Write a paragraph or two on what you learned:

Chapter 16 was mostly focused on forces using Newton's Second Law. When using velocity as a vector quantity, as magnitude and velocity change due to the flow of fluid, this results in a change in equal and opposite force. We learned from completing the problems below that a force is required to accomplish the change when direction or speed are deflected by a fluid stream. For a real life example of these practices, it can be used when looking at compressed air coming out of a nozzle being used to move products in a factory. In Chapter 17, we were introduced to lift and drag, which are important when analyzing the behavior of a body in fluid. Drag is the force on the body caused by the fluid that resists motion (opposes the direction of fluid flow), and lift is the force caused by the fluid in the direction perpendicular to the travel path of the body (net force in upward direction). These can occur simultaneously and the concepts are similar regardless of the phase they're in.

Chapter 16:

16.6: Ethan K.

16.11: Josiah

16.20: Kayla

16.29: Gershon

Chapter 17:

17.11: Gershon

17.14: Josiah2

17.16: Ethan K.

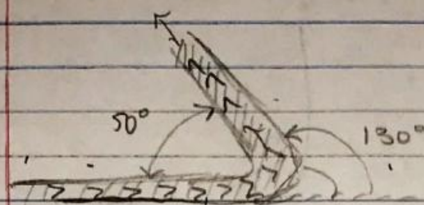
17.26: Ethan E.

17.30: Ethan E.

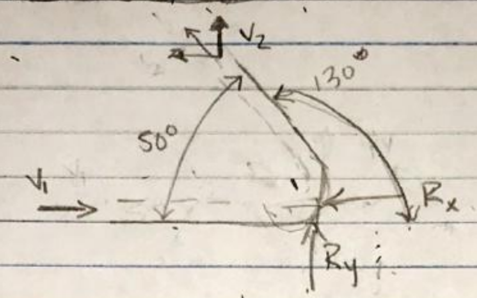
Solutions:

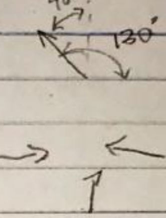
16.6:

Diagram



Free-Body Diagram





$Q = v_1 \cdot A = 22\ ft/s \cdot 0.02\ ft^2 = 0.449\ ft^3/s$

$F_x = pQ(V_{2x} - V_{1x})$ $F_x = pQ(V_{2x} - 22\ ft/s)$

$F_y = pQ(V_{2y} - V_{1y}) \rightarrow V_{1y} = 0$, $F_y = pQ\,V_{2y}$

$F_x = pQ(V_{2x} - 22\ ft/s)$, $V_{2x} = V_2 \cos(40°) = 16.853\ ft/s$
$F_y = pQ(V_{2y})$

$V_{2x} = 16.853\ ft/s$
$V_{2y} = \sqrt{V_2^2 - V_{2x}^2} = 14.1418\ ft/s$

$F_x = 60.58\ lb/ft^3 \cdot 0.449\ ft^3/s\,(16.853\ ft/s - 22) = -140\ lb \cdot ft/s^2$

$F_y = 60.58\ lb/ft^3 \cdot 0.449\ ft^3/s\,(14.1413) = 384.649\ lb \cdot ft/s^2$

$F_x + R_x = 0 \rightarrow R_x = -F_x \rightarrow R_x = 140\ lb \cdot ft/s^2$
$F_y + R_y = 0 \rightarrow R_y = -F_y \rightarrow R_y = -384.649\ lb \cdot ft/s^2$

$|F| = 409.33$; $|R| = -409.33$

16.11:

HW 16.11

$Q = 100\ g/min$ or $0.23\ ft^3/s$ $\quad 1\ in = 0.08\ ft$

$Q = \frac{V}{A} \quad A = \frac{\pi}{4} D^2$

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

$\rho = 1.93\ ft^3$

$V = \frac{Q}{A} \quad \frac{\pi}{4} D^2$

$V = \frac{0.23}{\frac{\pi}{4} 0.08^2 = 0.005}$

$F = (1.93)(0.23)(45.7 - (-45.7)) \quad V = 45.7$

$(1.93)(0.23)(91.4)$

$40.5\ lb$

16.20:

HW 2.2 - MET 330

16.20

A vehicle is to be propelled by a jet of water shown in fig 16.20.

