Homework #1.7

Ch 16 Forces Due to Fluids in motion

Ch 17 Drag and Lift

MET 330 Virginia Beach Distance Learning WC2 and Campus

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Due Date: 10/17/19

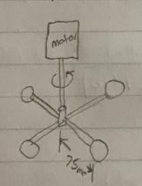
Zach Hollifield

Homework 1.7

1) From the solved problem in learned about forces due to motion of fluids, drag, and lift. When solving forces due to motion of fluids, it is important to sketch a free body diagram to solve for the forces. For an object to move, the air force is larger than the friction force. Assume direction of forces, if it is negative then your prediction was wrong. When solving drag and lift select a point to apply moment usually a pivot point. There are many types of drag coefficients. Table 17.1 has a list of the ones needed to solve problem

Chapter 17 11, 14, 16, 26, 30

11) Each cup d = 25 mm. A motor drives the cup.




$V = \frac{(20)(2\pi L)}{60} = \frac{(20)(2\pi)(0.075)}{60} = 0.157\ m/s$

$A = \frac{\pi D^2}{4} = \frac{\pi(0.025m)^2}{4} = 4.9\times10^{-4}\ m^2$

$N_R = \frac{vD}{\nu} = \frac{(0.157)(0.025)}{\nu} = 245.31$

$C_D = 1.35$ figure 17.3a

$F_D = C_D(\rho v^2/2)A = 1.35\left(\frac{1.164\ kg/m^3 \times 0.157^2 m/s}{2}\right)\times 4.9\times10^{-4} m^2$

$F_D = 9.5\times10^{-6}\ N$

$T = 4F_D r = (4)(9.5\times10^{-6})(0.075) = \boxed{2.85\times10^{-6}\ N\cdot m\ @\ 30°C}$

$N_R = \frac{vD}{\nu} = \frac{(0.157)(0.025)}{\nu} = 9300.9$

$C_D = 1.35$

$F_D = 1.35\left(\frac{680\ kg/m^3 \times 0.157^2 m/s}{2}\right)\times 4.9\times10^{-4} m^2 = 5.55\times10^{-3}\ N$

$T = (4)(5.55\times10^{-3}N)(0.075m) = \boxed{1.6\times10^{-3}\ N\cdot m\ @\ 20°C}$

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14) The wing on a race car is supported by 2 cylindrical rods, Compute the drag force exerted on the car to rods at -20°F air of 150 mph

$L = 32\text{in}\left(\frac{1\text{ft}}{12\text{in}}\right) = 2.67\text{in}$ $D = 2\text{in}\left(\frac{1\text{ft}}{12\text{in}}\right) = 0.167\text{ ft}$

$V = 150\text{ mph}(5280)\left(\frac{1}{3600}\right) = 220\text{ ft/s}$

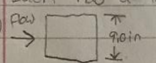
$F_D = C_D(\rho v^2/2)A$ $C_D = 0.80$

$N_R = \frac{vD}{\nu}$ $\nu = 1.17\times10^{-4}\text{ ft}^2/\text{s}$ $N_R = \frac{(220\text{ ft/s})(0.167\text{ ft})}{1.17\times10^{-4}\text{ ft}^2/\text{s}} = 3.14\times10^5$

$A = DL = (0.167)(2.67\times2) = 0.89\text{ ft}^2$ $\rho$ @ -20°F $= 2.8\times10^{-3}$ slugs/ft³

$F_D = (0.80)\left(\frac{2.8\times10^{-3}\text{ slugs/ft}^3\times220^2}{2}\right)(0.89\text{ ft}^2) = \boxed{48.3\text{ lb}}$

16) Each has a length of 60 in width 9.0 in, Compare drag force at 100 mph -20°F

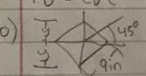
a) 


$N_R = \frac{vL}{\nu} = \frac{(146.67)(0.75)}{1.17\times10^{-4}}$ $b = 9\times\frac{1}{12} = 0.75\text{ ft}$ $L = 60\times\frac{1}{12} = 5\text{ ft}$

$N_R = 9.4\times10^5$ $C_D = 2.1$ $V = 100\times5280\times\frac{1}{3600} = 146.67\text{ ft/s}$

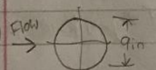
$A = LB = (0.75)(5) = 3.75\text{ ft}^2$ $\rho = 2.80\times10^{-3}$ slugs/ft³

