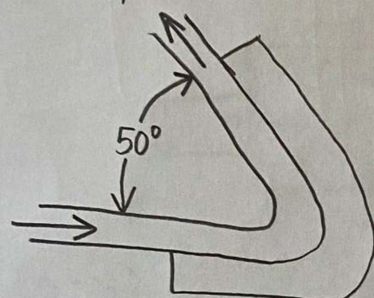
Taikori Booker

MET 330

HW 2.2

Chapter 16

6. The figure shows a free stream of water at 180°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 in² throughout the system. Compute the forces in the horizontal & vertical directions exerted on the water by the vane.



$A = 2.95\ in^2$

$2.95 \times \frac{1}{12^2} = 0.020\ ft^2$

angle of deflection = 130°

$V_1 = 22.0\ ft/s$

$t = 180°F$

density of water @ 180°F is $\rho = 1.883\ slugs/ft^3$

$Q = AV$

$Q = (0.020) \times (22)$

$Q = 0.44\ ft^3/s$

$F_x = \rho Q[(V_2)_x - (V_1)_x]$

$F_y = \rho Q[(V_2)_y - (V_1)_y]$

$F_x = (1.883) \times (0.44) \times [14.14 - (-22)]$

$\boxed{F_x = 29.94\ lb}$

$F_y = (1.883) \times (0.44) \times [16.85 - 0]$

$\boxed{F_y = 13.96\ lb}$

$(V_2)_x = V \times \cos(180 - \theta)$

$(V_2)_x = 22 \times \cos(180 - 130)$

$(V_2)_x = 14.14\ ft/s$

$(V_2)_y = V_2 \times \sin(180 - \theta)$

$(V_2)_y = 22 \times \sin(180 - 130)$

$(V_2)_y = 16.85\ ft/s$

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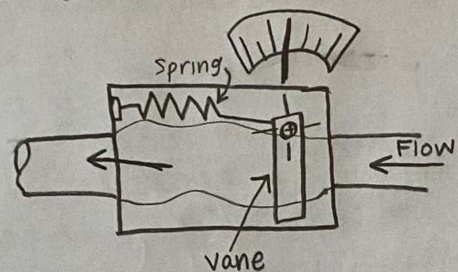
11. The figure represents a type of flowmeter in which the flat vane is rotated on a pivot as it deflects the fluid stream. The fluid force is counterbalanced by a spring. Calculate the spring force required to hold the vane in a vertical position when water at 100 gal/min flows from the 1-in Schedule 40 pipe to which the meter is attached.



$Q = 100 \text{ gal/min}$

$100 \text{ gal/min} \times \frac{0.1337 \text{ ft}^3}{\text{gal}} \times \frac{1 \text{ min}}{60 \text{ sec}}$

$= 0.223 \text{ ft}^3/\text{s}$

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

$v = \frac{Q}{A} = \frac{0.223 \text{ ft}^3/\text{s}}{0.006 \text{ ft}^2} = 37.17 \text{ ft/s}$

$F = (1.94 \text{ lb/ft}^3)(0.223 \text{ ft}^3/\text{s}) \times (37.17 \text{ ft/s} - (-31.17 \text{ ft/s}))$ $v_2 = v_1$

$\rho_{H_2O} = 1.94 \text{ lb/ft}^3$

$\boxed{F = 32.16 \text{ lb}}$

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30. For the airfoil with the performance characteristics shown in the figure, determine the lift & drag at an angle of attack of 10°. The airfoil has a chord length of 1.4 m & a span of 6.8 m. Perform the calculation at a speed of 200 km/h in the standard atmosphere at (a) 200 m & (b) 10,000 m.

chord = 1.4 m $\alpha = 10°$
span = 6.8 m

$v = 200\ km/h \times \left(\frac{1000\ m/km}{3600\ s}\right) = 55.56\ m/s$

Altitude A) 200 m B) 10,000 m

use Fig. 17.11 to find drag/lift coefficient

$C_D = 0.05$

$C_L = 0.875$

use table E.3 to find properties of air at given altitudes.

