Group 4

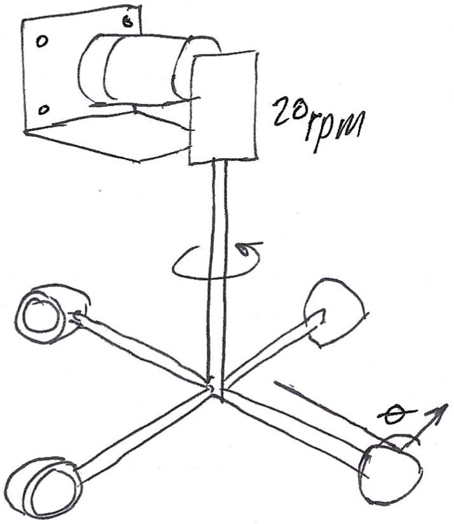
MET 330

10/20/2022

HW2.2

The practice problem associated with the chapter brought multiple previous concepts back into the equation. When dealing with the tipping force required by the wind, a moment had to be established about the pivoting point. The use of free body diagrams became essential again for determining drag force. The only really new concept beside the equations was that of the drag coefficient. The easiest route was using the table provided to determine the drag coefficient based on the shape of the object. However, the Reynold's number was the "long hand" route to determine the drag coefficient. What was interesting about the drag coefficient calculations was the fact that it could be done as an approximation. For example, if a shape was irregular but closely resembled a triangular cylinder, you could use the table value for such to get a rough estimate of the drag force. In all, the chapter appeared daunting at first glance but when breaking the problems down into smaller pieces, they were relatively simple.

17.11



FIND THE REQUIRED TORQUE TO MAINTAIN 20 rpm in 30°C AIR & 20°C GASOLINE.

DRAG COEFFICIENTS : TABLE 17.1

OPEN FRONT HEMISPHERICAL CUP

$$C_D = 1.35$$

TABLE E.1 $\rho_{AIR} @ 30°C = \cancel{1.164}\ 1.164\ kg/m^3$

TABLE B.1 $\rho_{gas} @ 25°C = 680\ kg/m^3$

$$A = \pi \frac{D^2}{4} = \pi \cdot \frac{0.025m^2}{4} = 4.908E\text{-}4\ m^2$$

Equation 17-11 : $F_D = C_D \cdot \frac{\rho V^2}{2} \cdot A$

NEED VELOCITY OF CUPS. $V = r\omega$

$$\omega = \frac{rev}{min} \cdot \frac{2\pi\ rad}{rev} = \frac{20\ \cancel{rev}}{min} \cdot \frac{2\pi\ rad}{\cancel{rev}} = 125.66\ m/min$$

$$= 2.094\ m/sec$$

$$V = 0.075m \cdot 2.094 = 0.157\ m/s$$

$$F_{D_{AIR}} = 1.35 \cdot \frac{1.164\ kg/m^3 \cdot 0.157\ m/s^2}{2} \cdot 4.908E\text{-}4\ m^2$$

$$F_{D_{AIR}} = 9.505E\text{-}6\ N = 9.505\ \mu N \text{ per cup}$$

$$F_{D_{gas}} = 1.35 \cdot \frac{680\ kg/m^3 \cdot 0.157\ m/s^2}{2} \cdot 4.908E\text{-}4\ m^2$$

$$F_{D_{gas}} = 5.552E\text{-}3\ N = 5.552\ mN \text{ per cup}$$

$T = rF_T \sin\theta, \quad \sin\theta = \sin 90° = 1$

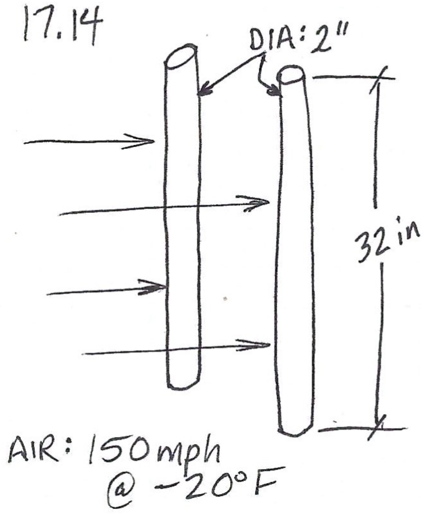
$F_{T_A} = F_{D_{AIR}} \cdot 4\text{ cups} = 3.802E\text{-}5 = \cancel{380.20\ mN}\ 38.02\ \mu N$