- $v_1 = 30$ m/s $d = 200$ mm $= 0.2$ m $v_0 = 12$ m/s $\theta = 15°$ $\rho = 1000$ kg/m³

calculate force on the vehicle if a) stationary b) moving at 12 m/s

A) stationary

$Q = Av = \frac{\pi}{4} d^2 \times v = \frac{\pi}{4} \times 0.2^2 \times 30$

$Q = 0.942$ m³/s

x-comp:

$v_{1x} = -v_1 \cos 15 = -28.98$ m/s

$v_2 = 30$ m/s

FORCE:

$F = \rho \times Q \times \Delta v$

$R_x = \rho \times Q(v_{2x} - v_{1x})$

$= 1000 \times 0.942(30 + 28.98)$

$= \boxed{55559.16\ N}$

y-comp:

$v_{1y} = -v_1 \sin 15 = -7.76$ m/s

$v_{2v} = 0$ m/s

FORCE:

$R_y = \rho \times Q(v_{2y} - v_{1y})$

$= 1000 \times 0.942(0 + 7.76)$

$= \boxed{7309.92\ N}$

B) moving @ 12 m/s

$v_{e \times 1x} = -v_1 \cos 15 = -16.68$ m/s

$v_{e \times 1y} = -v_1 \sin 15 = -7.77$ m/s

magnitude: $v_{e_1} = \sqrt{v^2_{e \times 1x} + v^2_{e 1y}} = \sqrt{(-16.68)^2 + (-7.77)^2} = 18.4$ m/s

direction: $\alpha = \tan^{-1}\left(\frac{v_{e1y}}{v_{e1x}}\right) = \tan^{-1}\left(-\frac{7.77}{-16.62}\right) = 25.05°$

$Q_e = A_1 v_{e1} = \frac{\pi}{4} \times 0.2^2 \times 18.4 = 0.578$ m³/s

$\beta = 25.05° - 15° = 10.05°$

$v_{e2} = v_{e1} \cos \beta = 18.4 \cos 10.5 = 17.77$ m/s

FORCE x-DIRECTION:

$R_x = \rho Q_e(v_{e \times 2x} - v_{e,x})$

$= 1000 \times 0.578(17.77 - 16.68)$

$= \boxed{630.02\ N}$

FORCE y-DIRECTION

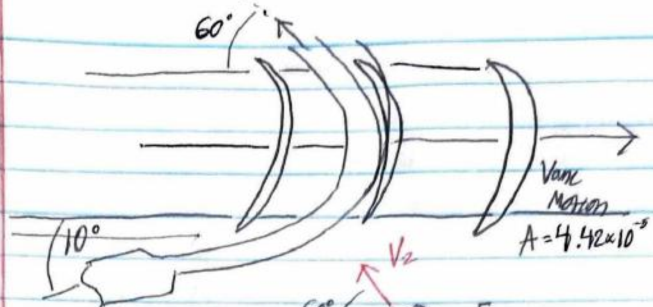
$R_y = \rho Q_e(v_{e \times 2y} - v_{e,y})$

$= 1000 \times 0.578(0 - (-7.77))$

$= \boxed{4491.06\ N}$

16.29:

16.29)



$T = 15°C$

$d_t = 7.5\ mm = 0.0075\ m$

$V = 25\ m/s$

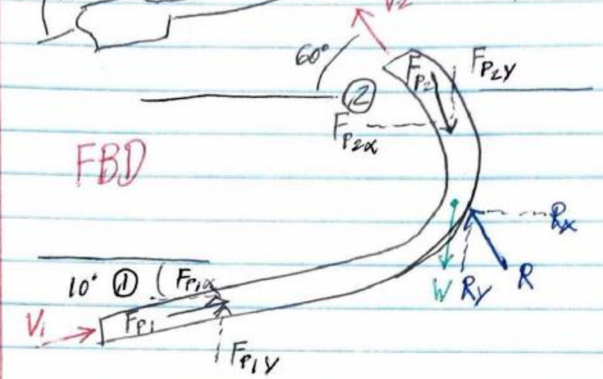
$\rho = 1000\ kg/m^3$

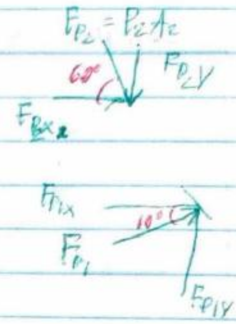
$A = 4.42\times10^{-5}$ $Q = VA$

$= 25\ m/s \left(\pi \cdot \left(\frac{0.0075\ m}{2}\right)^2\right)$

$= 1.105\times10^{-3}\ m^3/s$

FBD





$x: F_x = \rho Q(V_{2x} - V_{1x})$

$R_x = \rho Q V(\cos 60° - \cos 10°)$

$= 1000\ kg/m^3 \cdot 1.105\times10^{-3}\ m^3/s \cdot 25\ m/s\,(\cos 60° - \cos 10°)$