$F_D = C_D(\rho v^2/2)A = 2.1\left(\frac{2.8\times10^{-3}\times146.67^2}{2}\right)(3.75) = \boxed{237.2\text{ lb}}$

b) 

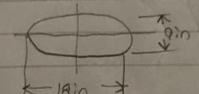

$y = 9\sin45° = 0.5302\text{ ft}$ $A = L\times2y = (5)(2\times0.5302) = 5.302\text{ ft}^2$

$C_D = 1.6$ $F_D = 1.6\left(\frac{2.8\times10^{-3}\times146.67^2}{2}\right)(5.302) = \boxed{255.48\text{ lb}}$

c) 


$A = (0.75)(5) = 3.75\text{ ft}^2$ $N_R = 9.4\times10^5$ $C_D = 0.3$

$F_D = 0.3\left(\frac{2.8\times10^{-3}\times146.67^2}{2}\right)3.75 = \boxed{33.9\text{ lb}}$

D) 


$A = 3.75\text{ ft}^2$

$N_R = \frac{146.67\times18/12}{1.17\times10^{-4}} = 1.88\times10^6$ $C_D = 0.25$

$F_D = 0.25\left(\frac{2.8\times10^{-3}\times146.67^2}{2}\right)3.75 = \boxed{28.3\text{ lb}}$

26) A small fast boat has a specific resistance ratio of 0.06 and displaces 125 long tons, Compute the total resistance and power @ 50 ft/s seawater 77°F

$P = R_{ts}V$ $R_{TS} = 0.006\Delta$ $\Delta = (125)\left(\frac{2240\text{ lb}}{1\text{ long ton}}\right) = 2.8\times10^5\text{ lb}$

$R_{ts} = 0.006(2.8\times10^5) = \boxed{1680\text{ lb resistance}}$

$P = (1680)(50) = 8.4\times10^4\text{ lb-ft/s}\left(\frac{1\text{hp}}{550\text{ lb-ft/s}}\right) = \boxed{152.727\text{ hp}}$

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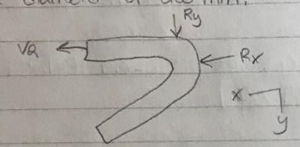
20) The jet has a velocity of 30 m/s and issues from a nozzle with a diameter of 200 mm.




$Q = AV = \frac{\pi}{4}(0.2)^2 \times 30 = 0.943\ m^3/s$

$R_x = \rho Q V (V_2 - V_1 \cos\theta)$

$= 1.966 \times 1000 \times 0.943 \times 30$

$\boxed{R_x = 55618.14\ N}$

$R_y = \rho Q V (0 + \sin\theta) = 0.25 \times 1000 \times 0.943 \times 30 \boxed{= R_y = 7072.5\ N}$

$V_x = V\cos\theta = 30\cos 15 = 28.98\ m/s$ $\quad V_{1x} = 28.98 - 12 = 16.98\ m/s$

$V_y = V\sin\theta = 30\sin 15 = 7.76\ m/s$ $\quad \sqrt{16.98^2 + 7.76^2} = 18.67\ m/s$

$\dot{m} = \rho \frac{\pi}{4} d^2 V_b = 1000 \times \frac{\pi}{4} \times 0.2^2 \times 18.67 = 556.6\ kg/s$ $\quad \alpha = \tan^{-1}\left(\frac{7.76}{16.98}\right) = 24.56°$

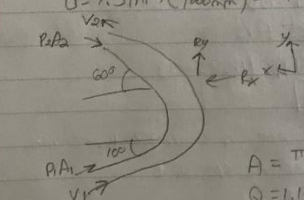
$\beta = \alpha - \theta = 24.56° - 15° = 9.56°$ $\quad V_{eff} = 18.67 \cos 9.56 = 18.40\ m/s$

$(R_x)_e = 586.6(18.4 - 16.98) = \boxed{833.0\ N}$

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

29) Incoming water at 15°C has a diameter of 7.50 mm and is moving with a velocity of 25 m/s.

$d = 7.5\,mm\left(\frac{1\,m}{1000\,mm}\right) = 0.0075\ m$




$R_x = \rho Q (V_2 \cos 60° + V_1 \cos 10°)$

$R_y = \rho Q (V_2 \sin 60° + V_1 \sin 10°)$

$V_1 = 25\ m/s \quad V_2 = 25\ m/s$

$A = \frac{\pi (0.0075)^2}{4} = 4.418 \times 10^{-5}\ m^2 \quad Q = (4.418 \times 10^{-5})(25)$

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

$R_x = 1000 \times 1.1045 \times 10^{-3} (25\cos 60 + 25\cos 10)$ $\boxed{R_x = 41.0\ N}$

$R_y = 1000 \times 1.1045 \times 10^{-3} (25\sin 60 + 25\sin 10)$ $\boxed{R_y = 19.1\ N}$

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30) For the airfoil determine the lift and drag at 10°. Chord length of 1.4m span of 6.8m. Speed at 200 km/h at 200m and 10000 m.

