Answers to Quick Quizzes and Odd-Numbered Problems

Chapter 1

Answers to Quick Quizzes

(a)
2. False
3. (b)

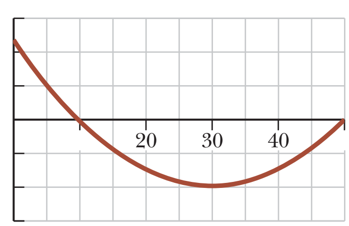
Answers to Odd-Numbered Problems

(a) 5.52 kg/m (b) It is between the density of alu minum and that of iron and is greater than the densities of typical surface rocks.
3. 23.0 kg
5. 7.69 cm
0.141 nm
9. (b) only
11. (a) kg m/s (b) N · s
13. No.
15. 11.4 kg/m
17. 871 m
19. By measuring the pages, we find that each page has area 0.277 m 0.217 m 0.060 m . The room has wall area 37 m , requiring 616 sheets that would be counted as 232 pages. Volume 1 of this textbook contains only 784 pages.
21. 1.00
23. 4.05
25. 2.86 cm
27. 151
29. (a) 507 years (b) 2.48 bills
31. balls in a room 4 m by 4 m by 3 m
33. piano tuners
35. (209 4) cm
37. 31 556 926.0 s
39.
41. 8.80%
43.
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 read ing precise numbers off the graph. (a) 0.015 g (b) 8% (c) 5.2 g/m (d) For shapes cut from this copy paper, the mass of the cutout is proportional to its area. The pro portionality constant is 5.2 g/m 8%, where the uncer tainty 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%
55. 316 m
57. 5.0 m
59. 3.41 m
61. (a) aluminum, 2.75 g/cm ; copper, 9.36 g/cm ; brass, 8.91 g/cm ; tin, 7.68 g/cm ; iron, 7.88 g/cm
(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. gal/yr
65. Answers may vary. (a) prokaryotes (b)
67. (a) 2.70 g/cm 1.19 g/cm (b) 1.39 kg
69. 0.579 (1.19 , where is in cubic feet and 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

(c)
2. (b)
3. False. Your graph should look something like the one shown below. This 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.

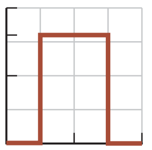


4. (b)
5. (c)
6. (a)–(e), (b)–(d), (c)–(f)
(i) (e) **(ii)** (d)

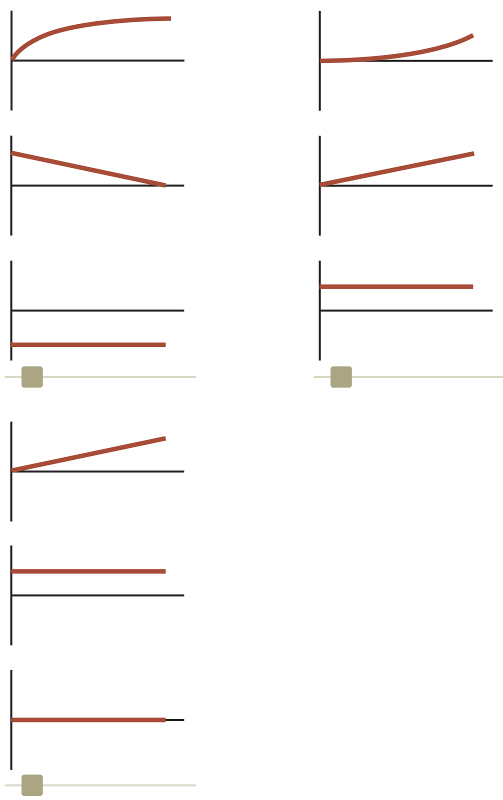
Answers to Odd-Numbered Problems

(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
(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
13. (a) 2.80 h (b) 218 km
15. (a)

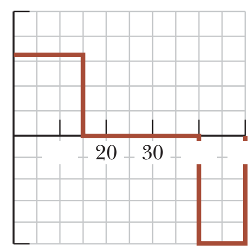


(b) 1.60 m/s (c) 0.800 m/s
17. (a) 1.3 m/s (b) 3 s, 2 m/s (c) 6 s, 10 s
(d) 1.5 m/s
19. (a) 20 m/s, 5 m/s (b) 263 m
21. (a) 2.00 m (b) 3.00 m/s (c) 2.00 m/s
23.



25. (a) 4.98 s (b) 1.20 m/s
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
31. (a) 202 m/s (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)) (Equation 2.17)
(d) (e) 1.25 m/s (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) 0 1.67 *ab* 50 375; 250 2.5 375 (In all three expressions, is in meters and 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)
59. (a) (10.0 3.00 (1.67 (1.50 (In these expressions, is in m/s is in meters, and 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 (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 direction from about 50 s to 50 s. From 50 s to 200 s, the Acela accelerates in the positive 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 direction, slows down and then stops at 350 s. Just after

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

71. (a) Here, must be greater than 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) ——— (c) ———

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

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

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

79. 1.60 m/s

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

83. (a) 5.32 m/s for Laura and 3.75 m/s 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 2.84 s

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

Chapter 3

Answers to Quick Quizzes

vectors: (b), (c); scalars: (a), (d), (e)

2. (c)

3. (b) and (c)

4. (b)

5. (c)

Answers to Odd-Numbered Problems

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) (4.30 cm, 326°)
(c) (8.60 cm, 34.0°) (d) (12.9 cm, 146°)

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

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 6.40) m (b) (1.65 2.86) cm
(c) (18.0 12.6) in.

21. 358 m at 2.00° S of E

23. (a) 2.00 6.00 (b) 4.00 2.00 (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 axis
(b) (39.3 181

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

33. (a) 8.00 12.0 4.00 (b) 2.00 3.00 1.00
(c) 24.0 36.0 12.0

35. (a) 3.00 2.00 (b) 3.61 at 146° (c) 3.00 6.00

37. (a) 5.00 and 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°

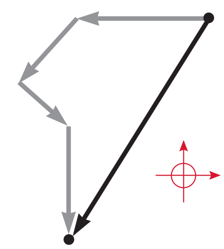
41. (a) 15.1 7.72 cm (b) 7.72 15.1 cm
(c) 7.72 15.1

43. (a) 20.5 35.5 m (b) 25.0 m
(c) 61.5 107 m (d) 37.5 m (e) 157 km

45. 1.43 m at 32.2° above the horizontal

47. (a) 10.4 cm (b) 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 , and components are, respectively, 2.00, 1.00, and 3.00. (b) 3.74 (c) 57.7°, 74.5°, 36.7°

59. 1.15°

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

63. (a) 2.00 m/s (b) its velocity vector

65. (a) (b) $^{1/2}$
(c)

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

(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

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

3. (a) (1.00 0.750) m/s (b) (1.00 0.500) m/s, 1.12 m/s

5. (a) 18.0 4.00 4.90 , where is in meters and is in seconds
(b) 18.0 4.00 9.80 , where is in meters per second and is in seconds
(c) = −9.80
(d) 54.0 32.1 18.0 25.4 m s; = −9.80

7. (a) $\vec{\mathbf{v}} = -12.0t\,\hat{\mathbf{j}}$, where $\vec{\mathbf{v}}$ is in meters per second and t is in seconds (b) $\vec{\mathbf{a}} = -12.0\hat{\mathbf{j}}$ m/s^2 (c) $\vec{\mathbf{r}} = (3.00\hat{\mathbf{i}} - 6.00\hat{\mathbf{j}})$ m; $\vec{\mathbf{v}} = -12.0\hat{\mathbf{j}}$ m/s

9. (a) $(0.800\hat{\mathbf{i}} - 0.300\hat{\mathbf{j}})$ m/s^2 (b) 339° (c) $(360\hat{\mathbf{i}} - 72.7\hat{\mathbf{j}})$ 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) $(2.00\hat{\mathbf{i}} - 5.00\hat{\mathbf{j}})$ m/s^2

63. (a) $(7.62\,\hat{\mathbf{i}} - 6.48\,\hat{\mathbf{j}})$ cm (b) $(10.0\,\hat{\mathbf{i}} - 7.05\,\hat{\mathbf{j}})$ 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) $(16.0\hat{\mathbf{i}} - 27.1\hat{\mathbf{j}})$ m/s (d) 6.53 s (e) $24.5\hat{\mathbf{i}}$ m

79. (a) 4.00 km/h (b) 4.00 km/h

81. (a) 43.2 m (b) $(9.66\hat{\mathbf{i}} - 25.6\,\hat{\mathbf{j}})$ 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) $(6.00\,\hat{\mathbf{i}} + 15.0\hat{\mathbf{j}})$ N (b) 16.2 N

5. (a) $(2.50\,\hat{\mathbf{i}} + 5.00\hat{\mathbf{j}})$ 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 15.0 m/s (b) 162° from the + axis (c) 225 75.0 m (d) 227 79.0

17. (a) — (b) — (c) $\frac{Fh}{mg}$ (d)

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

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

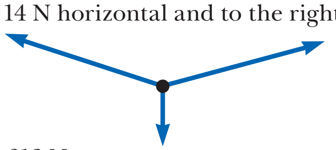
23. (a) 2.15 N forward (b) 645 N forward (c) 645 N toward the rear (d) 1.02 10 N at 74.1° below the horizontal and rearward

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

27. (a) cos 40° 0 and sin 40° 220 N 0; 342 N and 262 N (b) cos 40° (220 N) sin 40° 0 and sin 40 (220 N) cos 40° 0; 262 N and 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 without finding , method (b) is simpler.

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

31. (a)



(b) 613 N

33. 253 N, 165 N, 325 N

35. 100 N and 204 N

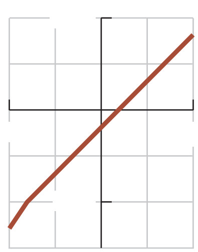
37. 8.66 N east

39. (a) tan (b) 4.16 m/s

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

43. (a) 79.8 N, 39.9 N (b) 2.34 m/s

45. (a) 19.6 N (b) 78.4 N (c)



47. 3.73 m

49. (a) 2.20 m/s (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

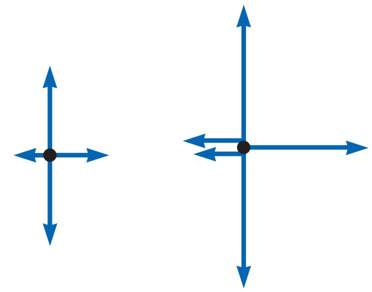
57. = 0.727, 0.577

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

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

63. 37.8 N

65. (a)



(b) 1.29 m/s to the right (c) 27.2 N

67. 6.84 m

69. 0.060 0 m

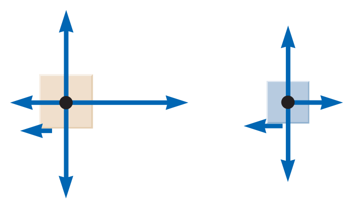
71. (a) 0.087 1 (b) 27.4 N

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

75. (a) (b)

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

79. (a)

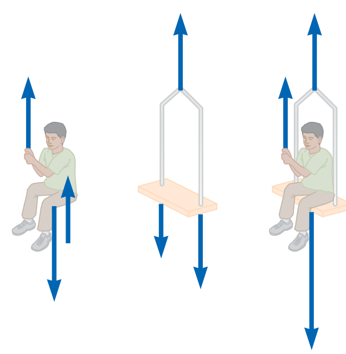


(b) (c) (d) (e)

(f) $- \mu$ $- \mu$

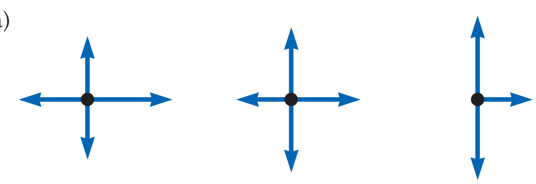
(g) $- \mu$

81. (a)



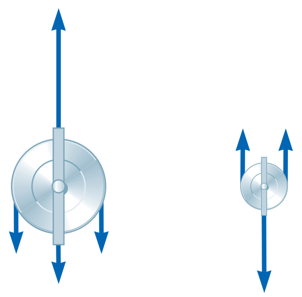
(b) 0.408 m/s (c) 83.3 N

83. (a)



(b) 2.00 m/s to the right (c) 4.00 N on , 6.00 N right on , 8.00 N right on (d) 14.0 N between and , 8.00 N between and (e) The block models the heavy block of wood. The contact force on your back is modeled by the force between the and the blocks, which is much less than the force . The difference between 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) /2, /2, /2, 3 /2, (c)

87. 0.287

89. (b) If is greater than tan (1/), motion is impossible.

91. (a) The net force on the cushion is in a fixed direction, downward and forward making angle tan) 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.

95. (a) 30.7° (b) 0.843 N

97. 72.0 N

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

101. (a) 4.90 m/s (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.

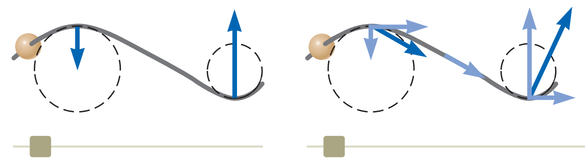
103. (a) 2.13 s (b) 1.66 m

Chapter 6

Answers to Quick Quizzes

(i) (a) **(ii)** (b)

(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

any speed up to 8.08 m/s

(a) 8.33 N toward the nucleus

(b) 9.15 m/s inward

5. 6.22

2.14 rev/min

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

11. 14.3 m/s

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

15. (a) (b) 2

17. (a) 8.62 m (b) , downward (c) 8.45 m/s (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/s

25. 0.527

27. 0.212 m/s , opposite the velocity vector

29. 3.01 N up

31. (a) 1.47 N s/m (b) 2.04 s (c) 2.94

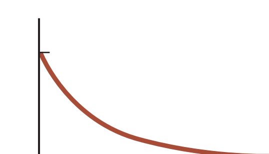
35. (a) 0.034 7 s (b) 2.50 m/s (c)

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) $mg \frac{mv}{}$ (b) $\sqrt{gR}$

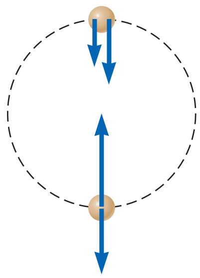
43. (a) $bt/$ (b)



(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

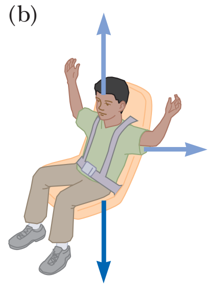
49. (a) 0.016 2 kg/m (b) - (c) 0.778 (d) 1.5% (e) For nested coffee filters falling in air at terminal speed, the graph of air resistance force as a function of the square of speed demonstrates that the force is proportional to the speed squared, within the experimental uncertainty estimated as 2%. This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

51. (cos tan sin

53. (a) The only horizontal force on the car is the force of friction, with a maximum value determined by the sur face roughness (described by the coefficient of static friction) and the normal force (here equal to the gravita tional force on the car). (b) 34.3 m (c) 68.6 m (d) Brak ing 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) $_{min}$ $\frac{\tan\theta - \mu}{+ \mu \tan}$ $_{max}$ $\frac{\tan\theta + \mu}{- \mu \tan}$

(b) tan

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 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

(a)

2. (c), (a), (d), (b)

3. (d)

4. (a)

5. (b)

6. (c)

(i) (c) **(ii)** (a)

8. (d)

Answers to Odd-Numbered Problems

(a) 1.59 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. 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

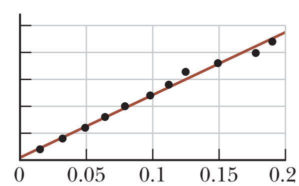
19. (a) 575 N/m (b) 46.0 J

21. (a) *mg* — — (b) — —

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 evi dence 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 (e) 6.34 kN (f) The two theories agree.

