

Chapter 17 overviewed the concepts of drag and lift. Through problem solving and lectures various concepts were discussed including determining design considerations for each specific problem that would be affected by movements of fluids and air. The concepts of determining moments within problem solving was also reviewed as various forces are applied. The forces to be identified and reviewed include weight, drag and reacting forces applied. Being able to identify components such as wind direction and fluid movement in a direction are key to assist with properly equalizing out moment equations. Velocity is also a crucial component to determine drag coefficients and the coefficient depends on Reynolds number.

Being able to identify other the location of drag force applied and the centroid areas within problems were also key as they assisted with utilizing the drag force equation. It appeared that majority that was overviewed within examples problems had a drag force that was located on w center of the object being reviewed. Being able to also identify the sources of "drag" was also key as drag force coefficient chart was needed to determine based on the specific objects. This could be seen as when drag is applied perpendicularly to a flat surface, the drag coefficient would be greater than in a rounded object. A rounded object would allow for left resistance naturally due to the shape of the surface when compared to a flat surfaced object.

HW 2.2 #11

- 4 hemispherical caps
- 25 mm diameter $= .025m$
- Find torque & moment
20 rpm

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

① Area of Sphere

$$A = \frac{\pi d^2}{4} = \frac{\pi (.025)^2}{4} = 4.9 \times 10^{-4} m^2$$

② rpm to m/s $= 20 \text{ rpm} \Rightarrow L = .075$

$$\frac{1 \text{ rev}}{\text{min}} = \frac{2\pi L}{60} \frac{m}{s}$$

$$v = \frac{(2\pi L)(20 \text{ rpm})}{60} = \frac{2(\pi)(.075)(20)}{60} = .157 \frac{m}{s}$$

③ Drag $F_D = C_D \left(\frac{\rho v^2}{2} \right) A$

• Air $\rho = 1.164 \frac{kg}{m^3}$
 • $\mu = 496$

• $v = .157 \frac{m}{s}$

• $A = 4.9 \times 10^{-4} m^2$

• $C_D = ?$

④ $C_D =$ Find N_p use chart pg 435

$$\text{Reynolds Number} = N_p = \frac{vD}{\nu} = \frac{(.157 \frac{m}{s})(.025m)}{1.60 \times 10^{-5} \frac{m^2}{s}}$$

Kinematic Viscosity $\mu = 496$ @ $30^\circ C$

$$= 245.3$$

Chart = 1.30
 B 435 A

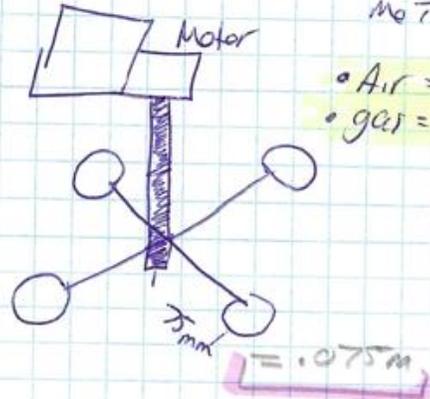
⑤ $F_D = C_D \left(\frac{\rho v^2}{2} \right) A$

$$= 1.30 \left(\frac{1.164 \frac{kg}{m^3}}{2} \right) \left(.157 \frac{m}{s} \right)^2 (4.9 \times 10^{-4} m^2)$$

Drag Force Air

$$= 9.2 \times 10^{-6} N$$

(1)



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- Air = $30^\circ C$
- $\mu_{air} = 20^\circ C$

$$\textcircled{1} \text{ Torque} = T = 4FDr = 4(9.2 \times 10^{-6})(.075) =$$

$$r = .075 \text{ m}$$

$$FD = 9.2 \times 10^{-6} \text{ N}$$

$$T = 2.8 \times 10^{-6} \text{ Nm}$$

Air

$$\frac{1.05 \text{ W } 24^\circ \text{C}}{\text{pg 490}}$$

$$v = 4.22 \times 10^{-7}$$

$$A = 4.9 \times 10^{-4} \text{ m}^2$$

$$\text{pg 490}$$

$$\rho = 680 \text{ kg/m}^3$$

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

• C_D = Find Re - use chart pg 435

$$\text{Reynolds Number} = Re = \frac{vD}{\nu} = \frac{(1.57)(.075)}{4.22 \times 10^{-7}} = 93001$$

