Answers to Quick Quizzes, Odd-Numbered Conceptual Questions and Problems

Chapter 1

CONCEPTUAL QUESTIONS

1. (a) ~0.1 m (b) ~1 m (c) Between 10 m and 100 m (d) ~10 m (e) ~100 m
3. (a) ~10^6 beats (b) ~10^9 beats
5. ~10^9 s
7. The length of a hand varies from person to person, so it isn't a useful standard of length.
9. The ark has an approximate volume of 10^4 m^3, whereas a home has an approximate volume of 10^3 m^3.
11. A dimensionally correct equation isn't necessarily true. For example, the equation 2 dogs = 5 dogs is dimensionally correct, but isn't true. However, if an equation is not dimensionally correct, it cannot be correct.

PROBLEMS

1. (b) $A_{\text{cylinder}} = \pi R^2$, $A_{\text{rectangular plate}}$ = length × width
5. m^3/(kg·s^2)
7. (a) three significant figures (b) four significant figures (c) three significant figures (d) two significant figures
9. (a) 797 (b) 1.1 (c) 17.66
11. 115.9 m
13. 228.8 cm
15. 2×10^8 fathoms
17. 1.39×10^3 m^2
19. 1×10^{17} ft
21. 6.71×10^8 mi/h
23. 3.08×10^4 m^3
25. 9.82 cm
27. (a) 1.0×10^3 kg (b) $m_{\text{cell}} = 5.2 \times 10^{-16}$ kg, $m_{\text{kidney}} = 0.27$ kg, $m_{\text{fly}} = 1.3 \times 10^{-5}$ kg
29. 1 800 balls (~10^3 balls) (assumes 81 games per season, nine innings per game, an average of ten hitters per inning, and one ball lost for every four hitters)
31. ~10^7 rev
33. ~10^6 balls
35. (2.0 m, 1.4 m)
37. $r = 2.2$ m, $\theta = 27°$
39. (a) 6.71 m (b) 0.894 (c) 0.746
41. 3.41 m
43. (a) 3.00 (b) 3.00 (c) 0.800 (d) 0.800 (e) 1.33
45. 5.00/7.00; the angle itself is 35.5°
47. The customer is incorrect. The cost of the pizza should be proportional to the area of the pizza, so the large one should cost more than the small one by a factor of $9^2/6^2 = 81/36 = 2.25$. Therefore, if the small one costs \$6, the large one should cost \$13.50.
49. The value of k, a dimensionless constant, cannot be found by dimensional analysis.
51. ~10^{-9} m
53. ~10^3 tuners (assumes one tuner per 10 000 residents and a population of 7.5 million)
55. (a) 3.16×10^7 s (b) Between 10^{10} yr and 10^{11} yr

Chapter 2

QUICK QUIZZES

1. (a) 200 yd (b) 0 (c) 0
2. (a) False (b) True (c) True
3. The velocity vs. time graph (a) has a constant slope, indicating a constant acceleration, which is represented by the acceleration vs. time graph (e).

   Graph (b) represents an object with increasing speed, but as time progresses, the lines drawn tangent to the curve have increasing slopes. Since the acceleration is equal to the slope of the tangent line, the acceleration must be increasing, and the acceleration vs. time graph that best indicates this behavior is (d).

   Graph (c) depicts an object which first has a velocity that increases at a constant rate, which means that the object's acceleration is constant. The velocity then stops changing, which means that the acceleration of the object is zero. This behavior is best matched by graph (f).
4. (b)
5. (a) blue graph (b) red graph (c) green graph
6. (e)
7. (c)
8. (a) and (f)

