MET 330 HW 2.2

Team Vortex

2/22/2024

<u>Chapter 17</u>

11)

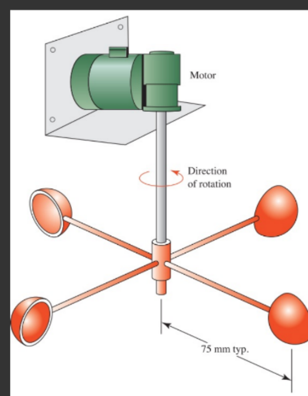
17.11 A type of level indicator incorporates four hemispherical cups with open fronts mounted as shown in Fig. 17.11 . Each cup is 25 mm in diameter. A motor drives the cups at a constant rotational speed. Calculate the torque that the motor must produce to maintain the motion at 20 rpm when the cups are in (a) air at 30°C and (b) gasoline at 20°C.

From Table 17.1

$\boxed{C_D = 1.35}$

From Table E.1

$\boxed{\rho @ 30° = 1.164 \ kg/m^3}$



$d = 25 \ mm = 0.025 \ m$

$r = 75 mm = 0.075 \ m$

$\omega = 20 \ RPM = 2.094 \ rad/s$

$A = \frac{\pi d^2}{4}$ $\quad A = \frac{\pi (0.025)^2}{4} = 4.909 \times 10^{-4} \ m^2$

$V = r \cdot \omega$ $\quad V = 0.076 m \cdot 2.094 \ rad/s = 0.157 \ m/s$

$F = \rho \cdot V \cdot A \cdot \Delta V \cdot C_D = 1.164 \ kg/m^3 \cdot 0.157 \cdot 4.9 \times 10^{-4} \cdot 0.157 \cdot 1.35 \cdot \frac{1}{2}$

$F = 9.511 \times 10^{-6} \ N$

$T = 4 \cdot F \cdot r$ $\quad T = 4 \cdot 9.511 \times 10^{-6} N \cdot 0.075 m$ $\quad \boxed{T = 2.85 \times 10^{-6} \ Nm}$

Table B.1

$\boxed{\rho_2 = 680 \ kg/m^3}$

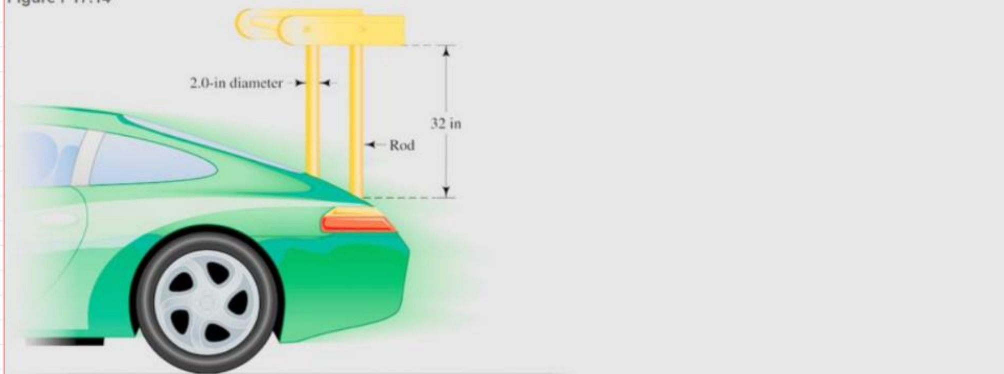
$F_2 = 680 \ kg/m^3 \cdot 0.157 \cdot 4.9 \times 10^{-4} \cdot 0.157 \cdot 1.35 \cdot \frac{1}{2} = 5.56 \times 10^{-3} \ N$

$T = 4 \cdot F \cdot r$ $\quad T = 4 \cdot 5.56 \times 10^{-3} N \cdot 0.075 m$ $\quad \boxed{T = 1.67 \times 10^{-3} \ Nm}$

14)

17.14 A wing on a race car is supported by two cylindrical rods, as shown in **Fig. P17.14**. Compute the drag force exerted on the car due to these rods when the car is traveling through still air at $-20^\circ F$ at a speed of 150 mph.

