Review

MOMENTUM AND IMPULSE

Review Questions

1. If an object is not moving, what is its momentum?
2. If two particles have equal kinetic energies, must they have the same momentum? Explain.
3. Show that $\mathbf{F} = m\mathbf{a}$ and $\mathbf{F} = \frac{\Delta \mathbf{p}}{\Delta t}$ are equivalent.

Conceptual Questions

4. A truck loaded with sand is moving down the highway in a straight path.
   - **a.** What happens to the momentum of the truck if the truck's velocity is increasing?
   - **b.** What happens to the momentum of the truck if sand leaks at a constant rate through a hole in the truck bed while the truck maintains a constant velocity?
5. Gymnasts always perform on padded mats. Use the impulse-momentum theorem to discuss how these mats protect the athletes.
6. When a car collision occurs, an air bag is inflated, protecting the passenger from serious injury. How does the air bag soften the blow? Discuss the physics involved in terms of momentum and impulse.
7. If you jump from a table onto the floor, are you more likely to be hurt if your knees are bent or if your legs are stiff and your knees are locked? Explain.
8. Consider a field of insects, all of which have essentially the same mass.
   - **a.** If the total momentum of the insects is zero, what does this imply about their motion?
   - **b.** If the total kinetic energy of the insects is zero, what does this imply about their motion?
9. Two students hold an open bed sheet loosely by its corners to form a "catching net." The instructor asks a third student to throw an egg into the middle of the sheet as hard as possible. Why doesn't the egg's shell break?
10. How do car bumpers that collapse on impact help protect a driver?

Practice Problems

For problem 11, see Sample Problem A.

11. Calculate the linear momentum for each of the following cases:
    - **a.** a proton with mass 1.67×10^{-27} kg moving with a velocity of 5.00×10^{6} m/s straight up
    - **b.** a 15.0 g bullet moving with a velocity of 325 m/s to the right
    - **c.** a 75.0 kg sprinter running with a velocity of 10.0 m/s southwest
    - **d.** Earth ($m = 5.98 \times 10^{24}$ kg) moving in its orbit with a velocity equal to 2.98×10^{4} m/s forward

For problems 12–13, see Sample Problem B.

12. A 2.5 kg ball strikes a wall with a velocity of 8.5 m/s to the left. The ball bounces off with a velocity of 7.5 m/s to the right. If the ball is in contact with the wall for 0.25 s, what is the constant force exerted on the ball by the wall?
13. A football punter accelerates a 0.55 kg football from rest to a speed of 8.0 m/s in 0.25 s. What constant force does the punter exert on the ball?

For problem 14, see Sample Problem C.

14. A 0.15 kg baseball moving at +26 m/s is slowed to a stop by a catcher who exerts a constant force of −390 N. How long does it take this force to stop the ball? How far does the ball travel before stopping?

CHAPTER 6

Review

ANSWERS

1. zero (because $v = 0$)
2. no; KE is related to the magnitude of $\mathbf{p}$ by $p = \sqrt{2mKE}$. Objects that have the same KE must also have the same mass and direction to have the same $\mathbf{p}$.
3. $\mathbf{F} = \frac{\Delta \mathbf{p}}{\Delta t} = \frac{m\mathbf{v_f} - m\mathbf{v_i}}{\Delta t} = \frac{m(\mathbf{v_f} - \mathbf{v_i})}{\Delta t} = m\frac{\Delta \mathbf{v}}{\Delta t} = m\mathbf{a}$
4. **a.** Momentum increases.
   b. Momentum decreases.
5. A mat decreases the average force on the gymnast by increasing the time interval in which the gymnast is brought to rest.
6. The air bag increases the time interval in which the passenger comes to rest, which decreases the average force on the passenger.
7. When your legs are stiff and your knees are locked, the time interval of the collision is short and the average force exerted by the floor is large, which may result in bone fracture.
8. **a.** The net velocity of all insects must equal zero (although each insect could be moving).
   b. The velocity of each insect must be zero.
9. The average force on the egg is small because of the large time interval in which the egg is in contact with the sheet.