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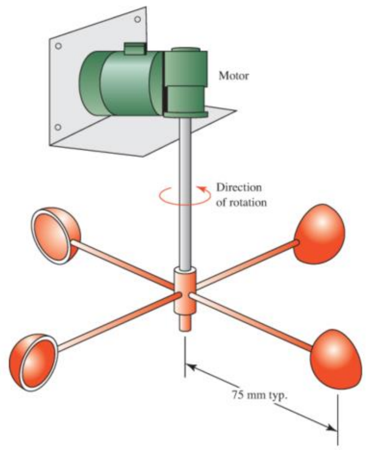
MET 330 HW 2.2 group 11



17.11 A type of level indicator incorporates four hemispherical cups with open fronts mounted as shown in **Fig. 17.13**. Each cup is 25 mm in diameter. A motor drives the cups at a constant rotational speed. Calculate the torque that the motor must produce to maintain the motion at 20 rpm

$$1\,\frac{rev}{min} = \frac{2\pi l}{60}\,m/s = \frac{20(2\pi)(0.075)}{60} = 0.157\,m/s$$

$$A = \frac{\pi}{4}(0.025)^2 = 4.91\times10^{-4}\,m^2$$

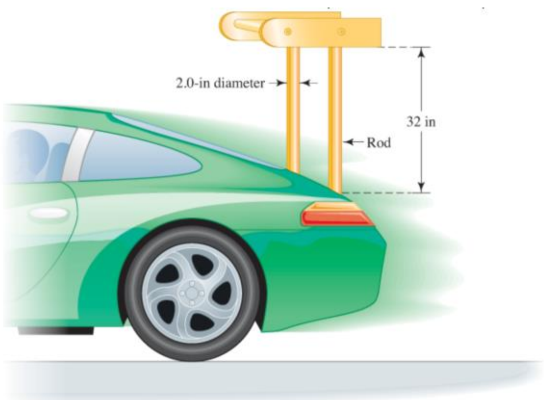
$$N_R = \frac{vD}{\nu} = \frac{(0.157)(0.025)}{1.6\times10^{-5}\,m^2/s} = 245.31$$

ν = air @ 30°C = $1.6\times10^{-5}\,m^2/s$

$$F_D = 1.35\left(\frac{(1.164)(0.157)^2}{2}\right)(4.91\times10^{-4})$$

$$F_D = 9.51\times10^{-6}\,N$$

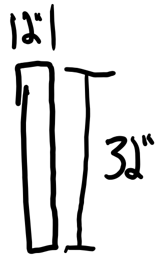
$$\tau = 4(9.51\times10^{-6})(0.075) = \underline{2.853\times10^{-6}\,N\cdot m}$$



17.14 A wing on a race car is supported by two cylindrical rods, as shown in **Fig. 17.15**. Compute the drag force exerted on the car due to these rods when the car is traveling through still air at −20°F at a speed of 150 mph.

$150\,mph = 67.056\ m/sec$

$a = 32(2) = 64\,in^2 = 0.0412902\,m^2$

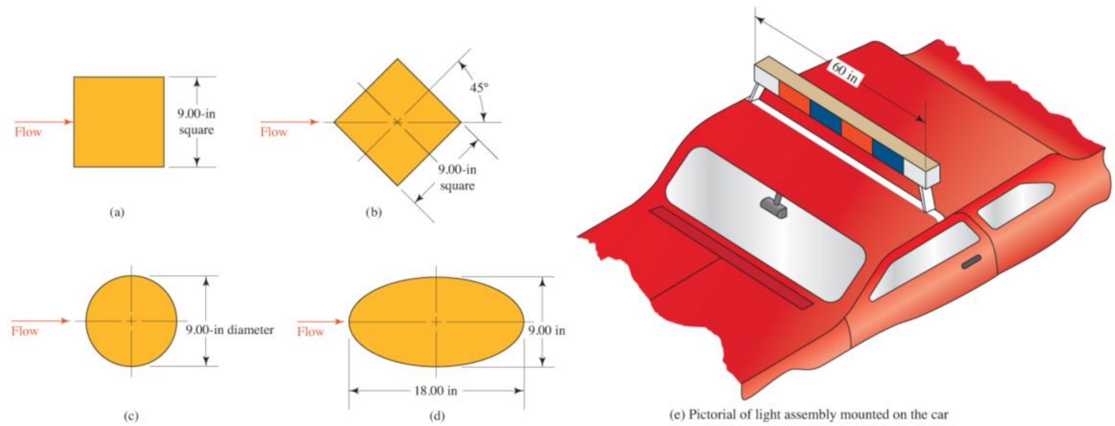


$F_D = 2\left(\tfrac{1}{2}\right)(1.225)(67.056)^2(0.0412902)$

$F_D = 227.436\ N$

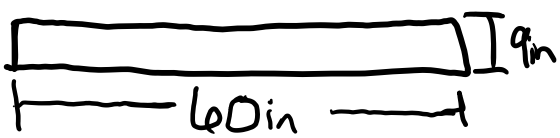
$\rho = 1.225\ kg/m^3$

$\boxed{F_D = 51.13\ lbf}$



17.16 The four designs shown in **Fig. 17.16** for the cross section of an emergency flasher lighting system for police vehicles are being evaluated. Each has a length of 60 in and a width of 9.00 in. Compare the drag force exerted on each proposed design when the vehicle moves at 100 mph through still air at −20°F.

a)



