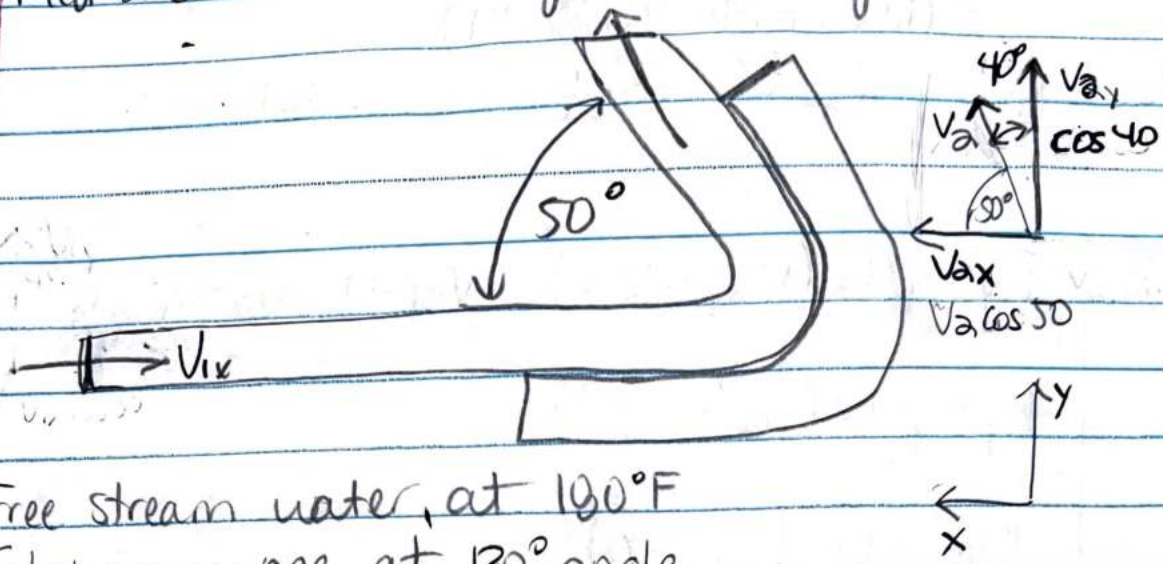
Dylan Arnold HW9 University ID: 01166349
MET 330 Professor Ayala July 16th, 2023

16.6



Free stream water, at 180°F
Stationary vane at 130° angle
Entering stream velocity = 22.0 ft/s
Cross-sectional area throughout constant 2.95 in²
Compute forces in horizontal & vertical directions exerted on the water by the vane

$$Q = Av = (2.95\,in^2)(22.0\,ft/s) \cdot \frac{1\,ft^2}{144\,in^2}$$

$$= 0.4507\,ft^3/s$$

$$\rho @ 180°F = 1.88\ slugs/ft^3 = 1.88\ \frac{lb \cdot s^2}{ft^4}$$

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

$$F_x = \rho Q (V_2 \cos 50 - (-22\,ft/s)) \qquad V_2 = V_1$$

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16.6 Cont'd $R_x = \rho Q((V_2)(\cos 50) + 22))$