A) 200 m
$\rho = 1.202\ \frac{kg}{m^3}$

B) 10,000 m
$\rho = 0.4135\ \frac{kg}{m^3}$

solve for area

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

calculate drag/lift force for both altitudes

A) 200 m

$F_D = (0.05)\left(\frac{(1.202\ kg/m^3)(55.56\ m/s)^2}{2}\right)(9.52\ m^2) = \boxed{883.09\ N}$

$F_L = (0.875)\left(\frac{(1.202\ kg/m^3)(55.56\ m/s)^2}{2}\right)(9.52\ m^2) = \boxed{15.454\ kN}$

B) 10,000 m

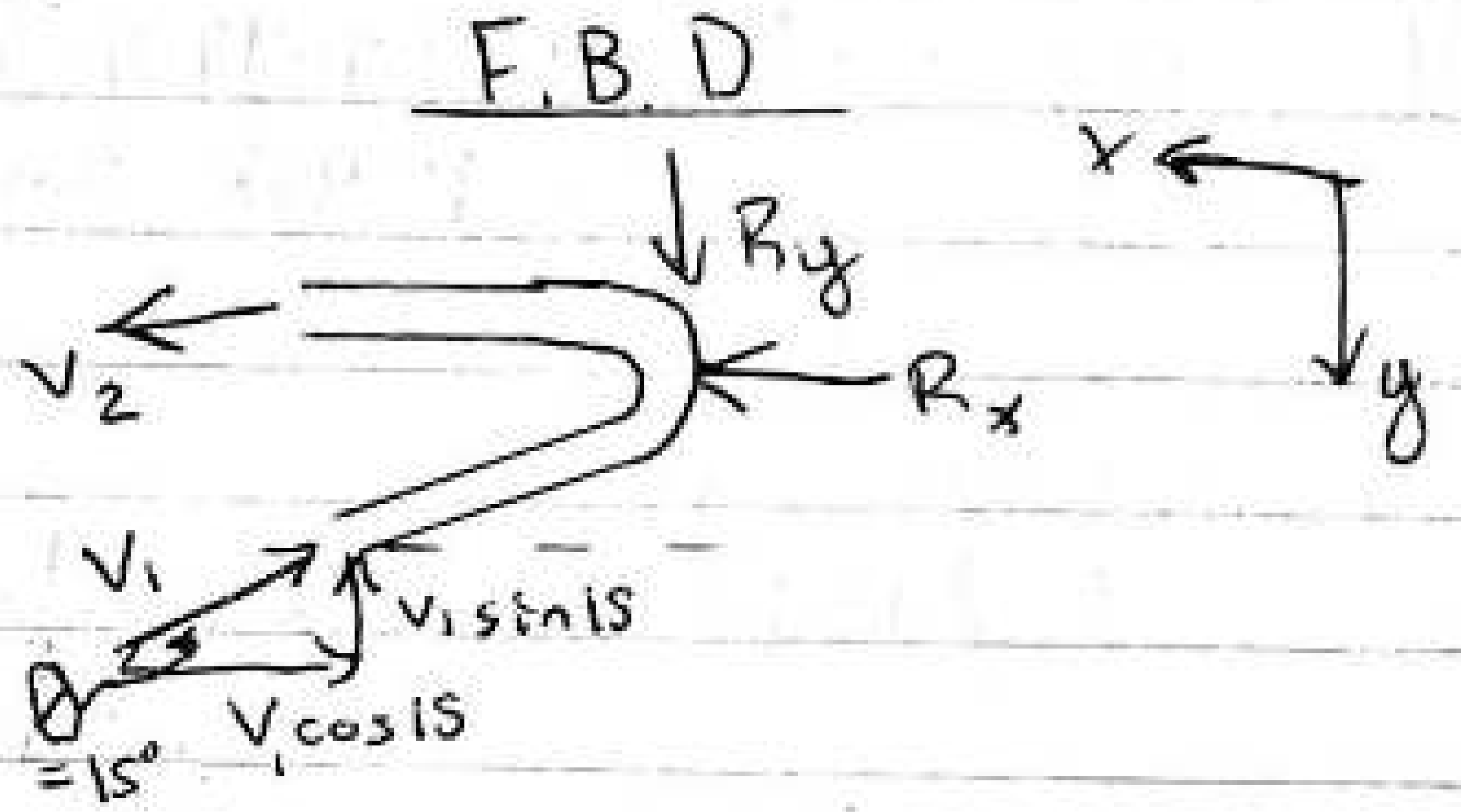
$F_D = (0.05)\left(\frac{(0.4135\ kg/m^3)(55.56\ m/s)^2}{2}\right)(9.52\ m^2) = \boxed{303.79\ N}$

