ANSWERS TO ODD-NUMBERED PROBLEMS

CHAPTER 1

1. 124 m^2
3. 10 159 m
5. 0.75 m^2/s
7. 2.0 magnums
9. **(a), (d),** and **(e)** are dimensionally correct.
11. $\frac{[M]}{[T]^2}$
13. 25.9° south of west
15. 0.25 m
17. 0.487 nm
19. 35.3°
21. 1.2×10^2 m
23. **(a)** 5.70×10^2 newtons
(b) 33.6° south of west
25. **(a)** $F = 551$ newtons, $\theta = 36.1°$ north of west
(b) $F = 551$ newtons, $\theta = 36.1°$ south of west
27. smallest magnitude: $\vec{\mathbf{F}}_1 + \vec{\mathbf{F}}_3 =$ 10.0 newtons, due east;
largest magnitude: $\vec{\mathbf{F}}_3 + \vec{\mathbf{F}}_4 =$ 70.0 newtons, due west
29. **(a)** 1200 m
(b) 26° south of east
31. **(a)** 5600 newtons
(b) along the dashed line
33. **(a)** 142 newtons, 67° south of east
(b) 142 newtons, 67° north of west
35. **(a)** 15.8 m/s
(b) 6.37 m/s
37. **(a)** 46 paces
(b) 88 paces
39. 222 m, 55.8°
41. Vectors $\vec{\mathbf{A}}$ and $\vec{\mathbf{C}}$ are equal (each has a magnitude of 100.0 m, and each is oriented at an angle of 36.9° above the $+x$ axis).
43. **(a)** 10.4 units
(b) 12.0 units
45. 7.1 m, 9.9° north of east
47. 30.2 m, 10.2°
49. 0.90 km, 56° north of west
51. **(a)** 2.7 km
(b) 6.0×10^1 degrees, north of east
53. 6.88 km, 26.9°
55. **(a)** 178 units
(b) 164 units
57. 5.5 km
59. $\vec{\mathbf{C}}$ has the largest x component.
$\vec{\mathbf{B}}$ has the largest y component.
61. **(a)** 147 km
(b) 47.9 km
63. **(a)** 9.4 ft
(b) 69°
65. **(a)** 25.0°
(b) 34.8 newtons
67. **(a)** 78 newtons
(b) 34°
69. x component: −288 units
y component: +156 units

CHAPTER 2

1. **(a)** 12.4 km
(b) 8.8 km, due east
3. 5×10^4 yr
5. **(a)** +8.0 m/s
(b) −8.0 m/s
(c) +20.0 m/s
7. 109 m
9. 52 m
11. 7.2×10^3 m
13. 2.1 s
15. **(a)** 0 m/s^2
(b) −14 m/s^2
17. **(a)** 3.0×10^2 days
(b) $+1.04 \times 10^{-4}$ m/s^2
19. **(a)** 18 m/s
(b) 6.0 m/s
(c) 6.0 m/s
(d) 18 m/s
21. 4.5 m/s^2
23. 8.0 m/s (Cycle A was initially traveling faster.)
25. 3.1 m/s^2 directed southward
27. **(a)** 1.7×10^2 cm/s^2
(b) 0.15 s
29. **(a)** 1.5 m/s^2
(b) 1.5 m/s^2
(c) 76 m
31. 0.74 m/s
33. **(a)** 2.2 m/s
(b) 4.4 m/s
(c) 0.021 m/s^2
35. 52.8 m
37. 96.9 m/s
39. +25.7 m
41. 14 s
43. **(a)** −9.80 m/s^2
(b) 5.7 m
45. 6.12 s
47. $d_1 = 0.018$ m, $d_2 = 0.071$ m, $d_3 = 0.16$ m
49. 1.7 s
51. **(a)** −7.9 m/s
(b) 3.2 m
53. 1.1 s
55. −5.06 m
57. 0.767 m/s
59. 10.6 m
61. 0.40 s
63. −11 m/s
65. segment A: 1.9 m/s^2, segment B: 0 m/s^2, segment C: 3.3 m/s^2
67. **(a)** segments A and C: positive, segment B: negative, segment D: zero
(b) segment A: +6.3 km/h, segment B: −3.8 km/h, segment C: +0.63 km/h, segment D: 0 km/h
69. −8.3 km/h^2
71. **(a)** 6.6 s
(b) 5.3 m/s
73. 44.1 m/s
75. −1.0 m/s^2
77. 1.6×10^{-2} s
79. 2.8 s
81. **(a)** 2.67×10^4 m
(b) 6.74 m/s, due north
83. 2.0×10^1 m
85. 11.1 s
87. **(a)** 13 m/s
(b) 0.93 m/s^2