 $C_D = ?$

Chart pg 435A $C_D = 1.30$

$$\textcircled{3} FD = C_D \left(\frac{\rho v^2}{2} \right) (A) = (1.30) \left(\frac{680 \text{ kg/m}^3}{2} \right) (1.57)^2 \times (4.9 \times 10^{-4})$$

$$FD = \frac{0.108}{2} = 0.054 \text{ N}$$

$$\textcircled{9} \text{ Torque} = 4FDr$$

$$= 4(0.054)(.075)$$

$$T = 1.62 \times 10^{-3} \text{ Nm}$$

$$\textcircled{10} \text{ Ratio} = \frac{T_2}{T_1} = \frac{1.62 \times 10^{-3} \text{ Nm}}{2.8 \times 10^{-6} \text{ Nm}} = 582.38$$

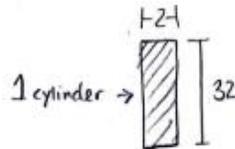
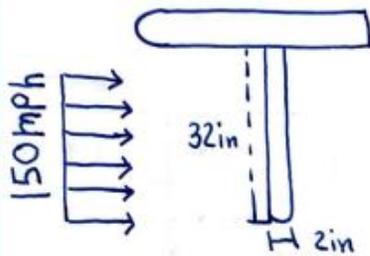
②

HWK 2.2

Met 330

Caeroll, Shaunmark

17.14) A wing on a car is supported by two cylindrical rods, compute the drag force exerted on the car due to these rods when the car is travelling through still air @ -20°F @ 150 mph.



$$V = 150 \frac{\text{mi}}{\text{h}} \left(\frac{5280 \text{ ft}}{1 \text{ mile}} \right) \left(\frac{1 \text{ h}}{3600 \text{ sec}} \right) \rightarrow 220 \text{ ft/sec}$$

$$L = 32 \text{ in} \left(\frac{\text{ft}}{12 \text{ in}} \right) \rightarrow 2.667 \text{ ft}$$

$$D = 2 \text{ in} \left(\frac{\text{ft}}{12 \text{ in}} \right) \rightarrow .1667 \text{ ft}$$

$$A = LD \rightarrow 2.667 \times .1667$$

$$\rightarrow A = .444 \text{ ft}^2$$

$$\text{Total Area} = A \times 2 \rightarrow A_T = .888 \text{ ft}^2$$

$$\text{Air @ } -20^{\circ}\text{F} \rightarrow \rho = 2.80 \times 10^{-3} \frac{\text{slugs}}{\text{ft}^3} ; \quad \nu = 1.17 \times 10^{-4} \frac{\text{ft}^2}{\text{s}}$$

need to find C_D for cylinder by using NR

$$NR = \frac{VD}{\nu} \rightarrow \frac{220 \frac{\text{ft}}{\text{s}} (.1667 \text{ ft})}{1.17 \times 10^{-4} \frac{\text{ft}^2}{\text{s}}} \rightarrow NR = \frac{313453}{3.1 \times 10^5}$$

$$\text{figure 17.4} \rightarrow C_D = .8$$

$$1 \text{ slug} = \frac{\text{lb} \cdot \text{s}^2}{\text{ft}}$$

$$F_D = C_D \left(\frac{\rho V^2}{2} \right) A_T \rightarrow 0.8 \left(\frac{2.80 \times 10^{-3} \frac{\text{lb} \cdot \text{s}^2}{\text{ft}^3} \times (220 \frac{\text{ft}}{\text{s}})^2}{2} \right) .888 \text{ ft}^2$$

