5.50

5.50 A horizontal circular cross section jet of air having a diameter of 6 in. strikes a conical deflector as shown in Fig. P5.50. A horizontal anchoring force of 5 lb is required to hold the cone in place. Estimate the nozzle flow rate in ft³/s. The magnitude of the velocity of the air remains constant.

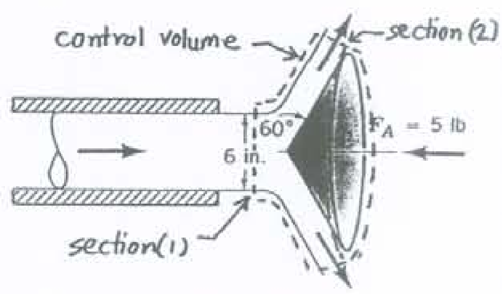

FIGURE P5.50

The control volume shown in the sketch is used. Application of the axial or x-direction component of the linear momentum equation yields

$$-u_1 \rho u_1 A_1 + u_2 \rho u_2 A_2 = -F_{A,x}$$

With the conservation of mass principle we can conclude for this incompressible flow that

$$u_1 A_1 = u_2 A_2 = Q$$

Also

$$u_2 = V \cos 60^\circ$$

and

$$u_1 = V = \frac{Q}{A_1}$$

Thus

$$-V\rho Q + V\cos 60^\circ \rho Q = -F_{A,x} = -\frac{Q^2}{A_1}\rho + \frac{Q^2}{A_1}\cos 60^\circ \rho$$

or

$$Q = \left[\frac{F_{A,x}\, A_1}{\rho(1-\cos 60^\circ)}\right]^{\frac{1}{2}} = \left[\frac{F_{A,x}\left(\frac{\pi D_1^2}{4}\right)}{\rho(1-\cos 60^\circ)}\right]^{\frac{1}{2}}$$

Thus

$$Q = \left[\frac{(5\text{ lb})(\pi)(6\text{ in.})^2}{\left(0.00238\frac{\text{slugs}}{\text{ft}^3}\right)(1-\cos 60^\circ)(4)\left(144\frac{\text{in.}^2}{\text{ft}^2}\right)\left(\frac{1\text{ lb}}{\text{slug}\frac{\text{ft}}{\text{s}^2}}\right)}\right]^{\frac{1}{2}}$$

and

$$Q = \underline{\underline{28.7}}\ \frac{\text{ft}^3}{\text{s}}$$