Chapter 17

(1) Cup diameter = 25 mm

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

20 rpm
air @ 30°c
gas @ 20°c

$$V = \frac{(20)(2\pi L)}{60}\ \text{m/s} \qquad A = \frac{\pi D^2}{4}$$

$$V = \frac{(20)(2\pi)(0.075)}{60} \qquad A = \frac{\pi(0.025)^2}{4}$$

$$V = 0.157\ \text{m/s} \qquad A = 4.908 \times 10^{-4}\ \text{m}^2$$

Reynolds #

$$N_R = \frac{VD}{\nu} \rightarrow \text{Table E.1}$$

$$= \frac{(0.157)(0.025)}{1.60 \times 10^{-5}}$$

$$N_R = 245.31$$

$$C_D = 1.35$$

Drag Force on cups in air @ 30°c

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

$$F_D = 1.35\left(\left((1.164)(0.157)^2/2\right)(4.908 \times 10^{-4}\right)$$

$$F_D = 9.5 \times 10^{-6}\ N$$

Torque produced when cups in air @ 30°c

$$T = 4F_D r$$

$$T = 4(9.5 \times 10^{-6})(0.075)$$

$$\boxed{T = 2.85 \times 10^{-6}\ N \cdot m \text{ in air @ } 30°c}$$

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11) $N_R = \frac{VD}{\nu} \nearrow$ Table E.1

$N_R = \frac{(0.157)(0.025)}{4.22\times10^{-7}}$

$N_R = 9300.9$

$\downarrow$

$C_D = 1.35$

Drag Force on cups in gas @ 20°C

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

$F_D = 1.35((680)(0.157)^2/2)(4.908\times10^{-4})$

$F_D = 0.00555 N$

Torque produced when cups in gas @ 20°C

$T = 4F_D r$

$T = 4(0.00555)(0.075)$

$\boxed{T = 1.665\times10^{-3}\ N\cdot m \text{ in gasoline @ } 20°C}$

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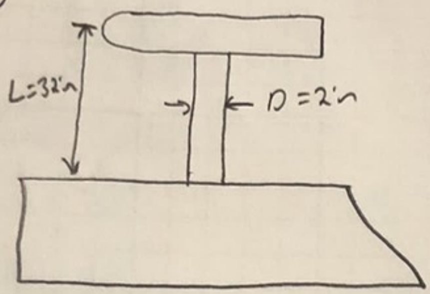
14)



$L = 32 \times \frac{1}{12}$ $D = 2\left(\frac{1}{12}\right)$

$L = 2.67 ft$ $D = 0.167 ft$

$T = -20°F$

$V = 150(5280)\left(\frac{1}{3600}\right)$

$V = 220 ft/s$

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

$F_D = (0.80)((2.8\times10^{-3})(220)^2/2(0.89178)$

$\boxed{F_D = 48.34 / 5 \ lb}$

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

$= \frac{(220)(0.167)}{(1.17\times10^{-4})}$

$N_R = 3.14\times10^5$

$\downarrow$

$C_D = 0.80$

$A = DL$

$= (0.167)(2.67+2.67)$

$A = 0.89178 ft^2$

$\rho = 2.8\times10^{-3} slug/ft^3$

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16) $T = -20°F$

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

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

<u>Square lighting</u>

$b = 9\left(\frac{1}{12}\right)$

$b = 0.75\,ft$

$l = 60\left(\frac{1}{12}\right)$

$l = 5\,ft$

$v = 100(5280)\left(\frac{1}{3600}\right)$

$v = 146.67\,ft/s$

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

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

$N_R = 9.401 \times 10^5$

$\downarrow$

$C_D = 2.10$

$A = lb$

$A = (0.75)(5)$

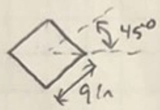
$A = 3.75\,ft^2$

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

$F_D = 2.10\left(\frac{2.80\times10^{-3}(146.67)^2}{2}\right)(3.75)$

$\boxed{F_D = 237.17\,lb}$

<u>Square light angled</u>



$\sin 45 = \frac{y}{9}$

$y = 9(\sin 45)$

$y = 6.363\,in$

$y = 0.5302\,ft$

$A = l(2y)$

$A = 5(2)(0.5302)$

$A = 5.302\,ft^2$

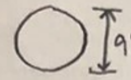
$F_D = C_D\left(\frac{\rho v^2}{2}\right)A$