39. (a) 97.8 J (b) 4.31 31.6 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.

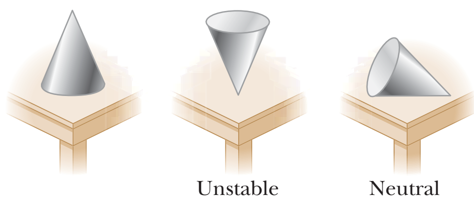
45. (a) 125 J (b) 50.0 J (c) 66.7 J (d) nonconservative (e) The work done on the particle depends on the path followed by the particle.

47. away from the other particle

49.

51. (a) 40.0 J (b) 40.0 J (c) 62.5 J

53.



55. 90.0 J

57. (a) 8 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 can not happen. (c) 0.8 J (d) 0.15 mm (e) 10

59. 0.299 m/s

61. (a) 20.5 14.3 N 36.4 21.0 N
(b) 15.9 35.3 N
(c) 3.18 7.07 m
(d) 5.54 23.7 m
(e) 2.30 39.3 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) (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) 3.62 /(4.30 23.4), where is in meters and 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 when is only a few grams. Then it grows faster and faster, diverging to infinity for 0.184 kg.

Chapter 8

Answers to Quick Quizzes

(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 radia tion (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), mechani cal 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.

5. (c)

Answers to Odd-Numbered Problems

(a) $_{int}$ $_{ER}$
(b) $_{int}$
(c) (d) 0 $_{ER}$

3. 10.2 m

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

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

9. 5.49 m/s

11. $\frac{gh}{15}$

13.

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) $_{system}\,mgh$ (d) $_{system}$ $-mgh$ $-$
(e) $_{system}\,mgy$ $_{max}$ $-$
(f) gh (g) $_{max}$ $-\cos$) (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

33. $145

35.

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) 0.196 J, 0.392 J

45.

47. (a) , where is in seconds and is in joules (b) 12 and 48 , where is in seconds, is in m/s , and is in newtons (c) P 48 288 , where is in seconds and is in watts (d) 1.25

49. (a) 11.1 m/s (b) 1.00 J (c) 1.35 m

51. (a) 6.08 J (b) 4.59 J (c) 4.59

53. (a) 4.0 mm (b) 1.0 cm

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

57. (a) 1.38 J (b) 5.51
(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 6.00 cm, 0 J at 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.

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) $-\mu_k g x/L$ (b) $(\mu_k g L)^{1/2}$
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) $\dfrac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$ (b) $(v_1 - v_2)\sqrt{\dfrac{m_1 m_2}{k(m_1 + m_2)}}$
(c) $v_{1f} = \dfrac{(m_1 - m_2)v_1 + 2m_2 v_2}{m_1 + m_2}$,
$v_{2f} = \dfrac{2m_1 v_1 + (m_2 - m_1)v_2}{m_1 + m_2}$
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 trans formed into internal energy. (c) No; the turntable bear ing promptly imparts impulse 44.9 kg m/s north into the turntable–clay system and thereafter keeps changing the system momentum.
37. (a) down (b) /(
39. (a) (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 /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: 2.50 J; 1.69 J. Most of the initial kinetic energy is transformed to internal energy in the collision.
43. 5.46
45. 0.910 km/s
47. 7.50
49. (a) 7 /3 (b) *mgd* (c) 3 counterclockwise (d) 2 /7 upward (e) *mgd* (f) (g) 14*gd* (h) *gd* 21
51. (a) isolated system (angular momentum) (b) /2 (c) 12 (d) 12 (e) *mv* (f) *mv* (g) (h)
53. (a) (b) ((c) *mv*
55. (a) 3 750 kg m /s (b) 1.88 kJ (c) 3 750 kg m /s (d) 10.0 m/s (e) 7.50 kJ (f) 5.62 kJ
57. (a) 2 (b) 2 /3 (c) 4 /3 (d) 4 (e) (f) 26 /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 momen tum stays constant. Internal forces cannot affect momen tum conservation and angular momentum conservation, but they can affect mechanical energy.
59. an increase of 6.368 % or 0.550 s, which is not significant
61. (a) (b) (c) (d) 18
63. *ga*

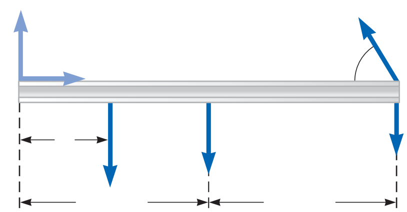
Chapter 12

Answers to Quick Quizzes

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

Answers to Odd-Numbered Problems

0, 0,
cos sin 0.5 cos
3. (3.85 cm, 6.85 cm)
5. 0.750 m
(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) 268 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) 370 910 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. 501 N, 672 N, 384 N
27. (a) 0.053 (b) 1.09 kg/m (c) With only a 5% change in volume in this extreme case, liquid water is indeed nearly incompressible in bio logical and student laboratory situations.
29. 23.8
31. (a) 3.14 N (b) 6.28
33. 4.90 mm
35. 0.029 2 mm
37. 5.98 N, 4.80
39. 0.896 m
41. 724 N, 716 N
43. (a)



(b) 343 N, 171 N to the right, 683 N up (c) 5.14 m
45. (a))/[sin (2)] (b)) cot /(2); /(2
47. 6.47 10 1.27 10 N, 6.47 10 N
49. (a) 5.08 kN (b) 4.77 kN (c) 8.26 kN
51. (a) $\frac{\sin\theta - \cos}{\cos\theta - \mu \sin}$ (b) $+ \mu$ (c) $+ \mu$
53. (a) 9.28 kN (b) The moment arm of the force is no longer 70 cm from the shoulder joint but only 49.5 cm, therefore reducing to 6.56 kN.
55. (a) 66.7 N (b) increasing at 0.125 N/s
57. (a) 15 *mgd* (b) *mg* *mgd* (c) 15 *mgd* *mgd* (to the right and down ward on the right half of the ladder)
59. (a) 1.67 N, 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) $v_1 = m_2\sqrt{\dfrac{2G}{d(m_1 + m_2)}}$, $v_2 = m_1\sqrt{\dfrac{2G}{d(m_1 + m_2)}}$, $v_{\text{rel}} = \sqrt{\dfrac{2G(m_1 + m_2)}{d}}$ (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. $\sqrt{\dfrac{GM}{4R_E}}$
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

49. (a) 1.91 m/s (b) 8.65×10^{-4} m^3/s
51. 347 m/s
53. (a) 4.43 m/s (b) 10.1 m
55. 12.6 m/s
57. (a) 1.02×10^7 Pa (b) 6.61×10^5 N
59. (a) 6.70 cm (b) 5.74 cm
61. 2.25 m
63. 455 kPa
65. 0.556 m
67. 160 kg/m^3
69. (a) 8.01 km (b) yes
71. upper scale: 17.3 N; lower scale: 31.7 N
73. 91.64%
75. 27 N · m
77. 758 Pa
79. 4.43 m/s
81. (a) 1.25 cm (b) 14.3 m/s
85. (a) 18.3 mm (b) 14.3 mm (c) 8.56 mm

Chapter 15

Answers to Quick Quizzes

1. (d)
2. (f)
3. (a)
4. (b)
5. (c)
6. **(i)** (a) **(ii)** (a)

Answers to Odd-Numbered Problems

1. (a) 17 N to the left (b) 28 m/s^2 to the left
3. 0.63 s
5. (a) 1.50 Hz (b) 0.667 s (c) 4.00 m (d) π rad (e) 2.83 m
7. 0.628 m/s
9. 40.9 N/m
11. 12.0 Hz
13. (a) −2.34 m (b) −1.30 m/s (c) −0.076 3 m (d) 0.315 m/s
15. (a) $x = 2.00 \cos (3.00\pi t - 90°)$ or $x = 2.00 \sin (3.00\pi t)$ where x is in centimeters and t is in seconds (b) 18.8 cm/s (c) 0.333 s (d) 178 cm/s^2 (e) 0.500 s (f) 12.0 cm
17. (a) 20 cm (b) 94.2 cm/s as the particle passes through equilibrium (c) ± 17.8 m/s^2 at maximum excursion from equilibrium
19. (a) 40.0 cm/s (b) 160 cm/s^2 (c) 32.0 cm/s (d) −96.0 cm/s^2 (e) 0.232 s
21. 2.23 m/s
23. (a) 0.542 kg (b) 1.81 s (c) 1.20 m/s^2
25. 2.60 cm and −2.60 cm
27. (a) 28.0 mJ (b) 1.02 m/s (c) 12.2 mJ (d) 15.8 mJ
29. (a) $\frac{8}{9}E$ (b) $\frac{1}{9}E$ (c) $x = \pm\sqrt{\frac{2}{3}}\,A$ (d) No; the maximum potential energy is equal to the total energy of the system. Because the total energy must remain constant, the kinetic energy can never be greater than the maximum potential energy.
31. (a) 4.58 N (b) 0.125 J (c) 18.3 m/s^2 (d) 1.00 m/s (e) smaller (f) the coefficient of kinetic friction between the block and surface (g) 0.934
33. (b) 0.628 s
35. (a) 1.50 s (b) 0.559 m
37. 0.944 kg · m^2
39. 1.42 s, 0.499 m
41. (a) 0.820 m/s (b) 2.57 rad/s^2 (c) 0.641 N (d) $v_{max} = 0.817$ m/s, $\alpha_{max} = 2.54$ rad/s^2, $F_{max} = 0.634$ N (e) The answers are close but not exactly the same. The answers computed from conservation of energy and from Newton's second law are more precise.
43. (a) 3.65 s (b) 6.41 s (c) 4.24 s
45. (a) 5.00×10^{-7} kg · m^2 (b) 3.16×10^{-4} N · m/rad
47. (a) 7.00 Hz (b) 2.00% (c) 10.6 s
51. 11.0 cm
53. (a) 3.16 s^{-1} (b) 6.28 s^{-1} (c) 5.09 cm
55. 0.641 Hz or 1.31 Hz
57. (a) 2.09 s (b) 0.477 Hz (c) 36.0 cm/s (d) $E = 0.064\,8m$, where E is in joules and m is in kilograms (e) $k = 9.00m$, where k is in newtons/meter and m is in kilograms (f) Period, frequency, and maximum speed are all independent of mass in this situation. The energy and the force constant are directly proportional to mass.
59. (a) $2Mg$ (b) $Mg\left(1 + \dfrac{y}{L}\right)$ (c) $\dfrac{4\pi}{3}\sqrt{\dfrac{2L}{g}}$ (d) 2.68 s
61. 1.56×10^{-2} m
63. (a) $L_{Earth} = 25$ cm (b) $L_{Mars} = 9.4$ cm (c) $m_{Earth} = 0.25$ kg (d) $m_{Mars} = 0.25$ kg
65. 6.62 cm
67. $\dfrac{1}{2\pi L}\sqrt{gL + \dfrac{kh^2}{M}}$
69. 7.75 s^{-1}
71. (a) 1.26 m (b) 1.58 (c) The energy decreases by 120 J. (d) Mechanical energy is transformed into internal energy in the perfectly inelastic collision.
73. (a) $\omega = \sqrt{\dfrac{200}{0.400 + M}}$, where ω is in s^{-1} and M is in kilograms (b) 22.4 s^{-1} (c) 22.4 s^{-1}
75. (a) 3.00 s (b) 14.3 J (c) $\theta = 25.5°$
77. (b) 1.46 s
79. (a) $x = 2\cos\left(10t + \dfrac{\pi}{2}\right)$ (b) ± 1.73 m (c) 0.105 s = 105 ms (d) 0.098 0 m
81. (b) $T = \dfrac{2}{r}\sqrt{\dfrac{\pi M}{\rho g}}$
83. 9.12×10^{-5} s
85. (a) 0.500 m/s (b) 8.56 cm
87. (a) $\frac{1}{2}(M + \frac{1}{3}m)v^2$ (b) $2\pi\sqrt{\dfrac{M + \frac{1}{3}m}{k}}$
89. (a) $\dfrac{2\pi}{\sqrt{g}}\sqrt{L_i + \dfrac{1}{2\rho a^2}\left(\dfrac{dM}{dt}\right)t}$ (b) $2\pi\sqrt{\dfrac{L_i}{g}}$

Chapter 16

Answers to Quick Quizzes

1. **(i)** (b) **(ii)** (a)
2. **(i)** (c) **(ii)** (b) **(iii)** (d)
3. (c)
4. (f) and (h)
5. (d)

Answers to Odd-Numbered Problems

1. 184 km

3. $y = \dfrac{6.00}{(x - 4.50t)^2 + 3.00}$ where x and y are in meters and t is in seconds

5. (a) 2.00 cm (b) 2.98 m (c) 0.576 Hz (d) 1.72 m/s

7. 0.319 m

9. (a) $3.33\hat{\mathbf{i}}$ m/s (b) −5.48 cm (c) 0.667 m (d) 5.00 Hz (e) 11.0 m/s

11. (a) 31.4 rad/s (b) 1.57 rad/m (c) $y = 0.120 \sin(1.57x - 31.4t)$, where x and y are in meters and t is in seconds (d) 3.77 m/s (e) 118 m/s^2

13. (a) 0.500 Hz (b) 3.14 rad/s (c) 3.14 rad/m (d) $0.100 \sin(\pi x - \pi t)$ (e) $0.100 \sin(-\pi t)$ (f) $0.100 \sin(4.71 - \pi t)$ (g) 0.314 m/s

15. (a) −1.51 m/s (b) 0 (c) 16.0 m (d) 0.500 s (e) 32.0 m/s

17. (a) 0.250 m (b) 40.0 rad/s (c) 0.300 rad/m (d) 20.9 m (e) 133 m/s (f) positive x direction

19. (a) $y = 0.080\,0 \sin(2.5\pi x + 6\pi t)$ (b) $y = 0.080\,0 \sin(2.5\pi x + 6\pi t - 0.25\pi)$

21. 185 m/s

23. 13.5 N

25. 80.0 N

27. 0.329 s

29. (a) 0.051 0 kg/m (b) 19.6 m/s

31. 631 N

33. (a) 1 (b) 1 (c) 1 (d) increased by a factor of 4

35. (a) 62.5 m/s (b) 7.85 m (c) 7.96 Hz (d) 21.1 W

37. (a) $y = 0.075 \sin(4.19x - 314t)$, where x and y are in meters and t is in seconds (b) 625 W

39. (a) 15.1 W (b) 3.02 J

45. 0.456 m/s

47. 14.7 kg

49. (a) 39.2 N (b) 0.892 m (c) 83.6 m/s

51. (a) 21.0 ms (b) 1.68 m

53. $\sqrt{\dfrac{mL}{Mg \sin\theta}}$

55. 0.084 3 rad

57. $\dfrac{1}{\omega}\sqrt{\dfrac{m}{M}}$

59. (a) $v = \sqrt{\dfrac{T}{\rho(1.00 \times 10^{-5}\,x + 1.00 \times 10^{-6})}}$, where v is in meters per second, T is in newtons, ρ is in kilograms per meter cubed, and x is in meters (b) $v(0) = 94.3$ m/s, $v(10.0\text{ m}) = 9.38$ m/s

61. (a) $\dfrac{\mu\omega^3}{2k} A_0^{\,2} e^{-2bx}$ (b) $\dfrac{\mu\omega^3}{2k} A_0^{\,2}$ (c) e^{-2bx}

63. 3.86×10^{-4}

65. (a) $(0.707)(2\sqrt{L/g})$ (b) $L/4$

67. (a) $\mu v_0^{\,2}$ (b) v_0 (c) clockwise: 4π; counterclockwise: 0

Chapter 17

Answers to Quick Quizzes

1. (c)

2. (b)

3. (b)

4. (e)

5. (e)

6. (b)

Answers to Odd-Numbered Problems

1. (a) 2.00 μm (b) 40.0 cm (c) 54.6 m/s (d) −0.433 μm (e) 1.72 mm/s

3. $\Delta P = 0.200 \sin(20\pi x - 6\,860\pi t)$ where ΔP is in pascals, x is in meters, and t is in seconds

5. 0.103 Pa

7. 0.196 s

9. (a) 0.625 mm (b) 1.50 mm to 75.0 μm

11. (a) 5.56 km (b) No. The speed of light is much greater than the speed of sound, so the time interval required for the light to reach you is negligible compared to the time interval for the sound.