$\rho_{air} = 0.0826$

$W = 9(1/12) = 0.75 ft$

$l = 60(1/12) = 5 ft$

$V = 100(5280)(1/3600) = 146.67 ft/s$

$F_D = C_D \left(\frac{\rho v^2}{2}\right) A$

$N_R = \frac{vL}{\nu}$

$\nu = 1.17 \times 10^{-4} ft^2/s$

$\rho = 2.80 \times 10^{-3} slugs/ft^3$

$N_R = \frac{(146.67)(0.75)}{1.17 \times 10^{-4}} = 9.401 \times 10^5$

$C_D = 2.10$

$A = 60(9) = 540 in^2 (1/144) = 3.75 ft^2$

$F_D = 2.10 \left(\frac{(2.8 \times 10^{-3})(146.67)^2}{2}\right)(3.75)$

$F_D = 237.17 lb$

b) $\sin 45 = y/9$

$y = 9\sin 45$

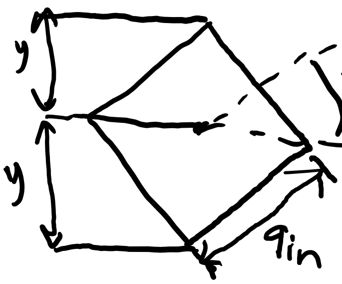
$y = 6.363\text{in}$

$= 0.5302\text{ft}$

$A = 5(2)(0.5302)$

$= 5.302\text{ft}^2$

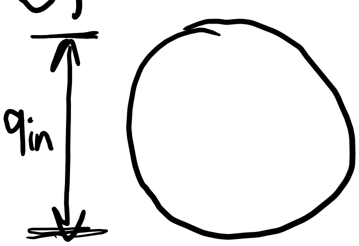
$C_D = 1.6$



$F_D = 1.6\left(\frac{(2.80\times10^{-3})(146.67)^2}{2}\right)(5.302)$

$\underline{F_D = 255.48\text{lb}}$

c)



$A = (60)(9)(1/144) = 3.75\text{ft}^2$

$N_R = \frac{(146.67)(0.75)}{1.17\times10^{-4}} = 9.401\times10^5$

$C_D = 0.3$

$F_D = 0.3\left(\frac{(2.80\times10^{-3})(146.67)^2}{2}\right)(3.75)$

$\underline{F_D = 33.88\text{lb}}$

D)

$A = 3.75\text{ft}^2$

$N_R = \frac{(146.67)(18/12)}{1.17\times10^{-4}} = 1.88\times10^6$

$C_D = 0.25$

$F_D = 0.25\left(\frac{(2.80\times10^{-3})(146.67)^2}{2}\right)(3.75)$

$\underline{F_D = 28.23\text{lb}}$

Table 17.2 Resistance of ships

Ship Type	R_{ts}/Δ
Ocean freighter	0.001
Passenger liner	0.004
Tugboat	0.006
Fast naval ship	0.01–0.12

17.26 A small, fast boat has a specific resistance ratio of 0.06 (see **Table 17.2**) and displaces 125 long tons. Compute the total ship resistance and the power required to overcome drag when it is moving at 50 ft/s in seawater at 77°F.

$$\Delta = (125 LT)\left(\frac{2240 lb}{1 LT}\right)$$

$$\Delta = 2.8 \times 10^5 \text{ lb}$$

$$R_{ts} = (0.06)(2.8 \times 10^5)$$

$$= \underline{16{,}800 \text{ lb}}$$

$$P = (16800)(50) = 8.4 \times 10^5 \text{ lb ft/s} \left(\frac{1 hp}{550 \text{ lb ft/s}}\right) \quad \underline{P = 1527.27 hp}$$

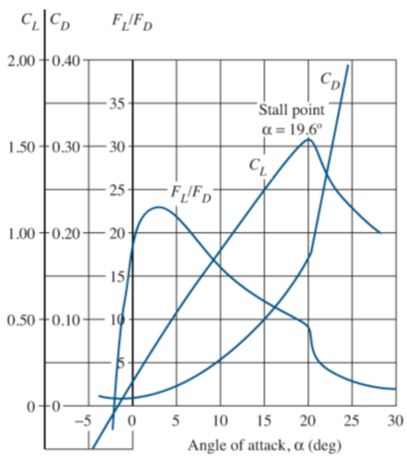


Figure 17.11

Airfoil performance curves.

17.30 For the airfoil with the performance characteristics shown in **Fig. 17.11**, determine the lift and drag at an angle of attack of 10°. The airfoil has a chord length of 1.4 m and a span of 6.8 m. Perform the calculation at a speed of 200 km/h in the standard atmosphere at (a) 200 m and (b) 10 000 m.

$$V = 200(1000)(1/3600) = 55.55\ m/s$$

$$A = (1.4)(6.8) = 9.52\ m^2$$

$$C_D = 0.05$$

$$C_L = 0.9$$

$$\rho = 1.202\ kg/m^3$$

A)

$$F_D = 0.05\left(\frac{(1.202)(55.55)^2}{2}\right)(9.52)$$

$$\underline{F_D = 882.77\ N}$$

$$F_L = 0.9\left(\frac{(1.202)(55.55)^2}{2}\right)(9.52)$$

$$\underline{F_L = 15889.9\ N}$$

b)

$$F_D = 0.05\left(\frac{(0.4135)(55.55)^2}{2}\right)(9.52)$$

$$\underline{F_D = 303.683\ N}$$

$$F_L = 0.9\left(\frac{(0.4135)(55.55)^2}{2}\right)(9.52)$$

$$\underline{F_L = 5466.29\ N}$$