

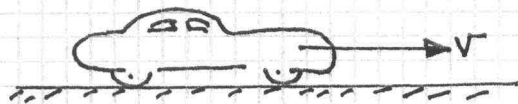
PROBLEM 2.20

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

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

(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),

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