MET 330 HW 2.2

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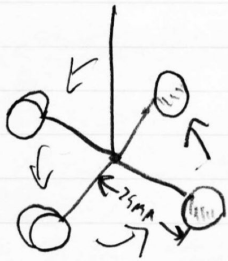
3/3/22

17.11, 14 16.6

17.11



$\omega = 20$ RPM
Find motor torque

$D_{cup} = 25mm$

C_D of an open hemispherical cup: 1.35

$\rho = 1.204\ kg/m^3$ $V = \frac{20\ rev/min \cdot 2\pi \cdot .075mm}{60\ sec/min} = .157\ m/s$

$A = 4 \cdot \frac{\pi}{4}(.025mm)^2 = .0019\ m^2$

$F_D = 1.35 \cdot \left(\frac{1.204 kg/m^3 \cdot (.157 m/s)^2}{2}\right) \cdot .0019 m^2 = 1.35 \cdot \frac{.189\ N/m^2}{2} \cdot .0019 m^2$

$= 2.5 \times 10^{-4} N$

$\tau = 2.5 \times 10^{-4} N \cdot .075m = \boxed{1.88 \times 10^{-5}\ N \cdot m}$

17.14

$D = 2in$ $T = -20°F$ $V = 150$ MPH
Find drag force $= 220\ ft/s$

C_D of a cylinder: 1.24

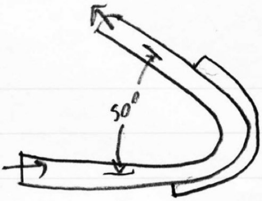
$R_N = \frac{2.8 \times 10^{-3}\ slugs/ft^3 \cdot 220\ ft/s \cdot \frac{1}{6} ft}{3.27 \times 10^{-7}\ lb \cdot s/ft^2} = 314000$ $V = 220\ ft/s$

$\rho = 2.8 \times 10^{-3}\ slugs/ft^3$ $A = 32 in \cdot 2 in \cdot 2 = 128 in^2 = .861\ ft^2$

$F_D = 1.24 \cdot \left(\frac{2.8 \times 10^{-3} slugs/ft^3 (220 ft/s)^2}{2}\right) \cdot .861\ ft^2 = 1.24 \cdot 91.96\ lb/ft^2 \cdot .861 ft^2$

$= \boxed{98.2 lb}$

16.6



$T = 180^\circ F$ $V = 22\,ft/s$ $A = 2.95\,in^2$

Find the forces in the horizontal and vertical exerted on the water by the vane

$\gamma = 60.6\,lb/ft^3$ $A: 2.95\,in^2 = .0205\,ft^2$ $\rho = 1.88\,slug/ft^3$

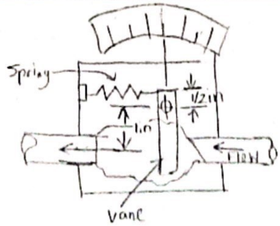
$Q = 22\,ft/s \cdot .0205\,ft^2 = .4507\,ft^3/s = 27.3\,lb/s$

$F_y = 1.88\,slugs/ft^3 \cdot .4507\,ft^3/s \cdot (\sin(50^\circ)\,22\,ft/s - 0) = \boxed{14.28\,lb}$

$F_x = 1.88\,slugs/ft^3 \cdot .4507\,ft^3/s \cdot (-\cos(50^\circ) \cdot 22\,ft/s - 22\,ft/s) = \boxed{30.62\,lb}$

In this assignment I learned that drag is a relatively weak force at low speeds, but a strong one at higher speeds. This is because it scales with the square of velocity. I also learned that C_D is dependent on Reynold's Number for some shapes, while for others it is fixed.

11.



