Sample Problem Set I Solutions

Momentum and Collisions

ADDITIONAL PRACTICE A

Givens *Solutions*

1. $v = 40.3$ km/h

$p = 6.60 \times 10^2$ kg•m/s

$$m = \frac{p}{v} = \frac{6.60 \times 10^2 \text{ kg•m/s}}{(40.3 \times 10^3 \text{ m/h})(1 \text{ h}/3600 \text{ s})} = \boxed{59.0 \text{ kg}}$$

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2. $m_h = 53$ kg

$\mathbf{v} = 60.0$ m/s to the east

$\mathbf{p_{tot}} = 7.20 \times 10^3$ kg•m/s to the east

$$\mathbf{p_{tot}} = m_h\mathbf{v} + m_p\mathbf{v}$$

$$m_p = \frac{\mathbf{p_{tot}} - m_h\mathbf{v}}{\mathbf{v}} = \frac{7.20 \times 10^3 \text{ kg•m/s} - (53 \text{ kg})(60.0 \text{ m/s})}{60.0 \text{ m/s}}$$

$$m_p = \frac{7.20 \times 10^3 \text{ kg•m/s} - 3.2 \times 10^3 \text{ kg•m/s}}{60.0 \text{ m/s}} = \frac{4.0 \times 10^3 \text{ kg•m/s}}{60.0 \text{ m/s}} = \boxed{67 \text{ kg}}$$

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3. $m_1 = 1.80 \times 10^2$ kg

$m_2 = 7.0 \times 10^1$ kg

$\mathbf{p_{tot}} = 2.08 \times 10^4$ kg•m/s to the west

$= -2.08 \times 10^4$ kg•m/s

$$\mathbf{v} = \frac{\mathbf{p_{tot}}}{m_1 + m_2} = \frac{-2.08 \times 10^4 \text{ kg•m/s}}{1.80 \times 10^2 \text{ kg} + 7.0 \times 10^1 \text{ kg}} = \frac{-2.08 \times 10^4 \text{ kg•m/s}}{2.50 \times 10^2 \text{ kg}}$$

$\mathbf{v} = -83.2$ m/s $= \boxed{83.2 \text{ m/s to the west}}$

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4. $m = 83.6$ kg

$p = 6.63 \times 10^5$ kg•m/s

$$v = \frac{p}{m} = \frac{6.63 \times 10^5 \text{ kg•m/s}}{83.6 \text{ kg}} = \boxed{7.93 \times 10^3 \text{ m/s} = 7.93 \text{ km/s}}$$

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5. $m = 6.9 \times 10^7$ kg

$v = 33$ km/h

$$p = mv = (6.9 \times 10^7 \text{ kg})(33 \times 10^3 \text{ m/h})(1 \text{ h}/3600 \text{ s}) = \boxed{6.3 \times 10^8 \text{ kg•m/s}}$$

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6. $h = 22.13$ m

$m = 2.00$ g

$g = 9.81$ m/s^2

$$mgh = \tfrac{1}{2}mv_f^2$$

$$v_f = \sqrt{2gh}$$

$$p = mv_f = m\sqrt{2gh} = (2.00 \times 10^{-3} \text{ kg})\sqrt{(2)(9.81 \text{ m/s}^2)(22.13 \text{ m})}$$

$\mathbf{p} = \boxed{4.17 \times 10^{-2} \text{ kg•m/s downward}}$

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

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