Figure P17.14



$V = 150\ mph = 67.056\ m/s$

$F_D = \frac{1}{2} \rho V^2 C_D A$

$A = 2\ inch \cdot 32\ inch = 64\ inchs^2 = 0.04129\ m^2$

$\rho = 1452\ kg/m^3$

$C_D = 1.2$

$F_D = \frac{1}{2}\left(1.44\ \frac{kg}{m^3} \cdot (67.056\ m/s)^2\right) \cdot 1.2 \cdot 0.04129\ m^2$

$160.41\ N = 35.96\ lb \cdot 2 = \boxed{71.9389\ lb}$

16)

Chapter 17

16. $L = 60\text{ in}$, $w = 4.00\text{ in}$, 100 mph, $-20°F$

100 mph $\rightarrow$ 147 ft/s

$$F_D = C_D\left(\tfrac{1}{2}\rho v^2\right)A = C_D(0.5)(2.80\times10^{-3})(147)^2(A)$$

$$= (30.12)(C_D)(A)$$

$$A = (4\text{ in})(60\text{ in})\frac{1}{144} = 3.75\text{ ft}^2$$

A) $N_R = \frac{vL}{\nu} = \frac{(147)(0.75)}{1.17\times10^{-4}} = 9.42\times10^5$

$F_D = 30.12(2.10)(3.75) = \boxed{237.16}$

B) $F_D = 30.12(1.60)(3.75) = \boxed{25616}$

C) $N_R = \frac{vD}{\nu} = \frac{147(0.75)}{1.17\times10^{-4}} = 9.42\times10^5$

$F_D = 30.12(0.30)(3.75) = \boxed{33.916}$

D) $N_R = \frac{(147)(1.150)}{1.16\times10^{-4}} = 1.88\times10^6$, $F_D = 30.12(0.25)(3.75) = \boxed{28.216}$

26)

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.

Refrencing example Problem 17.3

disp = 125 Long ton = 2.8×10^5 lb.

$S_{rr} = 0.06$

$R_{ts} = S_{rr} \cdot disp.$ $R_{ts} = 0.06 \cdot 2.8 \times 10^5 \text{ lb} = 1.68 \times 10^4 \text{ lb}$

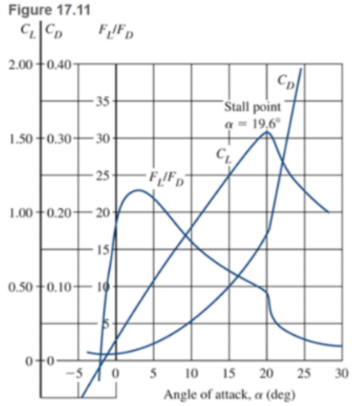
$Power = R_{ts} \cdot v$ $Power = 1.68 \times 10^4 \text{ lb} \cdot 50 \text{ ft/s} = 8.4 \times 10^5 \text{ lb} \cdot \text{ft/s}$

$8.4 \times 10^5 \text{ lb} \cdot \text{ft/s} / 550 = \boxed{1527.3 \text{ hp}}$

30)

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.

Figure 17.11



$C = 1.4\ m$

$b = 1.6\ m$

Speed $= 55.56\ m/s$

angle $= 10^\circ$

$C_D = 0.5$

$C_L = 0.9$

$h = 200\ m$ and $10,000$

Area $= 1.4 \cdot 6.8\ m^2 = 9.52\ m$

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

☆ 2000 m

$F_D = \frac{1}{2} \cdot 1.202 \cdot 0.05 \cdot (55.56)^2 \cdot 9.52 = \boxed{0.883\ KN}$ Drag force

$F_b = \frac{1}{2} \cdot 0.9 \cdot 1.202 \cdot (55.56)^2 \cdot 9.52 = \boxed{15.89\ KN}$ lift force