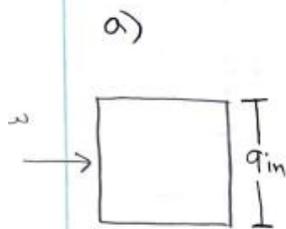
$$F_D = 48.14 \text{ lb}$$

Hwk 2.2

Met 330

Carroll, Shaunmark

17.16) The four emergency flasher designs are being evaluated. Each has a Length of 60 in and a Width of 9.00 in. Compare the drag force exerted on each design when the vehicle moves at 100 mph through still air at -20°F .



$$L = 60 \text{ in } \left(\frac{1 \text{ ft}}{12 \text{ in}} \right) \rightarrow 5 \text{ ft}$$

$$W = 9 \text{ in } \left(\frac{1 \text{ ft}}{12 \text{ in}} \right) \rightarrow 0.75 \text{ ft}$$

$$\text{air @ } -20^{\circ}\text{F}$$

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

$$v = 1.17 \times 10^{-4} \frac{\text{ft}^2}{\text{s}}$$

$$V = 100 \frac{\text{mi}}{\text{h}} \left(\frac{5280 \text{ ft}}{\text{mi}} \right) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) \rightarrow 146.666 \text{ ft/s}$$

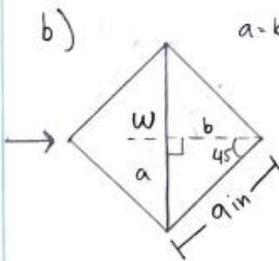
$$NR = \frac{V \cdot W}{\nu} \rightarrow \frac{146.666 \times 0.75}{1.17 \times 10^{-4}} \rightarrow NR = \frac{940170.9}{9.4 \times 10^5}$$

extrapolate C_D Fig 17.4

$$\begin{pmatrix} 1.5 \times 10^4, 2 \\ 6 \times 10^4, 2.1 \end{pmatrix} \quad Y(9.4 \times 10^5) = 2 + \left(\frac{9.4 \times 10^5 - 1.5 \times 10^4}{6 \times 10^4 - 1.5 \times 10^4} \right) (2.1 - 2) = 4.05$$

$$A = L \times W \rightarrow 5(0.75) \rightarrow A = 3.75 \text{ ft}^2$$

$$F_D = C_D \left(\frac{\rho v^2}{2} \right) A \rightarrow 4.05 \left(\frac{2.80 \times 10^{-3} (146.666)^2}{2} \right) 3.75 \rightarrow F_D = 457.38 \text{ lb}$$



$$a = b; a^2 + b^2 = 9^2 \rightarrow 2a^2 = 81 \rightarrow a = 6.364 \text{ in}$$

$$W = 2a \rightarrow W = 12.727 \text{ in} \rightarrow W = 1.06 \text{ ft}$$

$$A = L \times W \rightarrow 5 \text{ ft} (1.06 \text{ ft}) \rightarrow A = 5.303 \text{ ft}^2$$

table 17.1 square cylinder $C_D = 1.60$
with flow hitting corner

$$F_D = C_D \left(\frac{\rho v^2}{2} \right) A \rightarrow 1.60 \left(\frac{2.80 \times 10^{-3} (146.666)^2}{2} \right) 5.303$$

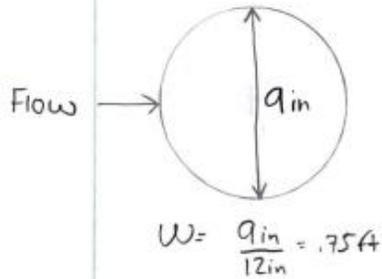
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17.16 Continued)

c)



$$A = W \cdot L \rightarrow .75 \text{ ft} \times 5 \text{ ft} \rightarrow 3.75 \text{ ft}^2$$

