Name:_____ Class:_____ Date:_____

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 7.32×10^8 kg•m/s to the north, what was its mass?

SOLUTION

Given: $\Delta\mathbf{x} = 861.0$ km to the north

$\Delta t = 22.67$ h

$$\mathbf{p_{avg}} = 7.32 \times 10^8 \ \frac{\text{kg} \bullet \text{m}}{\text{s}} \text{ to the north}$$

Unknown: $\mathbf{v_{avg}} = ?$ $m = ?$

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

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

$$p_{avg} = m v_{avg}$$

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

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 6.60×10^2 kg•m/s, what was her mass?**
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 7.20×10^3 kg•m/s to the east. What was the mass of the pilot?**
3. **One of the smallest planes ever flown was the *Bumble Bee II*, which had a mass of 1.80×10^2 kg. If the pilot's mass was 7.0×10^1 kg, what was the velocity of both plane and pilot if their momentum was 2.08×10^4 kg•m/s to the west?**

4. The first human-made satellite, *Sputnik I*, had a mass of 83.6 kg and a momentum with a magnitude of 6.63×10^5 kg•m/s. What was the satellite's speed?

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 of6.9×10^7 kg, and can reach a top cruising speed of 33 km/h. Calculate the magnitude of the ship's momentum.

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. (Hint: PE = KE, Solve for v_f)