☆ 10000

$F_D = \frac{1}{2} \cdot 0.4135 \cdot 0.05 \cdot (55.56)^2 \cdot 9.52\ N = \boxed{0.303\ KN}$ Drag force

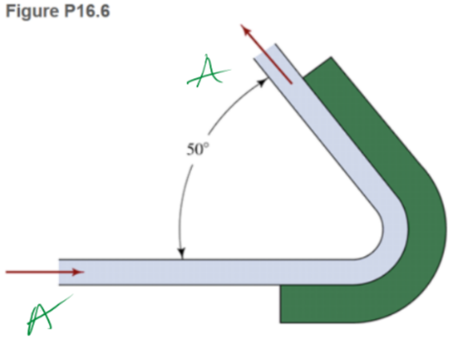
$F_L = \frac{1}{2} \cdot 0.4135 \cdot 0.9 \cdot 9.52 (55.56)^2 = \boxed{5.4683\ KN}$ lift force

Chapter 16

6)

16.6 **Figure P16.6** shows a free stream of water at $180^\circ F$ being deflected by a stationary vane through a 130° angle. The entering stream has a velocity of 22.0 ft/s. The cross-sectional area of the stream is constant at $2.95 in^2$ throughout the system. Compute the forces in the horizontal and vertical directions exerted on the water by the vane.

Figure P16.6



Redirected stream for **Problem 16.6**.

$A = 2.95 in^2$ $T = 180 F$ 130 Degrees   22 ft/s $6.705 \, m/s$ = Velocity

$A = 0.0019 m^2$ $82.22^\circ C$

$6.705 \cdot 0.0019 = 0.0127395 \, m^3/s$ $971 \, Kg/m^3$

$F = \rho Q \Delta V$ $V_{2x} = 6.705 \, m/s \cdot Cos(50) = 4.309 \, m/s$

$F_x = \rho Q (V_{2x} - V_{1x})$ $V_{2y} = 6.705 \, m/s \cdot Sin(50) = 5.13627 \, m/s$

$F_y = \rho Q (V_{2y} - V_{1y})$

opposite directions

$F_x = 971 \frac{Kg}{m^3} \cdot 0.0127 \frac{m^3}{s} (4.309 \, m/s + 6.9 \, m/s) = \boxed{138.226 \, N}$

$F_y = 971 \frac{Kg}{m^3} \cdot 0.0127 \, m^3 (5.136 \, m/s - 0) = \boxed{63.335 \, N}$

11)

11. Calculate spring force vertical position

W = 100 gal/min flows 1 in schedule 40 pipe is attached

$$q = \frac{100(0.1337)}{60} = 0.2228 \text{ ft}^3/\text{s}$$

$$F = \rho Q[v_2 - v_1]$$

Density = 1.94 lb/ft^3

Area of 1 in schedule 40 = 0.006 ft^2

$$\text{vel of flow} = \frac{0.226 \text{ ft}^3/\text{s}}{0.006 \text{ ft}^2} = 37.1 \text{ ft/s}$$

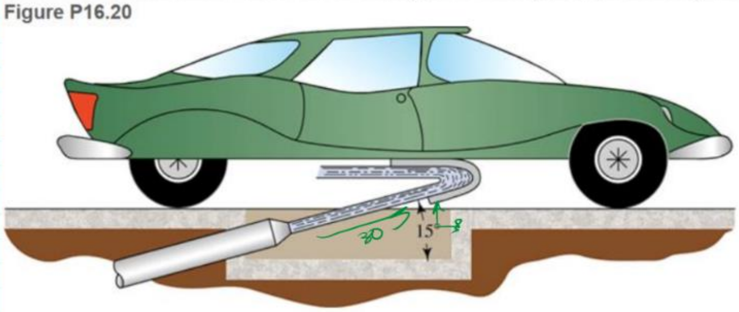
$$F = (1.94)(0.228)(37.1 - (37.1))$$

$$\boxed{F = 32.06 \text{ lb}}$$

20)

16.20 A vehicle is to be propelled by a jet of water impinging on a vane as shown in **Fig. P16.20**. The jet has a velocity of 30 m/s and issues from a nozzle with a diameter of 200 mm. Calculate the force on the vehicle (a) if it is stationary and (b) if it is moving at 12 m/s.