CHAPTER 3

1. 2.8 m
3. $v_x = 11$ m/s, $v_y = 13$ m/s
5. $x = 75.3$ km, $y = 143$ km
7. 8.8×10^2 m
9. **(a)** 2.47 m/s^2
(b) 2.24 m/s^2
11. **(a)** 1.35 km, 21° north of west
(b) 0.540 km/h, 21° north of west
13. 14.6 s
15. 5.4 m/s
17. 1.7 s
19. 4.90 m
21. **(a)** 1.78 s
(b) 20.8 m/s
23. **(a)** 239 m/s, 57.1° above the horizontal
(b) 239 m/s, 57.1° above the horizontal
25. 1130 m/s, 37.7° above the $+x$ axis
27. 30.0 m
29. 0.844 m
31. 14.1 m/s
33. 5.2 m
35. 33.2 m
37. **(a)** 1380 m
(b) 66.0° below the ground
39. 14.7 m/s
41. 56 m
43. 14.9 m
45. 5.79 m/s
47. 0.141° and 89.860°
49. $D = 850$ m, $H = 31$ m
51. $\theta_1 = 28.1°$ and $\theta_2 = 67.7°$

53. **(a)** 2.0×10^3 s
(b) 1.8×10^3 m
55. 4.5 m/s
57. **(a)** 41 m/s, due east
(b) 41 m/s, due west
59. 6.3 m/s, 18° north of east
61. 2.3 m/s
63. 5.2 m/s, 52° west of south
65. 3.05 m/s, 14.8° north of west
67. 8.6 m/s
69. **(a)** 6.0×10^1 m
(b) 290 m
71. **(a)** 1.1 s
(b) 1.3 s
73. 5.17 s
75. 42°
77. 21.9 m/s, 40.0° above the horizontal
79. 8.79 m/s, 81.5°