13. 7.82 m

15. (a) 27.2 s (b) 25.7 s; the time interval in part (a) is longer.

17. (a) the pulse that travels through the rail (b) 23.4 ms

19. 66.0 dB

21. (a) 3.75 W/m^2 (b) 0.600 W/m^2

23. 3.0×10^{-8} W/m^2

25. (a) 0.691 m (b) 691 km

27. (a) 1.3×10^2 W (b) 96 dB

29. (a) 2.34 m (b) 0.390 m (c) 0.161 Pa (d) 0.161 Pa (e) 4.25×10^{-7} m (f) 7.09×10^{-8} m

31. (a) 1.32×10^{-4} W/m^2 (b) 81.2 dB

33. 68.3 dB

35. (a) 30.0 m (b) 9.49×10^5 m

37. (a) 475 Hz (b) 430 Hz

39. (a) 3.04 kHz (b) 2.08 kHz (c) 2.62 kHz; 2.40 kHz

41. (a) 441 Hz (b) 439 Hz (c) 54.0 dB

43. (a) 0.021 7 m/s (b) 28.9 Hz (c) 57.8 Hz

45. 26.4 m/s

47. (a) 56.3 s (b) 56.6 km farther along

49. 0.883 cm

51. (a) 0.515 trucks per minute (b) 0.614 trucks per minute

53. 67.0 dB

55. (a) 4.16 m (b) 0.455 μs (c) 0.157 mm

57. It is unreasonable, implying a sound level of 123 dB. Nearly all the decrease in mechanical energy becomes internal energy in the latch.

59. (a) 5.04×10^3 m/s (b) 1.59×10^{-4} s (c) 1.90×10^{-3} m (d) 2.38×10^{-3} (e) 4.76×10^8 N/m^2 (f) $\dfrac{\sigma_y}{\sqrt{\rho Y}}$

61. (a) 55.8 m/s (b) 2 500 Hz

63. (a) 3.29 m/s (b) The bat will be able to catch the insect because the bat is traveling at a higher speed in the same direction as the insect.

65. (a) 0.343 m (b) 0.303 m (c) 0.383 m (d) 1.03 kHz

67. (a) 0.983° (b) 4.40°

69. 1.34×10^4 N

71. (a) 531 Hz (b) 466 Hz to 539 Hz (c) 568 Hz

Chapter 18

Answers to Quick Quizzes

1. (c)

2. **(i)** (a) **(ii)** (d)

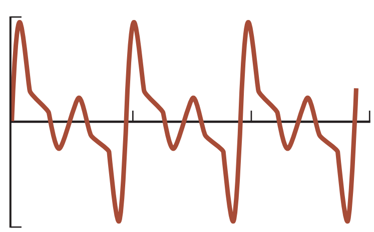
3. (d)

4. (b)

5. (c)

Answers to Odd-Numbered Problems

5.66 cm
3. (a) 1.65 cm (b) 6.02 cm (c) 1.15 cm
5. 91.3°
(a) : positive direction; : negative direction
(b) 0.750 s (c) 1.00 m
9. (a) 9.24 m (b) 600 Hz
11. (a) 156° (b) 0.058 4 cm
13. (c) Yes; the limiting form of the path is two straight lines through the origin with slope 0.75.
15. (a) 15.7 m (b) 31.8 Hz (c) 500 m/s
17. (a) 4.24 cm (b) 6.00 cm (c) 6.00 cm (d) 0.500 cm, 1.50 cm, 2.50 cm
19. at 0.089 1 m, 0.303 m, 0.518 m, 0.732 m, 0.947 m, and 1.16 m from one speaker
21. 19.6 Hz
23. (a) 163 N (b) 660 Hz
25. (a) second harmonic (b) 74.0 cm (c) 3
27. (a) 350 Hz (b) 400 kg
29. 1.86 g
31. (a) 3.8 cm (b) 3.85%
33. (a) three loops (b) 16.7 Hz (c) one loop
35. (a) 3.66 m/s (b) 0.200 Hz
37. 57.9 Hz
39. (a) 0.357 m (b) 0.715 m
41. (a) 0.656 m (b) 1.64 m
43. (a) 349 m/s (b) 1.14 m
45. (a) 0.195 m (b) 841 Hz
47. (0.252 m) with 1, 2, 3, . . .
49. 158 s
51. (a) 50.0 Hz (b) 1.72 m
53. (a) 21.5 m (b) seven
55. (a) 1.59 kHz (b) odd-numbered harmonics (c) 1.11 kHz
57. 5.64 beats/s
59. (a) 1.99 beats/s (b) 3.38 m/s
61. The following coefficients are approximate: 100, 156, 62, 104, 52, 29, 25.



63. 31.1 N
65. 800 m
67. 1.27 cm
69. 262 kHz
71. (a) 45.0 or 55.0 Hz (b) 162 or 242 N
73. (a) 0.078 2 — (b) 3 (c) 0.078 2 m
(d) The sphere floats on the water.
75. (a) 34.8 m/s (b) 0.986 m
77. 3.85 m/s away from the station or 3.77 m/s toward the station
79. 283 Hz
81. 407 cycles
83. (b) 11.2 m, 63.4°
85. (a) 78.9 N (b) 211 Hz
87. $\overline{15}Mg$

Chapter 19

Answers to Quick Quizzes

(c)
2. (c)
3. (c)
4. (c)
5. (a)
6. (b)

Answers to Odd-Numbered Problems

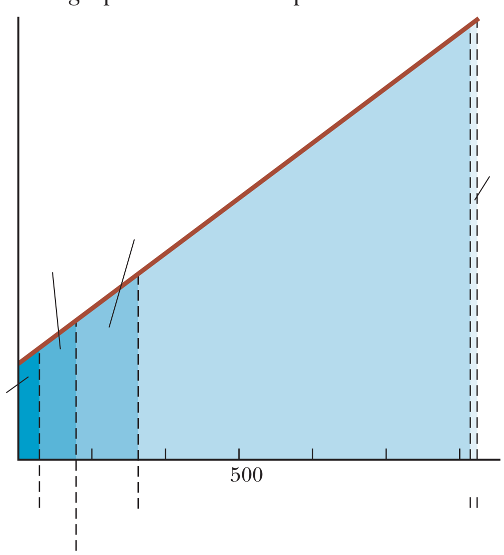
(a) 106.7°F (b) Yes; the normal body temperature is 98.6°F, so the patient has a high fever and needs immediate attention.
3. (a) 109°F, 195 K (b) 98.6°F, 310 K
5. (a) 320°F (b) 77.3 K
(a) 270°C (b) 1.27 atm, 1.74 atm
9. (a) 0.176 mm (b) 8.78 m (c) 0.093 0 cm
11. 3.27 cm
13. 1.54 km. The pipeline can be supported on rollers. -shaped loops can be built between straight sections. They bend as the steel changes length.
15. (a) 0.109 cm (b) increase
17. (a) 437°C (b) 2.1 °C (c) No; aluminum melts at 660°C (Table 20.2). Also, although it is not in Table 20.2, Internet research shows that brass (an alloy of copper and zinc) melts at about 900°C.
19. (a) 99.8 mL (b) It lies below the mark. The acetone has reduced in volume, and the flask has increased in volume.
21. (a) 99.4 mL (b) 2.01 L (c) 0.998 cm
23. (a) 11.2 kg/m (b) 20.0 kg
25. 1.02 gallons
27. 4.28 atm
29. (a) 2.99 mol (b) 1.80 molecules
31. 1.50 molecules
33. (a) 41.6 mol (b) 1.20 kg (c) This value is in agreement with the tabulated density.
35. 3.55 L
37. (a) 3.95 atm 400 kPa (b) 4.43 atm 449 kPa
39. 473 K
41. 3.68 cm
43. 1.89 MPa
45. 6.57
47. (a) 2.542 cm (b) 300°C
49. 1.12 atm
51. 3.37 cm
53. 0.094 2 Hz
55. (a) 94.97 cm (b) 95.03 cm
57. (b) As the temperature increases, the density decreases (assuming is positive). (c) 5 (°C)
(d) 2.5 (°C)
59. (a) 9.5 s (b) It loses 57.5 s.
61. (b) It assumes is much less than 1.
63. (a) yes, as long as the coefficients of expansion remain constant (b) The lengths and at 0°C need to satisfy 17 . Then the steel rod must be longer. With 5.00 cm, the only possibility is 14.2 cm and 9.17 cm.

65. (a) 0.34% (b) 0.48% (c) All the moments of inertia have the same mathematical form: the product of a con stant, the mass, and a length squared.
67. 2.74 m
69. (a) $\frac{gP}{+ \rho \ gh}$ (b) decrease (c) —— 10.3 m
73. (a) 6.17 kg/m (b) 632 N (c) 580 N (d) 192 Hz
75. No; steel would need to be 2.30 times stronger.
77. (a) (b) (2.00)% (c) 59.4% (d) With this approach, 102 mL of turpentine spills, 2.01 L remains in the cylinder at 80.0°C, and the turpentine level at 20.0°C is 0.969 cm below the cylinder's rim.
79. 4.54 m

Chapter 20

Answers to Quick Quizzes

(i) iron, glass, water **(ii)** water, glass, iron
2. The figure below shows a graphical representation of the internal energy of the system as a function of energy added. Notice that this graph looks quite different from Figure 20.3 in that it doesn't have the flat portions dur ing the phase changes. Regardless of how the tempera ture is varying in Figure 20.3, the internal energy of the system simply increases linearly with energy input; the line in the graph below has a slope of 1.



3.

Situation	System	Q	W	int
(a) Rapidly pumping up a bicycle tire	Air in the pump	0	+	+
(b) Pan of room-temperature water sitting on a hot stove	Water in the pan			
(c) Air quickly leaking out of a balloon	Air originally in the balloon		–	–

4. Path A is isovolumetric, path B is adiabatic, path C is iso thermal, and path D is isobaric.
5. (b)

Answers to Odd-Numbered Problems

(a) 2.26 J (b) 2.80 steps (c) 6.99 steps
3. 23.6°C
5. 0.845 kg
1.78
9. 88.2 W
11. 29.6°C
13. (a) 1 822 J/kg °C (b) We cannot make a definite iden tification. It might be beryllium. (c) The material might be an unknown alloy or a material not listed in the table.
15. (a) 380 K (b) 2.04 atm
17. 2.27 km
19. 16.3°C
21. (a) 10.0 g of ice melts, 40.4°C (b) 8.04 g of ice melts, 0°C
23. (a) 0°C (b) 114 g
25. 466 J
27. (a) (b) According to nRV , it is pro portional to the square of the volume.
29. 1.18 MJ
31.

Process			int

33. 720 J
35. (a) 0.041 0 m (b) 5.48 kJ (c) 5.48 kJ
37. (a) 7.50 kJ (b) 900 K
39. (a) 0.048 6 J (b) 16.2 kJ (c) 16.2 kJ
41. (a) 9.08 kJ (b) 9.08 kJ
43. (a) 6.45 W (b) 5.57
45. 74.8 kJ
47. 3.49
49. (a) 1.19 (b) a factor of 1.19
51. 8.99 cm
53. (a) 1.85 ft °F h/Btu (b) a factor of 1.78
55. 51.2°C
57. (a) W (b) K/s
59. (a) 6.08 J (b) 4.56
61. (a) 17.2 L (b) 0.351 L/s
63. 1.90 J/kg
65. (a) 9.31 J (b) 8.47 J (c) 8.38
67. (a) 13.0°C (b) 0.532°C/s
69. (a) 2 000 W (b) 4.46°C
71. 2.35 kg
73. (5.87)°C
75. (a) 3.16 W (b) 3.17 (c) It is 0.408% larger. (d) 5.78
77. 3.76 m/s
79. 1.44 kg
81. (a) 4.19 mm/s (b) 12.6 mm/s
83. 3.66 10.2 h

Chapter 21

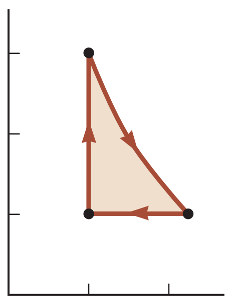
Answers to Quick Quizzes

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

Answers to Odd-Numbered Problems

(a) 3.54 atoms (b) 6.07 ^{21} J (c) 1.35 km/s
3. (a) 0.943 N (b) 1.57 Pa
5. 3.32 mol

5.05 21
9. (a) 4.00 u 6.64 27 kg (b) 55.9 u 9.28 kg (c) 207 u 3.44
11. (a) 2.28 kJ (b) 6.21 −21
13. 17.4 kPa
15. 13.5
17. (a) 3.46 kJ (b) 2.45 kJ (c) 1.01 kJ
19. 74.8 J
21. (a) 5.66 J (b) 1.12 kg
23. 2.32 21
25. (a) 41.6 J/K (b) 58.2 J/K (c) 58.2 J/K, 74.8 J/K
27. (a) a factor of 0.118 (b) a factor of 2.35 (c) 0 (d) 135 J (e) 135 J
29. 227 K
31. 25.0 kW
33. (a)



