17: 11 + 14

Pg 446

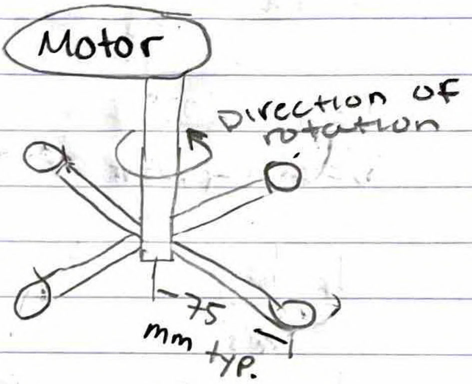
HW 2.2

17.11 A type of level indicator incorporates four hemispherical cups with open fronts mounted as shown below. 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 when are in a) air @ 30°C + b) gasoline @ 20°C

$\omega = 20 \text{ rpm}$

$D = 25\text{mm} = .025\text{m}$

$L = 75\text{mm} = .075\text{m} = r$



$V = \frac{\omega 2\pi L}{60} = \frac{20 \text{ rpm}(2\pi)(.075\text{m})}{60 \text{ sec}}$

$V = .157 \text{ m/s}$

$A = \frac{\pi(.025\text{m})^2}{4} = 4.909\times10^{-4}\text{ m}^2$

a) $N_R = \frac{VD}{\nu} \rightarrow \frac{.157\text{ m/s}(.025\text{m})}{1.56\times10^{-5}} = 251.6 \rightarrow C_D = 1.36$

From E.1 Table

ρ @ $30°C = 1.164 \text{ kg/m}^3$

$F_D = C_D(\rho v^2/2)A \rightarrow 1.36\left(\frac{1.164 \text{ kg/m}^3(.157\text{ m/s})^2}{2}\right)4.909\times10^{-4}\text{ m}^2$

$F_D = 8.09\times10^{-6}\text{ N}$

$T = 4F_D r \rightarrow 4(8.09\times10^{-6})(.075\text{m}) = 2.43\times10^{-6}\text{ N}\cdot\text{m}$

b) $N_R = \frac{.157(.025\text{m})}{4.22\times10^{-7}} = 9300.95 \rightarrow C_D = 1.36 \rightarrow \rho = 680$

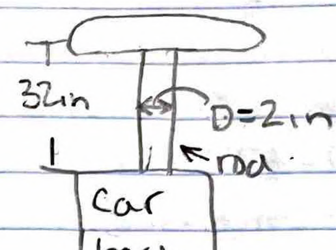
Table B.1

$F_D = 1.36\left(\frac{680 \text{ kg/m}^3(.157\text{ m/s})^2}{2}\right)4.909\times10^{-4}\text{ m}^2 \quad F_D = .0056\text{ N}$

$T = 4F_D r \rightarrow 4(.0056\text{N})(.075\text{m}) = .00167\text{ N}\cdot\text{m}$

17.14

A wing on a race car is supported by two cylindrical rods as shown below. Compute the drag force exerted on the car due to these rods when the car is traveling through still air @ -20°F @ 150 mph.



$T = -20°F$

$V = \frac{150\ mi}{hr} \times \frac{1\ hr}{3600\ s} \times \frac{5280\ ft}{1\ mi} = 220\ ft/s$

$L = 32\ in = 2.67\ ft$

$D = 2\ in = .167\ ft$

$A = DL = (.167)(2)(2.67\ ft) = .892\ ft^2$

$N_r = \frac{VD}{\nu}$

$\nu = 1.2\times10^{-4}$ @ $-20°F$

$N_r = \frac{(220\ ft/s)(.167\ ft)}{1.2\times10^{-4}} = 306166.7$

$C_D = .8$

ρ @ $-20°F = 2.8\times10^{-3}\ slugs/ft$

$F_D = C_D(\rho v^2/2)A$

$F_D = .8\left(\frac{2.8\times10^{-3}\ slugs/ft\,(220\ ft/s)^2}{2}\right)(.892\ ft^2)$

$F_D = 48.35\ lb$

17.2b

Resis. ratio = 0.06

$V = 50 \frac{ft}{s}$ $\Delta = 125 \text{ tons}$

$T_{water} = 77^{o}F$

Total ship resistance:

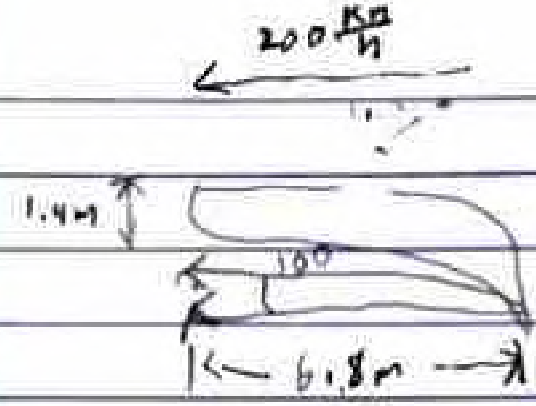
$\Delta = (125 \text{ tons})\left(\frac{2240 \text{ lb}}{1 \text{ ton}}\right) = 2.8 \times 10^5 \text{ lb}$

$R_{ts} = (0.06)(2.8 \times 10^5 \text{ lb}) = 16800 \text{ lb}$

$P_E = R_{ts} V = (16800 \text{ lb})(50 \frac{ft}{s}) = 840000 \frac{\text{lb-ft}}{s}$

$PE = \frac{8.4 \times 10^5 \frac{\text{lb-ft}}{s}}{550 \text{ hp}} = 1527.27 \text{ hp}$