CHAPTER 4

1. 93 N
3. **(a)** +6 N
(b) −24 N
(c) −9.0 N
5. 130 N
7. 3560 N
9. **(a)** 3.6 N
(b) 0.40 N
11. 1.83 m/s^2, directed to the left
13. 10.3 m/s^2, directed above the horizontal at 21.9°
15. 1.39×10^6 N
17. 0.78 m, 21° south of east
19. 18.4 N, 68° north of east
21. **(a)** weight = 1.13×10^3 N, mass = 115 kg
(b) weight = 0 N, mass = 115 kg
23. **(a)** 5.1×10^{-6} N
(b) 5.1×10^{-6} N
25. **(a)** 10.5 m/s^2
(b) 1.07
27. 0.223 m/s^2
29. **(a)** 1.04×10^3 N
(b) 1.04×10^3 N
(c) 2.45 m/s^2
(d) 1.74×10^{-22} m/s^2
31. 1.76×10^{24} kg
33. 4.7 kg
35. 178
37. $x = +0.414\,L$
39. 39 N
41. **(a)** 0.97
(b) 0.82
43. **(a)** 1.6×10^4 N
(b) 4.3×10^3 N
45. 0.444
47. **(a)** 390 N
(b) 7.7 m/s, direction is toward second base
49. 4.4 s
51. 1.65 m/s^2, 34.6° above the x axis
53. 1.00×10^2 N, 53.1° south of east
55. 11.6 N
57. **(a)** 1400 N
(b) 2400 N
59. 9.70 N
61. 62 N
63. 1.9×10^2 N
65. 0.141
67. 406 N
69. 0.29
71. 18.0 m/s^2, 56.3° above the $+x$ axis
73. 1730 N, due west
75. **(a)** 1.3 N
(b) 6.5 N
77. 6.6 m/s
79. 160 N
81. 2730 N
83. **(a)** 4.25 m/s^2
(b) 1080 N
85. 0.265 m
87. 820 N
89. **(a)** $\Delta T_A = 0$ N, $\Delta T_B = -4.7$ N, $\Delta T_C = 0$ N
(b) $\Delta T_A = 0$ N, $\Delta T_B = 0$ N, $\Delta T_C = +4.7$ N
91. **(a)** 13.7 N
(b) 1.37 m/s^2
93. **(a)** 0.60 m/s^2
(b) left string: 104 N, right string: 230 N
95. 1.8×10^{-7} N
97. 7.3×10^2 N
99. **(a)** 447 N
(b) 241 N
101. 29 400 N
103. 4290 N
105. **(a)** 3.75 m/s^2
(b) 2.4×10^2 N
107. **(a)** 3.56 m/s^2
(b) 281 N
109. 286 N
111. 8.7 s
113. 33 s
115. 16.3 N
117. 1.2 s
119. 68°

CHAPTER 5

1. 160 s
3. 1.6 m
5. 0.79 m/s^2
7. 3600
9. 332 m
11. 10 600 rev/min
13. 606 N
15. 0.68 m/s
17. 0.31 m
19. **(a)** 88 N
(b) 181 N
21. 28°
23. **(a)** 3510 N
(b) 14.9 m/s
25. **(a)** 19 m/s
(b) 23 m/s
27. 39°
29. 184 m
31. satellite A: 7690 m/s
satellite B: 7500 m/s
33. 1.33×10^4 m/s
35. 1/27
37. 12 m/s
39. 2.45×10^4 N
41. 14.0 m/s
43. 17 m/s
45. Twelve o'clock: 14 N
Six o'clock: 18 N
47. 8.48 m/s
49. **(a)** 1.2×10^4 N
(b) 1.7×10^4 N
51. 6.9 m/s^2
53. 33 m/s
55. **(a)** 1.70×10^3 N
(b) 1.66×10^3 N
57. **(a)** 3.0×10^5 m/s^2
(b) $3.1 \times 10^4\,g$
59. 3500 N
61. speed = 19 m/s: 23 N
speed = 38 m/s: 77 N

CHAPTER 6

1. 1.20×10^4 J
3. **(a)** 4.1×10^5 J
(b) -4.1×10^5 J
5. 42.8°
7. **(a)** More net work is done during the dive.
(b) 6.8×10^7 J
9. **(a)** 1.8×10^3 J
(b) -1.2×10^3 J
11. 45 N
13. 3.2×10^3 J
15. 39 m/s
17. 2.5×10^7 J
19. **(a)** 3.1×10^3 J
(b) 2.2×10^2 J
21. 9×10^3 m/s
23. 18%
25. 1.4×10^{11} J
27. 5.4×10^2 J
29. 444 J
31. **(a)** -3.0×10^4 J
(b) The resistive force is not a conservative force.
33. **(a)** 27 J
(b) 36 J
(c) 8.8 J
(d) The change in gravitational potential energy is −27 J = $-W$, where W is the work done by the weight.
35. **(a)** −1086 J
(b) The skater is 2.01 m below the starting point.
37. At $h = 20.0$ m: KE = 0 J, PE = 392 J, and $E = 392$ J
At $h = 10.0$ m: KE = 196 J, PE = 196 J, and $E = 392$ J
At $h = 0$ m: KE = 392 J, PE = 0 J, and $E = 392$ J

