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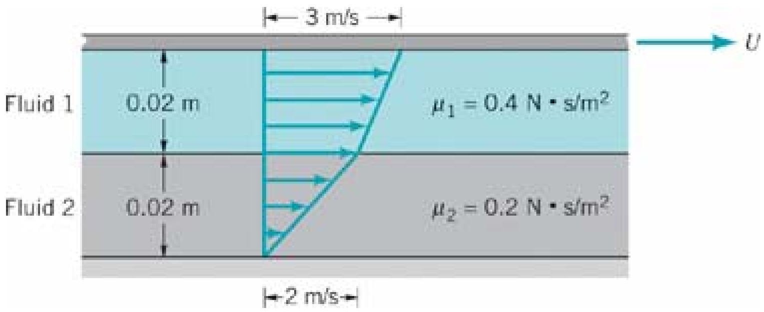
Prob. 1

Information and assumptions

Find

Determine the ratio of these two shear stresses.

Solution



For fluid 1:

$$\tau_1 = \mu_1 \left(\frac{du}{dy} \right)_{top\ \ surface} = \left(0.4 \frac{N \cdot s}{m^2} \right) \left(\frac{3-2}{0.02} \frac{m/s}{m} \right) = 20 \frac{N}{m^2} \qquad (+4.5)$$

For fluid 2:

$$\tau_2 = \mu_2 \left(\frac{du}{dy} \right)_{bottom\ \ surface} = \left(0.2 \frac{N \cdot s}{m^2} \right) \left(\frac{2-0}{0.02} \frac{m/s}{m} \right) = 20 \frac{N}{m^2} \qquad (+4.5)$$

Thus:

$$\frac{\tau_2}{\tau_1} = \frac{20 \frac{N}{m^2}}{20 \frac{N}{m^2}} = 1 \qquad (+1)$$

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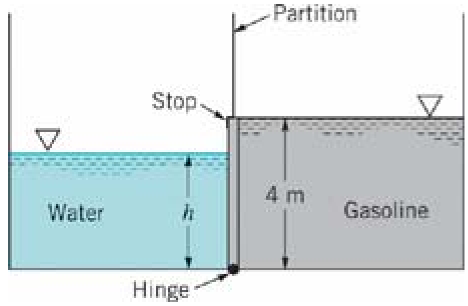
Prob. 2

Information and assumptions

Provided in problem statement

Find

Determine water depth h.



Solution

For water:

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

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

$$y_{Rw} = \frac{I_{xc}}{y_c A} + y_c = \frac{2h^3}{12(h/2)(2h)} + \frac{h}{2} = \frac{2h}{3}$$ (+4)

For gasoline:

$$h_{cg} = 2$$

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

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

Taking the moment about the hinge:

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

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

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

$$h = \left(\frac{64\gamma_g}{\gamma_w}\right)^{1/3} = \left(\frac{64\times 700}{1000}\right)^{1/3} = 3.55m$$ (+2)

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Prob. 3

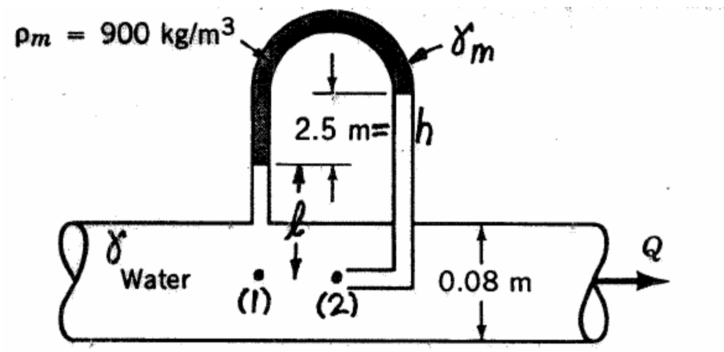
Information and assumptions

Provided in problem statement

Find

Determine the flowrate through the pipe.

Solution



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

$$\frac{p_1}{\gamma}+\frac{V_1^2}{2g}+z_1=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2$$ (+5)

Where $z_1 = z_2$ and $V_2 = 0$

Thus

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

$$V_1 = \sqrt{2g\frac{p_2-p_1}{\gamma}}$$ (+1)

The manometer equation:

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

$$p_2-p_1=(\gamma-\gamma_m)h$$ (+2)

So that

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

Thus

$$Q = A_1V_1 = \frac{\pi}{4}\times(0.08)^2\times 2.21 = 0.0111 m^3/s$$ (+1)

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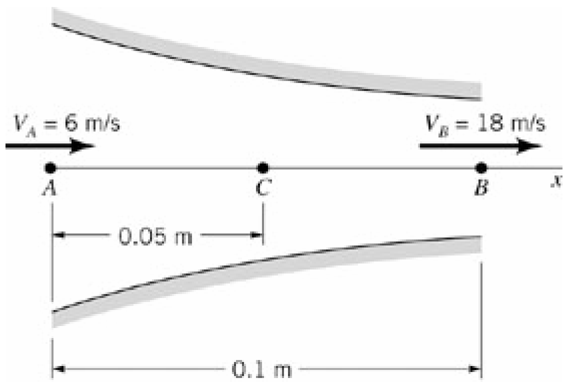
Prob. 4

Information and assumptions

Provided in problem statement

Find

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



Solution

The acceleration

$$\mathbf{a} = \frac{D\mathbf{V}}{Dt} = \frac{\partial \mathbf{V}}{\partial t} + \mathbf{V} \cdot \nabla \mathbf{V}$$ (+5)

With $u = u(x)$, $v = 0$, and $w = 0$

$$\mathbf{a} = \left(\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} \right) \mathbf{i} = u \frac{\partial u}{\partial x} \mathbf{i}$$ (+1)

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 $u = 120x + 6$, $\frac{\partial u}{\partial x} = 120$ (+1)

For $x_A = 0.0m$, $u_A = 6\, m/s$, $\mathbf{a}_A = 6 \times 120 \mathbf{i} = 720 \mathbf{i}\, m/s^2$ (+1)

For $x_C = 0.05m$, $u_C = 12\, m/s$, $\mathbf{a}_C = 12 \times 120 \mathbf{i} = 1440 \mathbf{i}\, m/s^2$ (+1)

For $x_B = 0.1m$, $u_C = 18\, m/s$, $\mathbf{a}_B = 18 \times 120 \mathbf{i} = 2160 \mathbf{i}\, m/s^2$ (+1)