$= (1.88)(0.4507)(36.14)$

$\boxed{= 30.6216}$ horizontal

$V_2 = V_1$

$F_y = \rho Q(V_{2y} - V_{1y})$ $V_{1y} = 0$ $V_2 = V_1 = 22\ ft/s$

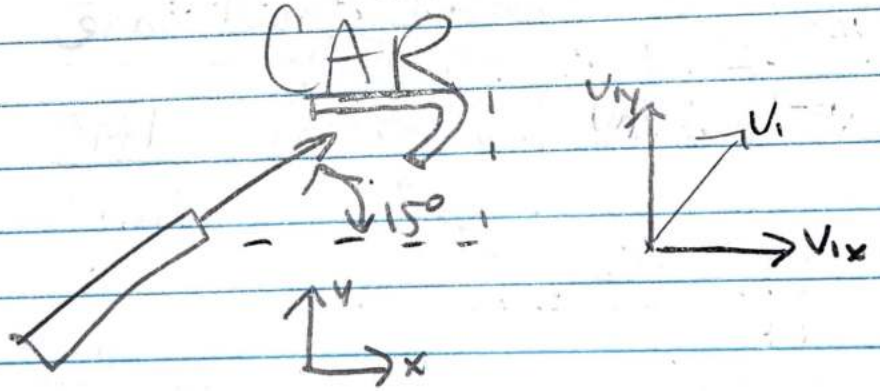
$R_y = \rho Q(V_2(\cos 40))$

$R_y = \rho Q_v(\cos 40)$

$= (1.89)(0.4507)(22)(0.7660)$

$\boxed{= 14.271b \text{ vertical}}$

16.20



Jet velocity 30 m/s
Nozzle diameter 200 mm
Calculate force on vehicle when
car is stationary (a) + moving at 12 m/s (b)

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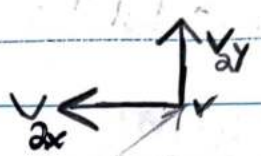
Stationary

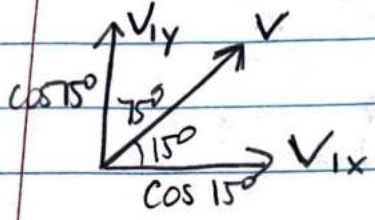
$F_x = \rho Q (V_{2x} - V_{1x})$

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

$\rho = 997\ kN/m^3$

assume 25°C





$$A = \left(\frac{200\,mm \cdot \frac{1\,m}{1000\,mm}}{2}\right)^2 \cdot \frac{\pi}{4}$$

$A = 0.0078\ m^2$

$Q = AV$

$Q = (0.0078\ m^2)(30\ m/s)$

$Q = 0.2356\ m^3/s$

$F_x = \rho Q(+(30\ m/s) - (V_1 \cos 15°))$

$(997)(0.2356)(.30 - 28.978)$

$(997)(0.2356)(1.022)$

$\boxed{R_x = 240.06\ N}$

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

$\rho Q(0 - (-V_1 \cos 75))$

$(997)(0.2356)(7.76)$

$\boxed{R_y = 1823.85\ N}$

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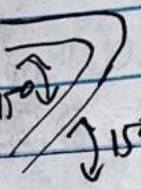
16.20 Cont'd Moving at 12 m/s

