It is important to note that length contraction occurs *only along the direction of motion*. For example, the moving spaceship in Fig. 26–7a is shortened in length, but its height is the same as when it is at rest.

Length contraction, like time dilation, is not noticeable in everyday life because the factor $\sqrt{1 - v^2/c^2}$ in Eq. 26–3 differs from 1.00 significantly only when v is very large.

EXAMPLE 26–5 **Painting's contraction.** A rectangular painting measures 1.00 m tall and 1.50 m wide. It is hung on the side wall of a spaceship which is moving past the Earth at a speed of $0.90c$. See Fig. 26–8a. (*a*) What are the dimensions of the picture according to the captain of the spaceship? (*b*) What are the dimensions as seen by an observer on the Earth?

APPROACH We apply the length contraction formula, Eq. 26–3, to the dimension parallel to the motion; v is the speed of the painting relative to the observer.

SOLUTION (*a*) The painting is at rest ($v = 0$) on the spaceship so it (as well as everything else in the spaceship) looks perfectly normal to everyone on the spaceship. The captain sees a 1.00-m by 1.50-m painting.
(*b*) Only the dimension in the direction of motion is shortened, so the height is unchanged at 1.00 m, Fig. 26–8b. The length, however, is contracted to

$$L = L_0\sqrt{1 - \frac{v^2}{c^2}}$$

$$= (1.50\text{ m})\sqrt{1 - (0.90)^2} = 0.65\text{ m}.$$

So the picture has dimensions $1.00\text{ m} \times 0.65\text{ m}$.

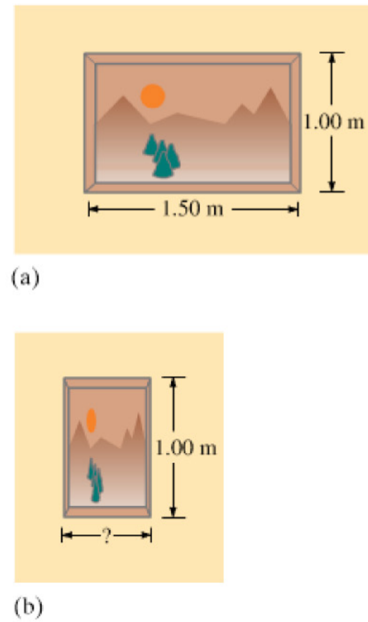

FIGURE 26–8 Example 26–5.

EXAMPLE 26–6 **A fantasy supertrain.** A very fast train with a proper length of 500 m is passing through a 200-m-long tunnel. The train's speed is so great that the train fits completely within the tunnel as seen by an observer at rest on the Earth (on the mountain above the tunnel); that is, the engine is just about to emerge from one end of the tunnel as the last car disappears into the other end. What is the train's speed?

APPROACH Since the train just fits inside the tunnel, its length measured by the person on the ground is 200 m. The length contraction formula, Eq. 26–3, can thus be used to solve for v.

SOLUTION Substituting $L = 200\text{ m}$ and $L_0 = 500\text{ m}$ into Eq. 26–3 gives

$$200\text{ m} = 500\text{ m}\sqrt{1 - \frac{v^2}{c^2}};$$

dividing both sides by 500 m and squaring, we get

$$(0.40)^2 = 1 - \frac{v^2}{c^2}$$

or

$$\frac{v}{c} = \sqrt{1 - (0.40)^2}$$

$$v = 0.92c.$$

NOTE No real train could go this fast. But it is fun to think about.

NOTE An observer on the *train* would *not* see the two ends of the train inside the tunnel at the same time; simultaneity is relative.

EXERCISE D At what spaceship speed would the painting of Example 26–5 look contracted by only 10 cm (to $L = 1.40\text{ m}$) according to Earth observers?