$R_x = -13.39\ N$ $\quad R_x \xrightarrow[13.39\ N]{}$

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

$R_y = \rho Q V(\sin 60° - \sin 10°)$

$= 1000\ kg/m^3 \cdot 1.105\times10^{-3}\ m^3/s \cdot 25\ m/s\,(\sin 60° - \sin 10°)$

$R_y = 19.13\ N$ $\quad \uparrow R_y = 19.13\ N$

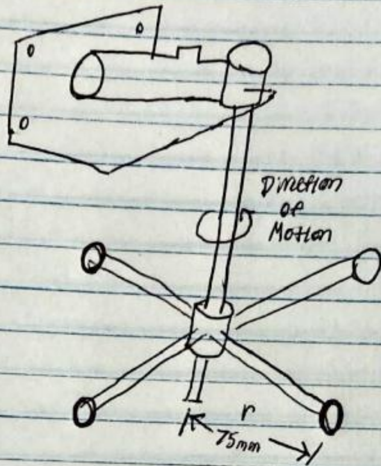
$R = \sqrt{R_x^2 + R_y^2}$

$= \sqrt{(13.39)^2 + (19.13)^2}$

$\boxed{R = 23.35\ N}$

17.11:

17.11)



$d = 25\,mm = 0.025\,m$

$\rho_{air} = 1.164\ kg/m^3$

$\rho_{gas} = 680\ kg/m^3$

$C_D = 0.41$

$A = 4.9087 \times 10^{-4}\ m^2$

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

$r = 0.075\ m$

$V = r \cdot \omega = (0.075\,m)(2.094\ rad/s) \rightarrow V = 0.157\ m/s$

$C_D = 24/N_R \rightarrow N_R = 58.53$

$\eta = 0.0456$

$$F_{D\,air} = C_D(\rho v^2/2)A = 0.41 \times \left(\frac{1.164 \times 0.157^2}{2}\right) \times (4.9087 \times 10^{-4})$$

$$F_{D\,air} = 2.887 \times 10^{-6}\ N$$

$$F_{D\,gas} = \frac{12\eta V A}{D} = \frac{12 \times (0.0456)(0.157\ m/s)(4.9087 \times 10^{-4})}{0.025}$$

$$F_{D\,gas} = 1.687 \times 10^{-3}\ N$$

$$P_{D\,air} = (2.887 \times 10^{-6}\ N)(0.157\ m/s) = 4.53 \times 10^{-10}\ kW$$

$$P_{D\,gas} = (1.687 \times 10^{-3}\ N)(0.157\ m/s) = 2.65 \times 10^{-7}\ kW$$

$$T_{air} = \frac{9.549 \times P_{D\,air}}{\omega} = \frac{9.549 \times (4.53 \times 10^{-10}\ kW)}{20\ rpm}$$

$$\boxed{T_{air} = 2.16 \times 10^{-10}\ N \cdot m}$$

$$T_{gas} = \frac{9.549 \times P_{D\,gas}}{\omega} = \frac{9.549 \times (2.65 \times 10^{-7}\ kW)}{20\ rpm}$$

$$\boxed{T_{gas} = 1.27 \times 10^{-7}\ N \cdot m}$$

17.14:

HW 17.14

Compute drag force exerted on the car due to these rocks when the car is traveling

$T = -20°F$

$V = 150$ mph or 2640 in/s or 67.1 m/s

$F_D = 2(1/2\ \rho\ v^2)(A)$

$\rho = (1.293\ kg/m^3)$

$A = (32 \times 2) = 64 = 0.041 m$

64

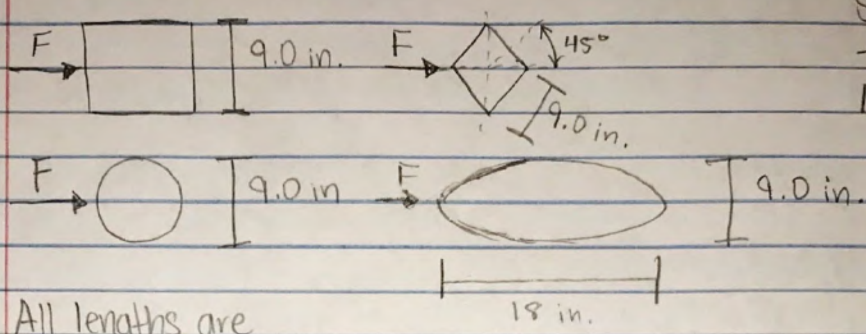
$F_D = 2(1/2)(1.293)(67.1)^2(0.041)$

$\boxed{F_D = 238.7\ N}$

17.16:

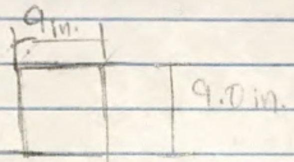
17.16

Diagram



Still air at
$-20°$ F.
100 mph.

