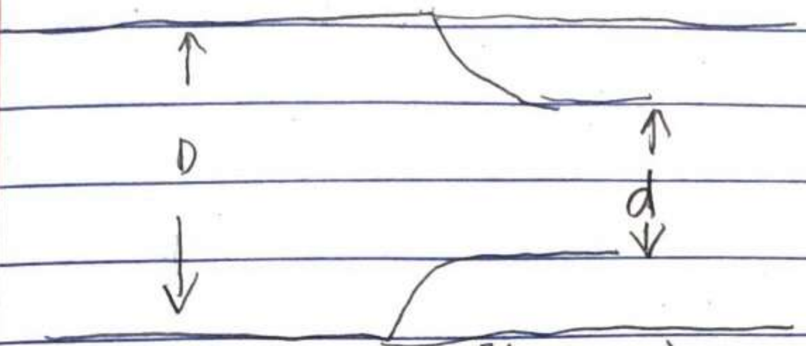
15.9




$T = 77^{\circ}F$

$Q_1 = 700 \frac{gal}{min}$

$Q_2 = 1000 \frac{gal}{min}$

Nanoscale ; 0 to 12 in

$D_{nozzle} = 5 in$

$Q_1 = 700 \frac{gal}{min} \left( \frac{1 \, ft^3/s}{449 \, gal/min} \right) = 1.56 \frac{ft^3}{s}$

$Q_2 = 1000 \frac{gal}{min} \left( \frac{1 \, ft^3/s}{449 \, gal/min} \right) = 2.23 \frac{ft^3}{s}$

Using Appendix H

5 in ; $D = 0.4004 \, ft$

$A_1 = \frac{\pi}{4} D^2 = \frac{\pi}{4} (0.4004 \, ft)^2 = 0.1259 \, ft^2$

Using Table B.2:

$T = 77^{\circ}F$ of linseed oil ; $\nu = 3.84 \times 10^{-4} \frac{ft^2}{s}$ (Kin. velocity)

$\gamma = 58.0 \frac{lb}{ft^3}$

Conuity equation for $Q_1 = 700$ :

$Q_{700} = A_1 V_1 \rightarrow V_1 = \frac{Q_{700}}{A_1} = \frac{1.56 \frac{ft^3}{s}}{0.1259 \, ft^2} = 12.39 \frac{ft}{s}$

Reynold Number

$N_R = \frac{V_1 D}{\nu} = \frac{(12.39 \, ft/s)(0.4004 \, ft)}{3.84 \times 10^{-4} \frac{ft^2}{s}} = 1.29 \times 10^4$

Using Fig 15.5 ; $C = 0.955$

Conuity equation for $Q_2 = 1000$ ;

$Q_{1000} = A_1 V_1 \rightarrow V_1 = \frac{Q_{1000}}{A_1} = \frac{2.23 \frac{ft^3}{s}}{0.1259 \, ft^2} = 17.71 \frac{ft}{s}$

Reynold Number : $N_R = \frac{V_1 D}{\nu} = \frac{(17.71 \, ft/s)(0.4004 \, ft)}{3.84 \times 10^{-4} \, ft^2/s} = 1.84 \times 10^4$

Using Fig. 15.5 ; $C = 0.96$

15.9 (continued)

Using Eq 15.6

$$V_t = C\sqrt{\frac{2gh\left[\left(\frac{\gamma_m}{\gamma_f}\right)-1\right]}{\left(\frac{A_1}{A_2}\right)^2-1}}$$

For $A_2$:

$$\frac{V_1}{C} = \sqrt{\frac{2gh\left[\left(\frac{\gamma_m}{\gamma_f}\right)-1\right]}{\left(\frac{A_1}{A_2}\right)^2-1}}$$

$$\left(\frac{V_1}{C}\right)^2 = \frac{2gh\left[\left(\frac{\gamma_m}{\gamma_f}\right)-1\right]}{\left(\frac{A_1}{A_2}\right)^2-1}$$

$$\left(\frac{C}{V_1}\right)^2 = \frac{\left(\frac{A_1}{A_2}\right)^2-1}{2gh\left[\left(\frac{\gamma_m}{\gamma_f}\right)-1\right]} \rightarrow \left(\frac{C}{V_1}\right)^2\left(2gh\left[\left(\frac{\gamma_m}{\gamma_f}\right)-1\right)\right) = \left(\frac{A_1}{A_2}\right)^2-1$$

$$\left(\frac{C}{V_1}\right)^2\left(2gh\left[\left(\frac{\gamma_m}{\gamma_f}\right)-1\right]+1\right) = \left(\frac{A_1}{A_2}\right)^2$$

$$A_2 = \frac{A_1}{\sqrt{\left(\frac{C}{V_1}\right)^2\left(2gh\left[\left(\frac{\gamma_m}{\gamma_f}\right)-1\right]\right)+1}}$$

$$A_2 = \frac{0.1259\,ft^2}{\sqrt{\left(\frac{0.96}{17.69\,ft/s}\right)^2\left(2\left(32.2\,\frac{ft}{s^2}\right)\left(8\,in\left(\frac{1\,ft}{12\,in}\right)\right)\left[\left(\frac{844.9}{58}\right)-1\right]\right)+1}}$$

$$A_2 = 0.0764\,ft^2$$

For diameter of $A_2$:

$$D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4(0.0764\,ft^2)}{\pi}} = 0.312\,ft$$

