41 Explain the difference for each of the following pairs of actions in terms of impulse: (a) a golfer's drive and chip shot, (b) a mower's job and kick-out punch, (c) a baseball player's batting action and home-run swing.

42 Explain the principle behind (a) using styrofoam as a protective object from breaking and (b) padding dashboards in cars to prevent injury to passengers.

43 If $K = p^2/2m$, how can kinetic energy be lost in an inelastic collision? Yet the total momentum still be conserved? Explain.

44 An inventor has the bright idea to make automobile bodies out of rubber so as to lower insurance costs for fender benders. Is this a good idea?

45 A neutron (an electrically neutral subatomic particle) moving at a high speed collides elastically with a stationary carbon atom and an neon atom. Compare what happens in each case. [Hint: Find the relative masses of these particles in Appendix V.]

46 When tossed upward and hit horizontally by a batter, a 0.20-kg softball receives an impulse of 4.0 N·s. With what speed does the ball move away from the bat?

47 An automobile with a linear momentum of $3.2 \times 10^4$ kg·m/s is brought to stop in 4.0 s. What is the magnitude of the average braking force?

48 A pool player imparts an impulse of 3.0 N·s to a 0.25-kg cue ball with a cue stick. What is the speed of the ball after impact?

49 During a snowball fight, a 0.15-kg snowball traveling at a speed of 8.0 m/s hits a student in the back of the head. (a) What is the impulse? Is this an elastic collision? (b) If the contact time is 0.1 s, what is the average impulse force on the student's head?

50 A 0.45-kg volley ball comes over the net with a horizontal velocity of 2.0 m/s. One of the players on the front line jumps up and hits it back with a horizontal velocity of 6.0 m/s. What was the impulse imparted to the ball?

51 A basketball with a mass of 0.50 kg is thrown horizontally against a wall with a velocity of 15 m/s. If the ball rebounds with a velocity of 13 m/s, what is the impulse of the collision? (Was the collision elastic?)

52 A boy catches a 0.16-kg baseball coming directly toward him at a speed of 25 m/s in both hands with his arms rigidly extended, and emit sounds like a "whoosh" because the ball stings his hands. He learns quickly to move his hands with the ball as he catches it. 0.0 the contact time for the collision is increased from 2.5 ms to 7.5 ms in this way, how do the magnitudes of the average impulse forces compare? (Assume that the ball has the same initial velocity for each catch.)

53 ■ For a typical drive, the golf club and the ball are in contact for about 0.20 ms, and the ball leaves the club with a speed of 70 m/s. What is the average force exerted by the club on the ball? Express your final answer in pounds. (The official weight of a golf ball is 1.620 g.)

54 ■ A 4.0-kg ball with a velocity of 4.0 m/s in the x direction has a head-on elastic collision with a stationary 2.0-kg ball. What are the velocities of the balls after the collision?

55 ■ A ball with a mass of 100 kg is traveling with a velocity of 50 cm/s in the x + direction and collides head-on with a 50-kg ball at rest. Find the velocities of the balls after the collision, assuming that it is elastic.

56 ■ A neutron (an electrically neutral subatomic particle) with a mass of $1.67 \times 10^{-27}$ kg and traveling with a speed of $4.0 \times 10^7$ m/s collides elastically head-on with a stationary nucleus with a mass of $6.64 \times 10^{-22}$ kg. (a) What are the velocities of the neutron and nucleus after collision? (b) What percentage of the neutron's initial kinetic energy is given to the nucleus?

57 ■ For the apparatus in Fig. 6.14, show that one ball swinging in with speed $v_0$ will not cause two balls to swing out with speed $v/2$.

58 ■ A one-dimensional impulse force acts on a 2.0-kg object as diagrammed in the graph of Fig. 6.27. Find (a) the magnitude of the impulse given to the object, (b) the average force, and (c) the final velocity if the object had an initial velocity of -6.0 m/s.