$V_i = 30\ m/s \quad V_o = 12\ m/s$

$V_e = 30 - 12 = 18\ m/s$

$Q_e = A_1 V_e = (0.0078 m^2)(18\ m/s)$
$= 0.1404\ m^3/s$

$R_x = \rho Q_e V_e (1 + \cos\theta)$
$R_y = \rho Q_e V_e (\sin\theta - 0)$



$R_x = (997)(0.1404)(18)(1 + \cos 75)$

$\boxed{R_x = 317.74\ N}$

$R_y = (997)(0.1404)(18)(\sin\theta - 0)$

$\boxed{R_y = 2433.76\ N}$

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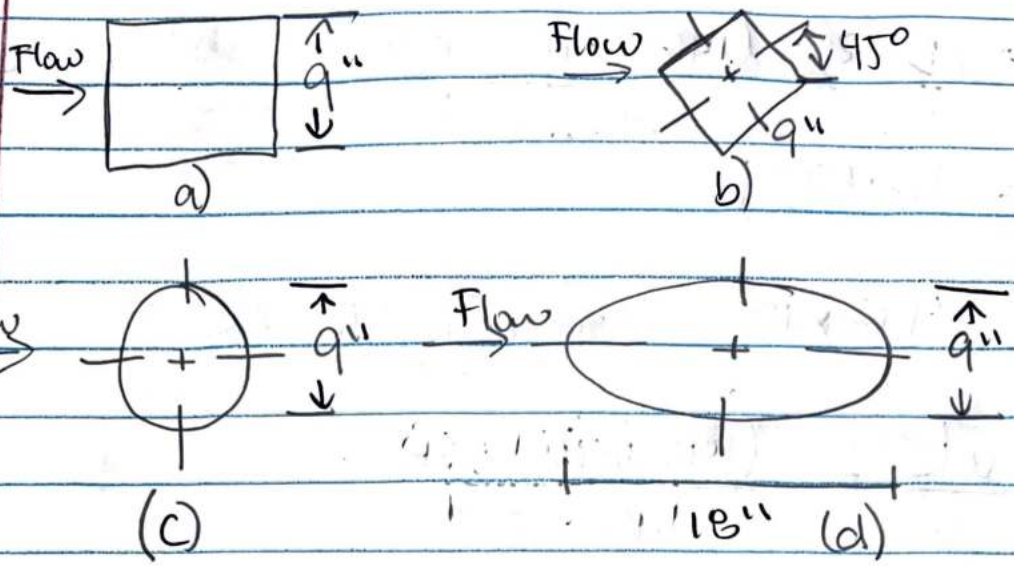
7.16



100 mph = 146.67 ft/s
still air @ -20°F

$F_d = C_d(\rho v^2/2)A$

$A_A = 2(wl + hl + hw) = 2((60 \cdot 9) + (9 \cdot 9) + (9 \cdot 60)) = 2322 in^2$
$A_B = 2322 in^2$
$A_C = 2\pi(4.5)(60) + 2\pi(4.5)^2 = 1823.69 in^2$
$A_d = (\pi \times (9 + 4.5) \cdot 60) + (2 \cdot \pi \cdot 9 \cdot 4.5) = 2799.15 in^2$

$Cd_A = 1.205$
$Cd_B = 1.60$
$Cd_C = \sim 3$
$Cd_D = 0.35$

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17.16 Contd $N_R = \frac{vD}{\nu} = \frac{(146.67)(0.75ft)}{1.14 \times 10^{-4}}$

$N_R = 964934$

9.6×10^5 Using Fig 17.4 $C_d = 3$

$N_R = \frac{vL}{\nu} = \frac{(146.67)(1.5ft)}{1.14 \times 10^{-4}}$

$N_R = 1929868.4$

1.9 or 2×10^6

Using Fig 17.6 $C_d = 0.35$

$F_d = C_d(\rho v^2/2)A$

$F_{d_A} = 1.205\left(\frac{2.37 \times 10^{-3} \cdot 146.67^2}{2}\right)\left(\frac{2322}{144}\right)$

$\boxed{F_{d_A} = 599.816}$

$F_{d_B} = 1.60\left(2.37 \times 10^{-3} \cdot \frac{146.67^2}{2}\right)\left(\frac{2322}{144}\right)$

$\boxed{F_{d_B} = 796.416}$

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17. Holtrop $F_{dc} = 3\left(2.87\times10^{-3} \cdot \frac{146.67^2}{2}\right)\left(\frac{1823.69}{144}\right)$

$$\boxed{F_{dc} = 1172.86\,lb}$$

$F_{db} = 0.35\left(2.87\times10^{-3} \cdot \frac{146.67^2}{2}\right)\left(\frac{2799.15}{144}\right)$

$$\boxed{F_{db} = 2101\,lb}$$ lowest drag ★

M. 26 Specific resistance ratio = 0.006
Displaces 125 tons
Total ship resistance? Power?
Moving at 50 ft/s @ 77°F seawater

$\Delta = (125\text{ tons})(2240\,lb/ton) = 280000\,lb$
$= 2.8\times10^5\,lb$

$R_{TS} = (0.006)(\Delta) = (0.006)(2.8\times10^5) = 1680\,lb$

$$\boxed{R_{TS} = 1680\,lb}$$

$P_E = R_{TS}V = (1680\,lb)(50\,ft/s) = 84000\,lb\cdot ft/s$

$= 84000\,lb\cdot ft/s \cdot \frac{1}{550} = 152.73\,HP$

$$\boxed{P_E = 153\,HP}$$