$F_{T_g} = F_{D_g} \cdot 4\text{ cups} = 2.221E\text{-}2 = 22.21\ mN$

∗ a) $T_{AIR} = 0.075m \cdot F_{T_A} = \boxed{2.852\ \mu N \cdot m}$

∗ b) $T_{gas} = 0.075m \cdot F_{T_g} = \boxed{1.666\ mN \cdot m}$

17.14



FIND F_D FOR TWO 32" CYLINDERS IN 150 mph AIR @ -20°F

TABLE E.2: $\rho = 2.80\text{E}{-3}\ slugs/ft$
$\nu = 1.17\text{E}{-4}\ ft^2/s$

$v = 150\,mph / 3600 = 0.04167\, mps \cdot 5280'$

$v = 220\ ft/s$

$$F_D = C_D \cdot \frac{\rho v^2}{2} \cdot A$$

USE FIGURE 17.4. NEED N_R

$$N_R = \frac{vD}{\nu} = \frac{220\,ft/s \cdot (2''/12)}{1.17\text{E}{-4}\ ft^2/s} =$$

$$N_R = 3.134\text{E}5$$

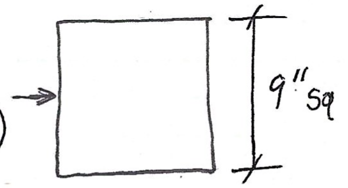
CYLINDER, $N_R = 3.134\text{E}5 \therefore C_D = 0.80$

$$A = \frac{2''}{12} \cdot \frac{32''}{12} \cdot 2 = 0.889\ ft^2$$

$$F_D = 0.80 \cdot \frac{2.80\text{E}{-3} \cdot 220}{2} \cdot 0.889 = \boxed{48.19\ lb}$$

17.16

FIND ~~E~~ F_D OF 60" LIGHT BAR IN 100 mph AIR @ -20°F.

a) 

$v = 100\text{ mph}/3600 = 0.0277\text{ mps}\cdot 5280'$

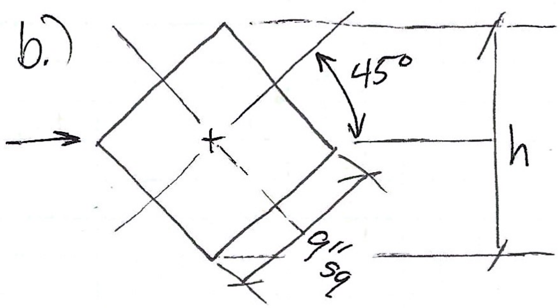
$v = 146.67\text{ ft/sec}$

$\nu = 1.17E{-4}\text{ ft}^2/\text{sec}, \quad \rho = 2.80E{-3}$

$N_R = \dfrac{146.67 \cdot 9/12}{1.17E{-4}} = 9.40E5$ FIG. 17.4 SQUARE CYLINDER $C_D = 2.1$

$F_{D_A} = C_D \cdot \dfrac{\rho v^2}{2} \cdot A \; ; \; A = \dfrac{9}{12} \cdot \dfrac{60}{12} = 3.75\text{ ft}^2$

$F_{D_A} = 2.1 \cdot \dfrac{2.80E{-3} \cdot 146.67^2}{2} \cdot 3.75\text{ ft}^2 = \boxed{237\text{ lb}}$

b.) 