39. **(a)** 28.3 m/s
(b) 28.3 m/s
(c) 28.3 m/s
41. **(a)** 52.2 J
(b) 48.8 m/s
43. 3.29 m/s
45. 6.33 m
47. 18 m
49. 0.33 m
51. 1.0×10^3 J
53. -4.51×10^4 J
55. -1.21×10^6 J
57. **(a)** -270 J
(b) 140 N
59. 2450 N
61. 13.5 m
63. 3.6×10^6 J
65. **(a)** 3.3×10^4 W
(b) 5.1×10^4 W
67. **(a)** 1.0×10^4 W
(b) 13 hp
69. 6.7×10^2 N
71. **(a)** Bow 1 requires more work.
(b) 25 J
73. **(a)** 93 J
(b) No work is done on the skater.
(c) 2.3 m/s
75. 7.07 m/s
77. 6.6 m/s
79. 2.2×10^3 J
81. 256 N
83. **(a)** 2.8 J
(b) 35 N
85. 1.7 m/s
87. 3.40×10^2 N

CHAPTER 7

1. 9.6 ms
3. 1.8 N, downward
5. -8.7 kg·m/s
7. $+5.1 \times 10^7$ kg·m/s
9. **(a)** $+2.2 \times 10^3$ N
(b) $+4.4 \times 10^3$ N
11. 6.7 m
13. 3.7 N·s
15. +344 N
17. 84 kg
19. 96 kg
21. 4500 m/s, in the same direction that the rocket had before the explosion
23. $m_1 = 1.00$ kg, $m_2 = 1.00$ kg
25. 0.707
27. +547 m/s
29. **(a)** -0.432 m/s
(b) $+1.82$ m/s
31. 7.4%
33. **(a)** 5.00-kg ball: -0.400 m/s, 7.50-kg ball: $+1.60$ m/s
(b) both balls: $+0.800$ m/s
35. +9.3 m/s
37. +9.09 m/s
39. **(a)** +8.9 m/s
(b) -3.6×10^4 N·s
(c) 5.9 m
41. **(a)** 73.0°
(b) 4.28 m/s
43. 2.175×10^{-3}
45. **(a)** 5.56 m/s
(b) 1.50-kg ball: -2.83 m/s, 4.60-kg ball: $+2.73$ m/s
(c) 1.50-kg ball: 0.409 m, 4.60-kg ball: 0.380 m
47. 8 bounces
49. **(a)** $+1.0$ m/s
(b) $+1.0$ m/s
(c) equal to
51. **(a)** -1.05 m/s
(b) $+2.53$ m/s
53. **(a)** -1.5 m/s
(b) $+1.1$ m/s
55. **(a)** 4.89 m/s
(b) 1.22 m
57. -1.5×10^{-4} m/s
59. 9.5%
61. 1.5×10^{-10} m/s
63. **(a)** -0.14 m/s
(b) -7.1×10^{-3} m/s
65. 0.097 m

CHAPTER 8

1. 63.7 grad
3. **(a)** $+7.3 \times 10^{-5}$ rad/s
(b) $+2.0 \times 10^{-7}$ rad/s
5. 21 rad
7. **(a)** +0.75 rad/s^2
(b) -0.75 rad/s^2
(c) +1.0 rad/s^2
(d) -2.0 rad/s^2
9. 8.0 s
11. 128 s
13. 1200 s
15. 6.05 m
17. **(a)** 2.00×10^{-2} s
(b) 4.00×10^{-2} s
19. 25 rev
21. **(a)** 4.00×10^1 rad
(b) 15.0 rad/s
23. **(a)** 54.0 rad/s
(b) 486 rad
25. **(a)** 10.0 s
(b) -2.00 rad/s^2
27. +267 rad
29. 1.95×10^4 rad
31. 2.1 rev
33. 7.37 s
35. **(a)** 7.50 rad/s
(b) -1.73×10^{-3} rad/s^2 (The angular velocity is decreasing.)
37. 0.18 m
39. 22 rev/s
41. **(a)** 1.25 m/s
(b) 7.98 rev/s
43. **(a)** 3.61 rad/s
(b) 6.53 rad/s^2
45. 0.87
47. **(a)** 0.583 m/s^2
(b) 31.0°
49. 0.577
51. **(a)** 2.4×10^5 m/s
(b) 5.3×10^{20} N
53. 8.71 rad/s^2
55. 693 rad
57. **(a)** -1.4 rad/s^2
(b) +33 rad
59. **(a)** 8.33 rad/s, counterclockwise
(b) 14.7 rad/s, clockwise
61. 974 rev
63. 2 rev
65. **(a)** 2.5 m/s^2
(b) 3.1 m/s^2
67. 157.3 rad/s
69. 0.62 m
71. 4.63 m/s
73. 12.5 s
75. 1.43×10^{-1} m/s