CONCEPTUAL QUESTIONS

1. Yes. If the velocity of the particle is nonzero, the particle is in motion. If the acceleration is zero, the velocity of the particle is unchanging or is constant.
3. Yes. If this occurs, the acceleration of the car is opposite to the direction of motion, and the car will be slowing down.
5. No. They can be used only when the acceleration is constant. Yes. Zero is a constant.
7. Once the objects leave the hand, both are in free fall, and both exhibit the same downward acceleration equal in magnitude to the free-fall acceleration g.
9. Yes. Yes.
11. (a) At the maximum height, the ball is momentarily at rest. (That is, it has zero velocity.) The acceleration remains constant, with magnitude equal to the free-fall acceleration g and directed downward. Thus, even though the velocity is momentarily zero, it continues to change, and the ball will begin to gain speed in the downward direction. (b) The acceleration of the ball remains constant in magnitude and direction throughout the ball's free flight, from the instant it leaves the hand until the instant just before it strikes the ground. The acceleration is directed downward and has a magnitude equal to the free-fall acceleration g.
13. No. If the velocity of A is greater than that of B, car A is moving faster than B at this instant. However, car B may be picking up speed (that is, accelerating) at a greater

rate than A. The driver of B may have stepped very hard on the gas pedal in the recent past, but car B has not yet reached the speed of A.

15. They are the same! You can see this for yourself by solving the kinematic equations for the two cases. The ball that was thrown upward will take longer to reach the ground, but when it arrives, it has the same velocity as the ball that was thrown downward.

17. Ignoring air resistance, in 16 s the pebble would fall a distance $\frac{1}{2}gt^2 = \frac{1}{2}(9.80\text{ m/s}^2)(16.0\text{ s})^2 = 1\,250\text{ m} = 1.25\text{ km}$. Air resistance is an important force after the first few seconds, when the pebble has gained high speed. Also, part of the 16-s interval must be occupied by the sound returning up the well. Thus, the depth of the well is less than 1.25 km, but on the order of 10^3 m.

19. Above. Your ball has zero initial speed and a smaller average speed during the time of flight to the passing point.

PROBLEMS

1. (a) 52.9 km/h (b) 90.0 km
3. (a) Boat A wins by 60 km (b) 0
5. (a) 180 km (b) 63.4 km/h
7. (a) 4.0 m/s (b) −0.50 m/s (c) −1.0 m/s (d) 0
9. (a) 2.50 m/s (b) −2.27 m/s (c) 0
11. 2.80 h, 218 km
13. 274 km/h
15. (a) 5.00 m/s (b) −2.50 m/s (c) 0 (d) 5.00 m/s
17. (a) 4.0 m/s (b) −4.0 m/s (c) 0 (d) 2.0 m/s
19. (a) 70.0 mi/h·s = 31.3 m/s^2 = 3.19g (b) 321 ft = 97.8 m
21. 3.7 s
23. (a) 8.0 m/s^2 (b) about 12 m/s^2
25. 2.74×10^5 m/s^2, or 2.79×10^4 times g
27. (a) 1.3 m/s^2 (b) 8.0 s
29. (a) 2.32 m/s^2 (b) 14.4 s
31. (a) 8.94 s (b) 89.4 m/s
33. −3.6 m/s^2
35. 200 m
37. (a) 1.5 m/s (b) 32 m
39. (a) 8.2 s (b) 1.3×10^2 m
41. 958 m
43. (a) 31.9 m (b) 2.55 s (c) 2.55 s (d) −25.0 m/s
45. 38.2 m
47. (a) 21.1 m/s (b) 19.6 m (c) 18.1 m/s; 19.6 m
49. (a) 308 m (b) 8.51 s (c) 16.4 s
51. (a) 10.0 m/s upward (b) 4.68 m/s downward
53. 15.0 s
55. (a) -3.50×10^5 m/s^2 (b) 2.86×10^{-4} s
57. 0.60 s
59. (a) 3.00 s (b) −24.5 m/s, −24.5 m/s (c) 23.5 m
61. (a) 5.46 s (b) 73.0 m (c) $v_{\text{Kathy}} = 26.7$ m/s, $v_{\text{Stan}} = 22.6$ m/s
63. (a) $t_1 = 5.0$ s, $t_2 = 85$ s (b) 200 ft/s (c) 18 500 ft from starting point (d) 10 s after starting to slow down (total trip time = 100 s)
65. (a) 5.5×10^3 ft (b) 3.7×10^2 ft/s (c) The plane would travel only 0.002 ft in the time it takes the light from the bolt to reach the eye.
67. (a) 7.82 m (b) 0.782 s
69. (a) 3.45 s (b) 10.0 ft
71. 4.2 m/s

Chapter 3

QUICK QUIZZES

1. (c)
2. (b)
3.