All lengths are
60 in. / 5 ft.



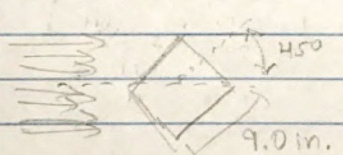
$F_D = C_D(\rho v^2/2)A$

C_D found from chart
using R_N: $R_N = \frac{vL}{\nu} = \frac{146.67 \cdot (0.75)}{1.170 \cdot 10^{-4}}$
$= 940,192.3$

$C_D \approx 1.21$

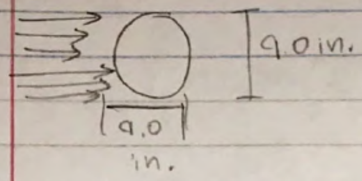
$C_D(2.80 \cdot 10^{-3} \cdot 146.67^2)/2)0.75 \cdot 5$

$F_D = 225.877 \ lb \cdot ft/s^2$



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

$C_D \approx 1.60$
↳ Excel
↳ $F_D = 361.4031 \ lb \cdot ft/s^2$



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

$N_R = \frac{vD}{\nu} = \quad \therefore C_D = 2$

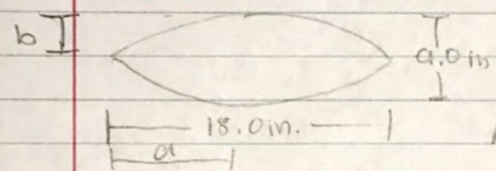
$A = \frac{1}{2} \cdot 2 \cdot \pi \cdot 0.375 = 1.17 \cdot 5$

$= 5.89\ ft^2$

$F_D = 2(0.0028 \cdot 146.67^2/2)\,5.89$

$= 35.48\ lb \cdot ft/s^2$

b



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

$A = 2\pi\sqrt{\frac{a^2+b^2}{2}} \cdot \frac{1}{2} \cdot 5$

$C_D = 0.89$

$\hookrightarrow F_D = 0.89(0.0028 \cdot 146.67^2/2) \cdot 8.58$

$= 100.78\ lb \cdot ft/s^2$

17.26:

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 $77^\circ F$.

1 long ton = 2240 lb

125 long ton = 280000 lb

$R_{ts} = (0.06)(280000)$
$= 16800 \text{ lb}$

$P_E = R_{ts} V$
$= (16800 \text{ lb})(50)$

$P_E = 840000 \text{ lb-ft/s}$

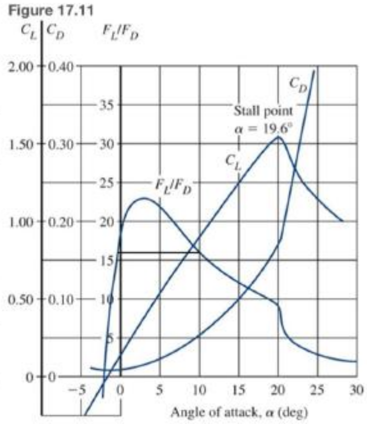
$1 \text{ hp} = 550 \text{ lb-ft/s}$

$$\frac{840000}{550} = \boxed{1527.3 \text{ hp}}$$

17.30:

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



Airfoil performance curves.

$F_L/F_D \approx 16$

Chord length = 1.4 m $V = 200 \frac{km}{h} \cdot \frac{5}{18} = 55.5 \frac{m}{s}$ $C_L = 0.9$

span = 6.8 m $\alpha = 10^\circ$

$A = bc$
$= (1.4)(6.8)$
$A = 9.52 \text{ m}^2$

$F_D = C_D\left(\frac{1}{2}\rho v^2\right)A$

$F_D = (0.05)\left(\frac{1}{2}(1.225 \frac{kg}{m^3})(55.5 \frac{m}{s})^2\right)(9.52 \text{ m}^2)$

$\boxed{F_D = 898.04 \text{ N}}$ at 200 m

$F_D = (0.05)\left(\frac{1}{2}(0.4135)(55.5)^2\right)(9.52)$
$\boxed{= 303.14 \text{ N}}$ at 10000 m

$F_L = (0.9)\left(\frac{1}{2}(0.4135)(55.5)^2\right)(9.52)$

$\boxed{F_L = 5456.46 \text{ N}}$ at 10000 m