CHAPTER 9

1. 1.70×10^3 N·m
3. 2.1×10^2 N
5. **(a)** 27 N·m
(b) 34°
7. 43.7°
9. **(a)** *FL*
(b) *FL*
(c) *FL*
11. 1.03 m
13. **(a)** 2590 N
(b) 2010 N
15. 1200 N, to the left
17. 24 m/s
19. $\vec{\mathbf{T}} = 56.4$ N, down
$\vec{\mathbf{F}} = 70.6$ N, up
21. $V = 170$ N, $P = 270$ N, $H = 210$ N
23. 37.6°
25. **(a)** 2260 N
(b) horizontal component: 1450 N, vertical component: 1450 N
27. **(a)** 1.21×10^3 N
(b) 1.01×10^3 N, downward
29. 51.4 N
31. 8.0×10^{-4} N·m
33. 0.027 kg·m^2
35. hoop: 0.20 N·m, disk: 0.10 N·m
37. 0.50 rad/s^2
39. 0.060 kg·m^2
41. 2.0 s
43. **(a)** system A: 229 kg·m^2, system B: 321 kg·m^2
(b) system A: -1270 N·m, system B: 0 N·m
(c) system A: -27.7 rad/s, system B: 0 rad/s
45. 0.78 N
47. 22.0 kg
49. 6.1×10^5 rev/min
51. **(a)** object 1: 12.0 m/s, object 2: 9.00 m/s, object 3: 18.0 m/s

(b) 1.08×10^3 J
(c) 60.0 kg·m^2
(d) 1.08×10^3 J
53. 2/7
55. 3/4
57. 1.3 m/s
59. 4.4 kg·m^2
61. 1.83 rad/s
63. 0.26 rad/s
65. 8%
67. 0.573 m
69. (a) 13 500 N·m
(b) 132 000 N·m
71. 8.2 rad/s^2
73. (a) 5.94 rad/s^2
(b) 44.0 N
75. (a) 7.40×10^2 N, downward
(b) 0.851 m
77. 34 m/s (for each module)
79. 1.7 m

CHAPTER 10

1. 237 N
3. 650 N/m
5. 0.012 m
7. 1.4 kg
9. 0.240 m
11. 2.29×10^{-3} m
13. (a) 0.407 m
(b) 397 N
15. 3.5×10^4 N/m
17. (a) −9.84 N
(b) 10.5 rad/s
(c) 1.26 m/s
(d) 13.2 m/s^2
19. (a) 0.450 m
(b) 3.31 rad/s
(c) 1.49 m/s
21. 4.3 kg
23. 140 N/m
25. (a) -1.84×10^2 J
(b) $+1.84 \times 10^2$ J
(c) 0 J
27. (a) 58.8 N/m
(b) 11.4 rad/s
29.

h (meters)	KE	PE (gravity)	PE (elastic)	*E*
0	0 J	0 J	8.76 J	8.76 J
0.200	1.00 J	3.92 J	3.84 J	8.76 J
0.400	0 J	7.84 J	0.92 J	8.76 J

