

## Momentum and Collisions

**Problem A****MOMENTUM****PROBLEM**

An ostrich with a mass of 146 kg is running with a momentum of 2480 kg• m/s to the right. What is the velocity of the ostrich?

**SOLUTION**

**Given:**  $m = 146 \text{ kg}$

$\mathbf{p} = 2480 \text{ kg}\cdot\text{m/s to the right}$

**Unknown:**  $\mathbf{v} = ?$

Use the equation for momentum to solve for  $\mathbf{v}$ .

$$\mathbf{p} = m\mathbf{v}$$

$$\mathbf{v} = \frac{\mathbf{p}}{m}$$

$$\mathbf{v} = \frac{2480 \text{ kg}\cdot\text{m/s}}{146 \text{ kg}} = \boxed{17.0 \text{ m/s to the right}}$$

**ADDITIONAL PRACTICE**

1. If a blue whale has a mass of  $1.46 \times 10^5 \text{ kg}$  and momentum of  $9.73 \times 10^5 \text{ kg}\cdot\text{m/s}$  to the south, what is its velocity?
2. The highest land speed for a rail-guided vehicle was set in 1982 by a rocket sled at Holloman Air Force Base in southern New Mexico. The sled was unmanned, but if it had a payload with a mass of 25 kg, the magnitude of the payload's momentum would have been  $6.8 \times 10^4 \text{ kg}\cdot\text{m/s}$ . What was the speed, in m/s and km/h, of the payload and sled?
3. Thoroughbred horses are among the fastest horses in the world and are used in famous racing events such as the Kentucky Derby. The mass of a thoroughbred is about  $5.00 \times 10^2 \text{ kg}$ . If a horse with this mass is galloping with a momentum of  $8.22 \times 10^3 \text{ kg}\cdot\text{m/s}$  to the west, what is its velocity?
4. The World Solar Challenge in 1987 was the first car race in which all the vehicles were solar powered. The winner was the *GM Sunracer*, which had a mass of 177.4 kg, not counting the driver's mass. Assume that the driver had a mass of 61.5 kg, so that the total momentum of the car and driver had a magnitude of  $4.416 \times 10^3 \text{ kg}\cdot\text{m/s}$ . What was the car's speed in m/s and km/h?
5. The current holder of the men's world record for running 200 m is Michael Johnson, who in 1996 ran 200.0 m in 19.32 s. Johnson's mass at the time of his record-breaking run was about 77 kg. What was the magnitude of his momentum at his average speed?

6. Although it cannot sustain its top speed for more than 8.65 s, the cheetah can run a distance of 274 m during that time. If a cheetah with a mass of 50.0 kg is moving north at its top speed, what is its momentum?
7. The high-speed 300-series Shinkansen trains of Japan consist of 16 aluminum cars with a combined mass of  $7.10 \times 10^5$  kg. The reduction in mass from the 100-series trains enables the 300-series trains to reach a top speed of 270 km/h. What is the magnitude of a 300-series train's momentum at its top speed?
8. The largest species of hummingbird is the *Patagonia gigas*, or the Giant Hummingbird of the Andes. This bird has a length of 21 cm and can fly with a speed of up to 50.0 km/h. Suppose one of these hummingbirds flies at this top speed. If the magnitude of its momentum is 0.278 kg•m/s, what is the hummingbird's mass?
9. A hovercraft, or air-cushion vehicle, glides on a cushion of air, allowing it to travel with equal ease on land or water. The first commercial hovercraft to cross the English Channel, the V. A-3, had an average velocity of 96 km/h to the southeast. Its average momentum was  $4.8 \times 10^4$  kg•m/s to the southeast. What was the mass of the V. A-3?
10. The brightest, hottest, and most massive stars (over 10 times as massive as the sun) are the brilliant blue stars designated as spectral class O. If a class O star moves with a speed of 255 km/s and has a momentum of  $8.62 \times 10^{36}$  kg•m/s, what is the star's mass?