2.65. Solve: (a) The quantity $\frac{2P}{m} = \frac{2(3.6\times10^4\text{ W})}{1200\text{ kg}} = 60\text{ m}^2/\text{s}^3$. Thus

$$v_x = \sqrt{\left(60\,\text{m}^2\!/\text{s}^3\right)t}$$

At $t = 10$ s, $v_x = \sqrt{\left(60\,\text{m}^2\!/\text{s}^3\right)(10\text{ s})} = 24\text{ m/s }(\approx 50\text{ mph})$, and at $\text{t} = 20$ s, $v_x = 35$ m/s (≈ 75 mph).

(b) With $v_x = \sqrt{\frac{2P}{m}}t^{1/2}$, we have

$$a_x = \frac{dv_x}{dt} = \sqrt{\frac{2P}{m}} \times \frac{1}{2}t^{-1/2} = \sqrt{\frac{P}{2mt}}$$

(c) At $t = 1$ s, $a_x = \sqrt{\frac{P}{2mt}} = \sqrt{\frac{(3.6\times10^4\text{ W})}{2(1200\text{ kg})(1\text{ s})}} = 3.9\text{ m/s}^2$. Similarly, at $t = 10$ s, $a_x = 1.2\text{ m/s}^2$.

(d) Consider the limiting case of very short times. Note that $a_x \to \infty$ as $t \to 0$. This is physically impossible for the Alfa Romeo.

(e) We can use the relationship that $v_x = \frac{dx}{dt}$ and integrate to find $x(t)$. We have $v_x = \sqrt{\frac{2P}{m}}t^{1/2}$ and the initial condition $x_i = 0$ at $t_i = 0$. Thus

$$\int_0^x dx = \sqrt{\frac{2P}{m}}\int_0^t t^{1/2}dt$$

$$\text{and } x = \sqrt{\frac{2P}{m}}\frac{t^{3/2}}{3/2} = \frac{2}{3}\sqrt{\frac{2P}{m}}t^{3/2}$$

(f) Time to travel a distance *x* is found by solving the above equation for *t*.

$$t = \left[\frac{3}{2}\sqrt{\frac{m}{2P}}x\right]^{2/3}$$

For $x = 402$ m, $t = 18.2$ s.