

# Momentum and Collisions

## Problem A

### MOMENTUM

#### PROBLEM

The world's most massive train ran in South Africa in 1989. Over 7 km long, the train traveled 861.0 km in 22.67 h. Imagine that the distance was traveled in a straight line north. If the train's average momentum was  $7.32 \times 10^8 \text{ kg}\cdot\text{m/s}$  to the north, what was its mass?

#### SOLUTION

**Given:**  $\Delta x = 861.0 \text{ km}$  to the north  
 $\Delta t = 22.67 \text{ h}$   
 $p_{\text{avg}} = 7.32 \times 10^8 \frac{\text{kg}\cdot\text{m}}{\text{s}}$  to the north

**Unknown:**  $v_{\text{avg}} = ?$   $m = ?$

Use the definition of average velocity to calculate  $v_{\text{avg}}$ , and then substitute this value for velocity in the definition of momentum to solve for mass.

$$v_{\text{avg}} = \frac{\Delta x}{\Delta t} = \frac{(861.0 \times 10^3 \text{ m})}{(22.67 \text{ h})(3600 \text{ s/h})} = 10.55 \frac{\text{m}}{\text{s}} \text{ to the north}$$

$$p_{\text{avg}} = mv_{\text{avg}}$$

$$m = \frac{p_{\text{avg}}}{v_{\text{avg}}} = \frac{\left(7.32 \times 10^8 \frac{\text{kg}\cdot\text{m}}{\text{s}}\right)}{\left(10.55 \frac{\text{m}}{\text{s}}\right)} = \boxed{6.94 \times 10^7 \text{ kg}}$$

### ADDITIONAL PRACTICE

1. In 1987, Marisa Canofoglia, of Italy, roller-skated at a record-setting speed of 40.3 km/h. If the magnitude of Canofoglia's momentum was  $6.60 \times 10^2 \text{ kg}\cdot\text{m/s}$ , what was her mass?

*59 kg*
2. In 1976, a 53 kg helicopter was built in Denmark. Suppose this helicopter flew east with a speed of 60.0 m/s and the total momentum of the helicopter and pilot was  $7.20 \times 10^3 \text{ kg}\cdot\text{m/s}$  to the east. What was the mass of the pilot?

*67 kg*
3. One of the smallest planes ever flown was the *Bumble Bee II*, which had a mass of  $1.80 \times 10^2 \text{ kg}$ . If the pilot's mass was  $7.0 \times 10^1 \text{ kg}$ , what was the velocity of both plane and pilot if their momentum was  $2.08 \times 10^4 \text{ kg}\cdot\text{m/s}$  to the west?

*83.2 m/s to the W*
4. The first human-made satellite, *Sputnik I*, had a mass of 83.6 kg and a momentum with a magnitude of  $6.63 \times 10^5 \text{ kg}\cdot\text{m/s}$ . What was the satellite's speed?

*7.93 x 10<sup>3</sup> m/s  
7.93 km/s*

5. Among the largest passenger ships currently in use, the *Norway* has been in service the longest. The *Norway* is more than 300 m long, has a mass of  $6.9 \times 10^7$  kg, and can reach a top cruising speed of 33 km/h. Calculate the magnitude of the ship's momentum.

$$6.3 \times 10^8 \text{ kg} \cdot \text{m/s}$$

6. In 1994, a tower 22.13 m tall was built of Lego® blocks. Suppose a block with a mass of 2.00 g is dropped from the top of this tower. Neglecting air resistance, calculate the block's momentum at the instant the block hits the ground.

$$4.17 \times 10^{-2} \text{ kg} \cdot \text{m/s}$$

down