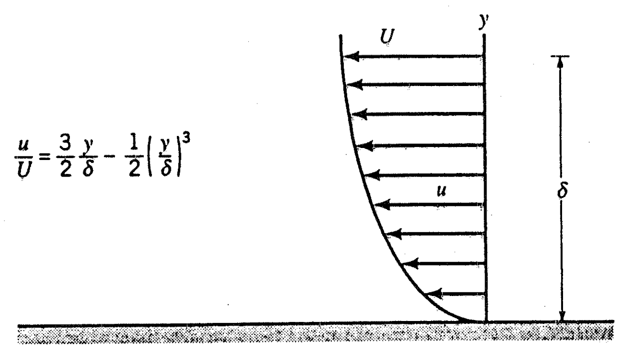
1.58

1.58 A Newtonian fluid having a specific gravity of 0.92 and a kinematic viscosity of 4×10^{-4} m²/s flows past a fixed surface. Due to the no-slip condition, the velocity at the fixed surface is zero (as shown in Video V1.2), and the velocity profile near the surface is shown in Fig. P1.58. Determine the magnitude and direction of the shearing stress developed on the plate. Express your answer in terms of U and δ, with U and δ expressed in units of meters per second and meters, respectively.



■ FIGURE P1.58

$$\tau_{\substack{surface \\ (y=0)}} = \mu \left(\frac{du}{dy}\right)_{y=0}$$

$$\frac{du}{dy} = U\left(\frac{3}{2\delta} - \frac{3}{2}\frac{y^2}{\delta^3}\right)$$

$$@\ y=0, \quad \frac{du}{dy} = \frac{3}{2}\frac{U}{\delta}$$

$$\text{Since, } \mu = \nu\rho$$

$$\tau_{surface} = \nu\rho\left(\frac{3}{2}\frac{U}{\delta}\right)$$

$$= \left(4 \times 10^{-4}\ \frac{m^2}{s}\right)\left(0.92 \times 10^3\ \frac{kg}{m^3}\right)\left(\frac{3}{2}\right)\frac{U}{\delta}$$

$$= \underline{\underline{0.552\,\frac{U}{\delta}\ N/m^2 \text{ acting to left on plate}}}$$