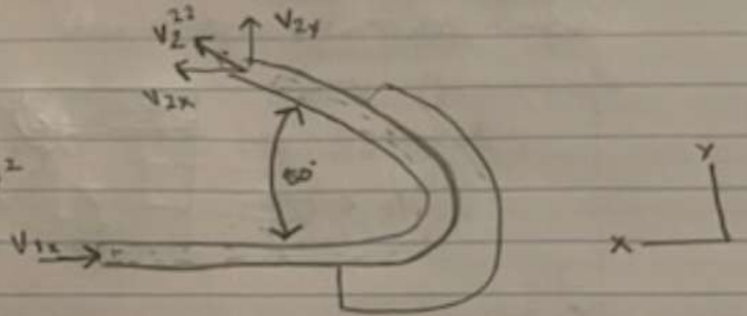
In inches; $D = 0.312\,ft\left(\frac{12\,in}{1\,ft}\right) = 3.743\,in$

$$\boxed{D = 3.743\,in}$$

15-10 This problem took a look at finding the appropriate diameter needed for an office. In order to do this, we have to assume that the fluid is incompressible, it's a isothermal process, and it's in a steady state. The equation used is changed so that we are solving for the area at the second part. The area is then converted to diameter + the diameter is solved.

6, 11,
Paragraph

16.6 The figure below shows a free stream of water @ 180°F being deflected by a stationary vane through a 130° angle. The entering stream has a velocity of 22 ft/s. The cross-sectional area of the stream is constant @ 2.95 in² throughout the system. Compute the forces in the horizontal + vertical directions exerted on the water by the vane.




$V = 22$ ft/s
$A = 2.95\ in^2 \rightarrow .0205\ ft^2$
$t = 180°F$
$\theta = 130°$
$\rho_{water} = 1.88$ slug/ft³

$Q = VA \rightarrow 22\ ft/s\ (.0205\ ft^2) = 0.451\ ft^3/s$

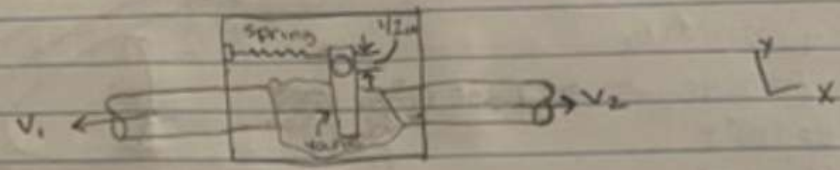
$\Sigma F_x = \rho Q (V_{2x} - V_{1x})$
$\Sigma F_y = \rho Q (V_{2y} - V_{2x})$

$V_{2x} = 22 \cos(180-130) = 14.14$ ft/s
$V_{2y} = 22 \sin(180-130) = 16.85$ ft/s

$\Sigma F_x = 1.88\ slug/ft^3 (.451\ ft^3/s)(14.14\ ft/s + 22) = 30.64\ slugs = F_x$

$\Sigma F_y = 1.88\ slug/ft^3 (.451\ ft^3/s)(16.85\ ft/s - 0) = 14.29\ slugs = F_y$

16.11 The Figure below 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 @ 100 gal/min flows from the 1-in schedule 40 pipe which the meter is attached.




$Q = 100\ \text{gal/min} \rightarrow 0.223\ \text{ft}^3/\text{s}$

$A = .006\ \text{ft}^2$ (schedule 40 pipe; 1 in)

$\rho = 1.94\ \text{slug/ft}^3$

$V = Q/A \rightarrow \dfrac{.223\ \text{ft}^3/\text{s}}{.006\ \text{ft}^2} = 37.17\ \text{ft/s}\ (v_1 + v_2)$

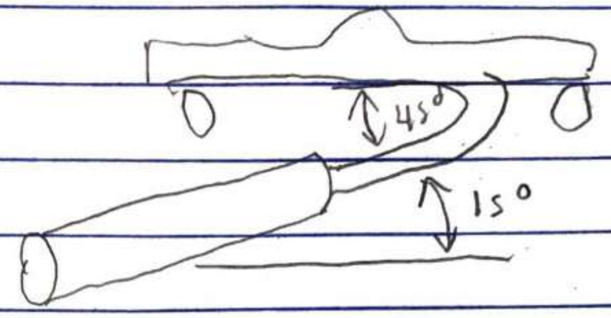
$F = \rho Q (V_2 - V_1)$

$= 1.94\ \text{slug/ft}^3 (.223\ \text{ft}^3/\text{s})(37.17 - (-37.17)\ \text{ft/s})$