$V = 200\ km/h \left(\frac{1000m}{1\ km}\right)\left(\frac{1\ h}{3600s}\right) = 55.55\ m/s$

$F_L = C_L\left(\frac{\rho v^2}{2}\right)A$ $\quad A = (1.4)(6.8) = 9.52\ m^2$ $\quad C_D = 0.05$ $\quad C_L = 0.9$ $\quad \rho = 1.202$

h = 200m $\quad F_D = (0.05)\left(\frac{1.202 \times 55.55^2}{2}\right)(9.52) = \boxed{F_D = 882.77N}$

$F_L = (0.9)\left(\frac{1.202 \times 55.55^2}{2}\right)(9.52) = \boxed{15.9\ KN}$

h = 10000 m $\quad \rho = 0.4135\ kg/m^3$

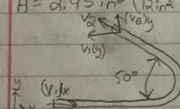
$F_D = (0.05)\left(\frac{0.4135 \times 55.55^2}{2}\right)(9.52) = \boxed{303.7\ N}$

$F_L = (0.9)\left(\frac{0.4135 \times 55.55^2}{2}\right)(9.52) = \boxed{5.46\ KN}$

Chapter 16: 6, 11, 20, 29

6) Free stream of water at 180°F being deflected by a stationary vane through a 130° angle. Entering stream velocity is 22.0 ft/s. Area at 2.95 in²

$A = 2.95 in^2 \left(\frac{1\ ft}{12 in^2}\right) = 0.020\ ft^2$




$F_x = \rho Q(V_{2x} - V_{1x})$ $\quad F_y = \rho Q(V_{2y} - V_{1y})$ $\quad \rho = 1.883\ slugs/ft^3$

$Q = AV = (0.020)(22) = 0.44\ ft^3/s$

$(V_2)_x = 22\cos(180-130) = 14.14\ ft/s$

$(V_2)_y = 22\sin(180-130) = 16.85\ ft/s$

$F_x = (1.883)(0.44) \times (14.14 - (-22))$ $\quad F_y = (1.883)(0.44) \times (16.85 - 0)$

$\boxed{F_x = 29.9\ lb}$ $\quad \boxed{F_y = 13.96\ lb}$

11) Calculate the spring force required to hold the vane in a vertical position when water at 100 gal/min flows from the 1in schedule 40 pipe

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

$F = \rho Q(V_2 - V_1)$ $\quad \rho = 1.94\ lb/ft^3$

$V = \frac{0.2226\ ft^3/s}{0.0060\ ft^2} = 37.1\ ft/s$

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

$\boxed{F = 32.0\ lb}$

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10/17/19

What we learned in Class

1) When solving for forces we need a free body diagram. This is especially important when solving for static or dynamic problems. Air force must be larger than its friction force for the object to move. Drag and lift problems can be solved by apply moment on the point of the drift. Drag coefficients can be found on the table 7.1 in the book.

Flow measurement in a pipe is meant to have find out how much money and time. All equations come from Bernoulli's equation. Discharge coefficient is dependent on Reynolds Number. Beta is ratio of the 2 diameters.

CH 17: 11, 14, 16, 28, 30
CH 16: 6, 11, 20, 29

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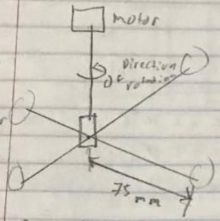
HW 7

CH 17: problem 11

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 (b) gasoline at 20°C

Each cup is 25 mm in diameter
motion = 20 rpm




(a)

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

$V = \frac{20(2\pi L)}{60}\ m/s$

$= \frac{(20)(2)(\pi)(0.075)}{60}$

$= 0.15708 = 0.157\ m/s$

Projected area

$A = \frac{\pi D^2}{4} = \frac{\pi(0.025)^2}{4} = \frac{1.963 \times 10^{-3}}{4} = 4.908 \times 10^{-4}\ m^2$