$F_L = (0.875)\left(\frac{(0.4135\ kg/m^3)(55.56\ m/s)^2}{2}\right)(9.52\ m^2) = \boxed{5.316\ kN}$

HW 2.2, Chris Betton, Team 7

CH 16

20. A vehicle is to be propelled by a jet of water impinging on a vane as shown. The jet has a velocity of 30 $\frac{m}{s}$ & issues from a nozzle w/ a diameter of 200 mm. Calculate the force on the vehicle (a) if stationary (b) moving @ 12 $\frac{m}{s}$



Data

$\rho = 1000 \frac{kg}{m^3}$, $V_i = 30 \frac{m}{s}$, $V_{car} = 12 \frac{m}{s}$, $d = 200\,mm = 0.2m$

a. $Q = V \cdot A$, $A = \frac{\pi}{4} d^2 \cdot v$, $Q = \frac{\pi}{4} \cdot 0.2^2 m^2 \cdot 30 \frac{m}{s} = 0.942477796 \frac{m^3}{s}$

$\Sigma F_x = 0$ $\quad R_x = \rho Q[(V_2) - (-v_1 \cos\theta)] = \rho Q v[1 + \cos\theta]$

$\hookrightarrow \rho Q v[1 + \cos\theta] = R_x$

$R_x = 1000 \frac{kg}{m^3} \cdot 0.942477796 \frac{m^3}{s} \cdot 30 \frac{m}{s} [1.965925826]$

$\boxed{R_x = 55585.2432 N}$

$\Sigma F_y = 0$ $\quad R_y = \rho Q[(V_2) - (-v_1 \sin\theta)] = \rho \cdot Q \cdot v[0 + \sin\theta]$

$1000 \frac{kg}{m^3} \cdot 0.942477796 \frac{m^3}{s} \cdot 30 \frac{m}{s}$

$\boxed{R_y = 7317.936096}$

b. $V_x = v \cdot \cos(\theta) \rightarrow V_x = 30 \frac{m}{s} \cdot \cos(15) = 28.97777479 \frac{m}{s}$

$V_{1x} = V_x - V_{car} = 28.9777 \frac{m}{s} - 12 \frac{m}{s} = 16.97777479 \frac{m}{s}$

$V_y = v \cdot \sin\theta = 30 \sin(15) = 7.764571353 \frac{m}{s}$

$V_f = \sqrt{V_{1x}^2 + V_y^2} = \sqrt{(16.97777479)^2 + (7.764571353)^2} = 18.66904939 \frac{m}{s}$

$M = \rho \cdot A \cdot V \quad , \quad A = \frac{\pi}{4} \cdot d^2$

$= 1000 \frac{kg}{m^3} \cdot \frac{\pi}{4} \cdot (0.2m)^2 \times 18.66904939 \frac{m}{s} = 586.5054841 \frac{kg}{s}$

