5.67

5.67 (See Fluids in the News article titled **"Where the plume goes,"** Section 5.2.2.) Air flows into the jet engine shown in Fig. P5.67 at a rate of 9 slugs/s and a speed of 300 ft/s. Upon landing, the engine exhaust exits through the reverse thrust mechanism with a speed of 900 ft/s in the direction indicated. Determine the reverse thrust applied by the engine to the airplane. Assume the inlet and exit pressures are atmospheric and that the mass flowrate of fuel is negligible compared to the air flowrate through the engine.

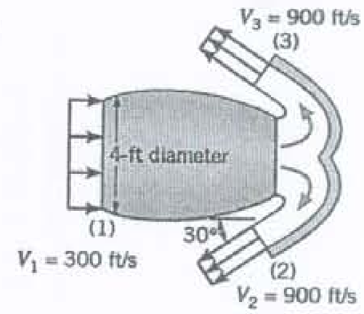
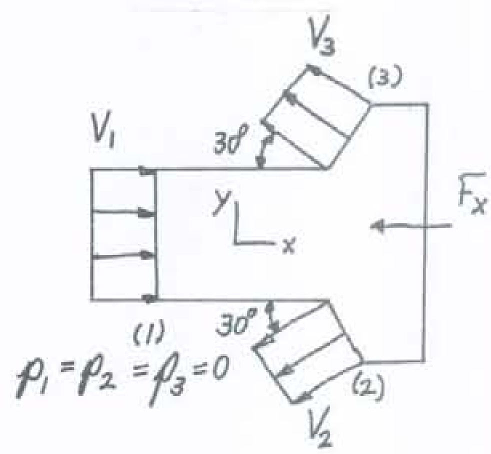


FIGURE P5.67



The momentum equation (x-component),

$\int_{cs} u \rho \vec{V}\cdot\hat{n}\, dA = \Sigma F_x$, for the control volume shown can be written as

$p_1 = p_2 = p_3 = 0$

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

or

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

But from conservation of mass,

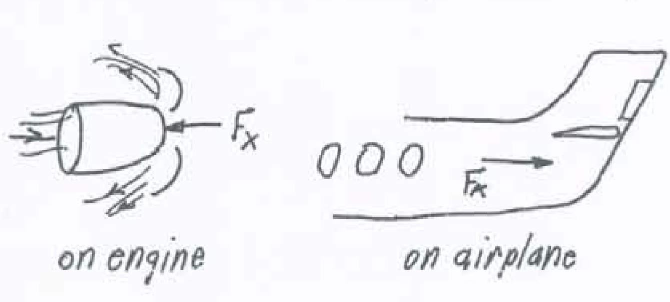
$$\rho V_1 A_1 = \rho V_2 A_2 + \rho V_3 A_3 = \dot{m} = 9\,\text{slugs}/\text{s}$$

Also, $V_2 = V_3$, so that Eq. (1) becomes

$$F_x = \dot{m}(V_1 + V_2\cos 30^\circ) = 9\,\frac{\text{slugs}}{\text{s}}\left(300\,\frac{\text{ft}}{\text{s}} + 900\cos 30^\circ\,\frac{\text{ft}}{\text{s}}\right)$$

$$= 9710\,\frac{\text{slugs}\cdot\text{ft}}{\text{s}^2} = \underline{\underline{9170\ \text{lb}}}$$

Note direction of F_x on engine and engine on airplane.



on engine   on airplane