

## Holt Physics

**Problem 6A****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  
 $\Delta t = 22.67 \text{ h}$   
 $\mathbf{p}_{\text{avg}} = 7.32 \times 10^8 \frac{\text{kg}\cdot\text{m}}{\text{s}}$  to the north

**Unknown:**  $\mathbf{v}_{\text{avg}} = ?$   $m = ?$

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

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

$$\mathbf{p}_{\text{avg}} = m\mathbf{v}_{\text{avg}}$$

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

**ADDITIONAL PRACTICE**

- 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?
- 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?
- 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?
- 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?