**A given force produces an acceleration of 5 m/s$^2$ on the standard object of mass $m_1$. When the same force is applied to a carton of ice cream of mass $m_2$, it produces an acceleration of 11 m/s$^2$. (*a*) What is the mass of the carton of ice cream? (*b*) What is the magnitude of the force?**

(*a*) 1. The ratio of the masses varies inversely as the ratio of the accelerations under the same applied force:

$$\frac{m_2}{m_1} = \frac{a_1}{a_2} = \frac{5\ \text{m/s}^2}{11\ \text{m/s}^2}$$

2. Solve for $m_2$ in terms of $m_1$, which is 1 kg:

$$m_2 = \frac{5}{11} m_1 = \frac{5}{11}(1\ \text{kg}) = 0.45\ \text{kg}$$

(*b*) The magnitude of the force $F$ is found by using the mass and acceleration of either object:

$$F = m_1 a_1 = (1\ \text{kg})(5\ \text{m/s}^2) = 5\ \text{N}$$

**Exercise** A force of 3 N produces an acceleration of 2 m/s$^2$ on an object of unknown mass. (*a*) What is the mass of the object? (*b*) If the force is increased to 4 N, what is the acceleration? (*Answers* (*a*) 1.5 kg, (*b*) 2.67 m/s$^2$)

It is found experimentally that two or more forces acting on an object accelerate it as if the object were acted on by a single force equal to the vector sum of the individual forces. That is, forces combine as vectors. Newton's second law is thus

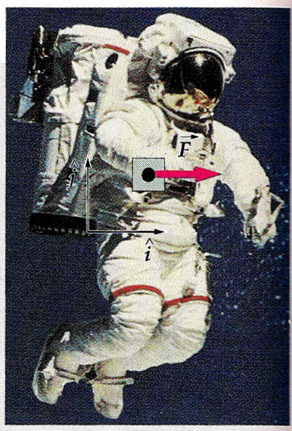
$$\sum \vec{F} = \vec{F}_{\text{net}} = m\vec{a}$$

## Example 4-2

**You're stranded in space away from your spaceship. Fortunately, you have a propulsion unit that provides a constant force $\vec{F}$ for 3 s. After 3 s you have moved 2.25 m. If your mass is 68 kg, find $\vec{F}$.**

**Picture the Problem** The force acting on you is constant, so your acceleration $\vec{a}$ is also constant. Hence, we use the kinematic equations of Chapter 2 to find $\vec{a}$, and then obtain the force from $\Sigma\vec{F} = m\vec{a}$. Choose $\vec{F}$ to be along the $x$ axis, so that $\vec{F} = F_x\hat{i}$ (Figure 4-1). The component of Newton's second law along the $x$ axis is then $F_x = ma_x$.

**Figure 4-1**




1. Apply $\Sigma\vec{F} = m\vec{a}$ to relate the net force to the mass and the acceleration:

$$F_x = ma_x$$

2. To find the acceleration, we use Equation 2-14 with $v_0 = 0$:

$$\Delta x = x - x_0 = v_0 t + \frac{1}{2}a_x t^2 = \frac{1}{2}a_x t^2$$

$$a_x = \frac{2\Delta x}{t^2} = \frac{2(2.25\ \text{m})}{(3\ \text{s})^2} = 0.500\ \text{m/s}^2$$

3. Substitute $a_x = 0.500$ m/s$^2$ and $m = 68$ kg to find the force:

$$F_x = ma_x = (68\ \text{kg})(0.500\ \text{m/s}^2) = 34.0\ \text{N}$$