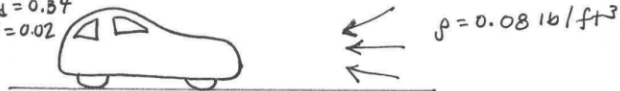


## PROBLEM 2.22

**KNOWN:** The drag force and the force associated with rolling resistance are known as functions of variables associated with a vehicle in motion.

**FIND:** (a) Determine the power required to overcome drag and rolling resistance when the vehicle is moving at 55 mi/h. (b) Plot the quantities of part (a) and their sum versus vehicle velocity ranging from 0 to 75 mi/h. Discuss the implication for vehicle fuel economy.

$$\begin{aligned} W &= 3550 \text{ lbf} \\ A &= 23.3 \text{ ft}^2 \\ C_d &= 0.34 \\ f &= 0.02 \end{aligned}$$



**ENGR. MODEL:** The vehicle is the system.

**ANALYSIS:** Applying Eq. 2.13, the power required to overcome drag is

$$\begin{aligned} \dot{W}_d &= F_d \cdot V = \left( \frac{1}{2} C_d A \rho V^2 \right) V = \frac{1}{2} C_d A \rho V^3 \\ &= \frac{1}{2} (0.34) (23.3 \text{ ft}^2) (0.08 \frac{\text{lb}}{\text{ft}^3}) \left[ V \left( \frac{\text{mi}}{\text{h}} \right) \left| \frac{5280 \text{ ft}}{\text{mi}} \right| \left| \frac{\text{h}}{3600 \text{ s}} \right| \right]^3 \left| \frac{1 \text{ lbf}}{32.2 \text{ lb} \cdot \text{ft/s}^2} \right| \left| \frac{\text{hp}}{550 \text{ ft} \cdot \text{lbf/s}} \right| \\ &= 5.65 \times 10^{-5} [V(\text{mi/h})]^3 \text{ hp} \quad (*) \end{aligned}$$

The power required to overcome rolling resistance is

$$\begin{aligned} \dot{W}_r &= F_r \cdot V = (f W) V = (0.02) (3550 \text{ lbf}) \left[ V \left( \frac{\text{mi}}{\text{h}} \right) \left| \frac{5280 \text{ ft}}{\text{mi}} \right| \left| \frac{\text{h}}{3600 \text{ s}} \right| \right] \left| \frac{\text{hp}}{550 \text{ ft} \cdot \text{lbf/s}} \right| \\ &= 0.189 V \left( \frac{\text{mi}}{\text{h}} \right) \text{ hp} \quad (** ) \end{aligned}$$

(a) When  $V = 55 \text{ mi/h}$ , we have

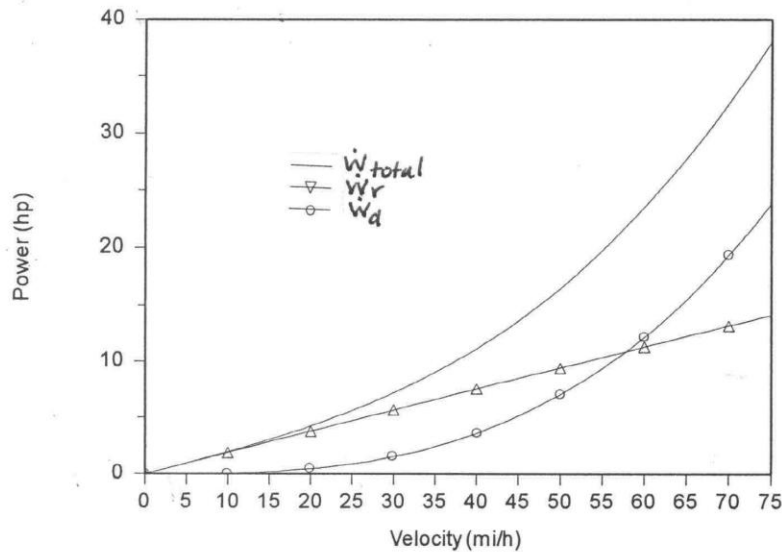
$$\dot{W}_d = 5.65 \times 10^{-5} [55]^3 = 9.4 \text{ hp}$$

$$\dot{W}_r = 0.189 [55] = 10.4 \text{ hp}$$

←  $\dot{W}_d, \dot{W}_r$

### PROBLEM 2.22 (Cont'd)

- (b) Letting  $V$  range from 0 to 75 mi/h, the accompanying plots can be developed.



We see from the plots that up to about 50 mi/h, the power required to overcome rolling resistance is more significant than the power to overcome drag. At higher speeds, the drag effect becomes dominant because of the  $V^3$  term in the expression for  $W_d$ . Since the power to overcome these effects is developed by the engine from the fuel stored on board the vehicle, high-speed driving has an especially significant effect on fuel consumption.