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Prob. 1

Information and assumptions

Provided in problem statement

Find

(a) a relation for the drag force
(b) the value of the drag force

Solution

Shear stress

$$\tau_w = -\mu \left.\frac{du}{dr}\right|_{r=R} = -\mu u_{\max} \frac{d}{dr}\left(1 - \frac{r^2}{R^2}\right) = \mu u_{\max} \left.\frac{2r}{R^2}\right|_{r=R} = \frac{2\mu u_{\max}}{R}$$

(Eqn. + Inter. + Ans. = 4+1+1)

Frictional drag force relation

$$F_D = \tau_w A_s = \left(\frac{2\mu u_{\max}}{R}\right)(2\pi RL) = 4\pi\mu L u_{\max}$$

(Eqn. +Ans. = 2)

Substituting

$$F_D = 4\pi\mu L u_{\max} = 4\pi \times 0.001 \times 15 \times 3 = 0.565N$$

(Eqn. +Ans. = 2)

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Prob. 2

Information and assumptions

Provided in problem statement

Find

The required weight

Solution

The average pressure is the pressure at the centroid of the surface

$$P_{ave} = \rho g y_C = 62.4 \times 32.2 \times \frac{12}{2} \times \left(\frac{1 lbf}{32.2 lbm \cdot ft/s^2} \right) = 374.4 \, lbf/ft^2$$

(Eqn. + Ans = 3)

The hydrostatic force

$$F_R = P_{ave} A = P_{ave} (ba) = 374.4 \times (12 \times 5) = 22,464 lbf$$

(Eqn. + Ans = 2)

The line of action of the force passes through the pressure center

$$y_p = y_C + \frac{I_{xx,C}}{y_C A} = \frac{1}{2} b + \frac{\frac{1}{12} ab^3}{\left(\frac{1}{2} b\right)(ba)} = \frac{2}{3} b = 8 \, ft$$

(Eqn. + Ans = 4)

Taking the momentum about the hinge point

$$\sum M = 0$$

$$F_R (s + y_p) = W \overline{AB}$$

$$W = \frac{s + y_p}{\overline{AB}} F_R = \frac{3+8}{8} \times 22,464 = 30,900 lbf$$

(Eqn. + Ans = 1)

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Prob. 3

Information and assumptions

Provided in problem statement

Find

$p_B - p_A$

$p_C - p_A$

Solution 1

$$\frac{P_A - P_B}{H} = \frac{\partial P}{\partial z} = -\rho\left(g + a_z\right)$$

$$P_B - P_A = \rho\left(g + a_z\right)H$$

$$= 1,300 \times \left(9.81 - \frac{2}{3} \times 9.81\right) \times 3 = 12.75kPa$$

(Eqn. + Inter. + Ans. = 3+1+1)

$$\frac{P_B - P_C}{L} = \frac{\partial P}{\partial x} = -\rho a_x = -\rho g$$

$$P_C - P_B = \rho g L = 1300 \times 9.81 \times 2 = 25.506kPa$$

(Eqn. + Inter. + Ans. = 3+1)

$$P_C - P_A = 12.75 + 25.51 = 38.26kPa$$

(Eqn. + Ans. = 1)

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Prob. 4

Information and assumptions

Provided in problem statement

Find

The acceleration

Solution 1

$$a_x = \frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z}$$

$$= x + (xt + 2y)t + (xt^2 - yt)(2) + 0$$

$$= 1 + (3+4)(3) + (9-6)(2) + 0 = 28\, m/s^2$$

(Eqn. + Inter. + Ans. = 2+2+1)

$$a_y = \frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z}$$

$$= (2xt - y) + (xt + 2y)t^2 + (xt^2 - yt)(-t) + 0$$

$$= (6-2) + (3+4)(9) + (9-6)(-3) + 0 = 58\, m/s^2$$

(Eqn. + Inter. + Ans. = 2+2+1)

$$\mathbf{a} = (28\mathbf{i} + 58\mathbf{j})\, m/s^2$$