Note that *acceleration tells us how quickly the velocity changes*, whereas *velocity tells us how quickly the position changes*.

CAUTION
Distinguish velocity from acceleration

CONCEPTUAL EXAMPLE 2–4 **Velocity and acceleration.** (*a*) If the velocity of an object is zero, does it mean that the acceleration is zero? (*b*) If the acceleration is zero, does it mean that the velocity is zero? Think of some examples.

CAUTION
If v or a is zero, is the other zero too?

RESPONSE A zero velocity does not necessarily mean that the acceleration is zero, nor does a zero acceleration mean that the velocity is zero. (*a*) For example, when you put your foot on the gas pedal of your car which is at rest, the velocity starts from zero but the acceleration is not zero since the velocity of the car changes. (How else could your car start forward if its velocity weren't changing—that is, accelerating?) (*b*) As you cruise along a straight highway at a constant velocity of 100 km/h, your acceleration is zero: $a = 0, v \neq 0$.

EXERCISE A A car is advertised to go from zero to 60 mi/h in 6.0 s. What does this say about the car: (*a*) it is fast (high speed); or (*b*) it accelerates well?

EXAMPLE 2–5 **Car slowing down.** An automobile is moving to the right along a straight highway, which we choose to be the positive *x* axis (Fig. 2–11). Then the driver puts on the brakes. If the initial velocity (when the driver hits the brakes) is $v_1 = 15.0\,\mathrm{m/s}$, and it takes 5.0 s to slow down to $v_2 = 5.0\,\mathrm{m/s}$, what was the car's average acceleration?

APPROACH We are given the initial and final velocities and the elapsed time, so we can calculate $\bar{a}$ using Eq. 2–4.

SOLUTION We use Eq. 2–4 and call the initial time $t_1 = 0$; then $t_2 = 5.0\,\mathrm{s}$. (Note that our choice of $t_1 = 0$ doesn't affect the calculation of $\bar{a}$ because only $\Delta t = t_2 - t_1$ appears in Eq. 2–4.) Then

$$\bar{a} = \frac{5.0\,\mathrm{m/s} - 15.0\,\mathrm{m/s}}{5.0\,\mathrm{s}} = -2.0\,\mathrm{m/s^2}.$$

The negative sign appears because the final velocity is less than the initial velocity. In this case the direction of the acceleration is to the left (in the negative *x* direction)—even though the velocity is always pointing to the right. We say that the acceleration is $2.0\,\mathrm{m/s^2}$ to the left, and it is shown in Fig. 2–11 as an orange arrow.

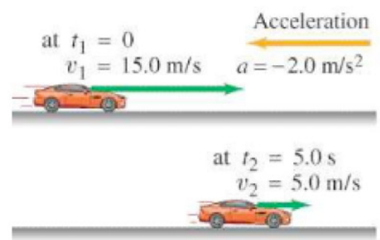

FIGURE 2–11 Example 2–5, showing the position of the car at times t_1 and t_2, as well as the car's velocity represented by the green arrows. The acceleration vector (orange) points to the left as the car slows down while moving to the right.

Deceleration

When an object is slowing down, we sometimes say it is **decelerating**. But be careful: deceleration does *not* mean that the acceleration is necessarily negative. For an object moving to the right along the positive *x* axis and slowing down (as in Fig. 2–11), the acceleration *is* negative. But the same car moving to the left (decreasing *x*), and slowing down, has positive acceleration that points to the right, as shown in Fig. 2–12. We have a deceleration whenever the magnitude of the velocity is decreasing, and then the velocity and acceleration point in opposite directions.

CAUTION
Deceleration means the magnitude of the velocity is decreasing; it does not *necessarily mean a is negative*

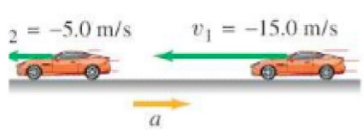

FIGURE 2–12 The car of Example 2–5, now moving to the *left* and decelerating. The acceleration is

$$a = \frac{v_2 - v_1}{\Delta t} = \frac{-5.0\,\mathrm{m/s} - (-15.0\,\mathrm{m/s})}{5.0\,\mathrm{s}} = \frac{-5.0\,\mathrm{m/s} + 15.0\,\mathrm{m/s}}{5.0\,\mathrm{s}} = +2.0\,\mathrm{m/s}.$$

EXERCISE B A car moves along the *x* axis. What is the sign of the car's acceleration if it is moving in the positive *x* direction with (*a*) increasing speed or (*b*) decreasing speed? What is the sign of the acceleration if the car moves in the negative direction with (*c*) increasing speed or (*d*) decreasing speed?