Vector	x-component	y-component
$\vec{A}$	−	+
$\vec{B}$	+	−
$\vec{A} + \vec{B}$	−	−

4. (b)
5. (a)
6. (c)
7. (b)

CONCEPTUAL QUESTIONS

1. The components of $\vec{A}$ will both be negative when $\vec{A}$ lies in the third quadrant. The components of $\vec{A}$ will have opposite signs when $\vec{A}$ lies in either the second quadrant or the fourth quadrant.

3. Assuming that the ship sails in a straight line, the wrench will strike the deck at the base of the mast. The wrench has the same horizontal velocity as the ship when it is released, and it will maintain that component of velocity as it falls. Thus, the wrench is always above the same spot on the deck and will strike that spot when it hits the deck. To an observer on the ship, the wrench appears to fall straight downward. To a stationary observer on shore, the wrench is seen to follow a parabolic trajectory.

5. Let v_{0x} and v_{0y} be the initial velocity components for the projectile fired on Earth. Because the projectile fired on the Moon is given the same initial velocity, its initial velocity components have the same values v_{0x} and v_{0y} as those for the projectile on Earth. From $v_y^2 = v_{0y}^2 - 2g\Delta y$, the maximum altitude reached by a projectile is found to be $H = v_{0y}^2/2g$. Because the free-fall acceleration g is smaller on the Moon than on Earth, the maximum altitude will be greater for the projectile fired on the Moon. If they start from the same elevation, the projectile on the Moon will have a longer time of flight and therefore a greater range. The Apollo astronauts made several long golf drives on the Moon.

7. A vector has both magnitude and direction and can be added only to other vectors representing the same physical quantity. A scalar has only a magnitude and can be added only to other scalars representing the same physical quantity.

9. (a) At the top of the projectile's flight, its velocity is horizontal and its acceleration is downward. This is the only point at which the velocity and acceleration vectors are perpendicular. (b) If the projectile is thrown straight up or down, then the velocity and acceleration will be parallel throughout the motion. For any other kind of projectile motion, the velocity and acceleration vectors are never parallel.

11. (a) The acceleration is zero, since both the magnitude and direction of the velocity remain constant. (b) The particle has an acceleration, since the direction of $\vec{v}$ changes.

13. The spacecraft will follow a parabolic path equivalent to that of a projectile thrown off a cliff with a horizontal velocity. As regards the projectile, gravity provides an acceleration that is always perpendicular to the initial velocity, resulting in a parabolic path. As regards the spacecraft, the initial velocity plays the role of the horizontal velocity of the projectile, and the leaking gas plays the role that gravity plays in the case of the projectile. If the orientation of the spacecraft were to change in response to the gas leak (which is by far the more likely result), then the acceleration would change direction and the motion could become very complicated.

15. For angles $\theta < 45°$, the projectile thrown at angle θ will be in the air for a shorter interval. For the smaller angle, the vertical component of the initial velocity is smaller than that for the larger angle. Thus, the projectile thrown at the smaller angle will not go as high into the air and will spend less time in the air before landing.
17. Yes. The projectile is a freely falling body, because gravity is the only force acting on it. The vertical acceleration will be the local free fall acceleration g; the horizontal acceleration will be zero.
19. If a projectile is to have zero speed at the top of its trajectory, it must be thrown straight upward with zero horizontal velocity. To give a projectile a nonzero speed at the top of its trajectory, the projectile should be thrown at any angle other than 90° to the horizontal.