Given: Flow Rate = Q = 100 gal/min

Pipe: 1 in schedule 40 steel pipe

Flow Area = 0.006 ft^2

ρ_{water} = 1.94 lb/ft^3

Convert $100\ gal/min \left(\frac{1 min}{60 sec}\right)\left(\frac{0.1337\ ft^3}{1 gal}\right) = 0.2228\ ft^3/s$

$$F = \rho Q (v_2 - v_1)$$

$$V = \frac{Q}{A} = \frac{0.2228\ ft^3/s}{0.006\ ft^2} = 37.13\ ft/s$$

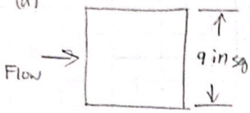
$$F = (1.94\ lb/ft^3)(0.2228\ ft^3/s)\left(37.13\ ft/s - (-37.13\ ft/s)\right)$$

$$\boxed{F = 32.1\ lb}$$

In chapter 17, I learned how to determine the value of Drag Coefficient of different shapes. Also how to calculate the amount of Drag force by using the drag force equation. In Chapter 16, I learned how to calculate for the amount and direction of forces on curved surface. As well as how to calculate for resultant force and determine the location of the center of the pressure.

16

(a)



Given: length $= 60\text{ in}/12 = 5\text{ ft}$
width $= 9\text{ in}/12 = 0.75\text{ ft}$
$V = 100\text{ mph}\left(\frac{5280\text{ ft}}{3600\text{ sec}}\right) = 146.7\text{ ft/s}$
$T = -20°F$
$\rho = 2.80 \times 10^{3}$ slugs/ft³
K Viscosity $= 1.17 \times 10^{-4}\text{ ft}^2/s$

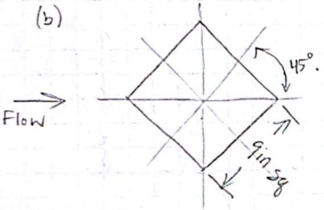
$$N_R = \frac{VL}{\nu} = \frac{(146.7\text{ ft/s})(0.75\text{ ft})}{1.17\times10^{-4}\text{ ft}^2/s} = 9.403\times10^{5}$$

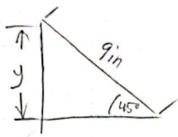
$A = lb = (5\text{ ft})(0.75\text{ ft}) = 3.75\text{ ft}^2$
$C_D = 2.10$

$$F_D = C_D\left(\frac{\rho V^2}{2}\right)A = (2.10)\left(\frac{(2.80\times10^{-3})(146.7)^2}{2}\right)3.75\text{ ft}^2$$

$$\boxed{F_D = 237.27\text{ lb}}$$

(b)



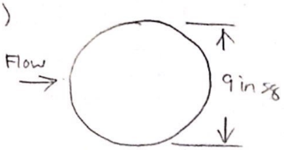


$y = 0.75 \sin 45 = 0.5303\text{ ft}$
$A = l \times 2y = 5\text{ ft}(2)(0.5303\text{ ft}) = 5.303\text{ ft}^2$
$C_D = 1.6$

$$F_D = C_D\left(\frac{\rho V^2}{2}\right)A = 1.6\left(\frac{(2.80\times10^{-3})(146.7)^2}{2}\right)5.303\text{ ft}^2$$

$$\boxed{F_D = 255.64\text{ lb}}$$

(c)



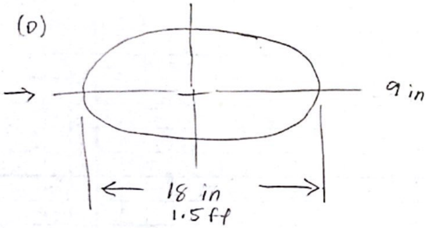
$A = lb = (5ft)(0.75ft) = 3.75 ft^2$

$N_R = 9.403 \times 10^5$, $C_D = 0.3$

$F_D = C_D\left(\frac{\rho v^2}{2}\right)A = 0.3\left(\frac{(2.80\times10^{-3})(146.7)^2}{2}\right)(3.75\ ft^2)$

$\boxed{F_D = 33.89\ lb}$

(D)