$F = 32.16\ \text{slugs}$

Hw 2.3

6.20




$V = 30\,m/s$

$D = 200\,mm = 0.2\,m$

$\alpha = 15^0$

$F = ?$

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

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

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

$Q = 0.9425\ \frac{m^3}{s}$

$F_x = \rho Q (V_2 - V_1 \cos\theta) = \rho Q V(1 + \cos(15^0))$

$F_x = (1000\frac{kg}{m^3})(0.9425\frac{m^3}{s})(30\frac{m}{s})(1.966)$

$F_x = 55587.34 \frac{kg \cdot m}{s^2} = \boxed{55587.34\,N}$

$F_y = \rho Q(V_2 - (V_1 \sin\theta)) = \rho Q V(0 + \sin\theta) = \rho Q V \sin 15^0$

$F_y = (1000\frac{kg}{m^3})(0.9425\frac{m^3}{s})(30\ \frac{m}{s})(0.2588) = \boxed{7317.57\,N}$

b) Moving car inlet velocity of water in x-dir. :

$V_{1x} = V_x - V_{car} = (30\frac{m}{s})\cos(15^0) - 12\frac{m}{s} = 16.98\ \frac{m}{s}$

$V_{1y} = V\ \sin\theta = (30\frac{m}{s})\sin(15^0) = 7.76\ \frac{m}{s}$

Resulted Velocity ($V_R$) : $V_R = \sqrt{V_{1x}^2 + V_{1y}^2} = \sqrt{(16.98)^2 + (7.76)^2}$

$V_R = 18.67\ \frac{m}{s}$

$\alpha = \tan^{-1}\left(\frac{V_y}{V_x}\right) = \tan^{-1}\left(\frac{7.76}{16.98}\right) = 24.56^0$

Total mass flow : $M_e = \rho A V_e = (1000\frac{kg}{s})(\frac{\pi}{4}(0.2m)^2(18.67\frac{m}{s})$

$M_e = 586.51\ \frac{kg}{s}$

16.20 (continued)

Angle between $\alpha$ and the angle of the vanelet

$\beta = \alpha - \theta = 24.56^\circ - 15^\circ = 9.56^\circ$

Effect velocity:

$V_e = V_R \cos\beta = (18.67 \frac{m}{s}) \cos(9.56^\circ) = 18.41 \frac{m}{s}$

Effect force both x and y directions:

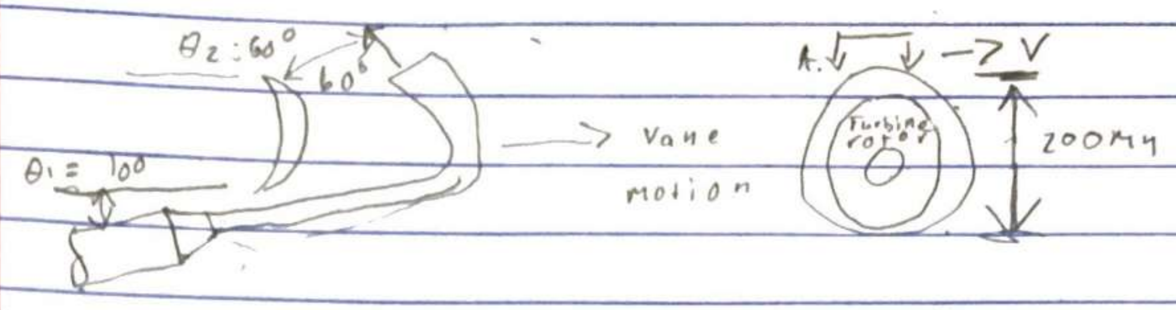
$(R_x)_e = M_e (v_{ex} - v_x) = 586.51 \frac{m}{s} (18.41 - 16.98)$

$\boxed{(R_x)_e = 839.12 \text{ N}}$

$(R_y)_e = M_e (v_{ey} - v_y) = 586.51 \frac{m}{s} (0 - (-7.76)) = 586.51 (7.76)$

$\boxed{(R_y)_e = 4551.32 \text{ N}}$

10.29




$T = 15°C$, $D = 7.50\,mm = 0.0075\,m$, $V = 25\,\frac{m}{s}$

$F = \rho Q \Delta V$

$Q = Av = \frac{\pi}{4} D_1^2 V_1 = \frac{\pi}{4}(0.0075\,m)^2 (25\,\frac{m}{s})$

$Q = 0.0011045\,\frac{m^3}{s}$

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

$R_x = (1000\,\frac{kg}{m^3})(0.0011045\,\frac{m^3}{s})(25\,\frac{m}{s})(\cos 60° + \sin 10°)$

$\boxed{R_x = 40.98N}$

$R_y = \rho Q (v_2 \sin 60 - V_1 \sin 10) = \rho Q V(\sin 60° - \sin 10°)$

$R_y = (1000\,\frac{kg}{m^3})(0.0011045\,\frac{m^3}{s})(25\,\frac{m}{s})(\sin 60° - \sin 10°)$

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