PROBLEMS

1. Approximately 421 ft at 3° below the horizontal
3. Approximately 15 m at 58° S of E
5. Approximately 310 km at 57° S of W
7. (a) Approximately 5.0 units at −53° (b) Approximately 5.0 units at +53°
9. 8.07 m at 42.0° S of E
11. (a) 5.00 blocks at 53.1° N of E (b) 13.0 blocks
13. 47.2 units at 122° from the positive x-axis
15. 157 km
17. 245 km at 21.4° W of N
19. 196 cm at 14.7° below the x-axis
21. (a) (10.0 m, 16.0 m)
23. 6.13 m
25. 12 m/s
27. 48.6 m/s
29. 25 m
31. (a) 32.5 m from the base of the cliff (b) 1.78 s
33. (a) 52.0 m/s horizontally (b) 212 m
35. 390 mi/h at 7.37° N of E
37. 1.88 m
39. 249 ft upstream
41. 18.0 s
43. 196 cm at 14.7° below the positive x-axis
45. (a) 57.7 km/h at 60.0° west of vertical (b) 28.9 km/h downward
47. 68.6 km/h
49. (a) 1.52×10^3 m (b) 36.1 s (c) 4.05×10^3 m
51. $R_{\text{moon}} = 18$ m, $R_{\text{Mars}} = 7.9$ m
53. (a) +, + (b) −, + (c) (i) must be in either the first or second quadrant
55. (a) 42 m/s (b) 3.8 s (c) $v_x = 34$ m/s, $v_y = -13$ m/s; $v = 37$ m/s
57. 7.5 m/s in the direction the ball was thrown
61. $R/2$
63. 7.5 min
65. 10.8 m
67. (b) $y = Ax^2$ with $A = \dfrac{g}{(2v_i^2)}$ where v_i is the muzzle velocity (c) 14.5 m/s
69. 227 paces at 165° from the positive x-axis
71. (a) 20.0° above the horizontal (b) 3.05 s
73. (a) 23 m/s (b) 360 m horizontally from the base of cliff

Chapter 4

QUICK QUIZZES

1. (a) True (b) False
2. (a) True (b) True (c) False
3. False
4. (a) (The value of g is smaller on the Moon than on Earth, so, for equal *weights*, the Moon *mass* must be greater.)
5. (c); (d)
6. (c)
7. (c)
8. (b)
9. (b)
10. (b) By exerting an upward force component on the sled, you reduce the normal force on the ground and so reduce the force of kinetic friction.

CONCEPTUAL QUESTIONS

1. (a) Two external forces act on the ball. (i) One is a downward gravitational force exerted by Earth. (ii) The second force on the ball is an upward normal force exerted by the hand. The reactions to these forces are (i) an upward gravitational force exerted by the ball on Earth and (ii) a downward force exerted by the ball on the hand. (b) After the ball leaves the hand, the only external force acting on the ball is the gravitational force exerted by Earth. The reaction is an upward gravitational force exerted by the ball on Earth.
3. No. If the car moves with constant acceleration, then a net force in the direction of the acceleration must be acting on it.
5. The coefficient of static friction is larger than that of kinetic friction. To start the box moving, you must counterbalance the maximum static friction force. This force exceeds the kinetic friction force that you must counterbalance to maintain the constant velocity of the box once it starts moving.
7. The inertia of the suitcase would keep it moving forward as the bus stops. There would be no tendency for the suitcase to be thrown backward toward the passenger. The case should be dismissed.
9. The force causing an automobile to move is the friction between the tires and the roadway as the automobile attempts to push the roadway backward. The force driving a propeller airplane forward is the reaction force exerted by the air on the propeller as the rotating propeller pushes the air backward (the action). In a rowboat, the rower pushes the water backward with the oars (the action). The water pushes forward on the oars and hence the boat (the reaction).
11. When the bus starts moving, Claudette's mass is accelerated by the force exerted by the back of the seat on her body. Clark is standing, however, and the only force acting on him is the friction between his shoes and the floor of the bus. Thus, when the bus starts moving, his feet accelerate forward, but the rest of his body experiences

almost no accelerating force (only that due to his being attached to his accelerating feet!). As a consequence, his body tends to stay almost at rest, according to Newton's first law, relative to the ground. Relative to Claudette, however, he is moving toward her and falls into her lap. Both performers won Academy Awards.

13. The tension in the rope is the maximum force that occurs in *both* directions. In this case, then, since both are pulling with a force of magnitude 200 N, the tension is 200 N. If the rope does not move, then the force on each athlete must equal zero. Therefore, each athlete exerts 200 N against the ground.

