6 REVIEW

10. Car bumpers increase the time interval over which a collision occurs, which decreases the force.

11. **a.** 8.35×10^{-21} kg•m/s upward
b. 4.88 kg•m/s to the right
c. 7.50×10^{2} kg•m/s to the southwest
d. 1.78×10^{29} kg•m/s forward

12. 160 N to the right

13. 18 N

14. 0.010 s; 0.13 m

15. Before they push, the total momentum of the system is zero. So, after they push, the total momentum of the system must remain zero.

16. no; Momentum can be transferred between balls.

17. Part of the ball's momentum is transferred to the ground; Earth's mass is so large that the resulting change in Earth's velocity is imperceptible.

18. As the ball accelerates toward Earth, Earth also accelerates toward the ball. Therefore, Earth is also gaining momentum in the direction opposite the ball's momentum.

19. The gun was pushed with a momentum equal in magnitude but opposite in direction to the momentum of the gases.

20. She should throw the camera in the direction away from the shuttle to cause her to move back toward the shuttle.

21. The gun recoils with a backward momentum equal to the forward momentum of the bullet. Because the gun's mass is so much greater than the bullet's, the gun's velocity will be smaller than the bullet's.

22. **a.** 2.43 m/s to the right
b. 7.97×10^{-2} m/s to the right

CONSERVATION OF MOMENTUM

Review Questions

15. Two skaters initially at rest push against each other so that they move in opposite directions. What is the total momentum of the two skaters when they begin moving? Explain.

16. In a collision between two soccer balls, momentum is conserved. Is momentum conserved for each soccer ball? Explain.

17. Explain how momentum is conserved when a ball bounces against a floor.

Conceptual Questions

18. As a ball falls toward Earth, the momentum of the ball increases. How would you reconcile this observation with the law of conservation of momentum?

19. In the early 1900s, Robert Goddard proposed sending a rocket to the moon. Critics took the position that in a vacuum such as exists between Earth and the moon, the gases emitted by the rocket would have nothing to push against to propel the rocket. To settle the debate, Goddard placed a gun in a vacuum and fired a blank cartridge from it. (A blank cartridge fires only the hot gases of the burning gunpowder.) What happened when the gun was fired? Explain your answer.

20. An astronaut carrying a camera in space finds herself drifting away from a space shuttle after her tether becomes unfastened. If she has no propulsion device, what should she do to move back to the shuttle?

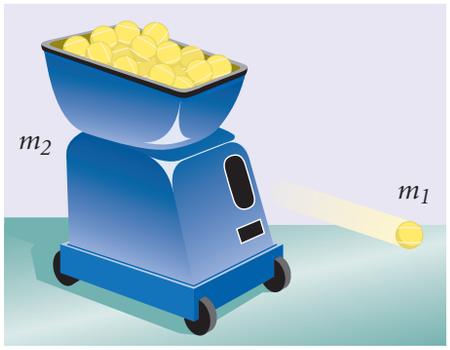
21. When a bullet is fired from a gun, what happens to the gun? Explain your answer using the principles of momentum discussed in this chapter.

Practice Problems

For problems 22–23, see Sample Problem D.

22. A 65.0 kg ice skater moving to the right with a velocity of 2.50 m/s throws a 0.150 kg snowball to the right with a velocity of 32.0 m/s relative to the ground.
a. What is the velocity of the ice skater after throwing the snowball? Disregard the friction between the skates and the ice.
b. A second skater initially at rest with a mass of 60.0 kg catches the snowball. What is the velocity of the second skater after catching the snowball in a perfectly inelastic collision?

23. A tennis player places a 55 kg ball machine on a frictionless surface, as shown below. The machine fires a 0.057 kg tennis ball horizontally with a velocity of 36 m/s toward the north. What is the final velocity of the machine?



ELASTIC AND INELASTIC COLLISIONS

Review Questions

24. Consider a perfectly inelastic head-on collision between a small car and a large truck traveling at the same speed. Which vehicle has a greater change in kinetic energy as a result of the collision?

25. Given the masses of two objects and their velocities before and after a head-on collision, how could you determine whether the collision was elastic, inelastic, or perfectly inelastic? Explain.

26. In an elastic collision between two objects, do both objects have the same kinetic energy after the collision as before? Explain.

27. If two objects collide and one is initially at rest, is it possible for both to be at rest after the collision? Is it possible for one to be at rest after the collision? Explain.

Practice Problems

For problems 28–29, see Sample Problem E.

28. Two carts with masses of 4.0 kg and 3.0 kg move toward each other on a frictionless track with speeds