Answers to Quick Quizzes and Odd-Numbered Problems

Chapter 1

Answers to Quick Quizzes

1. (a)
2. False
3. (b)

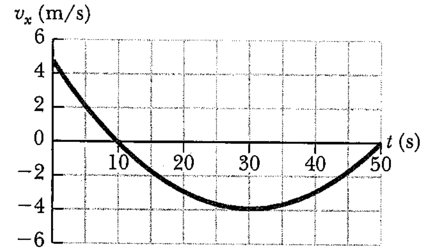
Answers to Odd-Numbered Problems

1. (a) 5.52×10^3 kg/m^3 (b) It is between the density of aluminum and that of iron and is greater than the densities of typical surface rocks.
3. 23.0 kg
5. 7.69 cm
7. 0.141 nm
9. (b) only
11. (a) kg · m/s (b) N · s
13. No.
15. 11.4×10^3 kg/m^3
17. 871 m^2
19. By measuring the pages, we find that each page has area 0.277 m $\times$ 0.217 m = 0.060 m^2. The room has wall area 37 m^2, requiring 616 sheets that would be counted as 1 232 pages. Volume 1 of this textbook contains only 784 pages.
21. 1.00×10^{10} lb
23. 4.05×10^3 m^2
25. 2.86 cm
27. 151 μm
29. (a) 507 years (b) 2.48×10^9 bills
31. $\sim 10^6$ balls in a room 4 m by 4 m by 3 m
33. $\sim 10^2$ piano tuners
35. (209 ± 4) cm^2
37. 31 556 926.0 s
39. 19
41. 8.80%
43. 63
45. (a) 6.71 m (b) 0.894 (c) 0.745
47. 48.6 kg
49. ± 3.46
51. Answers may vary somewhat due to variation in reading precise numbers off the graph. (a) 0.015 g (b) 8% (c) 5.2 g/m^2 (d) For shapes cut from this copy paper, the mass of the cutout is proportional to its area. The proportionality constant is 5.2 g/m^2 $\pm$ 8%, where the uncertainty is estimated. (e) This result is to be expected if the paper has thickness and density that are uniform within the experimental uncertainty. (f) The slope is the areal density of the paper, its mass per unit area.
53. 5.2 m^3, 3%
55. 316 m
57. 5.0 m
59. 3.41 m
61. (a) aluminum, 2.75 g/cm^3; copper, 9.36 g/cm^3; brass, 8.91 g/cm^3; tin, 7.68 g/cm^3; iron, 7.88 g/cm^3
(b) The tabulated values are smaller by 2% for aluminum, by 5% for copper, by 6% for brass, by 5% for tin, and by 0.3% for iron.
63. 1×10^{10} gal/yr
65. Answers may vary. (a) $\sim 10^{29}$ prokaryotes (b) $\sim 10^{14}$ kg
67. (a) $B = 2.70$ g/cm^3, $C = 1.19$ g/cm^4 (b) 1.39 kg
69. $V = 0.579t + (1.19 \times 10^{-9})t^2$, where V is in cubic feet and t is in seconds
71. (a) 0.529 cm/s (b) 11.5 cm/s
73. (a) 12.1 m (b) 135° (c) 25.2° (d) 135°

Chapter 2

Answers to Quick Quizzes

1. (c)
2. (b)
3. False. Your graph should look something like the one shown below. This v_x–t graph shows that the maximum speed is about 5.0 m/s, which is 18 km/h (= 11 mi/h), so the driver was not speeding.

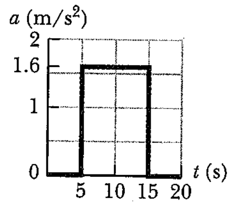


4. (b)
5. (c)
6. (a)–(e), (b)–(d), (c)–(f)
7. (i) (e) (ii) (d)

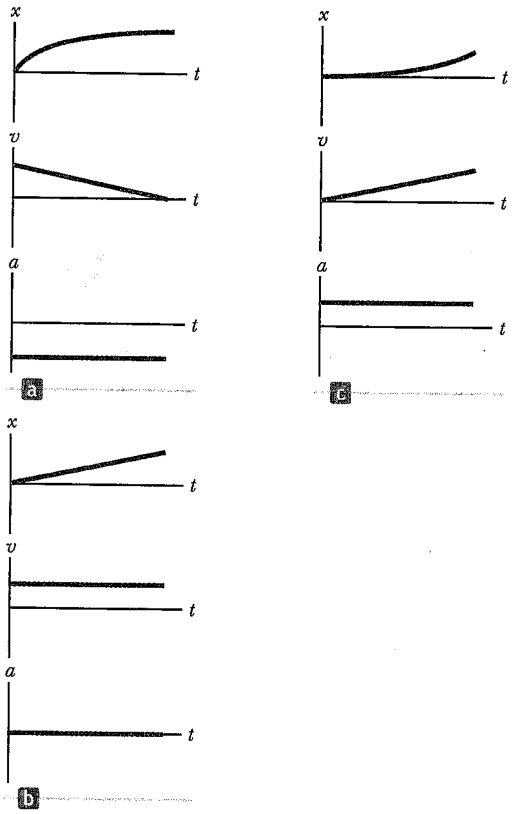
Answers to Odd-Numbered Problems

1. (a) 5 m/s (b) 1.2 m/s (c) −2.5 m/s (d) −3.3 m/s (e) 0
3. (a) 3.75 m/s (b) 0

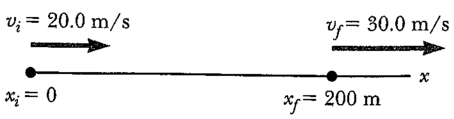
5. (a) 2.30 m/s (b) 16.1 m/s (c) 11.5 m/s
7. (a) −2.4 m/s (b) −3.8 m/s (c) 4.0 s
9. (a) 5.0 m/s (b) −2.5 m/s (c) 0 (d) +5.0 m/s
11. (a) 5.00 m (b) 4.88×10^3 s
13. (a) 2.80 h (b) 218 km
15. (a)



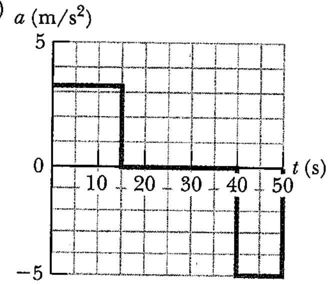
(b) 1.60 m/s^2 (c) 0.800 m/s^2
17. (a) 1.3 m/s^2 (b) $t = 3$ s, $a = 2$ m/s^2 (c) $t = 6$ s, $t > 10$ s (d) $a = -1.5$ m/s^2, $t = 8$ s
19. (a) 20 m/s, 5 m/s (b) 263 m
21. (a) 2.00 m (b) −3.00 m/s (c) −2.00 m/s^2
23.



25. (a) 4.98×10^{-9} s (b) 1.20×10^{15} m/s^2
27. (a) 9.00 m/s (b) −3.00 m/s (c) 17.0 m/s (d) The graph of velocity versus time is a straight line passing through 13 m/s at 10:05 a.m. and sloping downward, decreasing by 4 m/s for each second thereafter. (e) If and only if we know the object's velocity at one instant of time, knowing its acceleration tells us its velocity at every other moment as long as the acceleration is constant.
29. −16.0 cm/s^2
31. (a) −202 m/s^2 (b) 198 m
33. (a) 35.0 s (b) 15.7 m/s
35. 3.10 m/s
37. (a)



(b) Particle under constant acceleration
(c) $v_f^2 = v_i^2 + 2a(x_f - x_i)$ (Equation 2.17)
(d) $a = \dfrac{v_f^2 - v_i^2}{2(x_f - x_i)}$ (e) 1.25 m/s^2 (f) 8.00 s
39. (a) The idea is false unless the acceleration is zero. We define constant acceleration to mean that the velocity is changing steadily in time. So, the velocity cannot be changing steadily in space.
(b) This idea is true. Because the velocity is changing steadily in time, the velocity halfway through an interval is equal to the average of its initial and final values.
41. (a) 13.5 m (b) 13.5 m (c) 13.5 m (d) 22.5 m
43. (a) 1.88 km (b) 1.46 km
(c)



(d) $0a$: $x = 1.67t^2$; ab: $x = 50t - 375$; bc: $x = 250t - 2.5t^2 - 4\,375$ (In all three expressions, x is in meters and t is in seconds.) (e) 37.5 m/s
45. (a) 0.231 m (b) 0.364 m (c) 0.399 m (d) 0.175 m
47. David will be unsuccessful. The average human reaction time is about 0.2 s (research on the Internet) and a dollar bill is about 15.5 cm long, so David's fingers are about 8 cm from the end of the bill before it is dropped. The bill will fall about 20 cm before he can close his fingers.
49. (a) 510 m (b) 20.4 s
51. 1.79 s
53. (a) 10.0 m/s up (b) 4.68 m/s down
55. (a) 7.82 m (b) 0.782 s
57. (a) $a_x(t) = a_{xi} + Jt$; $v_x(t) = v_{xi} + a_{xi}t + \frac{1}{2}Jt^2$; $x(t) = x_i + v_{xi}t + \frac{1}{2}a_{xi}t^2 + \frac{1}{6}Jt^3$
59. (a) $a = -(10.0 \times 10^7)t + 3.00 \times 10^5$; $x = -(1.67 \times 10^7)t^3 + (1.50 \times 10^5)t^2$ (In these expressions, a is in m/s^2, x is in meters, and t is in seconds.) (b) 3.00 ms (c) 450 m/s (d) 0.900 m
61. (a) 4.00 m/s (b) 1.00 ms (c) 0.816 m
63. (a) 3.00 s (b) −15.3 m/s (c) 31.4 m/s down and 34.8 m/s down
65. (a) 3.00 m/s (b) 6.00 s (c) −0.300 m/s^2 (d) 2.05 m/s
67. (a) 2.83 s (b) It is exactly the same situation as in Example 2.8 except that this problem is in the vertical direction. The descending elevator plays the role of the speeding car, and the falling bolt plays the role of the accelerating trooper. Turn Figure 2.13 through 90° clockwise to visualize the elevator–bolt problem! (c) If each floor is 3 m high, the highest floor that can be reached is the 13th floor.
69. (a) From the graph, we see that the Acela is cruising at a constant positive velocity in the positive x direction from about −50 s to 50 s. From 50 s to 200 s, the Acela accelerates in the positive x direction reaching a top speed of about 170 mi/h. Around 200 s, the engineer applies the brakes, and the train, still traveling in the positive x direction, slows down and then stops at 350 s. Just after

350 s, the train reverses direction (v becomes negative) and steadily gains speed in the negative x direction. (b) approximately 2.2 mi/h/s (c) approximately 6.7 mi

71. (a) Here, v_1 must be greater than v_2 and the distance between the leading athlete and the finish line must be great enough so that the trailing athlete has time to catch up.