$F_D = 2.10\left(\frac{2.80\times10^{-3}(146.67)^2}{2}\right)(5.302)$

$\boxed{F_D = 255.48\,lb}$

16) Round lighting

Flow →



$A = lb$

$A = (0.75)(5)$

$A = 3.75\ ft^2$

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

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

$N_R = 9.401\times10^5$

$\downarrow$

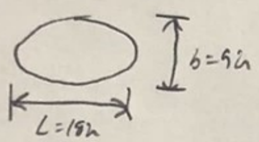
$C_D = 0.3$

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

$F_D = 0.3\left(\frac{2.00\times10^{-3}(146.67)^2}{2}\right)(3.75)$

$\boxed{F_D = 33.88\ lb}$

Elliptical lighting



$\frac{L}{b} = \frac{18}{9}$

$\frac{L}{b} = \frac{2}{1}$

$A = lb$

$A = (0.75)(5)$

$A = 3.75\ ft^2$

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

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

$N_R = 1.88\times10^6$

$\downarrow$

$C_D = 0.25$

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

$F_D = (0.25)\left(\frac{2.00\times10^{-3}(146.67)^2}{2}\right)(3.75)$

$\boxed{F_D = 28.23\ lb}$

HW. ch 16 6, 20

6)

180°F 130°

$A = 2.95 \times \frac{1}{12} = .020\ ft^2$

$\theta = 130°$

$V_1 = 22\ ft/s$

$t = 180°F$

$d = 1.883$ slugs for water

$Q = AV$

$Q = (.020) \cdot (22) = .44\ ft^3/s$

$v_{2_x} = 22 \cdot \cos(180 - 130) = 14.14\ ft/s$

$v_{2_y} = 22 \sin(180 - 130) = 16.85\ ft/s$

$F_x = (1.883) \cdot (.44) \cdot (14.14 - (-22)) \approx \boxed{29.94\ lb}$

$F_y = (1.883) \cdot (.44) \cdot (16.85 - 0) \approx \boxed{13.96\ lb}$

20.) ch. 16 HW

$Q = \frac{\pi}{4} d^2 \times v$ $Q = \frac{\pi}{4} \times .2^2 \times 30 = .943\ m^3/s$

$R_x = \rho Q [v_2 - (-v_1 \cos\theta))$

~~$R_x = .94 \cdot 998(\cos 15)$~~ $1.966 \times 1000 \times .943 \times 30$

~~$.94 \cdot 998 (30\cos 15) =$~~ $= 55618.14\ N$

$R_y = .25 \times 1000 \times .943 \times 30 = \boxed{7072.5 N}$

B.) $v_x = 30\cos 15 = 28.98\ m/s$

$v_{1x} = 28.98 - 12 = 16.98\ m/s$

$v_y = v\sin\theta = 7.76\ m/s$

$V_e = \sqrt{16.98^2 + 7.76^2} = 18.67\ m/s$

$M_e = 1000 \times \frac{\pi}{4} \times .2^2 \times 18.67 = 586.6\ kg/s$

$\alpha = \tan^{-1}\left(\frac{7.76}{16.98}\right) = 24.56°$

$\beta = \alpha - \theta = 9.56°$

$V_{ex} = V_e \cos\beta = 18.40\ m/s$

$R_x = 586.6(18.40 - (16.98)) = \boxed{832.97 N}$

$R_y = 586.6(0 - -7.76) = \boxed{4552.0 N}$

Chapter 17 Problem 26

Given,

Specific resistance Ratio = 0.06

Displacement of ship = 125 long tons

Speed of ship is $V = 50\,ft/s$

Temperature of sea water = $T = 77°F$

Solution

$P = R_{ts} V$

1 long ton = 2240 lb

Since $R_{ts} = 0.06\,\Delta$

$\therefore \Delta = (125 \text{ long ton})\left(\frac{2240\,lb}{1 \text{ long ton}}\right)$

$\Delta = 2.8 \times 10^5\,lb$

$\therefore R_{ts} = 0.06\,\Delta$

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

Total resistance = $\boxed{16800\,lb}$

Power required

$P = R_{ts} V$

$P = (16,800)(50)$

$P = 8.4 \times 10^5\,lb\text{-}ft/s$

$P = (8.4 \times 10^5\,lb\text{-}ft/s)\left(\frac{1\,hp}{550\,lb\text{-}ft/s}\right)$

$P = \boxed{1527.27\,hp}$

In this chapter we looked at different types of forces. We learned forces due to fluids in motion and still liquids. We used Newton's Second Law of motion $F = ma$ to developed the force equation used in this chapter. We then used the force equation to compute the force on moving objects such as vanes of a pump impeller, force exerted on bends in pipelines as well as forces exerted on a stationary object that causes the change in direction of a fluid stream.

We used the force equation in x, y and z direction and the main equation which we used was

$F_x = \rho Q \Delta V_x = \rho Q (V_{2x} - V_{1x})$, the equations is the same, you just have to be aware of the direction force you are solving for.

In the equation say x the term F_x refers to the net external force that acts on the fluid in that direction.

①

16.11

Since, volume flow rate equals to $Q = 100$ gall/min

so, $Q = \frac{100 \times 0.1337}{60} = 0.2228\ ft^3/s$

So, pipe used is 1in schedule 40 steel pipe.