15. (a) As the man takes the step, the action is the force his foot exerts on Earth; the reaction is the force exerted by Earth on his foot. (b) Here, the action is the force exerted by the snowball on the girl's back; the reaction is the force exerted by the girl's back on the snowball. (c) This action is the force exerted by the glove on the ball; the reaction is the force exerted by the ball on the glove. (d) This action is the force exerted by the air molecules on the window; the reaction is the force exerted by the window on the air molecules. In each case, we could equally well interchange the terms "action" and "reaction."

17. If the brakes lock, the car will travel farther than it would travel if the wheels continued to roll, because the coefficient of kinetic friction is less than that of static friction. Hence, the force of kinetic friction is less than the maximum force of static friction.

19. (a) The crate accelerates because of a friction force exerted by the floor of the truck on the crate. (b) If the driver slams on the brakes, the crate's inertia tends to keep the crate moving forward.

PROBLEMS

1. (a) 12 N (b) 3.0 m/s^2
3. 2×10^4 N
5. 3.71 N, 58.7 N, 2.27 kg
7. 9.6 N
9. 1.4×10^3 N
11. (a) 0.200 m/s^2 (b) 10.0 m (c) 2.00 m/s
13. 1.1×10^4 N
15. 600 N in vertical cable, 997 N in inclined cable, 796 N in horizontal cable
17. 150 N in vertical cable, 75 N in right-side cable, 130 N in left-side cable
19. 236 N (upper rope), 118 N (lower rope)
21. 613 N
23. 64 N
25. (a) 7.50×10^3 N backward (b) 50.0 m
27. (a) 7.0 m/s^2 horizontal and to the right (b) 21 N (c) 14 N horizontal and to the right
29. 7.90 m/s
31. (a) 14.2 m/s (b) 588 m
33. (a) 2.15×10^3 N forward (b) 645 N forward (c) 645 N rearward (d) 1.02×10^4 N at 74.1° below horizontal and rearward
35. $\mu_s = 0.38$, $\mu_k = 0.31$
37. (a) 0.256 (b) 0.509 m/s^2
39. (a) 14.7 m (b) Neither mass is necessary
41. 32.1 N
43. (a) 33 m/s (b) No. The object will speed up to 33 m/s from any lower speed and will slow down to 33 m/s from any higher speed.
45. $\mu_k = 0.287$
47. (a) 1.78 m/s^2 (b) 0.368 (c) 9.37 N (d) 2.67 m/s
49. 3.30 m/s^2
51. (a) 0.404 (b) 45.8 lb
53. (b) 2-kg block: 5.7 m/s^2 to left; 3-kg block: 5.7 m/s^2 to right; 10-kg block: 5.7 m/s^2 downward (c) 17 N, 41 N
55. (a) 84.9 N upward (b) 84.9 N downward
57. 50 m
59. (a) friction between box and truck (b) 2.94 m/s^2
61. (a) 2.22 m (b) 8.74 m/s down the incline
63. (a) 0.232 m/s^2 (b) 9.68 N
65. (a) 1.7 m/s^2, 17 N (b) 0.69 m/s^2, 17 N
67. 100 N, 204 N
69. (a) $T_1 = 78.0$ N, $T_2 = 35.9$ N (b) 0.656
71. (a) 30.7° (b) 0.843 N
73. 5.5×10^2 N
75. (a) 7.1×10^2 N (b) 8.1×10^2 N (c) 7.1×10^2 N (d) 6.5×10^2 N
77. 72.0 N
79. (a) 0.408 m/s^2 upward (b) 83.3 N
81. (b) 514 N, 558 N, 325 N

Chapter 5

QUICK QUIZZES

1. (C)
2. (d)
3. (c)
4. (c)

CONCEPTUAL QUESTIONS

1. Since no motion is taking place, the rope undergoes no displacement and no work is done on it. For the same reason, no work is being done on the pullers or the ground. Work is being done only within the bodies of the pullers. For example, the heart of each puller is applying forces on the blood to move blood through the body.