(b) $t = \dfrac{d_1}{v_1 - v_2}$ (c) $d_2 = \dfrac{v_2 d_1}{v_1 - v_2}$

73. (a) 5.46 s (b) 73.0 m
(c) $v_{\text{Stan}} = 22.6$ m/s, $v_{\text{Kathy}} = 26.7$ m/s

75. (a) $v_B = (1/\tan\theta)v$ (b) The velocity v_B starts off larger than v for small values of θ and then decreases, approaching zero as θ approaches 90°.

77. (a) 15.0 s (b) 30.0 m/s (c) 225 m

79. 1.60 m/s^2

81. (a) 35.9 m (b) 4.04 s (c) 45.8 m (d) 22.6 m/s

83. (a) 5.32 m/s^2 for Laura and 3.75 m/s^2 for Healan
(b) 10.6 m/s for Laura and 11.2 m/s for Healan
(c) Laura, by 2.63 m (d) 4.47 m at $t = 2.84$ s

85. (a) 26.4 m (b) 6.8%

Chapter 3

Answers to Quick Quizzes

1. vectors: (b), (c); scalars: (a), (d), (e)
2. (c)
3. (b) and (c)
4. (b)
5. (c)

Answers to Odd-Numbered Problems

1. (−2.75, −4.76) m

3. (a) 8.60 m (b) 4.47 m, −63.4°; 4.24 m, 135°

5. (a) (−3.56 cm, −2.40 cm) (b) (r = 4.30 cm, θ = 326°) (c) (r = 8.60 cm, θ = 34.0°) (d) (r = 12.9 cm, θ = 146°)

7. 70.0 m

9. This situation can *never* be true because the distance is the length of an arc of a circle between two points, whereas the magnitude of the displacement vector is a straight-line chord of the circle between the same points.

11. (a) 5.2 m at 60° (b) 3.0 m at 330° (c) 3.0 m at 150°
(d) 5.2 m at 300°

13. approximately 420 ft at −3°

15. 47.2 units at 122°

17. (a) yes (b) The speed of the camper should be 28.3 m/s or more to satisfy this requirement.

19. (a) $(-11.1\hat{\mathbf{i}} + 6.40\hat{\mathbf{j}})$ m (b) $(1.65\hat{\mathbf{i}} + 2.86\hat{\mathbf{j}})$ cm
(c) $(-18.0\hat{\mathbf{i}} - 12.6\hat{\mathbf{j}})$ in.

21. 358 m at 2.00° S of E

23. (a) $2.00\hat{\mathbf{i}} - 6.00\hat{\mathbf{j}}$ (b) $4.00\hat{\mathbf{i}} + 2.00\hat{\mathbf{j}}$ (c) 6.32 (d) 4.47
(e) 288°; 26.6°

25. 9.48 m at 166°

27. 4.64 m at 78.6° N of E

29. (a) 185 N at 77.8° from the positive x axis
(b) $(-39.3\hat{\mathbf{i}} - 181\hat{\mathbf{j}})$ N

31. (a) 2.83 m at θ = 315° (b) 13.4 m at θ = 117°

33. (a) $8.00\hat{\mathbf{i}} + 12.0\hat{\mathbf{j}} - 4.00\hat{\mathbf{k}}$ (b) $2.00\hat{\mathbf{i}} + 3.00\hat{\mathbf{j}} - 1.00\hat{\mathbf{k}}$
(c) $-24.0\hat{\mathbf{i}} - 36.0\hat{\mathbf{j}} + 12.0\hat{\mathbf{k}}$

35. (a) $-3.00\hat{\mathbf{i}} + 2.00\hat{\mathbf{j}}$ (b) 3.61 at 146° (c) $3.00\hat{\mathbf{i}} - 6.00\hat{\mathbf{j}}$

37. (a) a = 5.00 and b = 7.00 (b) For vectors to be equal, all their components must be equal. A vector equation contains more information than a scalar equation.

39. 196 cm at 345°

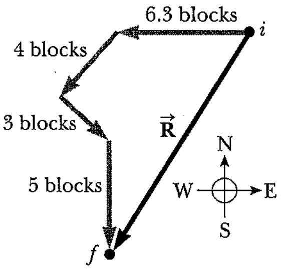
41. (a) $\vec{\mathbf{E}} = (15.1\hat{\mathbf{i}} + 7.72\hat{\mathbf{j}})$cm (b) $\vec{\mathbf{F}} = (-7.72\hat{\mathbf{i}} + 15.1\hat{\mathbf{j}})$cm
(c) $\vec{\mathbf{G}} = (-7.72\hat{\mathbf{i}} - 15.1\hat{\mathbf{j}})$ cm

43. (a) $(-20.5\hat{\mathbf{i}} + 35.5\hat{\mathbf{j}})$ m/s (b) $25.0\hat{\mathbf{j}}$ m/s
(c) $(-61.5\hat{\mathbf{i}} + 107\hat{\mathbf{j}})$ m (d) $37.5\hat{\mathbf{j}}$ m (e) 157 km

45. 1.43×10^4 m at 32.2° above the horizontal

47. (a) 10.4 cm (b) θ = 35.5°

49. (a)



(b) 18.3 b (c) 12.4 b at 233° counterclockwise from east

51. 240 m at 237°

53. (a) 25.4 s (b) 15.0 km/h

55. (a) 0.079 8 N (b) 57.9° (c) 32.1°

57. (a) The x, y, and z components are, respectively, 2.00, 1.00, and 3.00. (b) 3.74 (c) $\theta_x = 57.7°$, $\theta_y = 74.5°$, $\theta_z = 36.7°$

59. 1.15°

61. (a) $(10\,000 - 9\,600 \sin\theta)^{1/2}$ cm (b) 270°; 140 cm (c) 90°; 20.0 cm (d) They do make sense. The maximum value is attained when $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$ are in the same direction, and it is 60 cm + 80 cm. The minimum value is attained when $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$ are in opposite directions, and it is 80 cm − 60 cm.

63. (a) $-2.00\hat{\mathbf{k}}$ m/s (b) its velocity vector

65. (a) $\vec{\mathbf{R}}_1 = a\hat{\mathbf{i}} + b\hat{\mathbf{j}}$ (b) $R_1 = (a^2 + b^2)^{1/2}$
(c) $\vec{\mathbf{R}}_2 = a\hat{\mathbf{i}} + b\hat{\mathbf{j}} + c\hat{\mathbf{k}}$

67. (a) (10.0 m, 16.0 m) (b) This center of mass of the tree distribution is the same location whatever order we take the trees in. (We will study center of mass in Chapter 9.)

Chapter 4

Answers to Quick Quizzes

1. (a)
2. (i) (b) (ii) (a)
3. 15°, 30°, 45°, 60°, 75°
4. (i) (d) (ii) (b)
5. (i) (b) (ii) (d)

Answers to Odd-Numbered Problems

1. (a) 4.87 km at 209° from east (b) 23.3 m/s
(c) 13.5 m/s at 209°

3. (a) $(1.00\hat{\mathbf{i}} + 0.750\hat{\mathbf{j}})$ m/s (b) $(1.00\hat{\mathbf{i}} + 0.500\hat{\mathbf{j}})$ m/s, 1.12 m/s

5. (a) $\vec{\mathbf{r}} = 18.0t\hat{\mathbf{i}} + (4.00t - 4.90t^2)\hat{\mathbf{j}}$, where $\vec{\mathbf{r}}$ is in meters and t is in seconds
(b) $\vec{\mathbf{v}} = 18.0\hat{\mathbf{i}} + (4.00 - 9.80t)\hat{\mathbf{j}}$, where $\vec{\mathbf{v}}$ is in meters per second and t is in seconds
(c) $\vec{\mathbf{a}} = -9.80\hat{\mathbf{j}}$ m/s^2
(d) $\vec{\mathbf{r}} = (54.0\hat{\mathbf{i}} - 32.1\hat{\mathbf{j}})$ m; $\vec{\mathbf{v}} = (18.0\hat{\mathbf{i}} - 25.4\hat{\mathbf{j}})$ m/s; $\vec{\mathbf{a}} = -9.80\hat{\mathbf{j}}$ m/s^2