$A = lb = 3.75\ ft^2$

$N_R = \frac{VL}{\nu} = \frac{(146.7)(1.5ft)}{1.17\times10^{-4}} = 1.881\times10^6$

$C_D = 0.25$

$F_D = C_D\left(\frac{\rho v^2}{2}\right)A = 0.25\left(\frac{(2.80\times10^{-3})(146.7)^2}{2}\right)3.75\ ft^2$

$\boxed{F_D = 28.25\ lb}$

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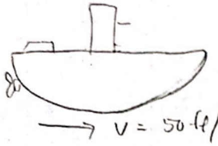
26.



Given: Specific Resistance ratio = 0.006
displaces 125 long tons
T = 77°F

$P = R_{ts} V$

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

R_{ts} = Specific Resistance Ratio × Δ

$R_{ts} = (0.006)(2.8 \times 10^5) = \boxed{1680 \text{ lb}}$

$P = R_{ts} V = (1680 \text{ lb})(50 \text{ ft/s}) = 84000 \text{ lb·ft/s}$

Convert to hp   1 hp = 550 lb·ft/s

$P = (84000 \text{ lb·ft/s})\left(\frac{1 \text{ hp}}{550 \text{ lb·ft/s}}\right) = \boxed{152.73 \text{ hp}}$

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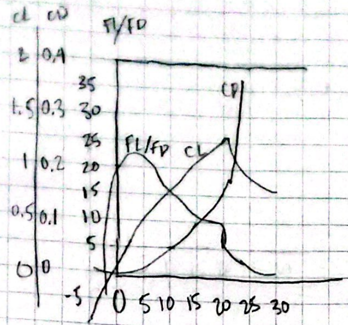
HW 2.2

17.30)



$\alpha = 10°$, $C_D = 0.05$, $C_L = 0,9$

$C = 1.4$ m

$b = 6.8$ m

$V = 200 \frac{km}{hr} \times \frac{1\ hr}{60\ min} \times \frac{1\ min}{60\ s} \times \frac{1000\ m}{1\ km} = 55.55$ m/s, $\rho = 1.202$ kg/m^3 @ 200 m,

@ 10000 m
$\rho = 0.4135$ kg/m^3

$A = c \times b \rightarrow 1.4 \times 6.8 = 9.52$ m^2

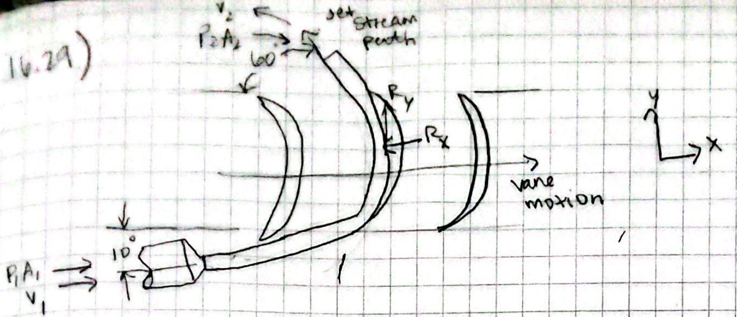
a) $F_D = C_D \frac{\rho V^2}{2} A \rightarrow 0.05 \times 1.202 \times \frac{55.55^2}{2} \times 9.52 = 882.72$ N

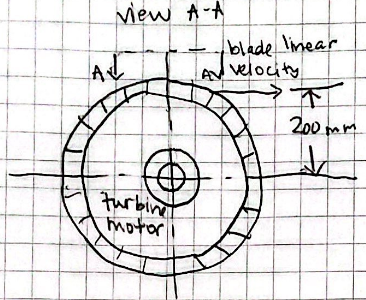
$F_L = C_L \frac{\rho V^2}{2} A \rightarrow 0.9 \times 1.202 \times \frac{55.55^2}{2} \times 9.52 = 15.89$ N

b) $F_D = 0.05 \times 0.4135 \times \frac{55.55^2}{2} \times 9.52 = 303.6$ N

$F_L = 0.9 \times 0.4135 \times \frac{55.55^2}{2} \times 9.52 = 5.47$ N

16.29)