3. When the slide is frictionless, changing the length or shape of the slide will not make any difference in the final speed of the child, as long as the difference in the heights of the upper and lower ends of the slide is kept constant. If friction must be considered, the path length along which the friction force does negative work will be greater when the slide is made longer or given bumps. Thus, the child will arrive at the lower end with less kinetic energy (and hence less speed).

5. If we ignore any effects due to rolling friction on the tires of the car, we find that the same amount of work would be done in driving up the switchback and in driving straight up the mountain, since the weight of the car is moved upwards against gravity by the same vertical distance in each case. If we include friction, there is more work done in driving the switchback, since the distance over which the friction force acts is much longer. So why do we use switchbacks? The answer lies in the force required, not the work. The force required from the engine to follow a gentle rise is much smaller than that required to drive straight up the hill. To negotiate roadways running straight uphill, engines would have to be redesigned to enable them to apply much larger forces. (It is for much the same reason that ramps are designed to move heavy objects into trucks, as opposed to lifting the objects vertically.)

7. (a) The tension in the supporting cord does no work, because the motion of the pendulum is always perpendicular to the cord and therefore to the tension force. (b) The air resistance does negative work at all times, because the air resistance is always acting in a direction opposite that of the motion. (c) The force of gravity always acts downwards; therefore, the work done by gravity is positive on the downswing and negative on the upswing.
9. Because the periods are the same for both cars, we need only to compare the work done. Since the sports car is moving twice as fast as the older car at the end of the time interval, it has four times the kinetic energy. Thus, according to the work–energy theorem, four times as much work was done, and the engine must have expended four times the power.
11. During the time that the toe is in contact with the ball, the work done by the toe on the ball is given by

$$W_{toe} = \frac{1}{2}m_{ball}v^2 - 0 = \frac{1}{2}m_{ball}v^2$$

where v is the speed of the ball as it leaves the toe. After the ball loses contact with the toe, only the gravitational force and the retarding force due to air resistance continue to do work on the ball throughout its flight.
13. Yes, the total mechanical energy of the system is conserved because the only forces acting are conservative: the force of gravity and the spring force. There are two forms of potential energy in this case: gravitational potential energy and elastic potential energy stored in the spring.
15. Let's assume you lift the book slowly. In this case, there are two forces on the book that are almost equal in magnitude: the lifting force and the force of gravity. Thus, the positive work done by you and the negative work done by gravity cancel. There is no net work performed and no net change in the kinetic energy, so the work–energy theorem is satisfied.
17. As the satellite moves in a circular orbit about the Earth, its displacement during any small time interval is perpendicular to the gravitational force, which always acts toward the center of the Earth. Therefore, the work done by the gravitational force during any displacement is zero. (Recall that the work done by a force is defined to be $F\Delta x \cos\theta$, where θ is the angle between the force and the displacement. In this case, the angle is 90°, so the work done is zero.) Since the work–energy theorem says that the net work done on an object during any displacement is equal to the change in its kinetic energy, and the work done in this case is zero, the change in the satellite's kinetic energy is zero: hence, its speed remains constant.
19. If a crate is located on the bed of a truck, and the truck accelerates, the friction force exerted on the crate causes it to undergo the same acceleration as the truck, assuming that the crate doesn't slip. Another example is a car that accelerates because of the frictional forces between the road surface and its tires. This force is in the direction of the motion of the car and produces an increase in the car's kinetic energy.