7. (a) $\vec{v} = -12.0t\hat{j}$, where $\vec{v}$ is in meters per second and t is in seconds (b) $\vec{a} = -12.0\hat{j}$ m/s^2 (c) $\vec{r} = (3.00\hat{i} - 6.00\hat{j})$ m; $\vec{v} = -12.0\hat{j}$ m/s
9. (a) $(0.800\hat{i} - 0.300\hat{j})$ m/s^2 (b) 339° (c) $(360\hat{i} - 72.7\hat{j})$ m, −15.2°
11. 12.0 m/s
13. (a) 2.81 m/s horizontal (b) 60.2° below the horizontal
15. 53.1°
17. (a) 3.96 m/s horizontally forward (b) 9.6%
19. 67.8°
21. $d \tan \theta_i - \dfrac{gd^2}{2v_i^2 \cos^2 \theta_i}$
23. (a) The ball clears by 0.89 m. (b) while descending
25. (a) 18.1 m/s (b) 1.13 m (c) 2.79 m
27. 9.91 m/s
29. (a) (0, 50.0 m) (b) $v_{xi} = 18.0$ m/s; $v_{yi} = 0$ (c) Particle under constant acceleration (d) Particle under constant velocity (e) $v_{xf} = v_{xi}$; $v_{yf} = -gt$ (f) $x_f = v_{xi}t$; $y_f = y_i - \frac{1}{2}gt^2$ (g) 3.19 s (h) 36.1 m/s, −60.1°
31. 1.92 s
33. 377 m/s^2
35. 2.06×10^3 rev/min
37. 0.749 rev/s
39. 7.58×10^3 m/s, 5.80×10^3 s
41. 1.48 m/s^2 inward and 29.9° backward
43. (a) Yes. The particle can be either speeding up or slowing down, with a tangential component of acceleration of magnitude $\sqrt{6^2 - 4.5^2} = 3.97$ m/s^2. (b) No. The magnitude of the acceleration cannot be less than $v^2/r = 4.5$ m/s^2.
45. (a) 1.26 h (b) 1.13 h (c) 1.19 h
47. (a) 15.0 km/h east (b) 15.0 km/h west (c) 0.016 7 h = 60.0 s
49. (a) 9.80 m/s^2 down and 2.50 m/s^2 south (b) 9.80 m/s^2 down (c) The bolt moves on a parabola with its axis downward and tilting to the south. It lands south of the point directly below its starting point. (d) The bolt moves on a parabola with a vertical axis.
51. (a) $\dfrac{2d/c}{1 - v^2/c^2}$ (b) $\dfrac{2d}{c}$

(c) The trip in flowing water takes a longer time interval. The swimmer travels at the low upstream speed for a longer time interval, so his average speed is reduced below c. Mathematically, $1/(1 - v^2/c^2)$ is always greater than 1. In the extreme, as $v \to c$, the time interval becomes infinite. In that case, the student can never return to the starting point because he cannot swim fast enough to overcome the river current.
53. 15.3 m
55. 54.4 m/s^2
57. The relationship between the height h and the walking speed is $h = (4.16 \times 10^{-3})v_x^2$, where h is in meters and v_x is in meters per second. At a typical walking speed of 4 to 5 km/h, the ball would have to be dropped from a height of about 1 cm, clearly much too low for a person's hand. Even at Olympic-record speed for the 100-m run (confirm on the Internet), this situation would only occur if the ball is dropped from about 0.4 m, which is also below the hand of a normally proportioned person.
59. (a) 101 m/s (b) 3.27×10^4 ft (c) 20.6 s
61. (a) 26.9 m/s (b) 67.3 m (c) $(2.00\hat{i} - 5.00\hat{j})$ m/s^2
63. (a) $(7.62\hat{i} - 6.48\hat{j})$ cm (b) $(10.0\hat{i} - 7.05\hat{j})$ cm
65. (a) 1.52 km (b) 36.1 s (c) 4.05 km
67. The initial height of the ball when struck is 3.94 m, which is too high for the batter to hit the ball.
69. (a) 1.69 km/s (b) 1.80 h
71. (a) 46.5 m/s (b) −77.6° (c) 6.34 s
73. (a) $x = v_i(0.164\,3 + 0.002\,299v_i^2)^{1/2} + 0.047\,94v_i^2$, where x is in meters and v_i is in meters per second (b) 0.041 0 m (c) 961 m (d) $x \approx 0.405v_i$ (e) $x \approx 0.095\,9v_i^2$ (f) The graph of x versus v_i starts from the origin as a straight line with slope 0.405 s. Then it curves upward above this tangent line, becoming closer and closer to the parabola $x = 0.095\,9v_i^2$, where x is in meters and v_i is in meters per second.
75. (a) 6.80 km (b) 3.00 km vertically above the impact point (c) 66.2°
77. (a) 20.0 m/s (b) 5.00 s (c) $(16.0\hat{i} - 27.1\hat{j})$ m/s (d) 6.53 s (e) $24.5\hat{i}$ m
79. (a) 4.00 km/h (b) 4.00 km/h
81. (a) 43.2 m (b) $(9.66\hat{i} - 25.6\hat{j})$ m/s (c) Air resistance would ordinarily make the jump distance smaller and the final horizontal and vertical velocity components both somewhat smaller. If a skilled jumper shapes her body into an airfoil, however, she can deflect downward the air through which she passes so that it deflects her upward, giving her more time in the air and a longer jump.
83. (a) swim perpendicular to the banks (b) 133 m (c) 53.1° (d) 107 m
85. 33.5° below the horizontal
87. $\tan^{-1}\left(\dfrac{\sqrt{2gh}}{v}\right)$
89. Safe distances are less than 270 m or greater than 3.48×10^3 m from the western shore.

Chapter 5

Answers to Quick Quizzes

1. (d)
2. (a)
3. (d)
4. (b)
5. **(i)** (c) **(ii)** (a)
6. (b)
7. (b) Pulling up on the rope decreases the normal force, which, in turn, decreases the force of kinetic friction.

Answers to Odd-Numbered Problems

1. (a) 534 N (b) 54.5 kg
3. (a) $(6.00\hat{i} + 15.0\hat{j})$ N (b) 16.2 N
5. (a) $(2.50\hat{i} + 5.00\hat{j})$ N (b) 5.59 N
7. 2.58 N
9. (a) 1.53 m (b) 24.0 N forward and upward at 5.29° with the horizontal
11. (a) 3.64×10^{-18} N (b) 8.93×10^{-30} N is 408 billion times smaller
13. (a) force exerted by spring on hand, to the left; force exerted by spring on wall, to the right (b) force exerted

by wagon on handle, downward to the left; force exerted by wagon on planet, upward; force exerted by wagon on ground, downward (c) force exerted by football on player, downward to the right; force exerted by football on planet, upward (d) force exerted by small-mass object on large-mass object, to the left (e) force exerted by negative charge on positive charge, to the left (f) force exerted by iron on magnet, to the left

15. (a) $(-45.0\hat{\mathbf{i}} + 15.0\hat{\mathbf{j}})$ m/s (b) 162° from the $+x$ axis (c) $(-225\hat{\mathbf{i}} + 75.0\hat{\mathbf{j}})$ m (d) $(-227\hat{\mathbf{i}} + 79.0\hat{\mathbf{j}})$ m

17. (a) $t = \sqrt{\frac{2h}{g}}$ (b) $a_x = \frac{F}{m}$ (c) $x = \frac{Fh}{mg}$ (d) $a = \sqrt{(F/m)^2 + g^2}$

19. (a) 5.00 m/s² at 36.9° (b) 6.08 m/s² at 25.3°

21. (a) 15.0 lb up (b) 5.00 lb up (c) 0

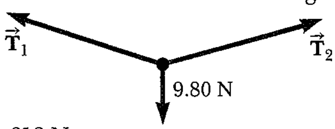
23. (a) 2.15×10^3 N forward (b) 645 N forward (c) 645 N toward the rear (d) 1.02×10^4 N at 74.1° below the horizontal and rearward

25. (a) 3.43 kN (b) 0.967 m/s horizontally forward

27. (a) $P\cos 40° - n = 0$ and $P\sin 40° - 220\text{ N} = 0$; $P = 342$ N and $n = 262$ N (b) $P - n\cos 40° - (220\text{ N})\sin 40° = 0$ and $n\sin 40 - (220\text{ N})\cos 40° = 0$; $n = 262$ N and $P = 342$ N (c) The results agree. The methods are of the same level of difficulty. Each involves one equation in one unknown and one equation in two unknowns. If we are interested in finding n without finding P, method (b) is simpler.