(b) 8.77 L (c) 900 K (d) 300 K (e) 336 J
35. 132 m/s
37. (a) 2.00 163 0 atoms (b) 2.70 atoms
39. (a) 2.37 K (b) 1.06
41. (b) 0.278
43. (b) 8.31 km
45. (a) 1.69 h (b) 1.00
47. (a) 367 K (b) The rms speed of nitrogen would be higher because the molar mass of nitrogen is less than that of oxygen. (c) 572 m/s
49. 5.74 Pa 56.6 atm
51. **(i)** (a) 100 kPa (b) 66.5 L (c) 400 K (d) 5.82 kJ (e) 7.48 kJ (f) 1.66 kJ; **(ii)** (a) 133 kPa (b) 49.9 L (c) 400 K (d) 5.82 kJ (e) 5.82 kJ (f) 0; **(iii)** (a) 120 kPa (b) 41.6 L (c) 300 K (d) 0 (e) 909 J (f) 909 J; **(iv)** (a) 120 kPa (b) 43.3 L (c) 312 K (d) 722 J (e) 0 (f) 722 J
53. 0.623
55. (a) 0.514 m (b) 2.06 m (c) 2.38 10 K (d) 480 kJ (e) 2.28 MJ
57. (a) 3.65 (b) 3.99 (c) 3.00 (d) $\frac{106}{\quad}$ (e) 7.98
59. (a) 300 K (b) 1.00 atm
61. (a) rms (18 1/2 (4.81 3/2, where rms is in meters per second and is in meters (b) (2.08 10 5/2, where is in seconds and is in meters (c) 0.926 mm/s and 3.24 ms (d) 1.32 m/s and 3.88
63. 0.480°C
65. (a) 0.203 mol (b) 900 K (c) 900 K (d) 15.0 L (e) : Lock the piston in place and put the cylinder into an oven at 900 K. : Keep the gas in the oven while gradually letting the gas expand to lift the piston as far as it can. : Move the cylinder from the oven back to the 300-K room and let the gas cool and contract.
(f, g)

		,	int
	1.52		1.52
	1.67	1.67	
	2.53	1.01	1.52
ABCA	0.656	0.656	

67. (a) 1.09 (b) 2.69 (c) 0.529 (d) 1.00 (e) 0.199 (f) 1.01 (g) 1.25 1 082
71. (a) 3.34 molecules (b) during the 27th day (c) 2.53
73. (a) 0.510 m/s (b) 20 ms
75. 510 K and 290 K

Chapter 22

Answers to Quick Quizzes

(i) (c) **(ii)** (b)
2. (d)
3. C, B, A
4. (a) one (b) six
5. (a)
6. false (The adiabatic process must be *reversible* for the entropy change to be equal to zero.)

Answers to Odd-Numbered Problems

(a) 10.7 kJ (b) 0.533 s
3. (a) 6.94% (b) 335 J
5. (a) 0.294 (or 29.4%) (b) 500 J (c) 1.67 kW
55.4%
9. (a) 75.0 kJ (b) 7.33
11. 77.8 W
13. (a) 4.51 J (b) 2.84 J (c) 68.1 kg
15. (a) 67.2% (b) 58.8 kW
17. (a) 8.70 J (b) 3.30
19. 9.00
21. 11.8
23. 1.86
25. (a) 564°C (b) No; a real engine will always have an effi ciency *less* than the Carnot efficiency because it operates in an irreversible manner.
27. (a) 741 J (b) 459 J
29. (a) 9.10 kW (b) 11.9 kJ
31. (a) 564 K (b) 212 kW (c) 47.5%
33. (a) — 1.40 $\frac{0.5 \quad 383}{383}$ where is in megawatts and is in kelvins (b) The exhaust power decreases as the firebox temperature increases. (c) 1.87 MW (d) 3.84 K (e) No answer exists. The energy exhaust cannot be that small.
35. 1.17
37. (a) 244 kPa (b) 192 J
39. (a)

Macrostate	Microstates	Number of ways to draw
All R	RRR	
2 R, 1 G	GRR, RGR, RRG	
1 R, 2 G	GGR, GRG, RGG	
All G	GGG	

(b)

Macrostate	Microstates	Number of ways to draw
All R	RRRR	
4R, 1G	GRRRR, RGRRR, RRGRR, RRRGR, RRRRG	
3R, 2G	GGRRR, GRGRR, GRRGR, GRRRG, RGGRR, RGRGR, RGRRG, RRGGR, RRGRG, RRRGG	10
2R, 3G	RRGGG, RGRGG, RGGRG, RGGGR, GRRGG, GRGRG, GRGGR, GGRRG, GGRGR, GGGRR	10
1R, 4G	RGGGG, GRGGG, GGRGG, GGGRG, GGGGR	
All G		

41. (a) one (b) six
43. 143 J/K
45. 1.02 kJ/K
47. 57.2 J/K
49. 0.507 J/K
51. 195 J/K
53. (a) 3.45 J/K (b) 8.06 J/K (c) 4.62 J/K
55. 3.28 J/K
57. 32.9 kJ
59. (a) (b)
61. 0.440 44.0%
63. (a) 5.00 kW (b) 763 W
65. (a) 0.390 (b) 0.545
67. (a) $3nRT$ (b) $3nRT$ ln 2 (c) nRT (d) nRT ln 2 (e) $3nRT$ (1 ln 2) (f) 2 nRT ln 2 (g) 0.273
69. (a) 39.4 J (b) 65.4 rad/s 625 rev/min (c) 293 rad/s 2.79 rev/min
71. 5.97 kg/s
73. (a) 4.10 J (b) 1.42 J (c) 1.01 J (d) 28.8% (e) Because 80.0%, the efficiency of the cycle is much lower than that of a Carnot engine operating between the same temperature extremes.
75. (a) 0.476 J/K (b) 417 J
77. ln 3
79. (b) yes (c) No; the second law refers to an engine operating in a cycle, whereas this problem involves only a single process.
81. (a) 25.0 atm, 1.97 4.13 atm, 1.19 10 m 1.00 atm, 3.28 10 m 6.05 atm, 5.43 (b) 2.99

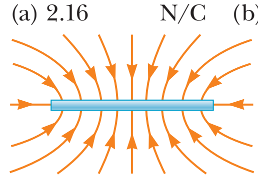
Chapter 23

Answers to Quick Quizzes

(a), (c), (e)
2. (e)
3. (b)
4. (a)
5.

Answers to Odd-Numbered Problems

(a) 1.60 C, 1.67 ^{27} kg
(b) 1.60 C, 3.82 kg
(c) 1.60 C, 5.89 kg
(d) 3.20 C, 6.65 kg
(e) 4.80 C, 2.33 kg
(f) 6.40 C, 2.33 kg
(g) 1.12 C, 2.33 kg
(h) 1.60 C, 2.99
3. 57.5 N
5. 3.60 N downward
2.25 N/m
9. (a) 8.74 N (b) repulsive
11. (a) 1.38 N (b) 77.5° below the negative axis
13. (a) 0.951 m (b) yes, if the third bead has positive charge
15. 0.872 N at 330°
17. (a) 8.24 N (b) 2.19 m/s
19.
21. (a) 2.16 N toward the other
(b) 8.99 N away from the other
23. (a) 5.58 10 ^{11} N (b) 1.02 10 N
25. (a) 3.06 5.06 (b) 3.06 5.06
27. (a) [(
(b) [(
29. 1.82 m to the left of the 2.50- C charge
31. (a) 1.80 N/C to the right
(b) 8.98 N to the left
33. 5.25
35. (a) 0.599 2.70 kN (b) 3.00 13.5
37. (a) 1.59 N/C (b) toward the rod
39. (a) 6.64 N/C away from the center of the ring
(b) 2.41 N/C away from the center of the ring
(c) 6.39 N/C away from the center of the ring
(d) 6.64 N/C away from the center of the ring
41. (a) 9.35 N/C (b) 1.04 N/C (about 11% higher)
(c) 5.15 N/C (d) 5.19 N/C (about 0.7% higher)
43. (a) (b) to the left
45. (a) 2.16 N/C (b) to the left
47.



49. (a) (b) is negative, and is positive.
51. (a) 6.13 m/s (b) 1.96 s (c) 11.7 m
(d) 1.20
53. 4.38 m/s for the electron; 2.39 m/s for the proton
55. (a) $\frac{}{ed}$ (b) in the direction of the velocity of the electron
57. (a) 111 ns (b) 5.68 mm (c) 450 102 km/s
59.

61. (a) $\frac{mg}{}$ sin (b) 3.19 N/C down the incline

63. —

65. (a) 2.18 m (b) 2.43 cm
67. (a) 1.09 C (b) 5.44
69. (a) 24.2 N (b) 4.21 8.42
71. 0.706
73. 25.9 cm
75. 1.67
77. 1.98
79. 1.14 C on one sphere and 5.69 C on the other
81. (a)
83. (a) 0.307 s (b) Yes; the downward gravitational force is not negligible in this situation, so the tension in the string depends on both the gravitational force and the electric force.
85. (a) 1.90 — (b) 3.29 —

(c) away from the origin
89. 1.36 1.96 kN
91. (a) $\frac{935}{0.062\,5}$ where is in newtons per coulomb and is in meters (b) 4.00 kN
(c) 0.016 8 m and 0.916 m
(d) nowhere is the field as large as 16 000 N/C

Chapter 24

Answers to Quick Quizzes

(e)
2. (b) and (d)
3. (a)

Answers to Odd-Numbered Problems

(a) 1.98 /C (b) 0
3. 4.14 MN/C
5. (a) 858 N /C (b) 0 (c) 657 N
28.2 N
9. (a) 6.89 MN /C (b) less than
11. for ; 0 for for ; 0 for
13. 1.77 C/m ; positive
15. (a) 339 N m /C (b) No. The electric field is not uniform on this surface. Gauss's law is only practical to use when all portions of the surface satisfy one or more of the conditions listed in Section 24.3.
17. (a) 0 (b) —

19. 18.8 kN

21. (a) — (b) —

23. 3.50 kN
25. 2.48 C/m
27. 508 kN/C up
29. (a) 0 (b) 7.19 MN/C away from the center
31. (a) 51.4 kN/C outward (b) 645 N
33. = ρ away from the axis
35. (a) 0 (b) 3.65 N/C (c) 1.46 N/C
(d) 6.49 N/C

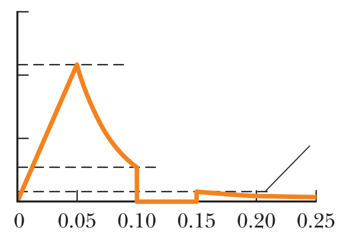
37. (a) 0 (b) 5.39 N/C outward (c) 539 N/C outward
39. —

41. glass
43. 2.00 N
45. (a) (b) (c) — radially outward

47. (a) 0 (b) 7.99 N/C (outward)
(c) 0 (d) 7.34 N/C (outward)
49. 0.438 N
51. 8.27

53. (a) — (b) — (c) —

55.



57. (a) 4.01 nC (b) 9.57 nC (c) 4.01 nC (d) 5.56 nC

59. — radially outward

61. (a) $\frac{Cd}{24}$ to the right for /2 and to the left for /2 (b) $\frac{Cx}{}$

63. (a) 0.269 N /C (b) 2.38

65. — radially outward

67. (a) — — (b) — —

Chapter 25

Answers to Quick Quizzes

(i) (b) (ii) (a)
2. to to to to
3. (i) (c) (ii) (a)
4. (i) (a) (ii) (a)

Answers to Odd-Numbered Problems

(a) 1.13 N/C (b) 1.80 $^{-14}$ N (c) 4.37 $^{-17}$
3. (a) 1.52 m/s (b) 6.49 m/s
5. 260 V
(a) 38.9 V (b) the origin
9. 0.300 m/s
11. (a) 0.400 m/s (b) It is the same. Each bit of the rod feels a force of the same size as before.
13. (a) 2.12 V (b) 1.21

15. 6.93 —

17. (a) 45.0 V (b) 34.6 km/s
19. (a) 0 (b) 0 (c) 44.9 kV

21. (a) – — (b) – $\frac{qQ}{}$

23. (a) 4.83 m (b) 0.667 m and 2.00 m
25. (a) 32.2 kV (b) 0.096 5 J

27. 8.94 J

29. —

31. (a) 10.8 m/s and 1.55 m/s (b) They would be greater. The conducting spheres will polarize each other, with most of the positive charge of one and the negative charge of the other on their inside faces. Immediately before the spheres collide, their centers of charge will be closer than their geometric centers, so they will have less electric potential energy and more kinetic energy.

33. 22.8 —

35. 2.74 27.4 fm

37. (a) 10.0 V, 11.0 V, 32.0 V
(b) 7.00 N/C in the positive direction

39. (a) *xy* *yz*
(b) 7.07 N/C

41. (a) 0 (b) —

43. 0.553 —

45. (a) — (b) ln —)]

47. 2 ln 3)

49. 1.56

51. (a) 1.35 V (b) larger sphere: 2.25 V/m (away from the center); smaller sphere: 6.74 V/m (away from the center)

53. Because is not an integer, this is not possible. Therefore, the energy given cannot be possible for an allowed state of the atom.

55. (a) 6.00 m/s (b) 3.64 m (c) 9.00 m/s (d) 12.0 m/s

57. 253 MeV

59. (a) 30.0 cm (b) 6.67 nC (c) 29.1 cm or 3.44 cm
(d) 6.79 nC or 804 pC
(e) No; two answers exist for each part.

61. 702 J

63. 4.00 nC at (1.00 m, 0) and 5.01 nC at (0, 2.00 m)

65. ln

67. ln

69. (a) 4.07 kV/m (b) 488 V (c) 7.82 J (d) 306 km/s
(e) 3.89 m/s toward the negative plate
(f) 6.51 N toward the negative plate
(g) 4.07 kV/m (h) They are the same.

71. (b) cos sin (c) yes (d) no
(e) *py*
(f) *pxy*

73. ln)]

75. (a) ln
(b) *dh* ln)]

Chapter 26

Answers to Quick Quizzes

(d)
2. (a)
3. (a)
4. (b)
5. (a)

Answers to Odd-Numbered Problems

(a) 9.00 V (b) 12.0 V

3. (a) 48.0 C (b) 6.00

5. (a) 2.69 nF (b) 3.02 kV

4.43

9. (a) 11.1 kV/m toward the negative plate (b) 98.4 nC/m
(c) 3.74 pF (d) 74.8 pC

11. (a) 1.33 C/m (b) 13.4 pF

13. (a) 17.0 F (b) 9.00 V (c) 45.0 C on 5 F, 108 C on 12

15. (a) 2.81 F (b) 12.7

17. (a) in series (b) 398 F (c) in parallel; 2.20

19. (a) 3.33 F (b) 180 C on the 3.00- F and 6.00- capacitors; 120 C on the 2.00- F and 4.00- F capacitors (c) 60.0 V across the 3.00- F and 2.00- F capacitors; 30.0 V across the 6.00- F and 4.00- F capacitors

21. ten

23. (a) 5.96 F (b) 89.5 C on 20 F, 63.2 C on 6 F, and 26.3 C on 15 F and 3

25. 12.9

27. 6.00 pF and 3.00 pF

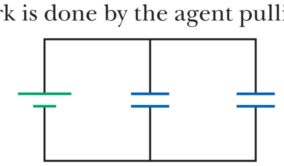
29. 19.8

31. 3.24

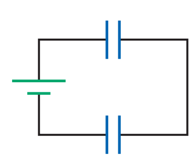
33. (a) 1.50 C (b) 1.83 kV

35. (a) 2.50 J (b) 66.7 V (c) 3.33 J (d) Positive work is done by the agent pulling the plates apart.