PROBLEMS

1. 700 J
3. 15.0 MJ
5. (a) 61.3 J (b) −46.3 J (c) 0
7. (a) 79.4 N (b) 1.49 kJ (c) −1.49 kJ
9. (a) 2.00 m/s (b) 200 N
11. 0.265 m/s
13. (a) -5.6×10^2 J (b) 1.2 m
15. (a) 90 J (b) 1.8×10^2 N
17. 1.0 m/s
19. 4.1 m
21. (a) 4.1 m (b) 6.4 m/s
23. $h = 6.94$ m
25. $W_{biceps} = 120$ J, $W_{chin\text{-}up} = 290$ J, additional muscles must be involved
27. 0.459 m
29. 1.53×10^5 N upwards
31. (a) 10.9 m/s (b) 11.6 m/s
33. (a) 544 N/m (b) 19.7 m/s
35. 10.2 m
37. (a) Yes. There are no nonconservative forces acting on the child, so the total mechanical energy is conserved. (b) No. In the expression for conservation of mechanical energy, the mass of the child is included in every term and therefore cancels out. (c) The answer is the same in each case. (d) The expression would have to be modified to include the work done by the force of friction. (e) 15.3 m/s.
39. 2.1 kN
41. 3.8 m/s
43. (a) 5.42 m/s (b) 0.300 (c) 147 J
45. 289 m
47. (a) 24.5 m/s (b) Yes (c) 206 m (d) Unrealistic; the actual retarding force will vary with speed.
49. (a) 1.24 kW (b) 20.9%
51. 8.01 W
53. (a) 2.38×10^4 W = 32.0 hp (b) 4.77×10^4 W = 63.9 hp
55. (a) 24.0 J (b) −3.00 J (c) 21.0 J
57. (a) The graph is a straight line passing through the points (0 m, −16 N), (2 m, 0 N), and (3 m, 8 N). (b) −12.0 J
59. (a) 575 N/m (b) 46.0 J
61. (a) 4.4 m/s (b) 1.5×10^5 N
63. (a) 3.13 m/s (b) 4.43 m/s (c) 1.00 m
65. (a) 0.588 J (b) 0.588 J (c) 2.42 m/s (d) $PE_C = 0.392$ J (e) $KE_C = 0.196$ J
67. (a) 423 mi/gal (b) 776 mi/gal
69. (a) 28.0 m/s (b) 30.0 m (c) 89.0 m beyond the end of the track
71. 1.68 m/s
73. (a) 6.15 m/s (b) 9.87 m/s
75. (a) 101 J (b) 0.410 m (c) 2.84 m/s (d) −9.80 mm (e) 2.85 m/s
77. 914 N/m
79. $W_{net} = 0$, $W_{grav} = -2.0 \times 10^4$ J, $W_{normal} = 0$, $W_{friction} = 2.0 \times 10^4$ J
81. (a) 10.2 kW (b) 10.6 kW (c) 5.82×10^6 J
83. $v = (8gh/15)^{1/2}$
85. between 25.2 km/h and 27.0 km/h
87. (a) 6.75 W/m² (b) 6.64 kW/m² (c) A powerful automobile running on sunlight would have to carry on its roof a solar panel that was huge compared with the size of the car.
89. 4.3 m/s

Chapter 6

QUICK QUIZZES

1. (d)
2. (c)
3. (c)

4. (a)
5. (a) Perfectly inelastic (b) Inelastic (c) Inelastic
6. (a)

CONCEPTUAL QUESTIONS

1. (a) No. It cannot carry more kinetic energy than it possesses. That would violate the law of energy conservation. (b) Yes. By bouncing from the object it strikes, it can deliver more momentum in a collision than it possesses in its flight.
3. If all the kinetic energy disappears, there must be no motion of either of the objects after the collision. If neither is moving, the final momentum of the system is zero, and the initial momentum of the system must also have been zero. A situation in which this could be true would be the head-on collision of two objects having momenta of equal magnitude but opposite direction.
5. Initially, the clay has momentum directed toward the wall. When it collides and sticks to the wall, neither the clay nor the wall appears to have any momentum. Thus, it is tempting to (wrongfully) conclude that momentum is not conserved. However, the "lost" momentum is actually imparted to the wall and Earth, causing both to move. Because of Earth's enormous mass, its recoil speed is too small to detect.
7. Before the step the momentum was zero, so afterward the net momentum must also be zero. Obviously, you have some momentum, so something must have momentum in the opposite direction. That something is Earth, the enormous mass of which ensures that its recoil speed will be too small to detect, but if you want to make Earth move, it is as simple as taking a step.
9. As the water is forced out of the holes in the arm, the arm imparts a horizontal impulse to the water. The water then exerts an equal and opposite impulse on the spray arm, causing the spray arm to rotate in the direction opposite that of the spray.
11. Its speed decreases as its mass increases. There are no external horizontal forces acting on the box, so its momentum cannot change as it moves along the horizontal surface. As the box slowly fills with water, its mass increases with time. Because the product mv must be a constant, and because m is increasing, the speed of the box must decrease.
13. It will be easiest to catch the medicine ball when its speed (and kinetic energy) is lowest. The first option—throwing the medicine ball at the same velocity—will be the most difficult, because the speed will not be reduced at all. The second option, throwing the medicine ball with the same momentum, will reduce the velocity by the ratio of the masses. Since $m_t v_t = m_m v_m$, it follows that