29. (a) 7.0 m/s² horizontal and to the right (b) 21 N (c) 14 N horizontal and to the right

31. (a)



(b) 613 N

33. $T_1 = 253$ N, $T_2 = 165$ N, $T_3 = 325$ N

35. 100 N and 204 N

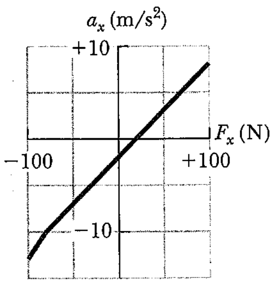
37. 8.66 N east

39. (a) $a = g\tan\theta$ (b) 4.16 m/s²

41. (a) 646 N up (b) 646 N up (c) 627 N up (d) 589 N up

43. (a) $T_1 = 79.8$ N, $T_2 = 39.9$ N (b) 2.34 m/s²

45. (a) $F_x > 19.6$ N (b) $F_x \leq -78.4$ N (c)



47. 3.73 m

49. (a) 2.20 m/s² (b) 27.4 N

51. (a) 706 N (b) 814 N (c) 706 N (d) 648 N

53. 1.76 kN to the left

55. (a) 0.306 (b) 0.245

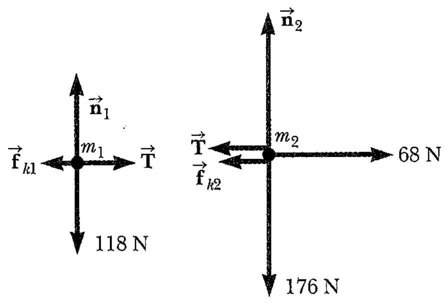
57. $\mu_s = 0.727$, $\mu_k = 0.577$

59. (a) 1.11 s (b) 0.875 s

61. (a) 1.78 m/s² (b) 0.368 (c) 9.37 N (d) 2.67 m/s

63. 37.8 N

65. (a)



(b) 1.29 m/s² to the right (c) 27.2 N

67. 6.84 m

69. 0.060 0 m

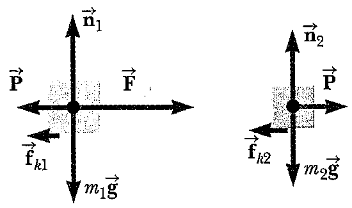
71. (a) 0.087 1 (b) 27.4 N

73. (a) Removing mass (b) 13.7 mi/h · s

75. (a) $a = -\mu_k g$ (b) $d = \frac{v_i^2}{2\mu_k g}$

77. (a) 2.22 m (b) 8.74 m/s down the incline

79. (a)

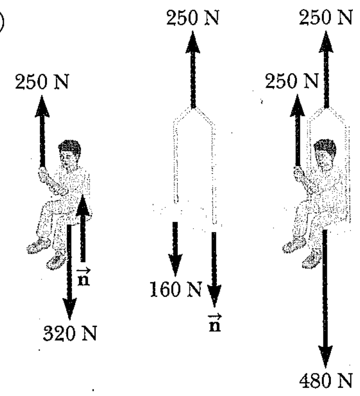


(b) F (c) $F - P$ (d) P (e) m_1: $F - P = m_1 a$; m_2: $P = m_2 a$

(f) $a = \frac{F - \mu_1 m_1 g - \mu_2 m_2 g}{m_1 + m_2}$

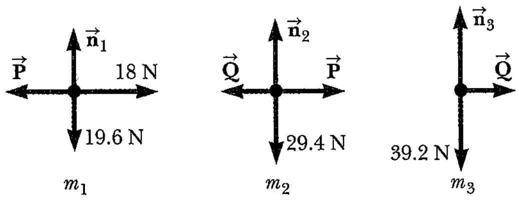
(g) $P = \frac{m_2}{m_1 + m_2}[F + m_1(\mu_2 - \mu_1)g]$

81. (a)



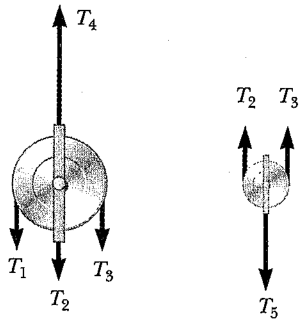
(b) 0.408 m/s² (c) 83.3 N

83. (a)



(b) 2.00 m/s² to the right (c) 4.00 N on m_1, 6.00 N right on m_2, 8.00 N right on m_3 (d) 14.0 N between m_1 and m_2, 8.00 N between m_2 and m_3 (e) The m_2 block models the heavy block of wood. The contact force on your back is modeled by the force between the m_2 and the m_3 blocks, which is much less than the force F. The difference between F and this contact force is the net force causing the acceleration of the 5-kg pair of objects. The acceleration is real and nonzero, but it lasts for so short a time that it is never associated with a large velocity. The frame of the building and your legs exert forces, small in magnitude relative to the hammer blow, to bring the partition, block, and you to rest again over a time interval large relative to the hammer blow.

85. (a) *Upper pulley:* *Lower pulley:*



(b) $Mg/2$, $Mg/2$, $Mg/2$, $3Mg/2$, Mg (c) $Mg/2$

87. $\mu_k = 0.287$

89. (b) If θ is greater than $\tan^{-1}(1/\mu_s)$, motion is impossible.

91. (a) The net force on the cushion is in a fixed direction, downward and forward making angle $\tan^{-1}(F/mg)$ with the vertical. Starting from rest, it will move along this line with (b) increasing speed. Its velocity changes in magnitude. (c) 1.63 m (d) It will move along a parabola. The axis of the parabola is parallel to the line described in part (a). If the cushion is thrown in a direction above this line, its path will be concave downward, making its velocity become more and more nearly parallel to the line over time. If the cushion is thrown down more steeply, its path will be concave upward, again making its velocity turn toward the fixed direction of its acceleration.

93. $(M + m_1 + m_2)(m_1 g/m_2)$

95. (a) 30.7° (b) 0.843 N

97. 72.0 N

99. (a) 0.931 m/s² (b) From a value of 0.625 m/s² for large x, the acceleration gradually increases, passes through a maximum, and then drops more rapidly, becoming negative and reaching −2.10 m/s² at $x = 0$. (c) 0.976 m/s² at $x = 25.0$ cm (d) 6.10 cm

101. (a) 4.90 m/s² (b) 3.13 m/s at 30.0° below the horizontal (c) 1.35 m (d) 1.14 s (e) The mass of the block makes no difference.

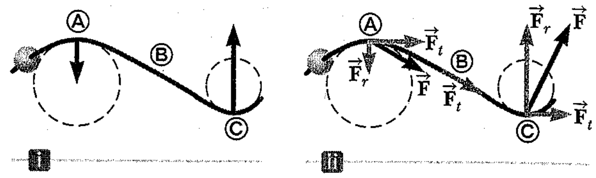
103. (a) 2.13 s (b) 1.66 m

Chapter 6

Answers to Quick Quizzes

1. **(i)** (a) **(ii)** (b)

2. **(i)** Because the speed is constant, the only direction the force can have is that of the centripetal acceleration. The force is larger at Ⓒ than at Ⓐ because the radius at Ⓒ is smaller. There is no force at Ⓑ because the wire is straight. **(ii)** In addition to the forces in the centripetal direction in part (a), there are now tangential forces to provide the tangential acceleration. The tangential force is the same at all three points because the tangential acceleration is constant.



3. (c)

4. (a)

Answers to Odd-Numbered Problems

1. any speed up to 8.08 m/s

3. (a) 8.33×10^{-8} N toward the nucleus (b) 9.15×10^{22} m/s² inward

5. 6.22×10^{-12} N

7. 2.14 rev/min

9. (a) static friction (b) 0.085 0

11. $v \le 14.3$ m/s

13. (a) 1.33 m/s² (b) 1.79 m/s² at 48.0° inward from the direction of the velocity

15. (a) $v = \sqrt{R\left(\frac{2T}{m} - g\right)}$ (b) $2T$ up

17. (a) 8.62 m (b) Mg, downward (c) 8.45 m/s² (d) Calculation of the normal force shows it to be negative, which is impossible. We interpret it to mean that the normal force goes to zero at some point and the passengers will fall out of their seats near the top of the ride if they are not restrained in some way. We could arrive at this same result without calculating the normal force by noting that the acceleration in part (c) is smaller than that due to gravity. The teardrop shape has the advantage of a larger acceleration of the riders at the top of the arc for a path having the same height as the circular path, so the passengers stay in the cars.

19. No. The archeologist needs a vine of tensile strength equal to or greater than 1.38 kN to make it across.

21. (a) 17.0° (b) 5.12 N

23. (a) 491 N (b) 50.1 kg (c) 2.00 m/s²

25. 0.527°

27. 0.212 m/s², opposite the velocity vector

29. 3.01 N up

31. (a) 1.47 N · s/m (b) 2.04×10^{-3} s (c) 2.94×10^{-2} N

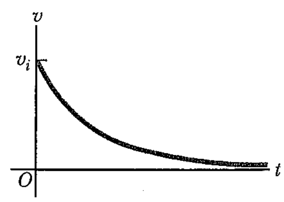
35. (a) 0.034 7 s⁻¹ (b) 2.50 m/s (c) $a = -cv$

37. (a) At Ⓐ, the velocity is eastward and the acceleration is southward. (b) At Ⓑ, the velocity is southward and the acceleration is westward.

39. 781 N

41. (a) $mg - \frac{mv^2}{R}$ (b) $\sqrt{gR}$

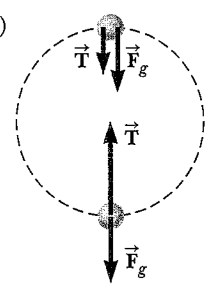
43. (a) $v = v_i e^{-bt/m}$ (b)



(c) In this model, the object keeps moving forever. (d) It travels a finite distance in an infinite time interval.

45. (a) the downward gravitational force and the tension force in the string, always directed toward the center of the path

(b)



(c) 6.05 N (d) 7.82 m/s

47. (a) 106 N up the incline (b) 0.396

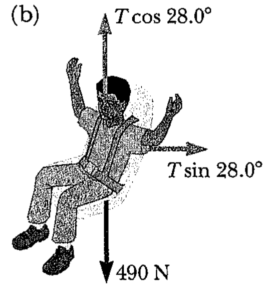
49. (a) 0.016 2 kg/m (b) $\frac{1}{2}D\rho A$ (c) 0.778 (d) 1.5% (e) For nested coffee filters falling in air at terminal speed, the graph of air resistance force as a function of the square of speed demonstrates that the force is proportional to the speed squared, within the experimental uncertainty estimated as 2%. This proportionality agrees with the theoretical model of air resistance at high speeds. The drag coefficient of a coffee filter is $D = 0.78 \pm 2\%$.

51. $g(\cos\phi\tan\theta - \sin\phi)$

53. (a) The only horizontal force on the car is the force of friction, with a maximum value determined by the surface roughness (described by the coefficient of static friction) and the normal force (here equal to the gravitational force on the car). (b) 34.3 m (c) 68.6 m (d) Braking is better. You should not turn the wheel. If you used any of the available friction force to change the direction of the car, it would be unavailable to slow the car and the stopping distance would be greater. (e) The conclusion is true in general. The radius of the curve you can barely make is twice your minimum stopping distance.