17.30



$c = 1.4\ m$ $\quad h_{1}air = 200\ m$

$b = 6.8\ m$ $\quad h_{2}air = 10000\ m$

$V = 200\ \frac{km}{h}$

$\alpha = 10^{0}$

Using the airfoil performace curve for $\alpha = 10^{0}$

$C_L = 0.9, \quad C_D = 0.05$

Using the property air for density of air at

$\rho_{1}air = 1.202\ \frac{kg}{m^3}, \quad \rho_{2}air = 0.4135\ \frac{kg}{m^3}$

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

$V = 200\ \frac{km}{h}\left(\frac{1000\ m}{1\ km}\right)\left(\frac{1\ h}{3600\ sec}\right) = 55.56\ \frac{m}{s}$

Lift force:

At 200 m: $F_L = C_L\left(\frac{\rho V^2}{2}\right)A = (0.9)\left(\frac{(1.202\ \frac{kg}{m^3})(55.56\ \frac{m}{s})^2}{2}\right)(9.52\ \frac{m}{s})$

$F_L = 15.9 \times 10^5\ N$

At 10000 m: $F_L = C_L\left(\frac{\rho V^2}{2}\right)A = (0.9)\left(\frac{(0.4135\ \frac{kg}{m^3})(55.56\ \frac{m}{s})^2}{2}\right)(9.52\ \frac{m}{s})$

$F_L = 5.5 \times 10^3\ N$

Drag force

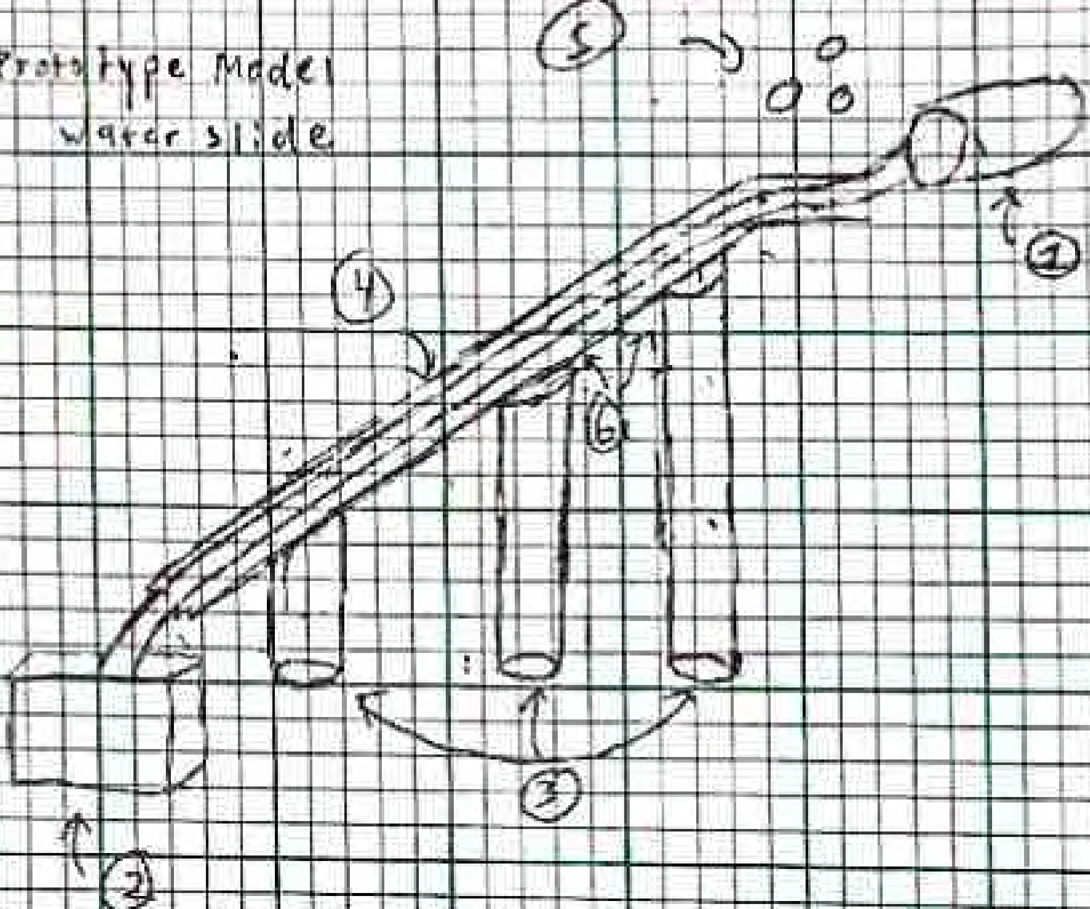
At 200 m: $F_D = C_D\left(\frac{\rho V^2}{2}\right)A = (0.05)\left(\frac{(1.202\ \frac{kg}{m^3})(55.56\ \frac{m}{s})^2}{2}\right)(9.52\ \frac{m}{s})$

$F_D = 883.09\ N$

At 10000 m: $F_D = C_D\left(\frac{\rho V^2}{2}\right)A = (0.05)\left(\frac{(0.4135\ \frac{kg}{m^3})(55.56\ \frac{m}{s})^2}{2}\right)(9.52\ \frac{m}{s})$

$F_D = 303.79\ N$

Prototype Model
Water slide



Ideal supplie budget list

	Cost
1. Large water container	$7
2. Small clear tube container	$5
3. 50 small disposible cups	$10
4. Reynold's wrap aluminum foil	$5
5. 10 pcs marbles 16mm	$7
6. 2 duct tapes	$8
Total Cost	$42