Reynolds number    Table E.1 $\nu = 1.60 \times 10^{-5}\ m^2/s$

$N_R = \frac{VD}{\nu} = \frac{(1.60 \times 10^{-5})(0.25)}{1.60 \times 10^{-5}} = 245.31$

drag coefficient
Table 17.3    $C_D = 1.35$

Drag force on cups at 30°C    $\rho = 1.164\ kg/m^3$

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

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

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

In 30°C    $T = 4 F_D r$

$T = 4(9.5 \times 10^{-6})(0.075\ m) = 285 \times 10^{-6}\ N \cdot m$

$T = 2.85 \times 10^{-6}\ N \cdot m$

3

$V = 4.22 \times 10^{-7}$

(b) Reynolds # $N_R = \frac{vD}{V}$ 2

Table E.1 $V = 4.22 \times 10^{-7}\ m^2/s$ KB viscosity

$$N_R = \frac{0.157 \times 0.025}{4.22 \times 10^{-7}} = 9300.9$$

Figure 17.3 $C_D = 1.35$ density gasoline at 20°C $\rho = 680\ kg/m^3$

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

$$F_D = \frac{(1.35)(680)(0.157)^2(4.980 \times 10^{-4})}{2} = 0.00555\ N$$

$T = 4 F_D r$

$= 4(0.00555)(0.075)$

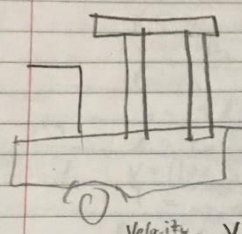
$= 0.001665\ N \cdot m$

20°C is

$$\boxed{T = 1.665 \times 10^{-3}\ N \cdot m}$$

Problem 14

Compute the drag force exerted on the car due to these rods when the car is traveling through still air at -20°F at a speed of 150 mph



Given

$L$ (cylindrical) $= 32\left(\frac{1}{12}\right) = 2.67\,ft$

$D$ (cylindrical) $= 2\left(\frac{1}{12}\right) = 0.167\,ft$

$T = -20°F$ $\quad V = 150\,mph$

Velocity $= V = 150\,(5280)\left(\frac{1}{3600}\right) = 220\,ft/s$

Drag force $\qquad \nu @ = -20°F$

$F_D = C_D\left(\frac{\rho v^2}{2}\right)A \qquad N_R = \frac{vD}{\nu} = \frac{(220)(0.167)}{(1.17\times10^{-4})} = 3.14\times10^5$

drag coefficient $C_D = 3.14\times10^5$ is $0.80$

$A = DL$

$A = (0.167)(2.67 + 2.67)$

$A = 0.89178\,ft^2$

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

$F_D = C_D\left(\frac{\rho v^2}{2}\right)A = \frac{(0.80)(2.8\times10^{-3})(220)^2(0.89178)}{2}$

cylindrical rod

$F_D = 48.3415\,lb$

Nathanael Yaprayon

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CH 17 problem 16

Each has a length of 60 in and width of 9.000 in
Compare the drag force exerted on each proposed design when the vehicle moves at 100 mph through still air at -20°F

Given

squar $b = 9\left(\frac{1}{12}\right) = 0.75\,ft$

Length $l = 60\left(\frac{1}{12}\right) = 5\,ft$

Velocity $V = (100\,mph)(5280)\left(\frac{1}{3600}\right) = 146.67\,ft/s$

$T = -20°F$

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

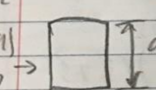
Reynolds number $N_R = \frac{VL}{\nu}$

Air tables @ -20°F

Viscosity Kinematic $V_k = 1.17 \times 10^{-4}\,ft^2/s$

Density $\rho = 2.80 \times 10^{-3}$

(a) flow




Reynold's number

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

$N_R = 9.401 \times 10^5$

Square cylinder $C_D = 2.10$

Projected area of the body is $A = lb = 60(9) = 540\,in^2$

$A = 540\left(\frac{1}{144}\right) =$

$A = 3.75\,ft^2$

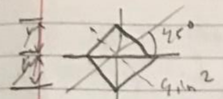
Drag force

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

$= 2.10\left[\frac{(2.80 \times 10^{-3})(146.67)^2}{2}\right](3.75)$

$F_D = 237.17\,lb$

(b)




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

$y = 6.363 \text{ in} \left(\frac{1}{12}\right)$

$y = 0.5302 \text{ ft}$

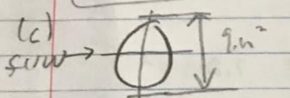
$A = l(2y)$
$= (5)(2)(0.5302)$
$= 5.302 \text{ ft}^2$ $C_D = 1.4$