→ The spring force required to hold the vane (vertically) $F = \underset{\text{Density of water}}{\rho} Q [V_2 - V_1]$

So, velocity of flow equals to $V = \frac{Q}{A}$ $\rho = 1.94\ lb/ft^3$

→ The area of 1 in schedule 40 pipe $A = 0.006\ ft^2$

velocity of flow $v = \frac{0.2226\ ft^3/s}{0.006\ ft^2}$

$v = 37.1\ ft/s$

→ spring force required to hold the vane in vertical position

$F = \rho Q [V_2 - V_1]$

$F = (1.94)(0.2228) \times [37.1 - (-37.1)]$

$\boxed{F = 32.0\ lb}$

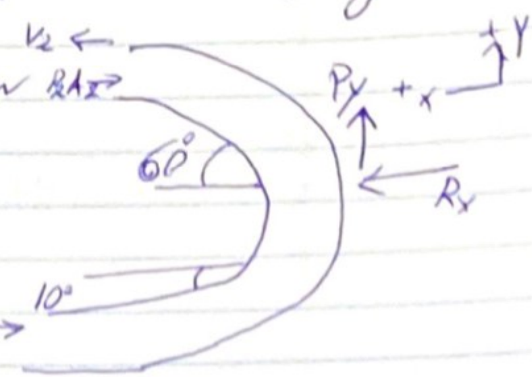
16.29

Since, the diameter of stream of water $d = 7.5$ mm

$d = 7.5 \times \frac{1}{1000}$ $\quad d = 0.0075\,m$

velocity of water $V = 25$ m/s water flowing at 15c

* Direction of forces and flow



Forces exerted by water in

direction

$R_x = \rho Q[(v_2 \cos 60°) + (v_1 \cos 10°)]$

Force exerted by water in Y-direction

$R_y = \rho Q[(v_2 \sin 60°) + (v_1 \sin 10°)]$

Volume flow rate can be calculted by $Q = Av$

Area of steam $A = \frac{\pi d^2}{4}$

$$= \frac{\pi (0.0075)^2}{4}$$

$$= 4.418 \times 10^{-5}\ m^2$$

The volum flow rate $Q = (4.418 \times 10^{-5})(25$

so, $Q = 1.1045 \times 10^{-3}\ m^3/s$

→ force exerted by water in x-direction

$R_x = PQ[(V_2 \cos 60^\circ) + (V_1 \cos 10^\circ)]$

$R_x = 1000 \times 1.1045 \times 10^{-3} [(25 \cos 60^\circ) + (25 \cos 10^\circ)]$

$R_x = 40.99 N$

→ force exerted by water in Y-direction

$R_y = PQ[(V_2 \sin 60^\circ) - (V_1 \sin 10^\circ)]$

$R_y = 1000 \times 1.1045 \times 10^{-3} [(25 \sin 60^\circ) - (25 \sin 10^\circ)]$

$R_y = 19.12 N$

Q17-30

since it is given that chord length of airfoil.

is $c = 1.4$ m span of the airfoil is $b = 6.8$ m

speed is $v = 200$ km/h

$v = 200 \times 1000 \times \frac{1}{3600} = 55.55$ m/s

Angle of a Hack is $a = 10^\circ$

Drag force is calculated using:-

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

Lift force is caluolated as follows:

$F_L = C_L (\rho v^2/2) A$

Area of the airfoil is:-

$A = cb$

$A = 1.4 \times 6.8 = 9.52\ m^2$

Since area of airfo $A = 9.52\ m^2$

→ The value of drag coefficient C_D for an angle of attact $10°$ obtained from airfoil Performance curve $C_D = 0.05$

→ The value of lift coefficient C_L for an angle of attack of $10°$ obtained from airfoil performance curve equals to $C_L = 0.9$

(a) when altitude $h = 2000\,m$

From the table of properties of air the value of density at an altitude of 20a m

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

so, $F_D = C_D(\rho V^2/2)A$

$= \frac{0.5 \times 1.202 \times (55.55)^2 \times 9.52}{2} = 882.77\,N$

Lift force

$F_L = C_L(\rho V^2/2)A$

$F_L = \frac{0.9 \times 1.202 \times (55.55)^2 \times 9.52}{2} = 15889.9\,N$

(b) when $h = 10000\,m$ from the table of properties of air the value of density at $10000\,m$:-

$\rho = 0.4135\ kg/m^3$

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

$= \frac{0.05 \times 0.4135 \times (55.55)^2 \times 9.52}{2} = \underline{303.683\,N}$

Lift force

$F_L = C_L(\rho V^2/2)A$

$= \frac{0.9 \times 0.4135 \times (55.55)^2 \times 9.52}{2} = 5466.29\,N$

so, $F_L = 5.466\,kN$