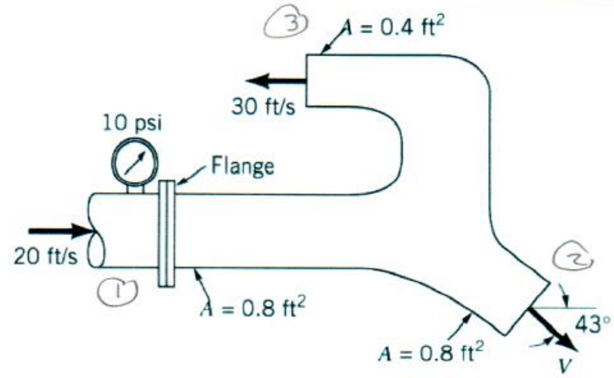
Munson 4E
Prob 5.59

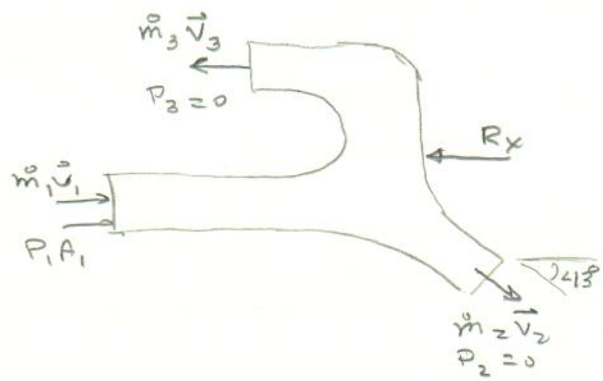
Linear Momentum Eqn.

Water discharges into the atmosphere through the device shown in the sketch. Neglecting friction effects, determine the x component of the force at the flange required to hold the device in place. Use $\rho_w = 62.4\ \text{lbm/ft}^3$.



momentum balance

$$\sum \vec{F} = \sum_{\text{outlets}} \dot{m}\vec{v} - \sum_{\text{inlets}} \dot{m}\vec{v}$$



in x-direction

$$P_1A_1 - R_x = \dot{m}_2|\vec{v}_2|\cos 43^\circ + \dot{m}_3(-1)|\vec{v}_3| - \dot{m}_1|\vec{v}_1|$$

R in neg direction

or $$R_x = P_1A_1 - \dot{m}_2|\vec{v}_2|\cos 43^\circ + \dot{m}_3|\vec{v}_3| + \dot{m}_1|\vec{v}_1| \quad (1)$$

From continuity eqn

$$Q = Q_2 + Q_3$$
$$A_1V_1 = A_2V_2 + A_3V_3$$

$$V_2 = \frac{A_1V_1 - A_3V_3}{A_2} = \frac{(0.8)(20) - (0.4)(30)}{0.8}$$

$$V_2 = 5\ \text{ft/s}$$

also

$$\dot{m} = \rho Q = \rho A v$$

$$\dot{m}_1 = (62.4)(0.8)(20) = 998.4\ \text{lbm/s}$$
$$\dot{m}_2 = (62.4)(0.8)(5) = 249.6\ \text{lbm/s}$$
$$\dot{m}_3 = (62.4)(0.4)(30) = 748.8\ \text{lbm/s} \quad \text{(ok)}$$

and

$$P_1A_1 = 10\frac{\text{lbf}}{\text{in}^2} \times \frac{144\ \text{in}^2}{\text{ft}^2} \times 0.8\ \text{ft}^2 = 1152\ \text{lbf}$$

be careful with units

$$\therefore R_x = 1152\ \text{lbf} - \frac{(249.6\ \text{lbm/s})(5\ \text{ft/s})(\cos 43^\circ)}{32.2\ \frac{\text{lbm ft/s}^2}{\text{lbf}}} + \frac{(748.8)(30)}{32.2} + \frac{(998.4)(20)}{32.2}$$

$$= 1152 - 28.3 + 697.6 + 620.1$$

or $$R_x = 2441\ \text{lbf}$$ ans