$F_D = 1.4 \frac{(2.80 \times 10^{-3})(146.67)^2}{2} (5.302)$

$F_D = 255.48 \text{ lb}$

$A = lb = (60)(9)\left(\frac{1}{144}\right)$
$A = 3.75 \text{ ft}^2$

(c)



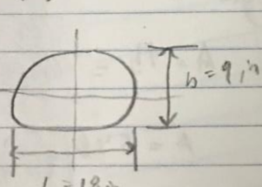

$N_R = \frac{v_x L}{\nu} = \frac{(146.67)(0.75)}{1.17 \times 10^{-4}} =$

$N_R = 9.40 \times 10^5$ $C_D = 0.3$

$F_D = C_D \left(\frac{\rho v^2}{2}\right) A = 0.3 \left(\frac{2.80 \times 10^{-3} \times 146.67^2}{2}\right)(3.75)$

$F_D = 33.881 \text{ lb}$

(d)




$A = 3.75 \text{ ft}^2$

$N_R = \frac{v_x L}{\nu} = \frac{(146.67)(18)\left(\frac{1}{12}\right)}{1.17 \times 10^{-4}}$

$N_R = 1.88 \times 10^6$ $C_D = 0.125$

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

$F_D = 0.125 \left(\frac{2.80 \times 10^{-3} \times 146.67^2}{2}\right)(3.75 \text{ ft}^2)$

$F_D = 28.23 \text{ lb}$

Problem 26

Boat has ratio of 0.06 (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

Given

Specific resistance $\frac{R_V}{\Delta} = 0.006$

Displacement $\Delta = 125$ tons

Speed ship = $V = 50$ ft/s

Seawater = $T = 77°F$

1 ton = 2240 lb

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

$\Delta = 2.8 \times 10^5$

$R_{ES}V = 0.006\Delta$

$R_{ES}V = 0.006(2.8 \times 10^5)$

$R_{ES} = 1680$ lb

Power

$P = R_{ES}V = (1680)(50)$

$P = 8.4 \times 10^4 \frac{lb\text{-}ft}{s}\left(\frac{1 hp}{550 \, lb ft/s}\right)$

$P = 152.7$ hp

## Problem 30

7

Base on fig 17.11

Determine the lift and drag at an angle of attack of $10^0$

Airfoil

Chord length $c = 1.4m$

span $b = 6.8$

Speed $V = (200 km/h)(1000)(\frac{1}{3600})$

$V = 55.55 m/s$

angle of attack $a = 10^0$

Drag coeff

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

Lift coeff

$F_L = C_L\left(\frac{\rho V^2}{2}\right)A$

$A = cb = (1.4 \times 6.8) = 9.52m^2$

(a) $C_D = 0.05$ $C_L = 0.9$

$\rho = 1.202 kg/m$

air table density

$F_D = C_D\left(\frac{\rho v^2}{2}\right)A = \frac{(0.05)(1.202)(55.55)^2(9.52)}{2}$

$F_D = 882.77 N$

$F_L = C_L\left(\frac{\rho v^2}{2}\right)A = \frac{(0.09)(1.202)(55.55)^2(9.52)}{2}$

$F_L = 15,889 kN$

(b) when altitude $h = 10000m$ $\rho = 0.4135 kg/m^3$

$F_D = \frac{(0.05)(0.4135)(55.55)^2(9.52)}{2}$

$F_D = 303.683 N$

$F_L = \frac{(0.9)(0.4135)(55.55)^2(9.52)}{2}$

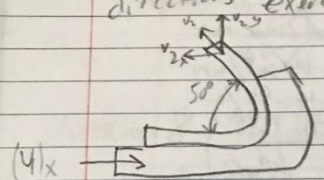
$F_L = 5966.29 N$

$F_L = 5.966 kN$

Problem 16

Problem 6 8

Compute the forces in the horizontal and vertical directions exerted on the water by the vane