55. (a) 735 N (b) 732 N (c) The gravitational force is larger. The normal force is smaller, just like it is when going over the top of a Ferris wheel.

57. (a) 5.19 m/s (b)



(c) 555 N

59. (b) The gravitational and friction forces remain constant, the normal force increases, and the person remains in motion with the wall. (c) The gravitational force remains constant, the normal and friction forces decrease, and the person slides relative to the wall and downward into the pit.

61. (a) $v_{\min} = \sqrt{\dfrac{Rg(\tan\theta - \mu_s)}{1 + \mu_s\tan\theta}}$, $v_{\max} = \sqrt{\dfrac{Rg(\tan\theta + \mu_s)}{1 - \mu_s\tan\theta}}$

(b) $\mu_s = \tan\theta$

63. 12.8 N

65. (a) 78.3 m/s (b) 11.1 s (c) 121 m

67. (a) 8.04 s (b) 379 m/s (c) 1.19×10^{-2} m/s (d) 9.55 cm

69. (a) 0.013 2 m/s (b) 1.03 m/s (c) 6.87 m/s

Chapter 7

Answers to Quick Quizzes

1. (a)
2. (c), (a), (d), (b)
3. (d)
4. (a)
5. (b)
6. (c)
7. (i) (c) (ii) (a)
8. (d)

Answers to Odd-Numbered Problems

1. (a) 1.59×10^3 J (b) smaller (c) the same

3. (a) 472 J (b) 2.76 kN

5. (a) 31.9 J (b) 0 (c) 0 (d) 31.9 J

9. 16.0

11. (a) 16.0 J (b) 36.9°

13. $\vec{A} = 7.05$ m at 28.4°

15. (a) 7.50 J (b) 15.0 J (c) 7.50 J (d) 30.0 J

17. (a) 0.938 cm (b) 1.25 J

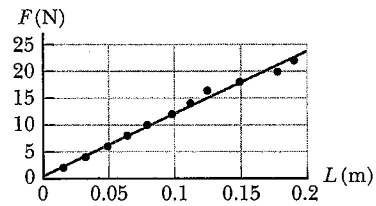
19. (a) 575 N/m (b) 46.0 J

21. (a) $x = mg\left(\dfrac{1}{k_1} + \dfrac{1}{k_2}\right)$ (b) $k = \left(\dfrac{1}{k_1} + \dfrac{1}{k_2}\right)^{-1}$

23. (a) Design the spring constant so that the weight of one tray removed from the pile causes an extension of the springs equal to the thickness of one tray. (b) 316 N/m (c) We do not need to know the length and width of the tray.

25. (b) mgR

27. (a)



(b) The slope of the line is 116 N/m. (c) We use all the points listed and also the origin. There is no visible evidence for a bend in the graph or nonlinearity near either end. (d) 116 N/m (e) 12.7 N

29. 50.0 J

31. (a) 60.0 J (b) 60.0 J

33. (a) 1.20 J (b) 5.00 m/s (c) 6.30 J

35. 878 kN up

37. (a) 4.56 kJ (b) 4.56 kJ (c) 6.34 kN (d) 422 km/s^2 (e) 6.34 kN (f) The two theories agree.

39. (a) 97.8 J (b) $(-4.31\hat{\imath} + 31.6\hat{\jmath})$ N (c) 8.73 m/s

41. (a) 2.5 J (b) −9.8 J (c) −12 J

43. (a) −196 J (b) −196 J (c) −196 J (d) The gravitational force is conservative.

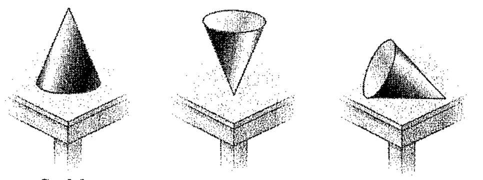
45. (a) 125 J (b) 50.0 J (c) 66.7 J (d) nonconservative (e) The work done on the particle depends on the path followed by the particle.

47. A/r^2 away from the other particle

49. $(7 - 9x^2y)\hat{\imath} - (3x^3)\hat{\jmath}$

51. (a) 40.0 J (b) −40.0 J (c) 62.5 J

53.



55. 90.0 J

57. (a) 8×10^7 N/m (b) It lasts for a time interval. If the interaction occupied no time interval, the force exerted by each ball on the other would be infinite, and that cannot happen. (c) 0.8 J (d) 0.15 mm (e) 10^{-4} s

59. 0.299 m/s

61. (a) $\vec{\mathbf{F}}_1 = (20.5\hat{\mathbf{i}} + 14.3\hat{\mathbf{j}})$ N, $\vec{\mathbf{F}}_2 = (-36.4\hat{\mathbf{i}} + 21.0\hat{\mathbf{j}})$ N
(b) $\sum \vec{\mathbf{F}} = (-15.9\hat{\mathbf{i}} + 35.3\hat{\mathbf{j}})$ N
(c) $\vec{\mathbf{a}} = (-3.18\hat{\mathbf{i}} + 7.07\hat{\mathbf{j}})$ m/s^2
(d) $\vec{\mathbf{v}} = (-5.54\hat{\mathbf{i}} + 23.7\hat{\mathbf{j}})$ m/s
(e) $\vec{\mathbf{r}} = (-2.30\hat{\mathbf{i}} + 39.3\hat{\mathbf{j}})$ m (f) 1.48 kJ (g) 1.48 kJ
(h) The work–kinetic energy theorem is consistent with Newton's second law.

63. 0.131 m

65. (a) $U(x) = 1 + 4e^{-2x}$ (b) The force must be conservative because the work the force does on the particle on which it acts depends only on the original and final positions of the particle, not on the path between them.

67. (a) $x = 3.62m/(4.30 - 23.4m)$, where x is in meters and m is in kilograms (b) 0.095 1 m (c) 0.492 m (d) 6.85 m (e) The situation is impossible. (f) The extension is directly proportional to m when m is only a few grams. Then it grows faster and faster, diverging to infinity for $m = 0.184$ kg.

Chapter 8

Answers to Quick Quizzes

1. (a) For the television set, energy enters by electrical transmission (through the power cord). Energy leaves by heat (from hot surfaces into the air), mechanical waves (sound from the speaker), and electromagnetic radiation (from the screen). (b) For the gasoline-powered lawn mower, energy enters by matter transfer (gasoline). Energy leaves by work (on the blades of grass), mechanical waves (sound), and heat (from hot surfaces into the air). (c) For the hand-cranked pencil sharpener, energy enters by work (from your hand turning the crank). Energy leaves by work (done on the pencil), mechanical waves (sound), and heat due to the temperature increase from friction.

2. **(i)** (b) **(ii)** (b) **(iii)** (a)

3. (a)

4. $v_1 = v_2 = v_3$

5. (c)

Answers to Odd-Numbered Problems

1. (a) $\Delta E_{\text{int}} = Q + T_{\text{ET}} + T_{\text{ER}}$
(b) $\Delta K + \Delta U + \Delta E_{\text{int}} = W + Q + T_{\text{MW}} + T_{\text{MT}}$
(c) $\Delta U = Q + T_{\text{MT}}$ (d) $0 = Q + T_{\text{MT}} + T_{\text{ET}} + T_{\text{ER}}$

3. 10.2 m

5. (a) $v = (3gR)^{1/2}$ (b) 0.098 0 N down

7. (a) 4.43 m/s (b) 5.00 m

9. 5.49 m/s

11. $\sqrt{\dfrac{8gh}{15}}$

13. $\dfrac{v^2}{2\mu_k g}$

15. (a) 0.791 m/s (b) 0.531 m/s

17. (a) 5.60 J (b) 2.29 rev

19. (a) 168 J

21. (a) 1.40 m/s (b) 4.60 cm after release (c) 1.79 m/s

23. (a) −160 J (b) 73.5 J (c) 28.8 N (d) 0.679

25. (a) 4.12 m (b) 3.35 m

27. (a) Isolated. The only external influence on the system is the normal force from the slide, but this force is always perpendicular to its displacement so it performs no work on the system. (b) No, the slide is frictionless. (c) $E_{\text{system}} = mgh$ (d) $E_{\text{system}} = \frac{1}{5}mgh + \frac{1}{2}mv_i^2$
(e) $E_{\text{system}} = mgy_{\text{max}} + \frac{1}{2}mv_{xi}^2$
(f) $v_i = \sqrt{\dfrac{8gh}{5}}$ (g) $y_{\text{max}} = h(1 - \frac{4}{5}\cos^2\theta)$ (h) If friction is present, mechanical energy of the system would *not* be conserved, so the child's kinetic energy at all points after leaving the top of the waterslide would be reduced when compared with the frictionless case. Consequently, her launch speed and maximum height would be reduced as well.

29. 1.23 kW

31. 4.5×10^3 N

33. $145

35. $\sim 10^4$ W

37. (a) 423 mi/gal (b) 776 mi/gal

39. 236 s or 3.93 min

41. (a) 10.2 kW (b) 10.6 kW (c) 5.82 MJ

43. (a) 0.588 J (b) 0.588 J (c) 2.42 m/s
(d) $K = 0.196$ J, $U = 0.392$ J

45. $H = h + \dfrac{d^2}{4h}$

47. (a) $K = 2 + 24t^2 + 72t^4$, where t is in seconds and K is in joules (b) $a = 12t$ and $F = 48t$, where t is in seconds, a is in m/s^2, and F is in newtons (c) $P = 48t + 288t^3$, where t is in seconds and P is in watts (d) 1.25×10^3 J

49. (a) 11.1 m/s (b) 1.00×10^3 J (c) 1.35 m

51. (a) -6.08×10^3 J (b) -4.59×10^3 J (c) 4.59×10^3 J

53. (a) $x = -4.0$ mm (b) −1.0 cm

55. (a) 2.17 kW (b) 58.6 kW

57. (a) 1.38×10^4 J (b) 5.51×10^3 W
(c) The value in part (b) represents only energy that leaves the engine and is transformed to kinetic energy of the car. Additional energy leaves the energy by sound and heat. More energy leaves the engine to do work against friction forces and air resistance.

