 0.036$$

Calculate the losses in ft per unit length by assuming $L = 1ft$.

$$h_f = \frac{(0.036)\,(1ft)\left(8.49\frac{ft}{s}\right)^2}{2\,(0.00208ft)\left(32.2\frac{ft}{s^2}\right)} = 19.47ft$$

Determine the pressure drop by multiplying by the specific weight, and convert to psi.

$$\Delta p = \left(100\frac{lb_f}{ft^3}\right)(19.47ft)\left(\frac{1ft^2}{144in^2}\right) = 13.5psi$$

Answer C