$A = 2.95 \, in^2$

$= 2.95\left(\frac{1}{12^2}\right)$

$A = 0.020 \, ft^2$

$\theta = 130°$

$v_1 = 22 \, ft/s$

$t = 180°F$

$\rho = 1.883 \, slugs$

$Q = AV$

$= (0.020)(22)$

$Q = 0.44 \, ft^3/s$

$180 - 50 = 130°$

$(v_2)_x = v\cos(180 - \theta) = 22\cos(50) = 14.14 \, ft/s$

$(v_2)_y = v_2 \sin(180 - 130) = 22\sin(50) = 16.85 \, ft/s$

$F_x = (1.883)(0.44)(-14.14 - (-22))$

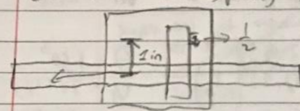
$F_x = 6.512 \, lb$

$F_y = (1.883)(0.44)(16.85 - 0)$

$F_y = 13.96 \, lb$

CH 16 Problem 11 8 

Calculate the spring force required to hold vane




Volume flow rate

$Q = 100\ gal/min$

convert to $ft^3/s$

steel pipe 40 steel pipe $Q = 100\left(\frac{0.1337}{60\ s}\right)$ $Q = 0.228\ ft^3/s$

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

Velocity flow rate $V = \frac{Q}{A} = \frac{0.2226\ ft^3/s}{0.006\ ft^2}$ $V = 37.1\ ft/s$

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

Spring force $F = 32.0\ lb$

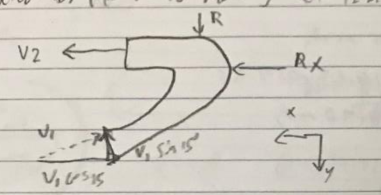
Problem 20



Calculate the force on the vehicle (a) if it is stationary and (b) if it is moving at 12 m/s

Nozzle

Jet of water




$Q = AV = \left(\frac{\pi}{4} d^2\right)(V) = \left(\frac{\pi}{4}\right)(0.2^2)(30)$

$Q = 0.943 \frac{m^3}{s}$

X-direction $R_x = \rho Q V [1 + \cos 15°]$

$R_x = \rho Q V [1 + \cos 15°]$

$= (1.966)(1000)(0.943)(30)$

$= 55618.14 N$

$\theta = 15°$

Y direction $= \rho Q V (0 + \sin\theta)$

$R_y = (1000)(0.943)(30)(.2588)$

$R_y = 7317.9 N$

Velocity of water

X dir

$V_x = 30 \cos 15° = 28.98 m/s$

$V_{1x} = V_x - V_{car}$ $V_{1x} = 28.98 - 12$

$V_{1x} = 16.98 m/s$

y-dir $V_y = v \sin\theta = 30 \sin 15$

$= 7.76 m/s$

Resultant $V_c = \sqrt{(V_{1x})^2 + (V_y)^2}$

$= \sqrt{16.98^2 + 7.76^2}$

$= 18.67 m/s$

Mass flow rate into the vane

$M_c = \rho A V_c$

$M_c = 1000\left(\frac{\pi}{4}\right)(0.2^2)(18.67$

$M_c = 586.6 kg/s$

11

$a = \tan^{-1}\left(\frac{V_y}{V_{1x}}\right) = \tan^{-1}\left(\frac{7.46}{16.98}\right)$

$a = 24.56°$

parallel to vane $V_{ex(par)} = V_c \cos\beta = 18.67 \cos 9.56$

$= 18.40$ m/s

effective force X-direction $(R_x)_c = m_c(\Delta V_{ex})$

$= m_c(V_{ex(par)} - V_{1x})$

$= 586.6(18.40 - (16.98))$

$= \boxed{832.97N}$

Y-direction $(R_y)_c = m_c(\Delta V_{ey})$

$= m(V_{ey(par)} - V_y)$

$= 586.6(0 - (-7.76))$

$= \boxed{4552.0N}$

# Problem 3a

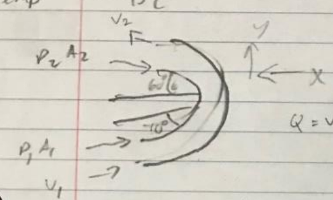
Compute the force on one blade of the turbine

Diameter $= 7.5\,mm\left(\frac{1}{1000}\right) = 0.0075\,m$

Flow of water: $V_1 = 25\,m/s$

Wheel rotates: $R = 200\,mm\left(\frac{1}{1000}\right) = 0.2\,m$

Temp: $t = 15°C$




Area of Stream

$A = \frac{\pi(0.0075)^2}{4} = 4.418\times10^{-5}\,m^2/s$

$Q = vA \quad Q = (4.418\times10^{-5})(25)$

Force

X-direction

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

$R_x = (1000)(1.1045\times10^{-3})[(25\cos 60) + (25\cos 10)]$

$\boxed{R_x = 40.99\,N}$

Y-direction

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

$R_y = (1000)(1.1045\times10^{-3})[(25\sin 60) - (25\sin 10)]$

$\boxed{R_y = 19.12\,N}$

Aaron Jackson

Hw 1.7 Chp 17: 11, 14, 16, 26, 30 chapter 16: 6, 11, 20, 29

1 We learned that in order to solve for forces due to motion in fluids that we have to start with a free body diagram. Drag is the force on a body caused by the fluid that resists motion in the direction of the body. Lift is a force caused by the fluid in a direction perpendicular to the direction of travel of the body. Solving drag and lift involves selecting a point to apply moment. Table 17.1 shows the different drag coefficients as there are multiple.