59. (a) 1.53 J at $x = 6.00$ cm, 0 J at $x = 0$ (b) 1.75 m/s (c) 1.51 m/s (d) The answer to part (c) is not half the answer to part (b) because the equation for the speed of an oscillator is not linear in position

61. (a) 100 J (b) 0.410 m (c) 2.84 m/s (d) −9.80 mm (e) 2.85 m/s

63. 0.328

65. (a) 0.400 m (b) 4.10 m/s (c) The block stays on the track.

67. 33.4 kW

69. $2m$

71. 2.92 m/s
75. (b) 0.342
77. (a) 14.1 m/s (b) 800 N (c) 771 N (d) 1.57 kN up
79. (a) $-\mu_k gx/L$ (b) $(\mu_k gL)^{1/2}$
81. (a) 6.15 m/s (b) 9.87 m/s
83. less dangerous
85. (a) 25.8 m (b) 27.1 m/s^2

Chapter 9

Answers to Quick Quizzes

1. (d)
2. (b), (c), (a)
3. (i) (c), (e) (ii) (b), (d)
4. (a) All three are the same. (b) dashboard, seat belt, air bag
5. (a)
6. (b)
7. (b)
8. (i) (a) (ii) (b)

Answers to Odd-Numbered Problems

1. (b) $p = \sqrt{2mK}$
3. 7.00 N
5. $\vec{\mathbf{F}}_{\text{on bat}} = (+3.26\hat{\mathbf{i}} - 3.99\hat{\mathbf{j}})$ kN
7. (a) $\vec{\mathbf{v}}_{pi} = -\left(\dfrac{m_g}{m_g + m_p}\right)v_{gp}\hat{\mathbf{i}}$ (b) $\vec{\mathbf{v}}_{gi} = \left(\dfrac{m_p}{m_g + m_p}\right)v_{gp}\hat{\mathbf{i}}$
9. 40.5 g
11. (a) $-6.00\hat{\mathbf{i}}$ m/s (b) 8.40 J (c) The original energy is in the spring. (d) A force had to be exerted over a displacement to compress the spring, transferring energy into it by work. The cord exerts force, but over no displacement. (e) System momentum is conserved with the value zero. (f) The forces on the two blocks are internal forces, which cannot change the momentum of the system; the system is isolated. (g) Even though there is motion afterward, the final momenta are of equal magnitude in opposite directions, so the final momentum of the system is still zero.
13. (a) 13.5 N · s (b) 9.00 kN
15. (c) no difference
17. (a) 9.60×10^{-2} s (b) 3.65×10^5 N (c) 26.6g
19. (a) $12.0\hat{\mathbf{i}}$ N · s (b) $4.80\hat{\mathbf{i}}$ m/s (c) $2.80\hat{\mathbf{i}}$ m/s (d) $2.40\hat{\mathbf{i}}$ N
21. 16.5 N
23. 301 m/s
25. (a) 2.50 m/s (b) 37.5 kJ
27. (a) 0.284 (b) 1.15×10^{-13} J and 4.54×10^{-14} J
29. (a) 4.85 m/s (b) 8.41 m
31. 91.2 m/s
33. 0.556 m
35. (a) 1.07 m/s at −29.7° (b) $\dfrac{\Delta K}{K_i} = -0.318$
37. $(3.00\hat{\mathbf{i}} - 1.20\hat{\mathbf{j}})$ m/s
39. $v_O = v_i \cos\theta$, $v_Y = v_i \sin\theta$
41. 2.50 m/s at −60.0°
43. (a) $(-9.33\hat{\mathbf{i}} - 8.33\hat{\mathbf{j}})$ Mm/s (b) 439 fJ
45. $\vec{\mathbf{r}}_{\text{CM}} = (0\hat{\mathbf{i}} + 1.00\hat{\mathbf{j}})$ m
47. 3.57×10^8 J
49. (a) 15.9 g (b) 0.153 m
51. (a) $(1.40\hat{\mathbf{i}} + 2.40\hat{\mathbf{j}})$ m/s (b) $(7.00\hat{\mathbf{i}} + 12.0\hat{\mathbf{j}})$ kg · m/s
53. 0.700 m
55. (a) $\vec{\mathbf{v}}_{1f} = -0.780\hat{\mathbf{i}}$ m/s, $\vec{\mathbf{v}}_{2f} = 1.12\hat{\mathbf{i}}$ m/s
(b) $\vec{\mathbf{v}}_{\text{CM}} = 0.360\,\hat{\mathbf{i}}$ m/s before and after the collision
57. (b) The bumper continues to exert a force to the left until the particle has swung down to its lowest point.
59. (a) $\sqrt{\dfrac{F(2d - \ell)}{2m}}$ (b) $\dfrac{F\ell}{2}$
61. 15.0 N in the direction of the initial velocity of the exiting water stream.
63. (a) 442 metric tons (b) 19.2 metric tons (c) It is much less than the suggested value of 442/2.50. Mathematically, the logarithm in the rocket propulsion equation is not a linear function. Physically, a higher exhaust speed has an extra-large cumulative effect on the rocket body's final speed by counting again and again in the speed the body attains second after second during its burn.
65. (a) zero (b) $\dfrac{mv_i}{\sqrt{2}}$ upward
67. 260 N normal to the wall
69. (a) $1.33\hat{\mathbf{i}}$ m/s (b) $-235\hat{\mathbf{i}}$ N (c) 0.680 s (d) $-160\hat{\mathbf{i}}$ N · s and $+160\hat{\mathbf{i}}$ N · s (e) 1.81 m (f) 0.454 m (g) −427 J (h) +107 J (i) The change in kinetic energy of one member of the system, according to Equation 8.2, will be equal to the negative of the change in internal energy for that member: $\Delta K = -\Delta E_{\text{int}}$. The change in internal energy, in turn, is the product of the friction force and the distance through which the member moves. Equal friction forces act on the person and the cart, but the forces move through different distances, as we see in parts (e) and (f). Therefore, there are different changes in internal energy for the person and the cart and, in turn, different changes in kinetic energy. The total change in kinetic energy of the system, −320 J, becomes +320 J of extra internal energy in the entire system in this perfectly inelastic collision.
71. (a) Momentum of the bullet–block system is conserved in the collision, so you can relate the speed of the block and bullet immediately after the collision to the initial speed of the bullet. Then, you can use conservation of mechanical energy for the bullet–block–Earth system to relate the speed after the collision to the maximum height. (b) 521 m/s upward
73. $2v_i$ for the particle with mass m and 0 for the particle with mass $3m$.
75. (a) $\dfrac{m_1v_1 + m_2v_2}{m_1 + m_2}$ (b) $(v_1 - v_2)\sqrt{\dfrac{m_1m_2}{k(m_1 + m_2)}}$
(c) $v_{1f} = \dfrac{(m_1 - m_2)v_1 + 2m_2v_2}{m_1 + m_2}$,
$v_{2f} = \dfrac{2m_1v_1 + (m_2 - m_1)v_2}{m_1 + m_2}$
77. m_1: 13.9 m m_2: 0.556 m
79. 0.960 m
81. 143 m/s
83. (a) 0; inelastic (b) $(-0.250\hat{\mathbf{i}} + 0.75\hat{\mathbf{j}} - 2.00\hat{\mathbf{k}})$ m/s; perfectly inelastic (c) either $a = -6.74$ with $\vec{\mathbf{v}} = -0.419\,\hat{\mathbf{k}}$ m/s or $a = 2.74$ with $\vec{\mathbf{v}} = -3.58\,\hat{\mathbf{k}}$ m/s
85. 0.403
87. (a) $-0.256\hat{\mathbf{i}}$ m/s and $0.128\hat{\mathbf{i}}$ m/s
(b) $-0.064\,2\hat{\mathbf{i}}$ m/s and 0 (c) 0 and 0
89. (a) 100 m/s (b) 374 J

91. (a) 2.67 m/s (incident particle), 10.7 m/s (target particle) (b) −5.33 m/s (incident particle), 2.67 m/s (target particle) (c) 7.11×10^{-3} J in case (a) and 2.84×10^{-2} J in case (b). The incident particle loses more kinetic energy in case (a), in which the target mass is 1.00 g.

93. (a) particle of mass m: $\sqrt{2}v_i$; particle of mass $3m$: $\sqrt{\frac{2}{3}}v_i$ (b) 35.3°

95. (a) $v_{\text{CM}} = \sqrt{\dfrac{F}{2m}(x_1 + x_2)}$

(b) $\theta = \cos^{-1}\left[1 - \dfrac{F}{2mgL}(x_1 - x_2)\right]$

Chapter 10

Answers to Quick Quizzes

1. (i) (c) (ii) (b)
2. (b)
3. (i) (b) (ii) (a)
4. (i) (b) (ii) (a)
5. (b)
6. (a)
7. (b)

Answers to Odd-Numbered Problems

1. (a) 7.27×10^{-5} rad/s (b) Because of its angular speed, the Earth bulges at the equator.