37. (a)



(b) 0.150 J (c) 268 V
(d)



39. 9.79 kg

41. (a) 400 C (b) 2.5 kN/m

43. (a) 13.3 nC (b) 272 nC

45. (a) 81.3 pF (b) 2.40 kV

47. (a) 369 pC (b) 1.2 F, 3.1 V (c) 45.5 nJ

49. (a) 40.0 J (b) 500 V

51. 9.43 10 N

55. (a) 11.2 pF (b) 134 pC (c) 16.7 pF (d) 67.0 pC
57. 2.51×10^{-3} m^3 = 2.51 L
59. 0.188 m^2
61. (a) volume 9.09×10^{-16} m^3, area 4.54×10^{-10} m^2 (b) 2.01×10^{-13} F (c) 2.01×10^{-14} C; 1.26×10^5 electronic charges
63. 23.3 V across the 5.00-μF capacitor, 26.7 V across the 10.0-μF capacitor
65. (a) $\dfrac{Q_0^2 d(\ell - x)}{2\epsilon_0 \ell^3}$ (b) $\dfrac{Q_0^2 d}{2\epsilon_0 \ell^3}$ to the right (c) $\dfrac{Q_0^2}{2\epsilon_0 \ell^4}$ (d) $\dfrac{Q_0^2}{2\epsilon_0 \ell^4}$ (e) They are precisely the same.
67. 4.29 μF
69. 750 μC on C_1, 250 μC on C_2
71. (a) One capacitor cannot be used by itself—it would burn out. The technician can use two capacitors in series, connected in parallel to another two capacitors in series. Another possibility is two capacitors in parallel, connected in series to another two capacitors in parallel. In either case, one capacitor will be left over: upper and lower (b) Each of the four capacitors will be exposed to a maximum voltage of 45 V.
73. $\dfrac{C_0}{2}(\sqrt{3} - 1)$
75. $\frac{4}{3}C$
77. 3.00 μF

Chapter 27

Answers to Quick Quizzes

1. (a) > (b) = (c) > (d)
2. (b)
3. (b)
4. (a)
5. $I_a = I_b > I_c = I_d > I_e = I_f$

Answers to Odd-Numbered Problems

1. 27.0 yr
3. 0.129 mm/s
5. 1.79×10^{16} protons
7. (a) $0.632 I_0 \tau$ (b) $0.999\,95 I_0 \tau$ (c) $I_0 \tau$
9. (a) 17.0 A (b) 85.0 kA/m^2
11. (a) 2.55 A/m^2 (b) 5.30×10^{10} m^{-3} (c) 1.21×10^{10} s
13. 3.64 h
15. silver ($\rho = 1.59 \times 10^{-8}\ \Omega \cdot$ m)
17. 8.89 Ω
19. (a) 1.82 m (b) 280 μm
21. (a) 13.0 Ω (b) 255 m
23. $6.00 \times 10^{-15} (\Omega \cdot \text{m})^{-1}$
25. 0.18 V/m
27. 0.12
29. 6.32 Ω
31. (a) 3.0 A (b) 2.9 A
33. (a) 31.5 nΩ · m (b) 6.35 MA/m^2 (c) 49.9 mA (d) 658 μm/s (e) 0.400 V
35. 227°C
37. 448 A
39. (a) 8.33 A (b) 14.4 Ω
41. 2.1 W
43. 36.1%
45. (a) 0.660 kWh (b) \$0.072 6
47. \$0.494/day
49. (a) 3.98 V/m (b) 49.7 W (c) 44.1 W
51. (a) 4.75 m (b) 340 W
53. (a) 184 W (b) 461°C
55. 672 s
57. 1.1 km
59. 15.0 h
61. 50.0 MW
63. (a) $\dfrac{Q}{4C}$ (b) $\dfrac{Q}{4}$ on C, $\dfrac{3Q}{4}$ on $3C$ (c) $\dfrac{Q^2}{32C}$ in C, $\dfrac{3Q^2}{32C}$ in $3C$ (d) $\dfrac{3Q^2}{8C}$
65. 0.478 kg/s
67. (a) 8.00 V/m in the positive x direction (b) 0.637 Ω (c) 6.28 A in the positive x direction (d) 200 MA/m^2
69. (a) 116 V (b) 12.8 kW (c) 436 W
71. (a) $\dfrac{\rho}{2\pi L} \ln\left(\dfrac{r_b}{r_a}\right)$ (b) $\dfrac{2\pi L\,\Delta V}{I \ln(r_b/r_a)}$
73. 4.1×10^{-3} (°C)$^{-1}$
75. 1.418 Ω
77. (a) $\dfrac{\epsilon_0 \ell}{2d}(\ell + 2x + \kappa\ell - 2\kappa x)$ (b) $\dfrac{\epsilon_0 \ell v\,\Delta V(\kappa - 1)}{d}$ clockwise
79. 2.71 MΩ
81. (2.02×10^3)°C

Chapter 28

Answers to Quick Quizzes

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

Answers to Odd-Numbered Problems

1. (a) 6.73 Ω (b) 1.97 Ω
3. (a) 12.4 V (b) 9.65 V
5. (a) 75.0 V (b) 25.0 W, 6.25 W, and 6.25 W (c) 37.5 W
7. $\frac{7}{3}R$
9. (a) 227 mA (b) 5.68 V
11. (a) 1.00 kΩ (b) 2.00 kΩ (c) 3.00 kΩ
13. (a) 17.1 Ω (b) 1.99 A for 4.00 Ω and 9.00 Ω, 1.17 A for 7.00 Ω, 0.818 A for 10.0 Ω
15. 470 Ω and 220 Ω
17. (a) 11.7 Ω (b) 1.00 A in the 12.0-Ω and 8.00-Ω resistors, 2.00 A in the 6.00-Ω and 4.00-Ω resistors, 3.00 A in the 5.00-Ω resistor
19. 14.2 W to 2.00 Ω, 28.4 W to 4.00 Ω, 1.33 W to 3.00 Ω, 4.00 W to 1.00 Ω
21. (a) 4.12 V (b) 1.38 A
23. (a) 0.846 A down in the 8.00-Ω resistor, 0.462 A down in the middle branch, 1.31 A up in the right-hand branch (b) −222 J by the 4.00-V battery, 1.88 kJ by the 12.0-V battery (c) 687 J to 8.00 Ω, 128 J to 5.00 Ω, 25.6 J to the 1.00-Ω resistor in the center branch, 616 J to 3.00 Ω, 205 J to the 1.00-Ω resistor in the right branch

(d) Chemical energy in the 12.0-V battery is transformed into internal energy in the resistors. The 4.00-V battery is being charged, so its chemical potential energy is increasing at the expense of some of the chemical potential energy in the 12.0-V battery. (e) 1.66 kJ

25. (a) 0.395 A (b) 1.50 V
27. 50.0 mA from to
29. (a) 0.714 A (b) 1.29 A (c) 12.6 V
31. (a) 0.385 mA, 3.08 mA, 2.69 mA (b) 69.2 V, with at the higher potential
33. (a) 0.492 A; 0.148 A; 0.639 A (b) $_{28.0}$ 6.77 W, $_{12.0}$ 0.261 W, $_{16.0}$ 6.54 W
35. 3.05 V, 4.57 V, 7.38 V, 1.62 V
37. (a) 2.00 ms (b) 1.80 C (c) 1.14
39. (a) 61.6 mA (b) 0.235 C (c) 1.96 A
41. (a) 1.50 s (b) 1.00 s (c) 200 100 , where is in microamperes and is in seconds
43. (a) 6.00 V (b) 8.29
45. (a) 0.432 s (b) 6.00
47. (a) 6.25 A (b) 750 W
49. (a) — (b) — (c) parallel
51. 2.22 h
53. (a) 1.02 A down (b) 0.364 A down (c) 1.38 A up (d) 0 (e) 66.0
55. (a) 2.00 k (b) 15.0 V (c) 9.00 V
57. (a) 4.00 V (b) Point is at the higher potential.
59. 87.3%
61. 6.00 , 3.00
63. (a) 24.1 C (b) 16.1 C (c) 16.1 mA
65. (a) 240(1 (b) 360(1), where in both answers, is in microcoulombs and is in milliseconds
67. (a) 9.93 C (b) 33.7 nA (c) 335 nW (d) 337 nW
69. (a) 470 W (b) 1.60 mm or more (c) 2.93 mm or more
71. (a) 222 C (b) 444
73. (a) 5.00 (b) 2.40 A
75. (a) 0 in 3 k , 333 A in 12 k and 15 k (b) 50.0 (c) 278 /0.180, where is in microamperes and is in seconds (d) 290 ms
77. (a) – (b) No; 2.75 , so the station is inadequately grounded.
79. (a) – (b) 3
81. (a) 3.91 s (b) 782
83. 20.0 or 98.1

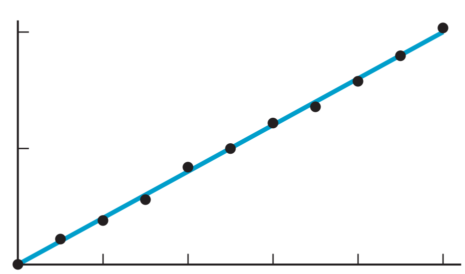
Chapter 29

Answers to Quick Quizzes

(e)
2. **(i)** (b) **(ii)** (a)
3. (c)
4. **(i)** (c), (b), (a) **(ii)** (a) (b) (c)

Answers to Odd-Numbered Problems

Gravitational force: 8.93 N down, electric force: 1.60 N up, and magnetic force: 4.80 down.
3. (a) into the page (b) toward the right (c) toward the bottom of the page
5. (a) the negative direction (b) the positive direction (c) The magnetic force is zero in this case.
(a) 7.91 N (b) zero
9. (a) 1.25 N (b) 7.50 m/s
11. 20.9
13. (a) 4.27 cm (b) 1.79
15. (a) (b)
17. 115 keV
19. (a) 5.00 cm (b) 8.79 m/s
21. 7.88
23. 8.00
25. 0.278 m
27. (a) 7.66 (b) 2.68 m/s (c) 3.75 MeV (d) 3.13 revolutions (e) 2.57
29. 244 kV/m
31. 70.0 mT
33. (a) 8.00 T (b) in the positive direction
35. 2.88
37. 1.07 m/s
39. (a) east (b) 0.245 T
41. (a) 5.78 N (b) toward the west (into the page)
43. 2.98 N west
45. (a) 4.0 m (b) 6.9
47. (a) north at 48.0° below the horizontal (b) south at 48.0° above the horizontal (c) 1.07
49. 9.05 m, tending to make the left-hand side of the loop move toward you and the right-hand side move away.
51. (a) 9.98 N m (b) clockwise as seen looking down from a position on the positive axis
53. (a) 118 m (b) 118 118
55. 43.2
57. (a) 9.27 (b) away from observer
59. (a) 3.52 1.60 10 ^{18} N (b) 24.4°
61. 0.588 T
63.
65. 39.2 mT
67. (a) the positive direction (b) 0.696 m (c) 1.09 m (d) 54.7 ns
69. (a) 0.713 A counterclockwise as seen from above
71. (a) *mg/NIw* (b) The magnetic field exerts forces of equal magnitude and opposite directions on the two sides of the coils, so the forces cancel each other and do not affect the balance of the system. Hence, the vertical dimension of the coil is not needed. (c) 0.261 T
73. (a) 1.04 m (b) 1.89
75. (a) (1.00 , where is in volts and is in teslas



(b) 0.125 mm
77. 3.71
79. (a) 0.128 T (b) 78.7° below the horizontal

Chapter 30

Answers to Quick Quizzes

1. $B > C > A$
2. (a)
3. $c > a > d > b$
4. $a = c = d > b = 0$
5. (c)

Answers to Odd-Numbered Problems

1. (a) 21.5 mA (b) 4.51 V (c) 96.7 mW
3. 1.60×10^{-6} T
5. (a) 28.3 μT into the page (b) 24.7 μT into the page
7. 5.52 μT into the page
9. (a) $2I_1$ out of the page (b) $6I_1$ into the page
11. $\dfrac{\mu_0 I}{2r}\left(\dfrac{1}{\pi} + \dfrac{1}{4}\right)$
13. 262 nT into the page
15. (a) 53.3 μT toward the bottom of the page (b) 20.0 μT toward the bottom of the page (c) zero
17. $\dfrac{\mu_0 I}{2\pi a d}(\sqrt{d^2 + a^2} - d)$ into the page
19. (a) 40.0 μT into the page (b) 5.00 μT out of the page (c) 1.67 μT out of the page
21. (a) 10 μT (b) 80 μN toward the other wire (c) 16 μT (d) 80 μN toward the other wire
23. (a) 3.00×10^{-5} N/m (b) attractive
25. $-27.0\hat{\mathbf{i}}$ μN
27. 0.333 m
29. (a) opposite directions (b) 67.8 A (c) It would be smaller. A smaller gravitational force would be pulling down on the wires, requiring less magnetic force to raise the wires to the same angle and therefore less current.
31. (a) 200 μT toward the top of the page (b) 133 μT toward the bottom of the page
33. 5.40 cm
35. (a) 4.00 m (b) 7.50 nT (c) 1.26 m (d) zero
37. (a) zero (b) $\dfrac{\mu_0 I}{2\pi R}$ tangent to the wall (c) $\dfrac{\mu_0 I^2}{(2\pi R)^2}$ inward
39. 20.0 μT toward the bottom of the page
41. 31.8 mA
43. (a) 226 μN away from the center of the loop (b) zero
45. (a) 920 turns (b) 12 cm
47. (a) 3.13 mWb (b) 0
49. (a) 8.63×10^{45} electrons (b) 4.01×10^{20} kg
51. 3.18 A
53. (a) $\sim 10^{-5}$ T (b) It is $\sim 10^{-1}$ as large as the Earth's magnetic field.
55. 143 pT
57. $\dfrac{\mu_0 I}{2\pi w} \ln\left(1 + \dfrac{w}{b}\right)\hat{\mathbf{k}}$
59. (a) $\mu_0 \sigma v$ into the page (b) zero (c) $\frac{1}{2}\mu_0 \sigma^2 v^2$ up toward the top of the page (d) $\dfrac{1}{\sqrt{\mu_0 \epsilon_0}}$; we will find out in Chapter 34 that this speed is the speed of light. We will also find out in Chapter 39 that this speed is not possible for the capacitor plates.
61. 1.80 mT
63. 3.89 μT parallel to the xy plane and at 59.0° clockwise from the positive x direction
65. (b) 3.20×10^{-13} T (c) 1.03×10^{-24} N (d) 2.31×10^{-22} N
67. $B = 4.36 \times 10^{-4}\, I$, where B is in teslas and I is in amperes
69. (a) $\dfrac{\mu_0 I N}{2\ell}\left[\dfrac{\ell - x}{\sqrt{(\ell - x)^2 + a^2}} + \dfrac{x}{\sqrt{x^2 + a^2}}\right]$
71. $-0.012\,0\,\hat{\mathbf{k}}$ N
73. (b) $\dfrac{\mu_0 I}{4\pi}(1 - e^{-2\pi})$ out of the page
75. (a) $\dfrac{\mu_0 I(2r^2 - a^2)}{\pi r(4r^2 - a^2)}$ to the left (b) $\dfrac{\mu_0 I(2r^2 + a^2)}{\pi r(4r^2 + a^2)}$ toward the top of the page
77. (b) 5.92×10^{-8} N