Chapter 17

17.11 $D = 25\,mm$

$v = \frac{20 \cdot 2\pi}{60} \cdot 0.075 = 0.157\,m/s$

$A = \frac{\pi D^2}{4} = \frac{\pi \cdot 0.025\,m^2}{4} = 4.9 \cdot 10^{-4}\,m^2$

$N_R = \frac{VD}{4} = \frac{0.157 \cdot 0.025}{4} = 245.31$

$C_D = 1.35$

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

$= \frac{1.35 \cdot 1.164\,kg/m^3 \cdot 0.157^2\,m/s}{2} \cdot 4.9 \times 10^{-4}\,m^2$

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

$T = 4 F_D r$

$= 4 \cdot 9.5 \times 10^{-4} \cdot 0.075 = 2.45 \cdot 10^{-6}\,N \cdot m$ @ 30° C

$N_R = \frac{VD}{4} = \frac{(0.157)(0.025)}{4} = 9300.9$

$CD = 1.35$

$FD = 1.35 \left( \frac{680\ kg/m^3 \cdot 0.157^2\ m/s}{2} \right) \cdot 4.9 \times 10^{-4}\ m^2 = 5.55 \times 10^{-3}\ N$

$T = 4 \cdot 5.55 \cdot 10^{-3}\ N \quad 0.075m = 1.6 \times 10^{-3}\ N \cdot m$ @ $20°C$

17.14 $D = 2in = 0.167\ ft$

$L = 32 in = 2.67 in$

$V = 150\ mph = 220\ ft/s$

$NR = \frac{220\ ft/s \cdot 0.167\ ft}{1.17 \cdot 10^{-4}\ ft^2/s} = 3.14 \times 10$

$FD = CD\ (\rho v^2/2)\ A$

$N_R = \frac{vD}{\nu} \quad \nu = 1.17 \cdot 10^{-4}\ ft^2/s$

$\rho$ @ $-20°F = 2.8 \times 10^{-3}\ slugs/ft^3$

$A = DL = 0.167 \cdot 2.67 \cdot 2$

$= 0.89$

$FD = 0.80 \cdot \frac{2.8 \cdot 10^{-3}\ slugs/ft^3 \cdot 220^2}{2} \cdot 0.89\ ft^2 = 48.3\ lb$

17.16 a) $N_R = \frac{VL}{\nu} = \frac{146.67 \cdot 0.75}{1.17 \times 10^{-4}}$

$b = 9 \cdot \frac{1}{12} = 0.75\ ft$

$v = 100\ mph = 146.67\ ft/s$

$\rho = 2.40 \times 10^{-3}\ slugs/ft^3$

$NR = 9.4 \times 10^5 \quad CD = 2.1$

$A = LB = 0.75 \cdot 5 = 3.75\ ft^2$

$FD = CD\ (\rho v^2/2) A = 2.1 \cdot \frac{2.8 \times 10^{-3} \cdot 146.67^2}{} \cdot 3.75 = 237.2\ lb$

b) $y = 9 \sin 45° = 0.5302\ ft \quad A = 1 \cdot 2y = 5 \cdot 0.5302 = 5.302\ ft^2$

$CD = 1.6$

$FD = 1.6 \left( \frac{2.8 \cdot 10^{-3} \times 146.67}{2} \right) \cdot 5.302 = 255.46\ lb$

c $A = 0.75 \cdot 5 = 3.75\ ft^2$

$F_D = 0.3 \cdot \frac{2.8\times10^{-3} \cdot 146.67^2}{2} \cdot 3.75 = 33.9\ lb$

D $A = 3.75\ ft^2$

$N_R = \frac{146.67 \cdot 10/12}{1.17\cdot10^{-4}} = 1.88\cdot10^6$ $\qquad C_D = 0.25$

$F_D = 0.25 \cdot \frac{2.8\cdot10^{-3} \cdot 146.67^2}{2} \cdot 3.75 = 28.3\ lb$