3. (a) 5.00 rad, 10.0 rad/s, 4.00 rad/s^2 (b) 53.0 rad, 22.0 rad/s, 4.00 rad/s^2

5. (a) 4.00 rad/s^2 (b) 18.0 rad

7. (a) 5.24 s (b) 27.4 rad

9. (a) 8.21×10^2 rad/s^2 (b) 4.21×10^3 rad

11. 13.7 rad/s^2

13. 3.10 rad/s

15. (a) 0.180 rad/s (b) 8.10 m/s^2 radially inward

17. (a) 25.0 rad/s (b) 39.8 rad/s^2 (c) 0.628 s

19. (a) 8.00 rad/s (b) 8.00 m/s (c) 64.1 m/s^2 at an angle 3.58° from the radial line to point P (d) 9.00 rad

21. (a) 126 rad/s (b) 3.77 m/s (c) 1.26 km/s^2 (d) 20.1 m

23. 0.572

25. (a) 3.47 rad/s (b) 1.74 m/s (c) 2.78 s (d) 1.02 rotations

27. −3.55 N · m

29. 21.5 N

31. 177 N

33. (a) 24.0 N · m (b) 0.035 6 rad/s^2 (c) 1.07 m/s^2

35. (a) 21.6 kg · m^2 (b) 3.60 N · m (c) 52.5 rev

37. 0.312

39. (a) 5.80 kg · m^2 (b) Yes, knowing the height of the door is unnecessary.

41. 1.28 kg · m^2

43. $\frac{11}{12}mL^2$

45. (a) 143 kg · m^2 (b) 2.57 kJ

47. (a) 24.5 m/s (b) no (c) no (d) no (e) no (f) yes

49. 1.03×10^{-3} J

51. 149 rad/s

53. (a) 1.59 m/s (b) 53.1 rad/s

55. (a) 11.4 N (b) 7.57 m/s^2 (c) 9.53 m/s (d) 9.53 m/s

57. (a) $2(Rg/3)^{1/2}$ (b) $4(Rg/3)^{1/2}$ (c) $(Rg)^{1/2}$

59. (a) 500 J (b) 250 J (c) 750 J

61. (a) $\frac{2}{3}g\sin\theta$ (b) The acceleration of $\frac{1}{2}g\sin\theta$ for the hoop is smaller than that for the disk. (c) $\frac{1}{3}\tan\theta$

63. (a) The disk (b) disk: $\sqrt{\frac{4}{3}gh}$; hoop: $\sqrt{gh}$

65. (a) 1.21×10^{-4} kg · m^2 (b) Knowing the height of the can is unnecessary. (c) The mass is not uniformly distributed; the density of the metal can is larger than that of the soup.

67. (a) 4.00 J (b) 1.60 s (c) 0.80 m

69. (a) 12.5 rad/s (b) 128 rad

71. (a) 0.496 W (b) 413 W

73. (a) $(3g/L)^{1/2}$ (b) $3g/2L$ (c) $-\frac{3}{2}g\hat{\mathbf{i}} - \frac{3}{4}g\hat{\mathbf{j}}$ (d) $-\frac{3}{2}Mg\hat{\mathbf{i}} + \frac{1}{4}Mg\hat{\mathbf{j}}$

75. $\dfrac{g(h_2 - h_1)}{2\pi R^2}$

77. (a) Particle under a net force (b) Rigid object under a net torque (c) 118 N (d) 156 N (e) $\dfrac{r^2}{a}(T_2 - T_1)$ (f) 1.17 kg · m^2

79. $\omega = \sqrt{\dfrac{2mgd\sin\theta + kd^2}{I + mR^2}}$

81. $\sqrt{\dfrac{10}{7}\left[\dfrac{g(R - r)(1 - \cos\theta)}{r^2}\right]}$

83. (a) $2.70R$ (b) $F_x = -20mg/7$, $F_y = -mg$

85. (a) $\sqrt{\frac{3}{4}gh}$ (b) $\sqrt{\frac{3}{4}gh}$

87. (a) 0.800 m/s^2 (b) 0.400 m/s^2 (c) 0.600 N, 0.200 N forward

89. (a) $\sigma = 0.060\,2\ \text{s}^{-1}$, $\omega_0 = 3.50$ rad/s (b) $\alpha = -0.176$ rad/s^2 (c) 1.29 rev (d) 9.26 rev

91. (b) to the left

93. (a) 2.88 s (b) 12.8 s

Chapter 11

Answers to Quick Quizzes

1. (d)
2. (i) (a) (ii) (c)
3. (b)
4. (a)

Answers to Odd-Numbered Problems

1. $\hat{\mathbf{i}} + 8.00\hat{\mathbf{j}} + 22.0\hat{\mathbf{k}}$

3. (a) $7.00\hat{\mathbf{k}}$ (b) 60.3°

5. (a) 30 N · m (counterclockwise) (b) 36 N · m (counterclockwise)

7. 45.0°

9. (a) $F_3 = F_1 + F_2$ (b) no

11. $17.5\hat{\mathbf{k}}$ kg · m^2/s

13. $m(xv_y - yv_x)\hat{\mathbf{k}}$

15. (a) zero (b) $(-mv_i^3\sin^2\theta\cos\theta/2g)\hat{\mathbf{k}}$ (c) $(-2mv_i^3\sin^2\theta\cos\theta/g)\hat{\mathbf{k}}$ (d) The downward gravitational force exerts a torque on the projectile in the negative z direction.

17. $mvR[\cos(vt/R) + 1]\hat{\mathbf{k}}$

19. $60.0\hat{\mathbf{k}}$ kg · m^2/s

21. (a) $-m\ell gt\cos\theta\,\hat{\mathbf{k}}$ (b) The Earth exerts a gravitational torque on the ball. (c) $-mg\ell\cos\theta\,\hat{\mathbf{k}}$

23. 1.20 kg · m^2/s

25. (a) 0.360 kg · m^2/s (b) 0.540 kg · m^2/s

27. (a) 0.433 kg · m^2/s (b) 1.73 kg · m^2/s

29. (a) 1.57×10^8 kg · m^2/s (b) 6.26×10^3 s = 1.74 h

31. 7.14 rev/min

33. (a) The mechanical energy of the system is not constant. Some chemical energy is converted into mechanical energy. (b) The momentum of the system is not constant. The turntable bearing exerts an external northward force on the axle. (c) The angular momentum of the system is constant. (d) 0.360 rad/s counterclockwise (e) 99.9 J

35. (a) 11.1 rad/s counterclockwise (b) No; 507 J is transformed into internal energy. (c) No; the turntable bearing promptly imparts impulse 44.9 kg · m/s north into the turntable–clay system and thereafter keeps changing the system momentum.

37. (a) $mv\ell$ down (b) $M/(M+m)$

39. (a) $\omega = 2mv_i d/[M + 2m]R^2$ (b) No; some mechanical energy of the system changes into internal energy. (c) The momentum of the system is not constant. The axle exerts a backward force on the cylinder when the clay strikes.

41. (a) yes (b) 4.50 kg · m²/s (c) No. In the perfectly inelastic collision, kinetic energy is transformed to internal energy. (d) 0.749 rad/s (e) The total energy of the system *must* be the same before and after the collision, assuming we ignore the energy leaving by mechanical waves (sound) and heat (from the newly-warmer door to the cooler air). The kinetic energies are as follows: $K_i = 2.50 \times 10^3$ J; $K_f = 1.69$ J. Most of the initial kinetic energy is transformed to internal energy in the collision.

43. 5.46×10^{22} N · m

45. 0.910 km/s

47. 7.50×10^{-11} s

49. (a) $7md^2/3$ (b) $mgd\hat{\mathbf{k}}$ (c) $3g/7d$ counterclockwise (d) $2g/7$ upward (e) mgd (f) $\sqrt{6g/7d}$ (g) $m\sqrt{14gd^3/3}$ (h) $\sqrt{2gd/21}$

51. (a) isolated system (angular momentum) (b) $mv_i d/2$ (c) $(\frac{1}{12}M + \frac{1}{4}m)d^2$ (d) $(\frac{1}{12}M + \frac{1}{4}m)d^2\omega$ (e) $\dfrac{6mv_i}{(M+3m)d}$ (f) $\frac{1}{2}mv_i^2$ (g) $\dfrac{3m^2v_i^2}{2(M+3m)}$ (h) $-\dfrac{M}{M+3m}$

53. (a) $v_i r_i / r$ (b) $(mv_i^2 r_i^2) r^{-3}$ (c) $\frac{1}{2}mv_i^2(r_i^2/r^2 - 1)$

55. (a) 3 750 kg · m²/s (b) 1.88 kJ (c) 3 750 kg · m²/s (d) 10.0 m/s (e) 7.50 kJ (f) 5.62 kJ

57. (a) $2mv_0$ (b) $2v_0/3$ (c) $4m\ell v_0/3$ (d) $4v_0/9\ell$ (e) mv_0^2 (f) $26mv_0^2/27$ (g) No horizontal forces act on the bola from outside after release, so the horizontal momentum stays constant. Its center of mass moves steadily with the horizontal velocity it had at release. No torques about its axis of rotation act on the bola, so the angular momentum stays constant. Internal forces cannot affect momentum conservation and angular momentum conservation, but they can affect mechanical energy.

