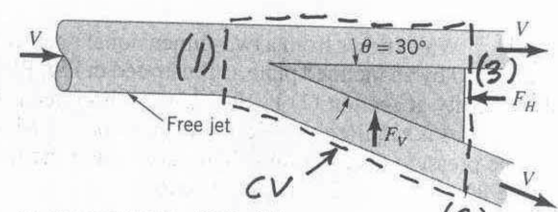
5.41

5.41 A free jet of fluid strikes a wedge as shown in Fig. P5.41. Of the total flow, a portion is deflected 30°; the remainder is not deflected. The horizontal and vertical components of force needed to hold the wedge stationary are F_H and F_V, respectively. Gravity is negligible, and the fluid speed remains constant. Determine the force ratio, F_H/F_V.



■ FIGURE P5.41

The horizontal and vertical components of the linear momentum equation are applied to the contents of the control volume shown to get

$$-V_1 \rho V_1 A_1 + V_2 \rho V_2 A_2 + V_3 \cos 30^\circ \rho V_3 A_3 = -F_H \qquad (1)$$

$$-V_3 \sin 30^\circ \rho V_3 A_3 = F_V \qquad (2)$$

However $V_1 = V_2 = V_3 = V$ so eqs. (1) and (2) become

$$V^2 \rho \left(A_2 + A_3 \cos 30^\circ - A_1\right) = -F_H$$

$$V^2 \rho A_3 \sin 30^\circ = -F_V$$

and

$$\frac{F_H}{F_V} = \frac{A_2 + A_3 \cos 30^\circ - A_1}{A_3 \sin 30^\circ} \qquad (3)$$

From conservation of mass we get

$$Q_1 = Q_2 + Q_3$$

or

$$A_1 V = A_2 V + A_3 V$$

and

$$A_1 = A_2 + A_3 \qquad (4)$$

Combining Eqs. (3) and (4) we get

$$\frac{F_H}{F_V} = \frac{A_2 + A_3 \cos 30^\circ - A_2 - A_3}{A_3 \sin 30^\circ} = \frac{A_3 (\cos 30^\circ - 1)}{A_3 \sin 30^\circ} = \underline{\underline{-0.27}}$$

The negative sign indicates that F_V is down rather than up as shown in the sketch