$\alpha = \tan^{-1}\left(\frac{V_{1y}}{V_{1x}}\right) = 24.57619117° \quad \beta = \alpha - \theta = 24.57619117° - 15° = 9.57619166°$

$V_{parallel} = V_f \cdot \cos\beta = 18.66904939 \frac{m}{s} \cdot \cos(9.57619166)$

$= 18.40890088 \frac{m}{s}$

$R_{x\,effs} = M \cdot (\Delta V_x)$

$= M \cdot (V_{x\,parallel} - V_{1x}) = 586.5054841 \cdot (18.4089 - 16.97777 \frac{m}{s})$

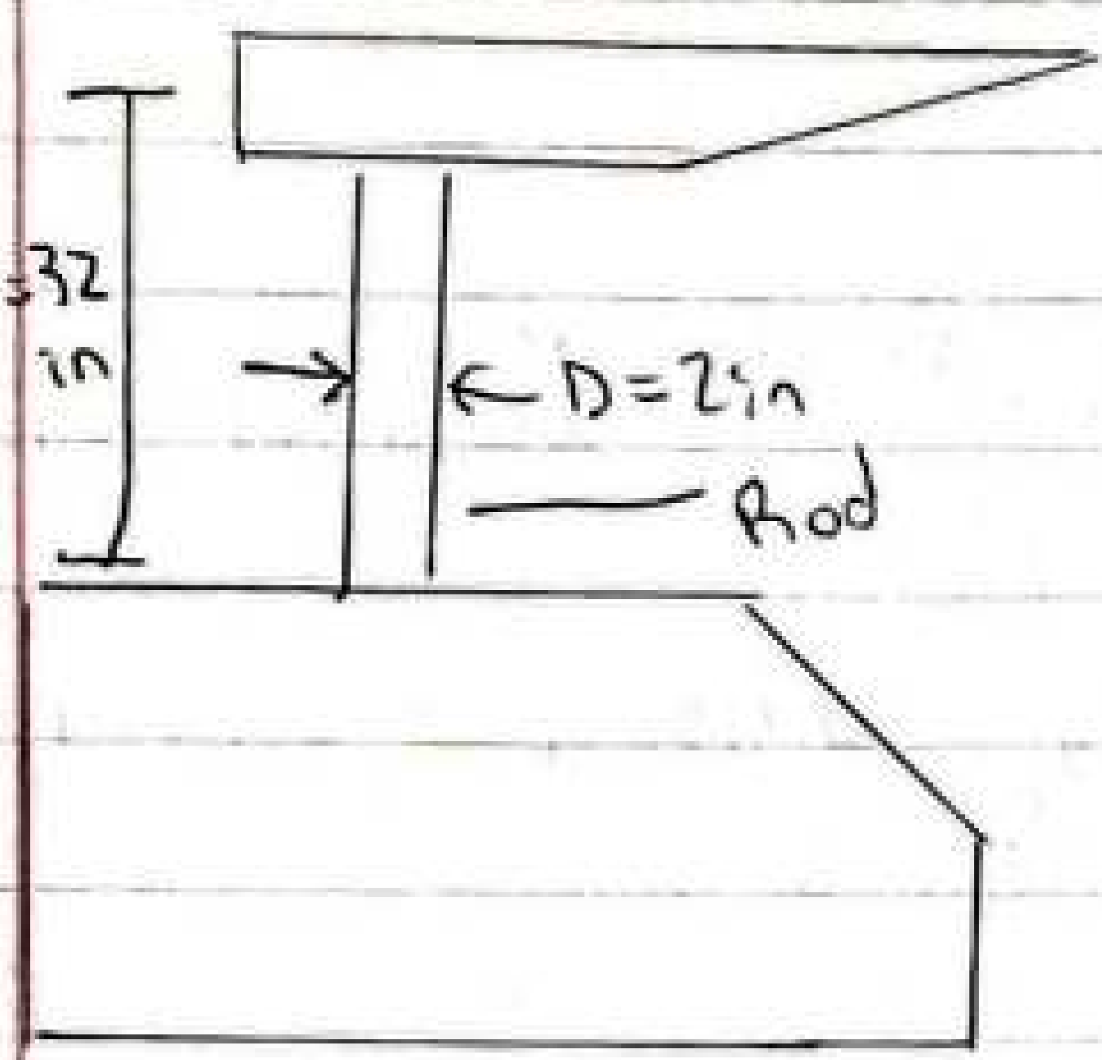
$= \boxed{839.3633008 \text{ N} \leftarrow}$

