Prob. 1

Information and assumptions

Find

Determine the ratio of these two shear stresses.

Solution

For fluid 1:

\[ \tau_1 = \mu_1 \left( \frac{du}{dy} \right)_{\text{top surface}} = \left( 0.4 \frac{N \cdot s}{m^2} \right) \left( \frac{3 - 2 \text{ m/s}}{0.02 \text{ m}} \right) = 20 \frac{N}{m^2} \]

For fluid 2:

\[ \tau_2 = \mu_2 \left( \frac{du}{dy} \right)_{\text{bottom surface}} = \left( 0.2 \frac{N \cdot s}{m^2} \right) \left( \frac{2 - 0 \text{ m/s}}{0.02 \text{ m}} \right) = 20 \frac{N}{m^2} \]

Thus:

\[ \frac{\tau_2}{\tau_1} = \frac{20 \frac{N}{m^2}}{20 \frac{N}{m^2}} = 1 \]
Prob. 2

Information and assumptions
Provided in problem statement

Find
Determine water depth $h$.

Solution

For water:

$$h_{cw} = \frac{h}{2}$$

$$F_{Rw} = \gamma_w h_{cw} A_w = \gamma_w \left(\frac{h}{2}\right)(2h) = \gamma_w h^2$$

$$y_{Rw} = \frac{I_{xc}}{y_c A} + y_c = \frac{2h^3}{12(h/2)(2h)} + \frac{h}{2} = \frac{2h}{3}$$

For gasoline:

$$h_{sg} = 2$$

$$F_{Rg} = \gamma_g h_{sg} A_g = \gamma_g (2)(2 \times 4) = 16\gamma_g$$

$$y_{Rg} = \frac{I_{xe}}{y_c A} + y_c = \frac{2 \times 4^3}{12(2)(2 \times 4)} + 2 = \frac{8}{3} m$$

Taking the moment about the hinge:

$$F_{Rw} (h - y_{Rw}) = F_{Rg} (4 - y_{Rg})$$

$$\gamma_w h^2 \left(\frac{h - \frac{2}{3} h}{3}\right) = 16\gamma_g \left(4 - \frac{8}{3}\right)$$

$$\gamma_w \frac{1}{3} h^3 = \frac{64}{3}\gamma_g$$

$$h = \left(\frac{64\gamma_g}{\gamma_w}\right)^{\frac{1}{3}} = \left(\frac{64 \times 700}{1000}\right)^{\frac{1}{3}} = 3.55 m$$
Prob. 3

**Information and assumptions**
Provided in problem statement

**Find**
Determine the flowrate through the pipe.

**Solution**

![Diagram of a pipe with pressure and flow rates]

The Bernoulli equation between points (1) and (2):

\[
\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2
\]

Where \( z_1 = z_2 \) and \( V_2 = 0 \)

Thus

\[
\frac{p_1}{\gamma} + \frac{V_1^2}{2g} = \frac{p_2}{\gamma}
\]

\[
V_1 = \sqrt{2g \left( \frac{p_2 - p_1}{\gamma} \right)} \quad \text{(1)}
\]

The manometer equation:

\[
p_1 - \gamma l - \gamma_m h + \gamma (l + h) = p_2
\]

\[
p_2 - p_1 = (\gamma - \gamma_m) h \quad \text{(2)}
\]

So that

\[
V_1 = \sqrt{2g \left( 1 - \frac{\gamma_m}{\gamma} \right) h} = \sqrt{2 \times 9.81 \times \left( 1 - \frac{900}{1000} \right) \times 2.5} = 2.21 \text{ m/s}
\]

Thus

\[
Q = A_1 V_1 = \frac{\pi}{4} \times (0.08)^2 \times 2.21 = 0.0111 \text{ m}^3/\text{s}
\]
Prob. 4

Information and assumptions
Provided in problem statement

Find
Determine the acceleration at points A, B, and C.

Solution
The acceleration
\[ \mathbf{a} = \frac{D\mathbf{V}}{Dt} = \frac{\partial \mathbf{V}}{\partial t} + \mathbf{V} \cdot \nabla \mathbf{V} \]

With \( u = u(x) \), \( v = 0 \), and \( w = 0 \)
\[ \mathbf{a} = \left( \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} \right) \mathbf{i} = u \frac{\partial u}{\partial x} \mathbf{i} \]  

Since \( u \) is a linear function of \( x \), \( u = c_1 x + c_2 \), where the constants \( c_1, c_2 \) are given as:
\[ u_A = 6 = c_2 \]
\[ u_B = 18 = 0.1 c_1 + c_2 \]
i.e., \( c_1 = 120 \), \( c_2 = 6 \)
Thus \( u = 120x + 6 \), \( \frac{\partial u}{\partial x} = 120 \)

For \( x_A = 0.0m \), \( u_A = 6 \text{ m/s} \), \( a_A = 6 \times 120 \mathbf{i} = 720 \mathbf{i} \text{ m/s}^2 \)

For \( x_C = 0.05m \), \( u_C = 12 \text{ m/s} \), \( a_C = 12 \times 120 \mathbf{i} = 1440 \mathbf{i} \text{ m/s}^2 \)

For \( x_B = 0.1m \), \( u_C = 18 \text{ m/s} \), \( a_B = 18 \times 120 \mathbf{i} = 2160 \mathbf{i} \text{ m/s}^2 \)