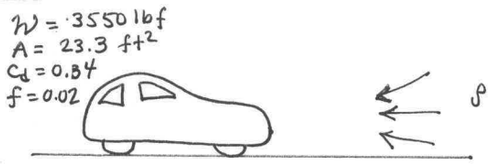
PROBLEM 2.22

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.



ENGR. MODEL: The vehicle is the system.

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

$$\dot{W}_d = F_d \cdot V = \left(\tfrac{1}{2} C_d A \rho V^2\right) V = \tfrac{1}{2} C_d A \rho V^3$$

$$= \tfrac{1}{2}(0.34)(23.3\,ft^2)\left(0.08\,\frac{lb}{ft^3}\right)\left[V\left(\frac{mi}{h}\right)\left|\frac{5280\,ft}{mi}\right|\left|\frac{h}{3600\,s}\right|\right]^3\left|\frac{1\,lbf}{32.2\,lb\cdot ft/s^2}\right|\left|\frac{hp}{550\,ft\,lbf/s}\right|$$

$$= 5.65\times10^{-5}\left[V(mi/h)\right]^3\ hp \qquad (*)$$

The power required to overcome rolling resistance is

$$\dot{W}_r = F_r \cdot V = (f\,W)\,V = (0.02)(3550\,lbf)\left[V\left(\frac{mi}{h}\right)\left|\frac{5280\,ft}{mi}\right|\left|\frac{h}{3600\,s}\right|\right]\left|\frac{hp}{550\,ft\,lbf/s}\right|$$

$$= 0.189\,V\left(\frac{mi}{h}\right)\ hp \qquad (**)$$

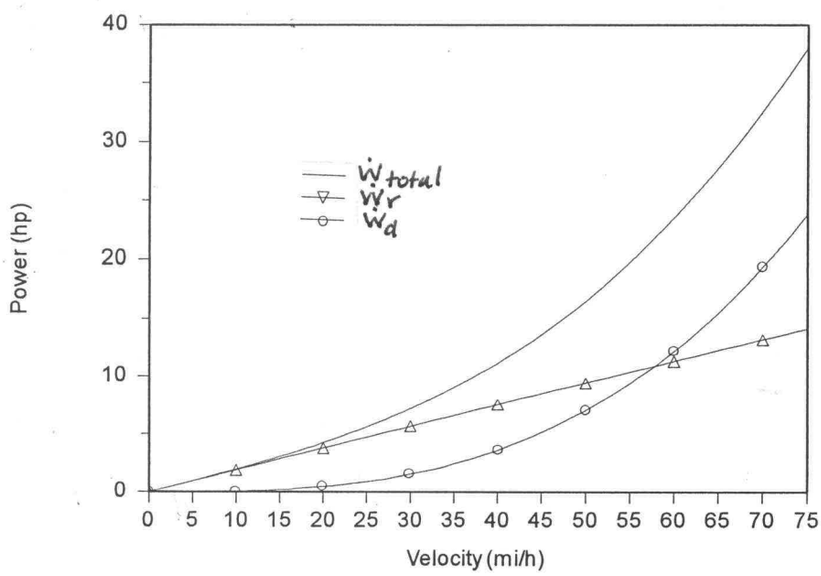
(a) When $V = 55$ mi/h, we have

$$\dot{W}_d = 5.65\times10^{-5}\left[55\right]^3 = 9.4\,hp$$

$$\dot{W}_r = 0.189\left[55\right] = 10.4\,hp$$

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 58 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 $\dot{W}_d$. 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.