Chapter 31

Answers to Quick Quizzes

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

Answers to Odd-Numbered Problems

1. 0.800 mA
3. (a) 101 μV tending to produce clockwise current as seen from above (b) It is twice as large in magnitude and in the opposite sense.
5. 33.9 mV
7. 10.2 μV
9. 61.8 mV
11. (a) 1.60 A counterclockwise (b) 20.1 μT (c) left
13. (a) $\dfrac{\mu_0 I L}{2\pi} \ln\left(1 + \dfrac{w}{h}\right)$ (b) 4.80 μV (c) counterclockwise
15. (a) 1.88×10^{-7} T $\cdot$ m^2 (b) 6.28×10^{-8} V
17. 272 m
19. $\boldsymbol{\mathcal{E}} = 0.422 \cos 120\pi t$, where $\boldsymbol{\mathcal{E}}$ is in volts and t is in seconds
21. 2.83 mV
23. 13.1 mV
25. (a) 39.9 μV (b) The west end is positive.
27. (a) 3.00 N to the right (b) 6.00 W
29. (a) 0.500 A (b) 2.00 W (c) 2.00 W
31. 2.80 m/s
33. 24.1 V with the outer contact negative
35. (a) 233 Hz (b) 1.98 mV
37. 145 μA upward in the picture
39. (a) 8.01×10^{-21} N (b) clockwise (c) $t = 0$ or $t = 1.33$ s
41. (a) $E = 9.87 \cos 100\pi t$, where E is in millivolts per meter and t is in seconds (b) clockwise
43. 13.3 V
45. (a) $\boldsymbol{\mathcal{E}} = 19.6 \sin 100\pi t$, where $\boldsymbol{\mathcal{E}}$ is in volts and t is in seconds (b) 19.6 V
47. $\boldsymbol{\mathcal{E}} = 28.6 \sin 4.00\pi t$, where $\boldsymbol{\mathcal{E}}$ is in millivolts and t is in seconds
49. (a) $\Phi_B = 8.00 \times 10^{-3} \cos 120\pi t$, where Φ_B is in T $\cdot$ m^2 and t is in seconds (b) $\boldsymbol{\mathcal{E}} = 3.02 \sin 120\pi t$, where $\boldsymbol{\mathcal{E}}$ is in volts and t is in seconds (c) $I = 3.02 \sin 120\pi t$, where I is in amperes and t is in seconds (d) $P = 9.10 \sin^2 120\pi t$, where P is in watts and t is in seconds (e) $\tau = 0.024\,1 \sin^2 120\pi t$, where τ is in newton meters and t is in seconds
51. (a) 113 V (b) 300 V/m

53. 8.80 A
55. 3.79 mV
57. (a) 43.8 A (b) 38.3 W
59. 7.22 cos 1 046 , where is in millivolts and is in seconds
61. 283 A upward
63. (a) 3.50 A up in 2.00 and 1.40 A up in 5.00 (b) 34.3 W (c) 4.29 N
65. 2.29
67. (a) 0.125 V clockwise (b) 0.020 0 A clockwise
69. (a) 97.4 nV (b) clockwise
71. (a) 36.0 V (b) 0.600 Wb/s (c) 35.9 V (d) 4.32 N · m
73. (a) NB (b) $\frac{NB}{}$ (c) (d) (e) clockwise (f) directed to the left.
75. 6.00 A
77. 87.1 cos (200), where is in millivolts and is in seconds
79. 0.062 3 A in 6.00 , 0.860 A in 5.00 , and 0.923 A in 3.00
81. $\frac{}{Bd}$ mR
83. $\frac{MgR}{}$

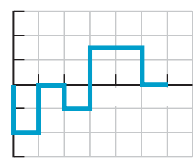
Chapter 32

Answers to Quick Quizzes

(c), (f)
2. **(i)** (b) **(ii)** (a)
3. (a), (d)
4. (a)
5. **(i)** (b) **(ii)** (c)

Answers to Odd-Numbered Problems

19.5 mV
3. 100 V
5. 19.2
4.00 mH
9. (a) 360 mV (b) 180 mV (c) 3.00 s
11. $\frac{}{Lk}$
13. 18.8 cos 120 , where is in volts and is in seconds
15. (a) 0.469 mH (b) 0.188 ms
17. (a) 1.00 k (b) 3.00 ms
19. (a) 1.29 k (b) 72.0 mA
21. (a) 20.0% (b) 4.00%
23. 92.8 V
25. (a) 0.500(1 10.0), where is in amperes and is in seconds (b) 1.50 0.250 10.0 , where is in amperes and is in seconds
27. (a) 0.800 (b) 0
29. (a) 6.67 A/s (b) 0.332 A/s
31. (a) 5.66 ms (b) 1.22 A (c) 58.1 ms
33. 2.44
35. (a) 44.3 nJ/m (b) 995 J/m
37. (a) 18.0 J (b) 7.20 J
39. (a) 8.06 MJ/m (b) 6.32 kJ
41. 1.00 V
43. (a) 18.0 mH (b) 34.3 mH (c) 9.00 mV
45. 781 pH
47. 281 mH
49. 400 mA
51. 20.0 V
53. (a) 503 Hz (b) 12.0 C (c) 37.9 mA (d) 72.0
55. (a) 135 Hz (b) 119 C (c) 114 mA
57. (a) 2.51 kHz (b) 69.9
59. (a) 0.693 (b) 0.347
61. (a) 20.0 mV (b) 10.0 , where is in megavolts and is in seconds (c) 63.2
63.
65. (a) 4.00 H (b) 3.50
67. (a) (b) 10 H (c) 10
69.



71. 91.2
73. (a) 6.25 J (b) 2.00 N/m
75. (a) 50.0 mT (b) 20.0 mT (c) 2.29 MJ (d) 318 Pa
79. (a) (b) 2.70
81. 300
83.

Chapter 33

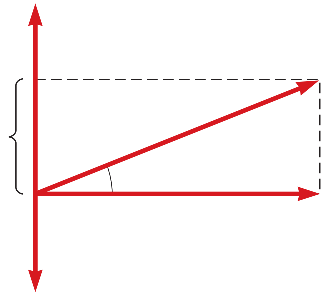
Answers to Quick Quizzes

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

Answers to Odd-Numbered Problems

(a) 96.0 V (b) 136 V (c) 11.3 A (d) 768 W
3. (a) 2.95 A (b) 70.7 V
5. 14.6 Hz
3.38 W
9. 3.14 A
11. 5.60 A
13. (a) 12.6 (b) 6.21 A (c) 8.78 A
15. 0.450 Wb
17. 32.0 A
19. (a) 41.3 Hz (b) 87.5
21. 100 mA
23. (a) 141 mA (b) 235 mA

25.



27. (a) 47.1 (b) 637 (c) 2.40 k (d) 2.33 k
(e) 14.2°
29. (a) 17.4° (b) the voltage
31. (a) 194 V (b) The current leads by 49.9°.
33.
35. 353 W
37. 88.0 W
39. (a) 16.0 (b) 12.0
41. $\frac{11 \quad \text{rms}}{14}$
43. 1.82 pF
45. 242 mJ
47. (a) 0.633 pF (b) 8.46 mm (c) 25.1
49. 687 V
51. 87.5
53. 0.756
55. (a) 34% (b) 5.3 W (c) $3.9
57. (a) 1.60 turns (b) 30.0 A (c) 25.3 A
59. (a) 22.4 V (b) 26.6° (c) 0.267 A (d) 83.9 (e) 47.2
(f) 0.249 H (g) 2.67 W
61. 2.6 cm
63. (a) could be 53.8 or it could be 1.35 k Ω (b) capacitive reactance is 53.8 (c) must be 1.43 k
65. (b) 31.6
67. (a) 19.7 cm at 35.0° (b) 19.7 cm at 35.0°
(c) The answers are identical. (d) 9.36 cm at 169°
69. (a) Tension and separation must be related by 274 , where is in newtons and is in meters.
(b) One possibility is 10.9 N and 0.200 m.
71. (a) 0.225 A (b) 0.450 A
73. (a) 78.5 (b) 1.59 k (c) 1.52 k (d) 138 mA
(e) 84.3° (f) 0.098 7 (g) 1.43 W
75. 56.7 W
77. (a) 580 H (b) 54.6 F (c) 1.00 (d) 894 Hz (e) At 200 Hz, 60.0° ($_{\text{out}}$ leads); at $_{\text{out}}$ is in phase with); and at 4.00 Hz, 60.0° $_{\text{out}}$ lags). (f) At 200 Hz and at 4.00 Hz, 1.56 W; and at 6.25 W. (g) 0.408
79. (a) 224 s (b) 500 W (c) 221 s and 226 s
81. 58.7 Hz or 35.9 Hz. The circuit can be either above or below resonance.

Chapter 34

Answers to Quick Quizzes

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

Answers to Odd-Numbered Problems

(a) out of the page (b) 1.85
3. (a) 11.3 GV m/s (b) 0.100 A
5. 2.87 5.75 10 m
(a) 0.690 wavelengths (b) 58.9 wavelengths
9. (a) 681 yr (b) 8.32 min (c) 2.56 s
11. 74.9 MHz
13. 2.25 m/s
15. (a) 6.00 MHz (b) 73.4 nT
(c) = −73.4 cos 0.126 3.77 10 , where is in nT, is in meters, and is in seconds
17. 2.9 m/s
19. (a) 0.333 T (b) 0.628 m (c) 4.77
21. 3.34 J/m
23. 3.33
25. (a) 1.19 W/m (b) 2.35
27. (a) 2.33 mT (b) 650 MW/m (c) 511 W
29. 307 W/m
31. 49.5 mV
33. (a) 332 kW/m radially inward (b) 1.88 kV/m and 222
35. 5.31 N/m
37. (a) 1.90 kN/C (b) 50.0 pJ (c) 1.67 kg m/s
39. 4.09°
41. (a) 1.60 kg each second (b) 1.60
(c) The answers are the same. Force is the time rate of momentum transfer.
43. (a) 5.48 N (b) 913 m/s away from the Sun (c) 10.6 days
45. (a) 134 m (b) 46.8 m
47. 56.2 m
49. (a) away along the perpendicular bisector of the line segment joining the antennas (b) along the extensions of the line segment joining the antennas
51. (a) 6.00 pm (b) 7.49 cm
53. (a) 4.16 m to 4.54 m (b) 3.41 m to 3.66 m
(c) 1.61 m to 1.67 m
55. (a) 3.85 W (b) 1.02 kV/m and 3.39
57. 5.50
59. (a) 3.21 W (b) 0.639 W/m
(c) 0.513% of that from the noon Sun in January
61.
63. 378 nm
65. (a) 6.67 T (b) 5.31 W/m
(c) 1.67 W (d) 5.56
67. (a) 625 kW/m (b) 21.7 kV/m (c) 72.4 T (d) 17.8 min
69. (a) 388 K (b) 363 K
71. (a) 3.92 W/m (b) 308 W
73. (a) 0.161 m (b) 0.163 m (c) 76.8 W (d) 470 W/m
(e) 595 V/m (f) 1.98 T (g) 119 W
75. (a) The projected area is , where is the radius of the planet. (b) The radiating area is 4 . (c) 1.61
77. (a) 584 nT (b) 419 m (c) 1.26
(d) vibrates in the plane. (e) 40.6
(f) 271 nPa (g) 407 nm
79. (a) 22.6 h (b) 30.6 s

Chapter 35

Answers to Quick Quizzes

1. (d)
2. Beams ② and ④ are reflected; beams ③ and ⑤ are refracted.
3. (c)
4. (c)
5. **(i)** (b) **(ii)** (b)

Answers to Odd-Numbered Problems

1. (a) 2.07×10^3 eV (b) 4.14 eV
3. 114 rad/s
5. (a) 4.74×10^{14} Hz (b) 422 nm (c) 2.00×10^8 m/s
7. 22.5°
9. (a) 1.81×10^8 m/s (b) 2.25×10^8 m/s (c) 1.36×10^8 m/s
11. (a) 29.0° (b) 25.8° (c) 32.0°
13. 86.8°
15. 158 Mm/s
17. (a) $\theta_{1i} = 30°$, $\theta_{1r} = 19°$, $\theta_{2i} = 41°$, $\theta_{2r} = 77°$ (b) First surface: $\theta_{\text{reflection}} = 30°$; second surface: $\theta_{\text{reflection}} = 41°$
19. $\sim 10^{-11}$ s, $\sim 10^3$ wavelengths
21. (a) 1.94 m (b) 50.0° above the horizontal
23. 27.1 ns
25. (a) 2.0×10^8 m/s (b) 4.74×10^{14} Hz (c) 4.2×10^{-7} m
27. 3.39 m
29. (a) 41.5° (b) 18.5° (c) 27.5° (d) 42.5°
31. 23.1°
33. 1.22
35. $\tan^{-1}(n_g)$
37. 0.314°
39. 4.61°
41. 62.5°
43. 27.9°
45. 67.1°
47. 1.000 07
49. (a) $\dfrac{nd}{n-1}$ (b) $R_{\text{min}} \to 0$. Yes; for very small d, the light strikes the interface at very large angles of incidence. (c) R_{min} decreases. Yes; as n increases, the critical angle becomes smaller. (d) $R_{\text{min}} \to \infty$. Yes; as $n \to 1$, the critical angle becomes close to 90° and any bend will allow the light to escape. (e) 350 μm
51. 48.5°
53. 2.27 m
55. 25.7°
57. (a) 0.042 6 or 4.26% (b) no difference
59. (a) 334 μs (b) 0.014 6%
61. 77.5°
63. 2.00 m
65. 27.5°
67. 3.79 m
69. 7.93°
71. $\sin^{-1}\left[\dfrac{L}{R^2}\left(\sqrt{n^2R^2 - L^2} - \sqrt{R^2 - L^2}\right)\right]$ or $\sin^{-1}\left[n \sin\left(\sin^{-1}\dfrac{L}{R} - \sin^{-1}\dfrac{L}{nR}\right)\right]$
73. (a) 38.5° (b) 1.44
75. (a) 53.1° (b) $\theta_1 \geq 38.7°$
77. (a) 1.20 (b) 3.40 ns
79. (a) 0.172 mm/s (b) 0.345 mm/s (c) and (d) northward and downward at 50.0° below the horizontal.
81. 62.2%
83. (a) $\left(\dfrac{4x^2 + L^2}{L}\right)\omega$ (b) 0 (c) $L\omega$ (d) $2L\omega$ (e) $\dfrac{\pi}{8\omega}$
87. 70.6%

Chapter 36

Answers to Quick Quizzes

1. false
2. (b)
3. (b)
4. (d)
5. (a)
6. (b)
7. (a)
8. (c)

