

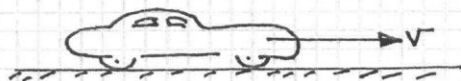
## PROBLEM 2.20

**KNOWN:** Data are provided for an automobile moving at (a) 25 mph, (b) 70 mph.

**FIND:** For each case, determine the power, in hp, to overcome aerodynamic drag.

**SCHEMATIC & GIVEN DATA:**

$$C_d = 0.28, A = 25 \text{ ft}^2$$



$$\text{Air} \\ \rho = 0.075 \text{ lb/ft}^3$$

**ENGINEERING MODEL:**

1. The automobile is the system.

**ANALYSIS:**

The aerodynamic drag force is  $F_d = C_d A \frac{1}{2} \rho V^2$ . By Eq. 2.13, the required power is  $\dot{W}_d = F_d \cdot V$ , giving

$$\begin{aligned} \dot{W}_d &= \left[ C_d A \frac{1}{2} \rho V^2 \right] V \\ &= C_d A \frac{1}{2} \rho V^3 \end{aligned} \quad (1)$$

(a)  $V = 25 \text{ mph}$ . Substituting into Eq. (1) and applying unit conversion factors,

$$\begin{aligned} \dot{W}_d &= \frac{1}{2} (0.28) (25 \text{ ft}^2) (0.075 \frac{\text{lb}}{\text{ft}^3}) \left[ 25 \frac{\text{mi}}{\text{h}} \left| \frac{1 \text{ h}}{3600 \text{ s}} \right| \left| \frac{5280 \text{ ft}}{1 \text{ mi}} \right| \right]^3 \left| \frac{1 \text{ lbf}}{32.2 \text{ lb} \cdot \text{ft/s}^2} \right| \left| \frac{1 \text{ hp}}{550 \frac{\text{ft} \cdot \text{lbf}}{\text{s}}} \right| \\ &= 0.73 \text{ hp} \quad \leftarrow \end{aligned}$$

(b)  $V = 70 \text{ mph}$ . Substituting into Eq. (1) and applying the same unit conversions as in (a),

$$\begin{aligned} \dot{W}_d &= \frac{1}{2} (0.28) (25) (0.075) \left[ (70) \left| \frac{5280}{3600} \right| \right]^3 \left| \frac{1}{32.2} \right| \left| \frac{1}{550} \right| \\ &= 16.04 \text{ hp} \quad \leftarrow \end{aligned}$$