$$v_m = v_t\left(\frac{m_t}{m_m}\right)$$

The third option, throwing the medicine ball with the same kinetic energy, will also reduce the velocity, but only by the square root of the ratio of the masses. Since

$$\frac{1}{2}m_t v_t^2 = \frac{1}{2}m_m v_m^2$$

it follows that

$$v_m = v_t\sqrt{\frac{m_t}{m_m}}$$

Thus, the slowest—and easiest—throw will be made when the momentum is held constant. If you wish to check this answer, try substituting in values of $v_t = 1$ m/s, $m_t = 1$ kg, and $m_m = 100$ kg. Then the same-momentum throw will be caught at 1 cm/s, while the same-energy throw will be caught at 10 cm/s.
15. The follow-through keeps the club in contact with the ball as long as possible, maximizing the impulse. Thus, the ball accrues a larger change in momentum than without the follow-through, and it leaves the club with a higher velocity and travels farther. With a short shot to the green, the primary factor is control, not distance. Hence, there is little or no follow-through, allowing the golfer to have a better feel for how hard he or she is striking the ball.
17. It is the product mv that is the same for both the bullet and the gun. The bullet has a large velocity and a small mass, while the gun has a small velocity and a large mass. Furthermore, the bullet carries much more kinetic energy than the gun.

PROBLEMS

1. 1.39 N · s up
3. (a) 8.35×10^{-21} kg · m/s (b) 4.50 kg · m/s (c) 750 kg · m/s (d) 1.78×10^{29} kg · m/s
5. (a) 31.0 m/s (b) the bullet, 3.38×10^3 J versus 69.7 J
7. $\sim 10^3$ N upward
9. 364 kg · m/s forward, 438 N forward
11. (a) 8.0 N · s (b) 5.3 m/s (c) 3.3 m/s
13. (a) 12 N · s (b) 8.0 N · s (c) 8.0 m/s, 5.3 m/s
15. (a) 9.60×10^{-2} s (b) 3.65×10^5 N (c) 26.6g
17. 6.7×10^3 N toward the west
19. 65 m/s
21. (a) 1.15 m/s (b) 0.346 m/s directed opposite to girl's motion
23. $KE_E/KE_b \sim 10^{-25}$
25. 1.67 m/s
27. (a) 1.80 m/s (b) 2.16×10^4 J
29. 57 m
31. 15.6 m/s
33. 273 m/s
35. (a) −6.67 cm/s, 13.3 cm/s (b) 0.889
37. 17.1 cm/s (25.0-g object), 22.1 cm/s (10.0-g object)
39. 7.94 cm
41. (a) 2.9 m/s at 32° N of E (b) 7.9×10^2 J converted into internal energy
43. 5.59 m/s north
45. (a) 2.50 m/s at −60° (b) elastic collision
47. (a) 9.0 m/s (b) −15 m/s
49. 1.78×10^3 N on truck driver, 8.89×10^3 N on car driver
51. (a) 8/3 m/s (incident particle), 32/3 m/s (target particle) (b) −16/3 m/s (incident particle), 8/3 m/s (target particle) (c) 7.1×10^{-2} J in case (a), and 2.8×10^{-3} J in case (b). The incident particle loses more kinetic energy in case (a), in which the target mass is 1.0 g.
53. 1.1×10^3 N (upward)
55. (a) 1.33 m/s (b) 235 N (c) 0.681 s (d) −160 N · s, 160 N · s (e) 1.82 m (f) 0.454 m (g) −427 J (h) 107 J (i) Equal friction forces act through different distances on the person and the cart to do different amounts of work on them. This is a perfectly inelastic collision in which the total work on both person and cart together is −320 J, which becomes +320 J of internal energy.