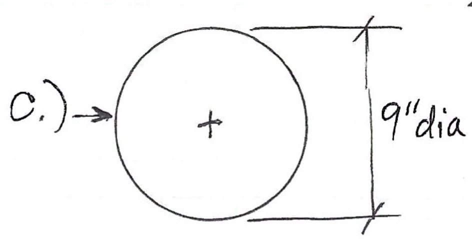
$\dfrac{h}{2} = 0.75' \sin 45° = 0.530\text{ ft}$

$h = 1.06\text{ ft}$

$A = 1.06\text{ ft} \cdot \dfrac{60"}{12} = 5.303\text{ ft}^2$

~~FIG.~~ TABLE 17.1 : $C_D = 1.60$

$F_{D_B} = 1.6 \cdot \dfrac{2.80E{-3} \cdot 146.67^2}{2} \cdot 5.303\text{ ft}^2 = \boxed{44.72\text{ lb}}$

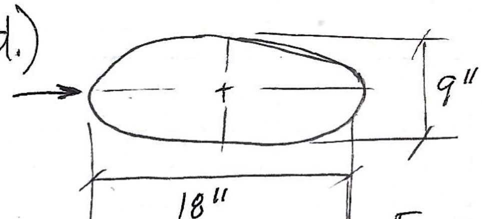
c.) 

$N_R = \dfrac{146.67 \cdot 9/12}{1.17E{-4}} = 9.40E5$

FIG. 17.4 : $C_D = 0.30$

$A = \dfrac{9}{12} \cdot \dfrac{60}{12} = 3.75\text{ ft}^2$

$F_{D_C} = 0.30 \cdot \dfrac{2.80E{-3} \cdot 146.67^2}{2} \cdot 3.75\text{ ft}^2 = \boxed{33.88\text{ lb}}$

d.) 

$N_R = \dfrac{146.67 \cdot 18/12}{1.17E{-4}} = 1.88E{-6}$

$C_D \approx 0.30$

~~CIRCUMFERENCE = 43.86" = 3.63'~~

~~$A = \frac{c}{2} \cdot \frac{60"}{12} =$~~

$A = 0.75 \cdot 5 = 3.75$

$F_{D_D} = 0.30 \cdot \dfrac{2.80E{-3} \cdot 146.67^2}{2} \cdot 3.75\text{ ft}^2 = \boxed{33.88\text{ lb}}$

17.26 SMALL, FAST BOAT : $R_{ts} = 0.06\Delta$, $\Delta = 125 \cdot 2240 = 2.8E5$

$v = 50\ ft/s$

$R_{ts} = 1.68E4$

$P = R_{ts} \cdot v = 1.68E4 \cdot 50\ ft/s = 8.4E5\ \cancel{\$}\ lb \cdot ft/s$

$$\frac{8.4E5\ lb \cdot ft/s}{550} = \boxed{1527\ hp}$$

17.30

$$v = \frac{200\ km/h}{3600\ sec} = 0.056\ km/s = 55.56\ m/s$$

$A = 1.4 \cdot 6.8 = 9.52\ m^2$ $\alpha = 10° \Rightarrow$ Fig. 17.11 $C_L = 0.9$, $C_D = 0.05$

TABLE E.3

a) 200m $\rho = 1.202\ kg/m^3$

$$F_{L_1} = C_L \cdot \frac{\rho \cdot v^2}{2} \cdot A = 0.9 \cdot \frac{1.202 \cdot 55.56^2 \cdot 9.52}{2} = \boxed{15.896\ kN}$$

$$F_{D_1} = \frac{C_D}{C_L} \cdot F_{L_1} = \frac{0.05}{0.9} \cdot F_{L_1} = \boxed{15.896\ kN}$$

b.) 10,000 $\rho = 0.4135\ kg/m^3$

$$F_{L_2} = 0.9 \cdot \frac{0.4135 \cdot 55.56^2}{2} \cdot 9.52 = \boxed{5.468\ kN}$$

$$F_{D_2} = \frac{0.05}{0.9} \cdot F_{L_2} = \boxed{303.792\ N}$$