In the book/movie *The Martian*, the mission of a crew of astronauts is derailed by a massive Martian windstorm. If the Martian atmosphere has a density of 0.016 kg/m^3 and the wind speed is 26.8 m/s (= 60 mph), what is the drag force acting on astronaut Mark Watney? Based on wind tunnel testing, assume that the drag coefficient multiplied by the frontal projected area of a typical person is $C_D A$ = 0.84 m^2 (see, for example, Table 7.3 in White, F.M., *Fluid Mechanics*, 7th ed., McGraw-Hill).

What wind speed on Earth would produce an equivalent drag force?

SOLUTION:
The drag force is given by,

$$D = C_D \tfrac{1}{2} \rho_{\text{Mars}} V^2 A \,, \tag{1}$$

where,

$C_D A = 0.84\ \text{m}^2$ (given),

$\rho_{\text{Mars}} = 0.016\ \text{kg/m}^3$,

$V = 26.8\ \text{m/s}$,

=> $\boxed{D = 4.8\ \text{N}\ (= 1.1\ \text{lb}_f)}$

Thus, we see that the author took considerable artistic liberty in portraying the damage caused by a Martian windstorm.

To determine the wind speed on Earth that would cause the same drag force, set the drag forces for Mars and Earth equal,

$$C_D \tfrac{1}{2} \rho_{\text{Mars}} V_{\text{Mars}}^2 A = C_D \tfrac{1}{2} \rho_{\text{Earth}} V_{\text{Earth}}^2 A \,, \tag{2}$$

$$V_{\text{Earth}} = V_{\text{Mars}} \sqrt{\frac{\rho_{\text{Mars}}}{\rho_{\text{Earth}}}} \,. \tag{3}$$

Using $\rho_{\text{Earth}} = 1.23\ \text{kg/m}^3$, $\boxed{V_{\text{Earth}} = 3.1\ \text{m/s}\ (= 6.8\ \text{mph})}$, which corresponds to a light breeze.