17.26 $P = R_{ts} V$

$R_{ts} = 0.006\ \Delta$

$\Delta = \frac{125 \cdot 2240\ lb}{1\ ton} = 2.8\times10^5\ lb$

$R_{ts} = 0.006 \cdot 2.8\cdot10^5 = 1680\ lb$ resistance

$P = 1680 \cdot 50 = 8.4\times10^4\ lb\cdot ft/s \cdot \frac{1hp}{550\ lb\cdot ft/s} = 152.727\ hp$

17.30 $V = 200\ km/h = 55.55\ m/s$ $\qquad A = 1.4 \cdot 6.8 = 9.52\ m^2$

$F_L = C_L \cdot \frac{\rho v^2}{2} \cdot A$

$A = 1.4 \cdot 6.8 = 9.52\ m^2$ $\qquad CD = 0.05$

$h = 200\ m$ $\quad F_D = 0.05 \frac{1.202 \cdot 56.55^2}{2} \cdot 9.52 =$

$F_D = 882.77$

$F_L = 0.9 \cdot \frac{1.202 \cdot 55.55^2}{2} \cdot 9.52 = 15.9\ kN$

$h = 10000\,m \quad \rho = 0.4135\ kg/m^3$

$F_D = 0.05 \cdot \frac{0.4135 \cdot 55.55^2}{2} \cdot 9.56 = 303.7\ N$

$F_L = 0.9 \cdot \frac{0.4135 \cdot 55.55^2}{2} \cdot 9.52 = 5.46\ kN$

Chapter 16

16.6 $F_x = \rho Q (V_{2x} - V_{1x})$

$Q = AV = 0.020 \cdot 22 = 0.44\ ft^3/s$

$V_{2x} = 22 \cos(180 - 130) = 14.14\ ft/s$

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

$F_y = 1.883 \cdot 0.44 \cdot 16.85 \cdot 0$

$F_y = 13.96$

$F_x = 1.883 \cdot 0.44 \cdot (14.14 - 22)$

$= 29.9\ lb$

16.11 $Q = \frac{100 \cdot 0.1337}{60}$

$= 0.2228\ ft^3/s$

$F = \rho Q (V_2 - V_1) \quad \rho = 1.94\ lb/ft^3$

$V = \frac{0.2226\ ft^3/s}{0.0006} = 37.1$

$F = 1.94 \cdot 0.2228 \cdot 37.1 - -37.1$

$= 32\ lb$

16.20 $Q = AV$

$= \frac{\pi}{4} \cdot (0.2)^2 \cdot 30 = 0.143\ m^3/s$

$R_x = \rho Q v (v_2 - v_1 \cos 6)$

$= 1.466 \cdot 1000 \cdot 0.943 \cdot 30$

$R_x = 55616.14\ N$

$V_{1x} = 28.98 - 12 = 16.98$

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

$\alpha = \tan^{-1} \frac{7.76}{17.98} = 24.56°$

$v = 18.67 \cos 9.56 = 18.40\ m/s$

$R_y = \rho Q V (0 + \sin \theta) = 0.25 \cdot 1000 \cdot 0.943 \cdot 30 = 7072.5\ N$

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

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

$M = \rho \frac{\pi}{4} d^2 v = 1000 \cdot \frac{\pi}{4} \cdot 0.2^2 \cdot 18.67 = 586.6\ kg/s$

$\beta = \alpha - \theta = 24.56° - 15 = 9.56$

$R_x\ \theta = 586.6\ (18.4 - 16.98) = 833.0\ N$

$R_y\ \theta = 586.6\ (0 - -7.76) = 4552.0\ N$

16.29 $R_x = \rho Q (V_2 \cos 60° + V_1 \cos 10°)$

$R_y = \rho Q (V_2 \sin 60° + V_1 \sin 10°)$

$V_1 = 25\ m/s \quad V_2 = 25\ m/s$

$D = 7.5\ mm = 0.0075\ m$

$A = \frac{\pi \cdot 0.0075^2}{4} = 4.418 \cdot 10^{-5}\ m^2$

$Q = 4.418 \cdot 10^{-5} \cdot 25$

$= 1.045 \cdot 10^{-3}\ m^3/s$

$R_x = 1000 \cdot 1.1045 \cdot 10^{-3}\ \ 25 \cos 60 + 25 \cos 10$ $R_x = 41\ N$

$R_y = 1000 \cdot 1.1045 \cdot 10^{-3}\ \ 25 \sin 60 + 25 \sin 10$ $R_y = 19.1\ N$