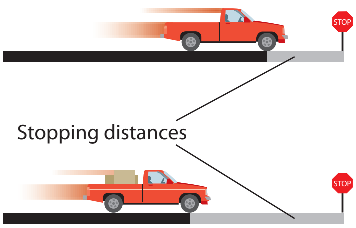

Figure 3
The loaded truck must undergo a greater change in momentum in order to stop than the truck without a load.

Stopping times and distances depend on the impulse-momentum theorem

Highway safety engineers use the impulse-momentum theorem to determine stopping distances and safe following distances for cars and trucks. For example, the truck hauling a load of bricks in **Figure 3** has twice the mass of the other truck, which has no load. Therefore, if both are traveling at 48 km/h, the loaded truck has twice as much momentum as the unloaded truck. If we assume that the brakes on each truck exert about the same force, we find that the stopping time is two times longer for the loaded truck than for the unloaded truck, and the stopping distance for the loaded truck is two times greater than the stopping distance for the truck without a load.

SAMPLE PROBLEM C

Stopping Distance

PROBLEM

A 2240 kg car traveling to the west slows down uniformly from 20.0 m/s to 5.00 m/s. How long does it take the car to decelerate if the force on the car is 8410 N to the east? How far does the car travel during the deceleration?

SOLUTION

Given: $m = 2240$ kg $\mathbf{v_i} = 20.0$ m/s to the west, $v_i = -20.0$ m/s
$\mathbf{v_f} = 5.00$ m/s to the west, $v_f = -5.00$ m/s
$\mathbf{F} = 8410$ N to the east, $F = +8410$ N

Unknown: $\Delta t = ?$ $\Delta \mathbf{x} = ?$

Use the impulse-momentum theorem.

$$\mathbf{F}\Delta t = \Delta \mathbf{p}$$

$$\Delta t = \frac{\Delta \mathbf{p}}{\mathbf{F}} = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\mathbf{F}}$$

$$\Delta t = \frac{(2240 \text{ kg})(-5.00 \text{ m/s}) - (2240 \text{ kg})(-20.0 \text{ m/s})}{8410 \text{ kg}\bullet\text{m/s}^2}$$

$$\boxed{\Delta t = 4.00 \text{ s}}$$

$$\Delta x = \tfrac{1}{2}(v_i + v_f)\Delta t$$

$$\Delta x = \tfrac{1}{2}(-20.0 \text{ m/s} - 5.00 \text{ m/s})(4.00 \text{ s})$$

$$\boxed{\Delta \mathbf{x} = -50.0 \text{ m} = 50.0 \text{ m to the west}}$$

TIP

For motion in one dimension, take special care to set up the sign of the speed. You can then treat the vectors in the equations of motion as scalars and add direction at the end.