Answers to Odd-Numbered Problems

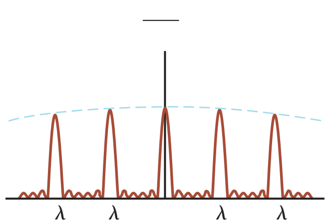
1. 89.0 cm
3. (a) younger (b) $\sim 10^{-9}$ s younger
5. (a) $p_1 + h$, behind the lower mirror (b) virtual (c) upright (d) 1.00 (e) no
7. (a) 1.00 m behind the nearest mirror (b) the palm (c) 5.00 m behind the nearest mirror (d) the back of her hand (e) 7.00 m behind the nearest mirror (f) the palm (g) All are virtual images.
9. **(i)** (a) 13.3 cm (b) real (c) inverted (d) −0.333 **(ii)** (a) 20.0 cm (b) real (c) inverted (d) −1.00 **(iii)** (a) ∞ (b) no image formed (c) no image formed (d) no image formed
11. (a) −12.0 cm; 0.400 (b) −15.0 cm; 0.250 (c) both upright
13. (a) −7.50 cm (b) upright (c) 0.500 cm
15. 3.33 m from the deepest point in the niche
17. 0.790 cm
19. (a) 0.160 m (b) −0.400 m
21. (a) convex (b) at the 30.0-cm mark (c) −20.0 cm
23. (a) 15.0 cm (b) 60.0 cm
25. (a) concave (b) 2.08 m (c) 1.25 m from the object
27. (a) 25.6 m (b) 0.058 7 rad (c) 2.51 m (d) 0.023 9 rad (e) 62.8 m
29. (a) 45.1 cm (b) −89.6 cm (c) −6.00 cm
31. (a) 1.50 m (b) 1.75 m
33. 4.82 cm
35. 8.57 cm
37. 1.50 cm/s
39. (a) 6.40 cm (b) −0.250 (c) converging
41. (a) 39.0 mm (b) 39.5 mm
43. 20.0 cm
45. (a) 20.0 cm from the lens on the front side (b) 12.5 cm from the lens on the front side (c) 6.67 cm from the lens on the front side (d) 8.33 cm from the lens on the front side
47. 2.84 cm
49. (a) 16.4 cm (b) 16.4 cm
51. (a) 1.16 mm/s (b) toward the lens
53. 7.47 cm in front of the second lens, 1.07 cm, virtual, upright
55. 21.3 cm

57. 2.18 mm away from the CCD
59. (a) 42.9 cm (b) 2.33 diopters
61. 23.2 cm
63. (a) −0.67 diopters (b) 0.67 diopters
65. (a) Yes, if the lenses are bifocal.
(b) 56.3 cm, 1.78 diopters (c) 1.18 diopters
67. 575
69. 3.38 min
71. (a) 267 cm (b) 79.0 cm
73. 40.0 cm
75. (a) 1.50 (b) 1.90
77. (a) 160 cm to the left of the lens (b) 0.800 (c) inverted
79. (a) 32.1 cm to the right of the second surface (b) real
81. (a) 25.3 cm to the right of the mirror (b) virtual (c) upright (d) 8.05
83. (a) 1.40 kW/m (b) 6.91 mW/m (c) 0.164 cm (d) 58.1 W/m
87. 8.00 cm
89. 11.7 cm
91. (a) 1.50 m in front of the mirror (b) 1.40 cm
(a) 0.334 m or larger (b) 0.025 5 or larger
95. (a) 1.99 (b) 10.0 cm to the left of the lens (c) 2.50 (d) inverted
97. and

Chapter 37

Answers to Quick Quizzes

(c)
2. The graph is shown here. The width of the primary maxima is slightly narrower than the 5 primary width but wider than the 10 primary width. Because 6, the secondary maxima are $\frac{}{36}$ as intense as the primary maxima.



3. (a)

Answers to Odd-Numbered Problems

641
3. 632 nm
5. 1.54 mm
2.40
9. (a) 2.62 mm (b) 2.62 mm
11. Maxima at 0°, 29.1°, and 76.3°; minima at 14.1° and 46.8°
13. (a) 55.7 m (b) 124 m
15. 0.318 m/s
17. 148 m
21. (a) 1.93 m (b) 3.00
(c) It corresponds to a maximum. The path difference is an integer multiple of the wavelength.
23. 0.968
25. 48.0
27. (a) 1.29 rad (b) 99.6 nm
29. (a) 7.95 rad (b) 0.453
31. 512 nm
33. 0.500 cm
35. 290 nm
37. 8.70
39. 1.31
41. 1.20 mm
43. 1.001
45. 1.25 m
47. 1.62 cm
49. 78.4
51. $\frac{}{48}$ 650, where and are in nanometers and 0, 1, 1, 2, 2, 3, 3, .
53. ————
55. 5.00 5.00 km
57. 2.50 mm
59. 113
61. (a) 72.0 m (b) 36.0 m
63. (a) 70.6 m (b) 136 m
65. (a) 14.7 m (b) 1.53 cm (c) 16.0 m
67. 0.505 mm
69. 3.58°
71. 115 nm
73. (a) $\frac{}{-\lambda}$ (b) 266 nm
75. 0.498 mm

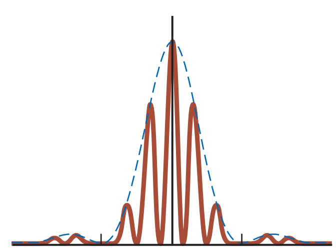
Chapter 38

Answers to Quick Quizzes

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

Answers to Odd-Numbered Problems

(a) 1.1 m (b) 1.7 mm
3. (a) four (b) 28.7°, 73.6°
5. 91.2 cm
2.30
9.



11. 1.62
13. 462 nm
15. 2.10 m
17. 0.284 m
19. 30.5 m
21. 0.40 rad
23. 16.4 m

25. 1.81
27. (a) three (b) 0°, 45.2°, 45.2°
29. 74.2 grooves/mm
31.
33. 514 nm
35. (a) 3.53 rulings/cm (b) 11
37. (a) 5.23 m (b) 4.58
39. 0.093 4 nm
41. (a) 0.109 nm (b) four
43. (a) 54.7° (b) 63.4° (c) 71.6°
45. 0.375
47. (a) six (b) 7.50°
49. 60.5°
51. 6.89 units
53. (a) 0.045 0 (b) 0.016 2
55. 5.51 m, 2.76 m, 1.84 m
57. 632.8 nm
59. (a) 7.26 rad, 1.50 arc seconds (b) 0.189 ly (c) 50.8 rad (d) 1.52 mm
61. (a) 25.6° (b) 18.9°
63. 545 nm
65. 13.7°
67. 15.4
69. (b) 3.77 nm/cm
71. (a) 4.49 compared with the prediction from the approximation of 1.5 4.71 (b) 7.73 compared with the prediction from the approximation of 2.5 7.85
73. (b) 0.001 90 rad 0.109°
75. (b) 15.3
77. (a) 41.8° (b) 0.592 (c) 0.262 m

Chapter 39

Answers to Quick Quizzes

(c)
2. (d)
3. (d)
4. (a)
5. (a)
6. (c)
(d)
8. **(i)** (c) **(ii)** (a)
9. (a) (b) (c)

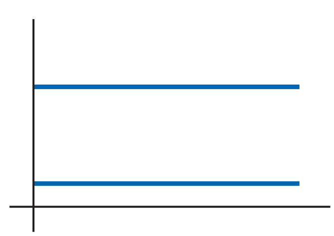
Answers to Odd-Numbered Problems

10.0 m/s toward the left in Figure P39.1
3. 5.70 degrees or 9.94 rad
5. 0.917
0.866
9. 0.866
11. 0.220
13. 5.00 s
15. The trackside observer measures the length to be 31.2 m, so the supertrain is measured to fit in the tunnel, with 18.8 m to spare.
17. (a) 25.0 yr (b) 15.0 yr (c) 12.0 ly
19. 0.800
21. (b) 0.050 4
23. (c) 2.00 kHz (d) 0.075 m/s 0.17 mi/h
25. 1.55 ns
27. (a) 2.50 m/s (b) 4.98 m (c) 1.33
29. (a) 17.4 m (b) 3.30°
31. Event B occurs first, 444 ns earlier than A
33. 0.357
35. 0.998 toward the right
37. (a) 0.943 2.83 m/s
(b) The result would be the same.
39. (a) 929 MeV/ (b) 6.58 MeV/ (c) No
41. 4.51
43. 0.285
45. (a) 3.07 MeV (b) 0.986
47. (a) 938 MeV (b) 3.00 GeV (c) 2.07 GeV
49. (a) 5.37 335 MeV
(b) 1.33 8.31 GeV
51. 1.63 MeV/
53. (a) smaller (b) 3.18 kg
(c) It is too small a fraction of 9.00 g to be measured.
55. 4.28 kg/s
57. (a) 8.63 J (b) 9.61
59. (a) 0.979 (b) 0.065 2 (c) 15.0
(d) 0.999 999 97 ; 0.948 ; 1.06
61. (a) 4.08 MeV (b) 29.6 MeV
63. 2.97
65. (a) 2.66 m (b) 3.87 km/s (c) 8.35
(d) 5.29 (e) 4.46
67. 0.712%
69. (a) 13.4 m/s toward the station and 13.4 m/s away from the station. (b) 0.056 7 rad/s
71. (a) 1.12 (b) 6.00 27
(c) $2.17
73. (a) 21.0 yr (b) 14.7 ly (c) 10.5 ly (d) 35.7 yr
75. (a) 6.67 (b) 1.97 h
77. (a) or 10 s (b)
79. (a) 0.905 MeV (b) 0.394 MeV
(c) 0.747 MeV/ 3.99 kg m/s (d) 65.4°
81. (b) 1.48 km
83. (a) 0.946 (b) 0.160 ly (c) 0.114 yr (d) 7.49
85. (a) 229 s (b) 174 s
87. 1.83
91. (a) 0.800 (b) 7.51 s (c) 1.44 m (d) 0.385
(e) 4.88

Chapter 40

Answers to Quick Quizzes

(b)
2. Sodium light, microwaves, FM radio, AM radio.
3. (c)
4. The classical expectation (which did not match the experiment) yields a graph like the following drawing:



5. (d)
6. (c)

(b)
8. (a)

Answers to Odd-Numbered Problems

6.85 m, which is in the infrared region of the spectrum
3. (a) lightning: m; explosion: m (b) lightning: ultraviolet; explosion: x-ray and gamma ray
5. 5.71 photons/s
(a) 2.99 K (b) 2.00
9. 5.18
11. 1.30 photons/s
13. (a) 0.263 kg (b) 1.81 W (c) 0.015 3°C/s 0.919°C/min (d) 9.89 m (e) 2.01 J (f) 8.99 photon/s
15. 1.34 ^{31}
17. (a) 295 nm, 1.02 PHz (b) 2.69 V
19. (a) 1.89 eV (b) 0.216 V
21. (a) 1.38 eV (b) 3.34
23. 8.34
25. 1.04
27. 22.1 keV/ = 478 eV
29. 70.0°
31. (a) 43.0° (b) 0.601 MeV; 0.601 MeV/ 3.21 kg m/s (c) 0.279 MeV; 0.279 MeV/ 3.21 kg m/s
33. (a) 4.89 nm (b) 268 keV (c) 31.8 keV
35. (a) 0.101 nm (b) 80.8°
37. To have photon energy 10 eV or greater, according to this definition, ionizing radiation is the ultraviolet light, x-rays, and rays with wavelength shorter than 124 nm; that is, with frequency higher than 2.42 Hz.
39. (a) 1.66 ^{27} kg m/s (b) 1.82 km/s
41. (a) 14.8 keV or, ignoring relativistic correction, 15.1 keV (b) 124 keV
43. 0.218 nm
45. (a) 3.91 10 (b) 20.0 GeV/ 1.07 10 kg m/s (c) 6.20 m (d) The wavelength is two orders of magnitude smaller than the size of the nucleus.
47. (a) $\frac{}{\gamma -}$ – where $\gamma =$ (b) 1.60
(c) no change (d) 2.00 (e) 1 (f)
49. (a) $_{\text{phase}}$ –
(b) This is different from the speed at which the particle transports mass, energy, and momentum.
51. (a) 989 nm (b) 4.94 mm (c) No; there is no way to identify the slit through which the neutron passed. Even if one neutron at a time is incident on the pair of slits, an interference pattern still develops on the detector array. Therefore, each neutron in effect passes through both slits.
53. 105 V
55. within 1.16 mm for the electron, 5.28 m for the bullet
57.
61. 1.36 eV
63. (a) 19.8 m (b) 0.333 m
65. (a) 1.7 eV (b) 4.2 s (c) 7.3
67. (a) 2.82 m (b) 1.06 J (c) 2.87
69. (a) 8.72 $10^{16}\,\frac{\text{electrons}}{\text{cm}}$ (b) 14.0 mA/cm
(c) The actual current will be lower than that in part (b).

71. (a) 0.143 nm (b) This is the same order of magnitude as the spacing between atoms in a crystal
(c) Because the wavelength is about the same as the spacing, diffraction effects should occur.
73. (a) The Doppler shift increases the apparent frequency of the incident light. (b) 3.86 eV (c) 8.76 eV

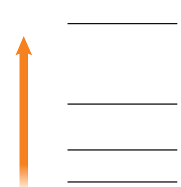
Chapter 41

Answers to Quick Quizzes

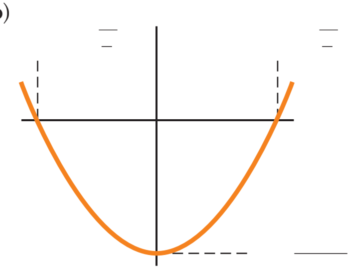
(d)
2. **(i)** (a) **(ii)** (d)
3. (c)
4. (a), (c), (f)

Answers to Odd-Numbered Problems

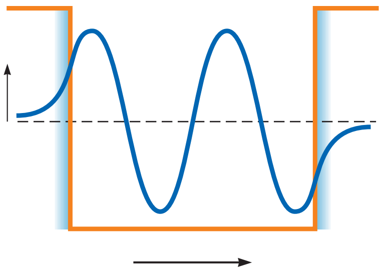
(a) 126 pm (b) 5.27 kg m/s (c) 95.3 eV
3. (a) (b) 0.037 0 (c) 0.750
5. (a) 0.511 MeV, 2.05 MeV, 4.60 MeV
(b) They do; the MeV is the natural unit for energy radiated by an atomic nucleus.
(a)



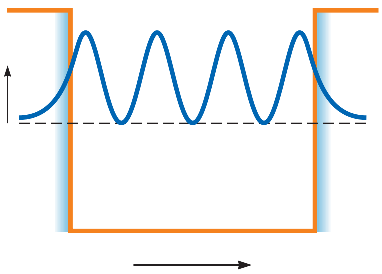
(b) 2.20 nm, 2.75 nm, 4.12 nm, 4.71 nm, 6.59 nm, 11.0 nm
9. 0.795 nm
11. (a) 6.14 MeV (b) 202 fm (c) gamma ray
13. (a) 0.434 nm (b) 6.00 eV
15. (a) (15 $^{1/2}$ (b) 1.25
17. (a) (b) 0.409
19. (a) – (b) 5.26 (c) 3.99
(d) In the 2 graph in the text's Figure 41.4b, it is more probable to find the particle either near /4 or /4 than at the center, where the probability density is zero. Nevertheless, the symmetry of the distribution means that the average position is /2.
21. (a) 0.196 (b) The classical probability is 0.333, which is significantly larger.
(c) 0.333 for both classical and quantum models
23. (a) 0.196 (b) 0.609
25. (b)
27. (a) $\frac{}{mL}$
(b)