59 ■ A 1500-kg car traveling east at 90.0 km/h and a 3000-kg minivan traveling south at 60.0 km/h collide at a perpendicular intersection. Assuming a completely inelastic collision, what is the velocity of the vehicles immediately after collision?

60 ■ A cue ball traveling at 0.75 m/s hits the stationary 8-ball, which moves off with a speed of 0.25 m/s at an angle of 30° relative to the cue ball's initial direction. Assuming an inelastic collision, at what angle will the cue ball be deflected and what will its speed be?

61 ■ A fellow student states that the total momentum of a 3-particle system $(m_1 = 0.25 \text{ kg}, m_2 = 0.20 \text{ kg}, \text{ and } m_3 = 0.03 \text{ kg})$ is initially zero, and that after an inelastic triple collision, he calculates the particles have velocities of $4.0 \text{ m/s}$ in the $x+$ direction, $6.0 \text{ m/s}$ at $230°$, and $2.5 \text{ m/s}$ at $230°$, respectively. Do you agree with his calculations? If not, assuming the first two answers to be correct, what should be the momentum of the third particle?

62 ■ In nuclear reactors, subatomic particles called neutrons are slowed down by allowing them to collide with the atoms of a moderator material, such as carbon. (a) In a head-on, elastic collision with a carbon atom, what percentage of energy loss is by a neutron? (b) If the neutron has an initial speed of $1.5 \times 10^7$ m/s, what will its speed be after collision?

63 ■ A freight car with a mass of $2.0 \times 10^4$ kg rolls down an inclined track through a vertical distance of $3.3 \text{ m}$. At the bottom of the incine, on a level track, the car collides and couples with an identical freight car that was at rest. What percentage of the initial kinetic energy is lost in the collision?

64 ■ A gomka car has a mass of 4.5 metric tons when empty. While it is moving at a speed of 2.0 m/s along a level track under a grain elevator, 7.5 metric tons of wheat are loaded into it from directly above. Is this an elastic collision? If not, where did the kinetic energy go?

65 ■ In an elastic, head-on collision with a stationary target particle, a moving particle recoils at $\gamma$ of its incident speed. (a) What is the ratio of the particle masses $(m_1/m_2)$? (b) What is the speed of the target particle after the collision in terms of the initial speed of the incoming particle?

66 ■ Show that the fraction of kinetic energy lost in the collision in Fig. 6.11b is equal to $m_1/(m_1 + m_2)$.

67 ■ Show that the fraction of kinetic energy lost in a ballistic pendulum collision (as in Fig. 6.20) is equal to $m_1/(m_1 + m_2)$.

68 ■ A 30-g bullet is fired horizontally into and becomes embedded in a suspended block of wood whose mass is 0.090 kg (see Fig. 6.26). (a) What is the speed of the block with the embedded bullet immediately after the collision in terms of the initial speed $v_0$? (b) If the block with the embedded bullet continues to move forward and its center of mass is raised $0.40 \text{ m}$, what was the initial speed of the bullet? (c) Was the collision elastic? If not, what percentage of the initial kinetic energy was lost?

69 ■ A moving billiard ball collides with an identical stationary one, and the incoming ball is deflected at an angle of $45°$ from its original direction. Show that if the collision is elastic, both balls will have the same speed afterward and will move at a right angle (90°) relative to each other.

70 ■ (a) For an elastic, two-body head-on collision, show that in general $n_1 - n_2 = n_2 - n_1$. That is, the relative speed of recession after the collision is the same as the relative speed before it. In general, a collision is either completely inelastic, completely elastic, or somewhere in between. The degree of elasticity is sometimes expressed as the coefficient of restitution, which is defined as the ratio of the relative velocity of recession and approach: $r = n_1 - n_2$. What are the values of $r$ for an elastic collision and a completely inelastic collision?

71 ■ The coefficient of restitution (see Exercise 75) for steel colliding with steel is 0.95. If a steel ball is dropped