$R_y = M \cdot (\Delta V_y) = M \cdot (V_{y\,par} - V_y) = M \cdot (0 + 7.7645 \frac{m}{s}) = 586.5054841 (7.7645 \frac{m}{s})$

$= \boxed{4553.9 \text{ N} \uparrow}$

CH.17

14.



$$v = 150\,\frac{mi}{hr}\cdot\frac{5280\,ft}{mi}\cdot\frac{1\,hr}{3600\,sec} = 220\,\frac{ft}{s}$$

$$\nu = 1.17\times10^{-4}\ ft^2/s$$

$$D = 2in\cdot\frac{1ft}{12in} = 0.16\overline{6}\ ft$$

$$L = 32in\cdot\frac{1ft}{12in} = 2.6\overline{6}\ ft$$

$$\rho = .002805\ \frac{slugs}{ft^3}$$

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

$$= \frac{220\,\cancel{ft}}{\cancel{sec}}\left|\,0.16\overline{6}\,\cancel{ft}\,\right|\frac{\cancel{sec}}{1.17\times10^{-4}\,ft^2} = 313390.3134$$

$$= 3.13\times10^5$$

$$CD = 8\times10^{-1} = 0.8$$

$$A = DL = (0.16\overline{6}ft)(2.6\overline{6}\ ft) = 0.4444\ ft^2 \times 2\,rods = 0.888\ ft^2$$

$$f_D = \frac{C\cdot\rho\cdot v^2\cdot A}{2} = \frac{0.80\cdot(.002805\ slugs/ft^3)\cdot\left(220\,\frac{ft}{s}\right)^2\cdot 0.888ft^2}{2}$$

$$f_D = 48.271\ lbf$$

$$\boxed{f_D = 48\ lbf}$$

Ch. 17

16. Compare drag force on each design when the vehicle moves at 100 mph through still air @ $-20°F$

Data: $l = 60\,in = 5\,ft$, $w = 9.00\,in = 0.75\,ft$, $v = 100\,\frac{mi}{hr} \cdot \frac{5280\,ft}{mi} \cdot \frac{1\,hr}{3600\,sec} = 146.\overline{66}\,\frac{ft}{s}$

$\rho_{air} = .002805\ slug/ft^3$

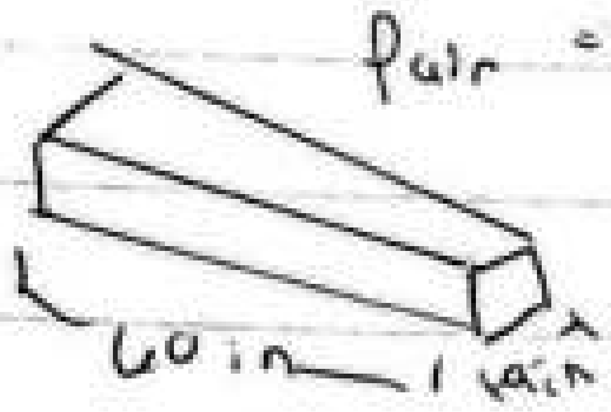


Table 17.1: $C_{D\,square\,cyl} = 2.00$, $C_{D\,square\,@45°} = 1.60$, $C_{D\,sphere} = 0.41$, $C_{D\,elliptical} = 0.25$