31. 14 m/s
33. 7.18×10^{-2} m
35. 0.50 m/s
37. 24.2 rad/s
39. 0.44 m/s
41. 2.37×10^3 N/m
43. 0.40 s
45. (a) 3.5 rad/s
(b) 2.0×10^{-2} J
(c) 0.41 m/s
47. (a) 1.64 s
(b) 1.64 s
49. 0.54 s
51. 5.2×10^{-4} m
53. 260 m
55. 2.9×10^{-2} m
57. 3.7×10^{-5} m
59. 1.6×10^5 N
61. 2.3×10^{-6} m
63. (a) 1.8×10^{-7} m
(b) 1.0×10^{-6} m
65. 1.2×10^{11} N/m^2
67. (a) 2.5×10^{-4}
(b) 7.5×10^{-5} m
69. 4.6×10^{-4}
71. 12 m
73. 2.1×10^{-5} m
75. 6.0 rad/s
77. 61 kg
79. +0.50 m
81. (a) amplitude = 3.59×10^{-2} m, frequency = 4.24 Hz
(b) amplitude = 5.08×10^{-2} m, frequency = 4.24 Hz
83. (a) 2.66 Hz
(b) 0.0350 m
85. 1.25 m/s (11.2-kg block), 0.645 m/s (21.7-kg block)
87. 33.4 m/s
89. -4.4×10^{-5}
91. (a) 0.25 s
(b) 0.75 s

CHAPTER 11

1. 8750 N.
The bed should not be purchased.
3. 317 m^2
5. 3.91×10^{-6} m^3
7. 1.9 gal
9. 4240 s
11. 1.1×10^3 N
13. 24
15. 32 N
17. 2.4×10^3 Pa
19. 0.750 m
21. 7.0×10^5 Pa
23. 2.9×10^4 Pa
25. 0.50 m
27. (a) 2.45×10^5 Pa
(b) 1.73×10^5 Pa
29. 31.3 rad/s
31. 2.3×10^8 N
33. 3.8×10^5 N
35. (a) 93.0 N
(b) 94.9 N
37. 108 N
39. 8.50×10^5 N·m
41. 4.89 m
43. 250 kg/m^3
45. 390 kg/m^3
47. 7.9×10^{-4} m^3
49. 6.3×10^{-3} kg
51. 7.6×10^{-2} m
53. 1120 N
55. 4.5×10^{-5} kg/s
57. (a) 0.18 m
(b) 0.14 m
59. 0.816
61. (a) 150 Pa
(b) The pressure inside the roof is greater than the pressure on the outside. Therefore, there is a net outward force on the roof that can blow it outward if the wind speed is sufficiently high.
63. 1.92×10^5 N
65. 96 Pa
67. 3.0×10^5 Pa
69. (a) 14 m/s
(b) 0.98 m^3/s
71. (a) 32.8 m/s
(b) 54.9 m
73. 33 m/s
75. 7.78 m/s
77. (a) 1.01×10^5 Pa
(b) 1.19×10^5 Pa
79. 1.19
81. 1.7 m
83. 2.25
85. (a) 1.26×10^5 Pa
(b) 19.4 m
87. 59 N
89. 8.3×10^3 lb
91. 7.0×10^{-2} m
93. 10.3 m
95. (a) 1.6×10^{-4} m^3/s
(b) 2.0×10^1 m/s
97. 0.20 m
99. 0.74 m
101. 78.4 gal/min
103. 1.41×10^5 N, downward

CHAPTER 12

1. −459.67 °F
3. (a) 102 °C (day), −173 °C (night)
(b) 215 °F (day), -2.80×10^2 °F (night)
5. (a) −196 °C
(b) −321 °F
7. −164 °C
9. $T_R = T_F + 459.67$
11. 1500 m
13. (a) The radius will be larger.
(b) 0.0017
15. 1.7×10^{-5} (C°)$^{-1}$
17. 5.8 m
19. 49 °C
21. 2.0027 s
23. 41 °C
25. 26 °C
27. 18 N
29. 2.5×10^{-7} m^3
31. 230 C°
33. 7.3×10^{-6} m^3
35. 0.33 gal
37. (a) The apparent weight will be larger after the sphere cools.
(b) 18 N
39. 45 atm