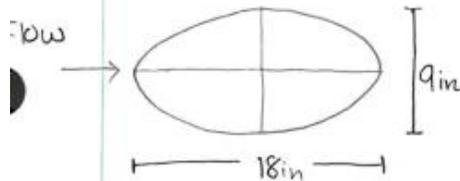
$$NR = \frac{VW}{\nu} \rightarrow \frac{146.6666 \times 3.75 \text{ ft}^2}{1.17 \times 10^{-4}} \rightarrow NR = 9.4 \times 10^5$$

$$\text{fig 17.4 for } NR = 9.4 \times 10^5 \quad CD = 3 \times 10^{-1} \rightarrow .30$$

$$F_D = CD \left(\frac{\rho V^2}{2} \right) A \rightarrow F_D = 0.3 (30.1153) 3.75$$

$$F_D = 33.8816$$

d)



$$L = 18 \text{ in} \left(\frac{1 \text{ ft}}{12 \text{ in}} \right) \rightarrow 1.5 \text{ ft}$$

$$\frac{18}{9} = \frac{2}{1} \text{ Ratio}$$

$$A = q \text{ in} (60 \text{ in}) \rightarrow .75 \times 5 \rightarrow 3.75 \text{ ft}^2$$

$$NR = \frac{VL}{\nu} \rightarrow \frac{146.6666 \times 1.5 \text{ ft}}{1.17 \times 10^{-4}} \rightarrow NR = 1880333.3$$

$$NR = 1.9 \times 10^6$$

Figure 17.6 using 2:1 Ellipse @ 1.9×10^6

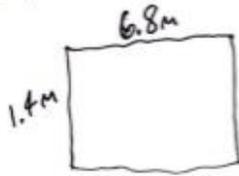
$$CD = 0.35$$

$$F_D = CD \left(\frac{\rho V^2}{2} \right) A \rightarrow 0.35 (30.1153) 3.75$$

$$F_D = 39.53$$

highest to lowest drag force → A, B, D, C

17.30)



Given

$$\alpha (\text{Angle of Attack}) = 10^\circ$$

$$L = 1.4 \text{ m}$$

$$W = 6.8 \text{ m}$$

$$V = 200 \frac{\text{km}}{\text{hr}} = 55.55 \frac{\text{m}}{\text{s}}$$

$$C_L (\text{from figure}) = 0.90$$

$$C_D (\text{from figure}) = 0.06$$

$$A = L \times W = 1.4 \text{ m} \times 6.8 \text{ m} = 9.52 \text{ m}^2$$

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HW 2.2
10/20/2021

a) At elevation of 200m

$$\rho_{\text{air @ 200m}} = 1.202 \frac{\text{kg}}{\text{m}^3} (\text{From table E.3})$$

$$F_D = \text{drag} = C_D \left(\frac{\rho V^2}{2} \right) A = 0.06 \left(\frac{1.202 (55.55)^2}{2} \right) 9.52 = (0.06)(1854.567)(9.52)$$

$$\therefore F_D = 1,059.329 \text{ N}$$

$$F_L = \text{Lift} = C_L \left(\frac{\rho V^2}{2} \right) A = (0.90) \left(\frac{1.202 (55.55)^2}{2} \right) (9.52) = (0.90)(1854.567)(9.52)$$

$$\therefore F_L = 15,889.930 \text{ N}$$

b) At elevation of 10,000m

$$\rho_{\text{air @ 10,000m}} = 0.4135 \frac{\text{kg}}{\text{m}^3} (\text{From table E.3})$$

$$F_D = \text{drag} = C_D \left(\frac{\rho V^2}{2} \right) A = (0.06) \left(\frac{0.4135 (55.55)^2}{2} \right) (9.52) = (0.06)(637.99)(9.52)$$

$$\therefore F_D = 364.42 \text{ N}$$

$$F_L = \text{Lift} = C_L \left(\frac{\rho V^2}{2} \right) A = (0.90) \left(\frac{0.4135 (55.55)^2}{2} \right) (9.52) = (0.90)(637.99)(9.52)$$

$$\therefore F_L = 5,466.30 \text{ N}$$