Figure P16.20



$V = 30\ m/s$ $\quad$ $12\ m/s$ $\quad$ $V_{x_1} = \cos 15 \cdot 30 = 28.97\ m/s$

Diameter $= 0.2\ m$ $\quad$ $\rho = 1000\ \frac{kg}{m^3}$ $\quad$ $V_{y_1} = \sin 15 \cdot 30 = 7.76\ m/s$

$F = \rho Q \Delta V$ $\quad$ $Q = (0.2\,m)^2 \cdot pi \cdot 30\ m/s = 3.76\ \frac{m^3}{s}$

$$F_x = 1000\ \frac{kg}{m^3} \cdot 3.76\ \frac{m^3}{s} \cdot (30 + 28.97) = \boxed{221.72\ kN}$$

$$F_y = 1000\ \frac{kg}{m^3} \cdot 3.76\ \frac{m^3}{s} \cdot (0 + 7.76) = \boxed{29.1776\ kn}$$

part 2

$$F_x = 1000\ \frac{kg}{m^3} \cdot 3.76\ \frac{m^3}{s} \cdot (30 + 28.97 - 12) = \boxed{176.6\ kN}$$

29)

Pg. 422

Chapter 16: # 29

Given:

Water = 15°C

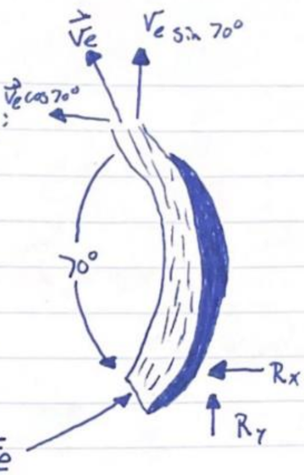
Jet $\varnothing$ = 7.5 mm

Jet $\vec{v}$ = 25 m/s

$\theta = 70°$

$\vec{v}_0 = 0$

Diagram:



$$\vec{v}_e = V_1 - V_0$$

$$\vec{V}_e = 25 \text{ m/s}$$

$$Q_e = A_1 \vec{v}_e$$

$$Q_e = 0.0000442 \text{ m}^2 (25.0 \text{ m/s})$$

$$Q_e = 0.001105 \text{ m}^3/\text{s}$$

$$R_x = \rho Q_e \vec{v}_e (1 + \cos\theta)$$

$$R_x = (1000)(0.001105 \text{ m}^3/\text{s})(25 \text{ m/s})(1 + \cos 70°)$$

$$\boxed{R_x = 37.07 \text{ N}}$$

$$R_y = \rho Q_e \vec{v}_e \sin\theta$$

$$R_y = (1000)(0.001105 \text{ m}^3/\text{s})(25 \text{ m/s})(\sin 70°)$$

$$\boxed{R_y = 25.96 \text{ N}}$$

MET330 HW 2.2 Reflection

Team Vortex

2/22/2024

Homework 2.2 reflection

In lecture this week we covered chapter 16 and 17. Chapter 16 was about channel flow, this relates to the flow of liquids, usually water in the channel. The channel can be made of several different materials all will have a different effect on friction. These frictions can be found via the tables in the book, with a large variety of materials to either pick from or match the terrain present. Bernoulli's equation can be used to derive the equation for finding the required element. In class, the example for fluids was to find the h of the given angle and distance.

Chapter 17 was based on forces relating to lift and drag. The primary idea behind this is that the force due to drag is equal to ½ of the density multiplied by velocity squared multiplied by the drag coefficient times the area. The drag coefficient is based upon the shape of the object that drag acts upon. Lift similarly is based upon a similar formula, but the drag coefficient is substituted for a lift coefficient.