29. (a)



(b)



31. (a) 0.010 3 (b) 0.990
33. 85.9
35. 3.92%
37. 600 nm

39. (a) (b)

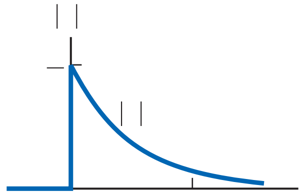
43. (a) 2.00 m (b) 3.31 kg m/s (c) 0.171 eV
45. 0.250
47. (a) 0.903 (b) 0.359 (c) 0.417 (d) 10 6.59
49. (a) 435 THz (b) 689 nm (c) 165 peV or more

51. (a) (b)

53. (a) nhc mc mc (b) 4.68

(c) 28.6% larger

55. (a) | |



(b) 0 (d) 0.865

57. (a) 0 (b) 0 (c)

59. (b) 0.092 0 (c) 0.908
61. (a) 0.200 (b) 0.351 (c) 0.376 eV (d) 1.50 eV

63. (a) (b) 0 (c) = ± (d)

(e) 0 (f)

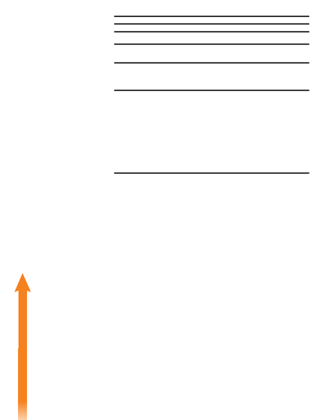
Chapter 42

Answers to Quick Quizzes

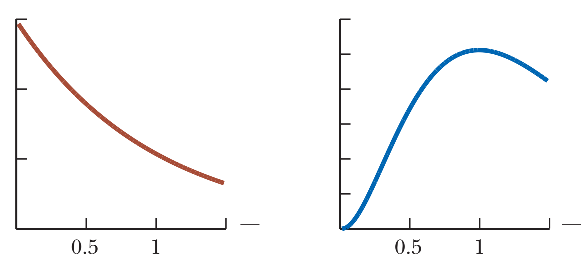
(c)
2. (a)
3. (b)
4. (a) five (b) nine
5. (c)
6. true

Answers to Odd-Numbered Problems

(a) 121.5 nm, 102.5 nm, 97.20 nm (b) ultraviolet
3. 1.94
5. (a) 5 (b) no (c) no
(a) 5.69 m (b) 11.3 N
9. (a) 13.6 eV (b) 1.51 eV
11. (a) 0.968 eV (b) 1.28 m (c) 2.34
13. (a) 2.19 m/s (b) 13.6 eV (c) 27.2 eV
15. (a) 2.89 kg · m /s (b) 2.74 (c) 7.30
17. (a) 0.476 nm (b) 0.997 nm
19. (a) 3 (b) 520 km/s
21. (a) 54.4 eV/ for 1, 2, 3, .



(b) 54.4 eV
23. (b) 0.179 nm
25.



27.
29. 797
31.
33. (a) 2.58 10 34 J
(b) 3.65 10 34 J

35. –
37. 2.58 10 ^{34} J
39. 3; 2; 2, 1, 0, 1, or 2; 1; 1, 0, or 1, for a total of 15 states
41. (a) 1
(b) ℓ ℓ
–
–
–
–
–
–
–
–
–
–

43. aluminum
45. (a) 30 (b) 36
47. 18.4 T
49. 17.7 kV
51. (a) 14 keV (b) 8.8
53. (a) If 2, then 2, 1, 0, 1, 2; if 1, then 1, 0, 1; if 0, then 0. (b) 6.05 eV
55. 0.068 nm
57. gallium
59. (a) 28.3 THz (b) 10.6 m (c) infrared
61. 3.49 photons
63. (a) 4.24 W/m (b) 1.20
65. (a) 3.40 eV (b) 0.136 eV
67. (a) 1.57 $^{3/2}$ (b) 2.47 ^{28}
(c) 8.69
69. 9.80 GHz
71. between 10 K and 10 K; use Equation 21.19 and set the kinetic energy equal to typical ionization energies
73. —, no
75. (a) 609 eV (b) 6.9 eV (c) 147 GHz (d) 2.04 mm
77. — 0.866
79. (a) 486 nm (b) 0.815 m/s
81. (a) — —
(b) — —
(c) 0, , and (d)
(e) where 0.191
83. (a) 4.20 mm (b) 1.05 photons
(c) 8.84
85. $\frac{}{mL}$
87. 0.125
89. (a) 0.106 , where is in nanometers and 1, 2, 3, . . . (b) $= -\frac{6.80}{}$ where is in electron volts and 1, 2, 3, . . .
91. The classical frequency is 4

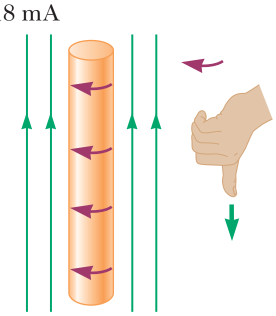
Chapter 43

Answers to Quick Quizzes

(a) van der Waals (b) ionic (c) hydrogen (d) covalent
2. (c)
3. (a)
4. A: semiconductor; B: conductor; C: insulator

Answers to Odd-Numbered Problems

10 K
3. 4.3 eV
5. (a) 74.2 pm (b) 4.46 eV
(a) 1.46 10 ^{46} kg m (b) The results are the same, suggesting that the molecule's bond length does not change measurably between the two transitions.
9. 9.77 rad/s
11. (a) 0.014 7 eV (b) 84.1
13. (a) 12.0 pm (b) 9.22 pm
15. (a) 2.32 kg (b) 1.82 kg (c) 1.62 cm
17. (a) 0, 3.62 eV, 1.09 eV
(b) 0.097 9 eV, 0.294 eV, 0.490 eV
19. (a) 472 m (b) 473 m (c) 0.715
21. (a) 4.60 kg (b) 1.32 Hz (c) 0.074 1 nm
23. 6.25
25. 7.83 eV
27. 5.28 eV
29.
31. (a) 4.23 eV (b) 3.27
33. (a) 2.54 ^{28} (b) 3.15 eV
35. 0.939
41. (a) 276 THz (b) 1.09
43. 1.91 eV
45. 227 nm
47. (a) 59.5 mV (b) 59.5 mV
49. 4.18 mA
51. (a)



(b) 10.7 kA
53. 203 A to produce a magnetic field in the direction of the original field
55.

57. 5.24 J/g
61. (a) 0.350 nm (b) 7.02 eV (c) 1.20
63. (a) 6.15 Hz (b) 1.59 ^{46} kg
(c) 4.78 m or 4.96

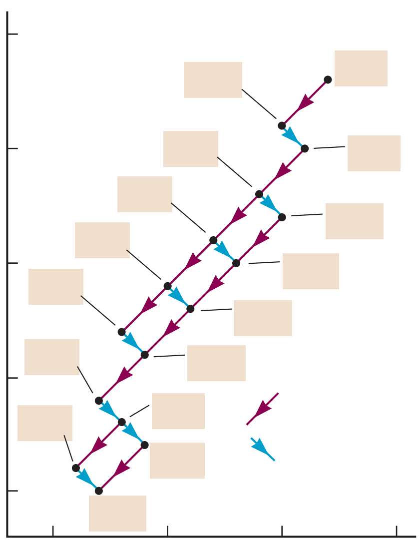
Chapter 44

Answers to Quick Quizzes

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

Answers to Odd-Numbered Problems

(a) 1.5 fm (b) 4.7 fm (c) 7.0 fm (d) 7.4 fm
3. (a) 455 fm (b) 6.05 m/s
5. (a) 4.8 fm (b) 4.7 (c) 2.3 kg/m
16 km
9. 8.21 cm
11. (a) 27.6 N (b) 4.16 ^{27} m/s (c) 1.73 MeV
13. 6.1 N toward each other
15. (a) 1.11 MeV (b) 7.07 MeV (c) 8.79 MeV (d) 7.57 MeV
17. greater for N by 3.54 MeV
19. (a) ^{139}Cs (b) ^{139}La (c) ^{139}
21. 7.93 MeV
23. (a) 491 MeV (b) term 1: 179%; term 2: 53.0%; term 3: 24.6%; term 4: 1.37%
25. 86.4 h
27. 1.16
29. 9.47 nuclei
31. (a) 0.086 2 d 3.59 9.98
(b) 2.37 nuclei (c) 0.200 mCi
33. 1.41
35. (a) cannot occur (b) cannot occur (c) can occur
37. 0.156 MeV
39. 4.27 MeV
41. (a) e (b) 2.75 MeV
43. (a) 148 Bq/m (b) 7.05 atoms/m (c) 2.17
45.



47. 1.02 MeV
49. (a) ^{21}Ne (b) ^{144}Xe (c) e
51. 8.005 3 u; 10.013 5 u
53. (a) 29.2 MHz (b) 42.6 MHz (c) 2.13 kHz
55. 46.5 d
57. (a) 2.7 fm (b) 1.5 N (c) 2.6 MeV
(d) 7.4 fm; 3.8 N; 18 MeV
59. 2.20
61. (a) smaller (b) 1.46 u (c) 1.45 % (d) no
63. (a) 2.52 (b) 2.29 Bq (c) 1.07
65. 5.94 Gyr
67. (b) 1.95
69. 0.401%
71. (a) Mo (b) electron capture: all levels; e emission: only 2.03 MeV, 1.48 MeV, and 1.35 MeV
73. (b) 1.16 u
75. 2.66 d

Chapter 45

Answers to Quick Quizzes

(b)
2. (a), (b)
3. (a)
4. (d)

Answers to Odd-Numbered Problems

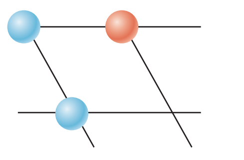
1.1 fissions
3. ^{144}Xe, ^{143}Xe, and ^{142}
5. ^{232}Th Th; Th Pa
Pa
126 MeV
9. 184 MeV
11. 5.58
13. 2.68
15. 26 MeV
17. (a) 3.08 g (b) 1.31 mol (c) 7.89 ^{31} nuclei
(d) 2.53 ^{21} J (e) 5.34 yr (f) Fission is not sufficient to supply the entire world with energy at a price of $130 or less per kilogram of uranium.
19. 1.01 g
21. (a) Be (b) C (c) 7.27 MeV
23. 5.49 MeV
25. (a) 31.9 g/h (b) 123 g/h
27. (a) 2.61 ^{31} J (b) 5.50
29. (a) 2.23 m/s (b)
31. (a) 10 (b) 1.2 J/m (c) 1.8 T
33. (a) 0.436 cm (b) 5.79 cm
35. (a) 10.0 h (b) 3.16 m
37. 2.39 °C, which is negligible
39. 1.66
41. (a) 421 MBq (b) 153 ng
43. (a) 0.963 mm (b) It increases by 7.47%.
45. (a) atoms (b)
47. 1.01 MeV
49. (a) 1.5 nuclei (b) 0.6 kg
51. (a) 3.12 (b) 3.12 electrons
53. (a) 1.94 MeV, 1.20 MeV, 7.55 MeV, 7.30 MeV, 1.73 MeV, 4.97 MeV (b) 1.02 MeV (c) 26.7 MeV
(d) Most of the neutrinos leave the star directly after their creation, without interacting with any other particles.
55. 69.0 W
57. 2.57
59. (b) 26.7 MeV

61. (a) 5.67 K (b) 120 kJ
63. 14.0 MeV or, ignoring relativistic correction, 14.1 MeV
65. (a) 3.4 Ci, 16 Ci, 3.1 Ci (b) 50%, 2.3%, 47% (c) It is dangerous, notably if the material is inhaled as a powder. With precautions to minimize human con tact, however, microcurie sources are routinely used in laboratories.
67. (a) 8 eV (b) 4.62 MeV and 13.9 MeV (c) 1.03 kWh
69. (a) 4.92 kg/h → 4.92 /h (b) 0.141 kg/h
71. 4.44 kg/h
73. (a) 10 electrons (b) 10 (c) 10

Chapter 46

Answers to Quick Quizzes

(a)
2. **(i)** (c), (d) **(ii)** (a)
3. (b), (e), (f)
4. (b), (e)
5. 0



6. false

Answers to Odd-Numbered Problems

(a) 5.57 J (b) $1.70
3. (a) 4.54 Hz (b) 6.61
5. 118 MeV
(b) The range is inversely proportional to the mass of the field particle. (c)
9. (a) 67.5 MeV (b) 67.5 MeV/ (c) 1.63
11. (a) muon lepton number and electron lepton number (b) charge (c) angular momentum and baryon number (d) charge (e) electron lepton number
13. (a) $^-$ (b) (c) $^-$ (d) (e) (f) $^-$ + ν
15. (a) It cannot occur because it violates baryon number conservation. (b) It can occur. (c) It cannot occur because it violates baryon number conservation. (d) It can occur. (e) It can occur. (f) It cannot occur because it violates baryon number conservation, muon lepton number conservation, and energy conservation.
17. 0.828
19. (a) 37.7 MeV (b) 37.7 MeV (c) 0 (d) No. The mass of the meson is much less than that of the proton, so it carries much more kinetic energy. The correct analy sis using relativistic energy conservation shows that the kinetic energy of the proton is 5.35 MeV, while that of the meson is 32.3 MeV.
21. (a) It is not allowed because neither baryon number nor angular momentum is conserved. (b) strong interaction (c) weak interaction (d) weak interaction (e) electromagnetic interaction
23. (a) K (scattering event) (b) (c)
25. (a) Strangeness is not conserved. (b) Strangeness is conserved. (c) Strangeness is conserved. (d) Strange ness is not conserved. (e) Strangeness is not conserved. (f) Strangeness is not conserved.
27. 9.25 cm
33. (a) (b) 0 (c) antiproton; antineutron
35. The unknown particle is a neutron, udd.
39. (a) 1.06 mm (b) microwave
41. (a) K (b)
43. 7.73
45. (a) 0.160 (b) 2.18
47. (a) 590.09 nm (b) 599 nm (c) 684 nm
49. 6.00
51. (a) Charge is not conserved. (b) Energy, muon lepton number, and electron lepton number are not conserved. (c) Baryon number is not conserved.
53. 0.407%
55.
59. 1.12 GeV/
61. (a) electron–positron annihilation; e (b) A neutrino col lides with a neutron, producing a proton and a muon; W
63.
65. neutron
67. 5.35 MeV and 32.3 MeV
69. (a) 0.782 MeV (b) 0.919 382 km/s (c) The electron is relativistic; the proton is not.
71. (b) 9.08 Gyr
73. (a) 2*Nmc* (b) $^-$*Nmc* (c) method (a)