59. an increase of 6.368×10^{-4} % or 0.550 s, which is not significant

61. (a) $\frac{1}{3}\omega_i$ (b) $-\frac{2}{3}$ (c) $\dfrac{R\omega_i}{3\mu g}$ (d) $\dfrac{R^2\omega_i^2}{18\mu g}$

63. $4\sqrt{\frac{1}{3}ga(\sqrt{2}-1)}$

Chapter 12

Answers to Quick Quizzes

1. (a)
2. (b)
3. (b)
4. **(i)** (b) **(ii)** (a) **(iii)** (c)

Answers to Odd-Numbered Problems

1. $F_x - R_x = 0$, $F_y + R_y - F_g = 0$, $F_y \cos\theta - F_x \sin\theta - 0.5F_g \cos\theta = 0$

3. (3.85 cm, 6.85 cm)

5. 0.750 m

7. (2.54 m, 4.75 m)

9. 177 kg

11. Sam exerts an upward force of 176 N, and Joe exerts an upward force of 274 N.

13. (a) $f_s = 268$ N, $n = 1\,300$ N (b) 0.324

15. (a) 29.9 N (b) 22.2 N

17. (a) 1.04 kN at 60.0° upward and to the right (b) $(370\hat{\mathbf{i}} + 910\hat{\mathbf{j}})$ N

19. (a) 27.7 kN (b) 11.5 kN (c) 4.19 kN

21. (a) 859 N (b) 1.04 kN at 36.9° to the left and upward

23. 2.81 m

25. $T_1 = 501$ N, $T_2 = 672$ N, $T_3 = 384$ N

27. (a) $-0.053\,8$ m³ (b) 1.09×10^3 kg/m³ (c) With only a 5% change in volume in this extreme case, liquid water is indeed nearly incompressible in biological and student laboratory situations.

29. 23.8 μm

31. (a) 3.14×10^4 N (b) 6.28×10^4 N

33. 4.90 mm

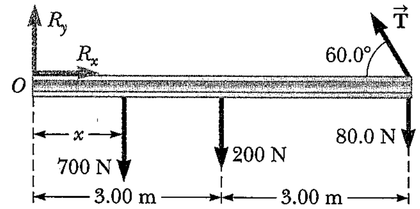
35. 0.029 2 mm

37. $n_A = 5.98 \times 10^5$ N, $n_B = 4.80 \times 10^5$ N

39. 0.896 m

41. $F_t = 724$ N, $F_s = 716$ N

43. (a)



(b) $T = 343$ N, $R_x = 171$ N to the right, $R_y = 683$ N up (c) 5.14 m

45. (a) $T = F_g(L+d)/[\sin\theta\,(2L+d)]$ (b) $R_x = F_g(L+d)\cot\theta/(2L+d)$; $R_y = F_g L/(2L+d)$

47. $\vec{\mathbf{F}}_A = (-6.47 \times 10^5\hat{\mathbf{i}} + 1.27 \times 10^5\hat{\mathbf{j}})$ N, $\vec{\mathbf{F}}_B = 6.47 \times 10^5\hat{\mathbf{i}}$ N

49. (a) 5.08 kN (b) 4.77 kN (c) 8.26 kN

51. (a) $\frac{1}{2}m\left(\dfrac{2\mu_s \sin\theta - \cos\theta}{\cos\theta - \mu_s \sin\theta}\right)$ (b) $(m+M)g\sqrt{1+\mu_s^2}$ (c) $g\sqrt{M^2 + \mu_s^2(m+M)^2}$

53. (a) 9.28 kN (b) The moment arm of the force $\vec{\mathbf{F}}_h$ is no longer 70 cm from the shoulder joint but only 49.5 cm, therefore reducing $\vec{\mathbf{F}}_m$ to 6.56 kN.

55. (a) 66.7 N (b) increasing at 0.125 N/s

57. (a) $\dfrac{1}{\sqrt{15}}\dfrac{mgd}{\ell}$ (b) $n_A = mg\left(\dfrac{2\ell - d}{2\ell}\right)$, $n_B = \dfrac{mgd}{2\ell}$ (c) $R_x = \dfrac{1}{\sqrt{15}}\dfrac{mgd}{\ell}$, $R_y = \dfrac{mgd}{2\ell}$ (to the right and downward on the right half of the ladder)

59. (a) $P_1 = P_3 = 1.67$ N, $P_2 = 3.33$ N (b) 2.36 N

61. 5.73 rad/s
63. (a) 443 N (b) 221 N (to the right), 217 N (upward)
65. 9.00 ft
67. $3F_g/8$

Chapter 13

Answers to Quick Quizzes

1. (e)
2. (c)
3. (a)
4. (a) Perihelion (b) Aphelion (c) Perihelion (d) All points

Answers to Odd-Numbered Problems

1. 7.41×10^{-10} N
3. (a) 2.50×10^{-7} N toward the 500-kg object (b) between the objects and 2.45 m from the 500-kg object
5. 2.67×10^{-7} m/s^2
7. 2.97 nN
9. 2.00 kg and 3.00 kg
11. 0.614 m/s^2, toward Earth
13. (a) 7.61 cm/s^2 (b) 363 s (c) 3.08 km (d) 28.9 m/s at 72.9° below the horizontal
15. $\frac{GM}{\ell^2}(\frac{1}{2} + \sqrt{2})$ at 45° to the positive x axis
17. 1.50 h or 90.0 min
19. (a) 0.71 yr (b) The departure must be timed so that the spacecraft arrives at the aphelion when the target planet is there.
21. 1.26×10^{32} kg
23. 35.1 AU
25. 4.99 days
27. 8.92×10^7 m
29. (a) yes (b) 3.93 yr
31. 2.82×10^9 J
33. (a) 1.84×10^9 kg/m^3 (b) 3.27×10^6 m/s^2 (c) -2.08×10^{13} J
35. (a) -1.67×10^{-14} J (b) The particles collide at the center of the triangle.
37. 1.58×10^{10} J
39. (a) 4.69×10^8 J (b) -4.69×10^8 J (c) 9.38×10^8 J
41. 1.78×10^3 m
43. (a) 850 MJ (b) 2.71×10^9 J
45. (a) 5.30×10^3 s (b) 7.79 km/s (c) 6.43×10^9 J
47. (a) same size force (b) 15.6 km/s
49. 2.52×10^7 m
51. $\omega = 0.057\,2$ rad/s or 1 rev in 110 s
53. (a) 2.43 h (b) 6.59 km/s (c) 4.74 m/s^2 toward the Earth
55. 2.25×10^{-7}
57. (a) 1.00×10^7 m (b) 1.00×10^4 m/s
59. (a) 15.3 km (b) 1.66×10^{16} kg (c) 1.13×10^4 s (d) No; its mass is so large compared with yours that you would have a negligible effect on its rotation.
61. (a) $v_1 = m_2\sqrt{\frac{2G}{d(m_1 + m_2)}}$, $v_2 = m_1\sqrt{\frac{2G}{d(m_1 + m_2)}}$, $v_{\text{rel}} = \sqrt{\frac{2G(m_1 + m_2)}{d}}$ (b) 1.07×10^{32} J and 2.67×10^{31} J
63. (a) -7.04×10^4 J (b) -1.57×10^5 J (c) 13.2 m/s
65. 7.79×10^{14} kg
67. (a) 2×10^8 yr (b) ~ 10^{41} kg (c) 10^{11}
69. (a) 2.93×10^4 m/s (b) $K = 2.74 \times 10^{33}$ J, $U = -5.39 \times 10^{33}$ J (c) $K = 2.56 \times 10^{33}$ J, $U = -5.21 \times 10^{33}$ J (d) Yes; $E = -2.65 \times 10^{33}$ J at both aphelion and perihelion.
71. 119 km
73. $\sqrt{\frac{GM}{4R_E}}$
75. $(800 + 1.73 \times 10^{-4})\hat{\mathbf{i}}$ m/s and $(800 - 1.73 \times 10^{-4})\hat{\mathbf{i}}$ m/s
77. 18.2 ms
79. (a) -3.67×10^7 J (b) 9.24×10^{10} kg · m^2/s (c) $v = 5.58$ km/s, $r = 1.04 \times 10^7$ m (d) 8.69×10^6 m (e) 134 min

Chapter 14

Answers to Quick Quizzes

1. (a)
2. (a)
3. (c)
4. (b) or (c)
5. (a)

Answers to Odd-Numbered Problems

1. 2.96×10^6 Pa
3. (a) 6.24 MPa (b) Yes; this pressure could puncture the vinyl flooring.
5. 24.8 kg
7. 8.46 m
9. 7.74×10^{-3} m^2
11. (a) 3.71×10^5 Pa (b) 3.57×10^4 N
13. 2.71×10^5 N
15. (a) 2.94×10^4 N (b) 1.63×10^4 N · m
17. 2.31 lb
19. 98.6 kPa
21. (a) 10.5 m (b) No. The vacuum is not as good because some alcohol and water will evaporate. The equilibrium vapor pressures of alcohol and water are higher than the vapor pressure of mercury.
23. (a) 116 kPa (b) 52.0 Pa
25. 0.258 N down
27. (a) 4.9 N down, 16.7 N up (b) 86.2 N (c) By either method of evaluation, the buoyant force is 11.8 N up.
29. (a) 7.00 cm (b) 2.80 kg
31. (a) 1 250 kg/m^3 (b) 500 kg/m^3
33. (a) 408 kg/m^3 (b) When m is less than 0.310 kg, the wooden block will be only partially submerged in the water. (c) When m is greater than 0.310 kg, the wooden block and steel object will sink.
35. (a) 3.82×10^3 N (b) 1.04×10^3 N; the balloon rises because the net force is positive: the upward buoyant force is greater than the downward gravitational force. (c) 106 kg
37. (a) 11.6 cm (b) 0.963 g/cm^3 (c) No; the density ρ is not linear in h.
39. 1.52×10^3 m^3
41. (a) 17.7 m/s (b) 1.73 mm
43. 0.247 cm
45. (a) 2.28 N toward Holland (b) 1.74×10^6 s
47. (a) 15.1 MPa (b) 2.95 m/s