$d = 7{,}5\ \text{mm} \times \dfrac{1\ \text{m}}{1000\ \text{mm}} = 0{,}0075\ \text{m}$

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

$A = \dfrac{\pi}{4} d^2 \rightarrow \dfrac{\pi (0.0075)^2}{4} = 0.00004418\ \text{m}^2$

$Q = AV \rightarrow 0{,}00004418 \times 25 = 0.0011045\ \text{m}^3/\text{s}$

$R_x = \rho Q (V_2 \cos\theta + V_1 \cos\theta) \rightarrow 1000 \times 1.1045 \times 10^{-3} ((25 \cos 60) + (25 \cos 10)) = 40{,}99\ \text{N}$

$R_y = \rho Q (V_2 \sin\theta + V_1 \sin\theta) \rightarrow 1000 \times 1.1045 \times 10^{-2} ((25 \sin 60) + (25 \sin 10)) = 19.12\ \text{N}$

I learned that in a forces due to fluids in motion problem it is always best to first draw an X and y plane to help you determine in which directions your fluid is moving. In a problem dealing with impulse theorem specifically if other forces have an impact on a problem due to air newtons law should be considered. If there is a vane that deflects the fluid in a problem it is necessary to determine which direction the velocity is moving in at different points of the fluid.

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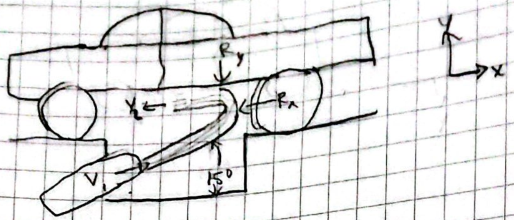
16.20)



$d = 200$ m
$V = 30$ m/s

$Q = \frac{\pi}{4} d^2 V \rightarrow \frac{\pi}{4}\left(\frac{200}{1000}\right)^2 \times 30 = 0.942$ m³/s

a) $R_x = \rho Q \left(V_{2x} - (-V_{1x} \cos\theta)\right)$

$= \rho Q V (1 + \cos\theta) \rightarrow 1000 \times 0.943 \,(30 + 30\cos 15) = 55618.14$ N

$R_y = \rho Q \left(V_{2y} - (-V_{1y} \sin\theta)\right)$

$\rightarrow 1000 \times 0.943 \,(0 + 30\sin 15) = 7072.5$ N

b) $V_x = V\cos\theta \rightarrow 30\cos 15 = 28.98$ m/s

$V_{1x} = V_x - V_{car} \rightarrow 28.95 - 12 = 16.98$ m/s

$V_y = V\sin\theta \rightarrow 30 \sin 15 = 7.76$ m/s

$V_c = \sqrt{V_{1x}^2 + V_y^2} \rightarrow \sqrt{16.98^2 + 7.76^2} = 18.67$ m/s

$M_c = \rho \frac{\pi}{4} d^2 V_c \rightarrow 1000 \times \frac{\pi}{4} (0.2)^2 \times 18.67 = 586.6$ kg/s

$\alpha = \tan^{-1}\left(\frac{V_y}{V_x}\right) \rightarrow \tan^{-1}\left(\frac{7.76}{16.91}\right) = 24.56°$

$\beta = \alpha - \theta \rightarrow 24.56 - 15 = 7.56$

$V_{cx} = V_c \cos\beta \rightarrow 18.67 \cos 9.56 = 18.4$ m/s

$R_{xc} = M_c (\Delta V_{cx}) \rightarrow 586.6\,(18.4 - 16.75) = 832.97$ N

$R_{yc} = M_c (\Delta V_{cy}) \rightarrow 586.6\,(0 - (-7.76)) = 4552$ N

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