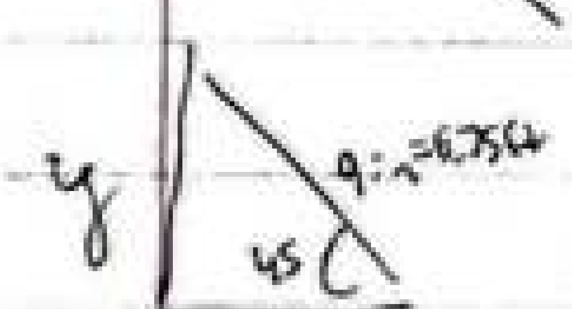
a.)

$A = 0.75\,ft \cdot 5\,ft = 3.75\,ft^2$ $\quad F_D = \frac{C_D \cdot \rho v^2 A}{2} = \frac{2.00(.002805)(146.\overline{66})^2(3.75)}{2}$

$\boxed{F_D = 226.2699\,lbf}$

b)

$A = l \cdot 2y = 5(2)(0.53033\,ft)$



$y = 0.75\,ft \cdot \sin(45)$ $\quad A = 5.3033\,ft^2$

$y = 0.53033\,ft$ $\quad CD = 1.60$

$F_D = \frac{1.60(.002805)(14.\overline{66})^2(5.3033\,ft^2)}{2}$ $\quad F_D = 255.995\,lbf$

$\boxed{F_D = 256\,lbf}$

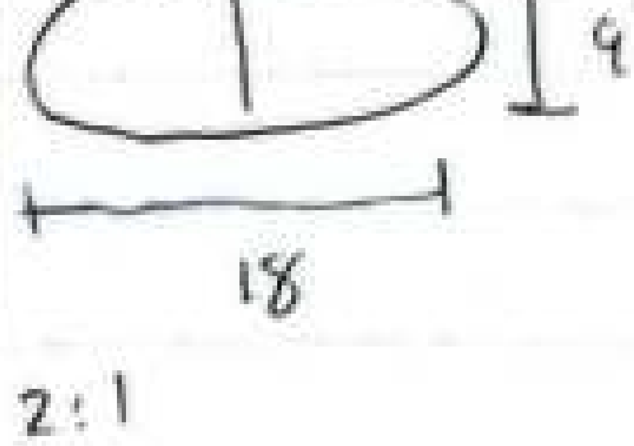
c)

$D = 0.75\,in$
$A = 3.75\,ft^2$

$F_D = \frac{(0.41)(.002805)(146.\overline{66})^2(3.75)}{2}$

$\boxed{F_D = 92.77069157\,lbf}$

d)



$A = 3.75\,ft^2$

$F_D = \frac{(0.25)(.002805)(146.\overline{66})^2(3.75)}{2}$

$\boxed{F_D = 28.28\,lbf}$

CH 17

26. A small, fast boat has specific resistance ratio = (0.06) & displaces 125 long tons. Compute the total ship resistance & the power req'd to overcome drag when it is at $50 \frac{ft}{s}$ in seawater @ 77°F

Data: $\frac{R_{ts}}{\Delta} = 0.006$ (Table 17.2), $\Delta = 125$ long tons, $V = 50 \frac{ft}{sec}$

$P_E = R_{ts} V$, $\Delta = \frac{125 \text{ long tons}}{} \bigg| \frac{2240 \text{ lb}}{1 \text{ long ton}}$ $\Delta = 280000 \text{ lb}$

$R_{ts} = 0.006 \cdot \Delta = \boxed{1680 \text{ lb}}$

$P_E = 1680 \text{ lb} \cdot 50 \frac{ft}{sec} = 84000 \frac{lb \cancel{ft}}{\cancel{sec}} \cdot \frac{1 hp \cdot \cancel{sec}}{550 lb \cancel{ft}}$

$= \boxed{152.727 \text{ HP}}$