

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

$$\Delta t = 22.67 \text{ h}$$

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

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

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

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

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

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

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?

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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 6.9×10^7 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.