41. 6.9
43. 43.0 °C
45. 19 °C
47. 21.03 °C
49. 940 °C
51. 650 W
53. 1.2×10^{-2} kg
55. 4.0×10^{5} J
57. 3.9×10^{5} J
59. **(a)** 4.52×10^{6} J
(b) 5.36×10^{6} J
61. 9.49×10^{-3} kg
63. 0.42 kg
65. 64 °C
67. 0.223
69. 1.9×10^{4} J/kg
71. 3.50×10^{2} m/s
73. 0.237 kg
75. 5.5
77. 87%
79. 2.8×10^{5} J
81. 39%
83. 28%
85. 4.9×10^{-2} m
87. 3.9×10^{-3} kg
89. 110 C°
91. 3.1×10^{-3} m^3
93. 33%
95. 2.6×10^{-3} kg
97. 4.4×10^{3} N
99. 0.016 C°
101. 1.1×10^{3} N

CHAPTER 13

1. 1.5 C°
3. 8.0×10^{2} J/s
5. 2.0×10^{-3} m
7. 17
9. 287 °C
11. 85 J
13. **(a)** 21 °C
(b) 18 °C
15. 103.3 °C
17. **(a)** 101.2 °C
(b) 110.6 °C
19. **(a)** 2.0
(b) 0.61
21. 14.5 d
23. **(a)** 6.3 J/s
(b) 4.8 J/s
25. 1.2×10^{4} s
27. 532 K
29. 320 K
31. 0.39 kg
33. 12
35. 12 J
37. 5800 K
39. 0.70
41. −15 °C
43. 4.5

CHAPTER 14

1. 1.07×10^{-22} kg
3. **(a)** 294.307 u
(b) 4.887×10^{-25} kg
5. 1.00×10^{-2} g
7. **(a)** 2.3×10^{3} mol
(b) 1.4×10^{27}
9. 42.4 mol
11. 1.1 g
13. **(a)** 201 mol
(b) 1.21×10^{5} Pa
15. 67.0 m^3
17. 12
19. 925 K
21. 39
23. **(a)** 3.3×10^{2} K
(b) 2.8×10^{5} Pa
25. 5.9×10^{4} g
27. 0.93 mol/m^3
29. 0.090 %
31. 308 K
33. 750 K
35. 3.9×10^{5} J
37. 327 m/s
39. 1.6×10^{-15} kg
41. 343 m/s
43. **(a)** −120 N (assuming the bullets travel in the + direction)
(b) 120 N
(c) 4.0×10^{5} Pa
45. 0.14 kg/m^3
47. 1.34×10^{-7} kg
49. **(a)** 2.1 s
(b) 1.6×10^{-5} s
(c) because the diffusional path is a zigzag path and not a straight-line path
51. **(a)** The answer is a derivation.
(b) 31 s
53. 304 K
55. 2.2 kg/m^3
57. **(a)** 46.3 m^2/s^2
(b) 40.1 m^2/s^2
59. 8.1 g
61. 2820 m
63. 7.23×10^{-20} J

CHAPTER 15

1. **(a)** $+1.6 \times 10^{4}$ J
(b) -4.2×10^{4} J
(c) -2.6×10^{4} J
3. **(a)** −87 J
(b) +87 J
5. 32 miles
7. **(a)** -5.03×10^{5} J
(b) 1.20×10^{2} nutritional calories
9. 1.2×10^{7} Pa
11. 4.5×10^{-3} m^3
13. **(a)** 0 J
(b) $+2.1 \times 10^{3}$ J
(c) -1.5×10^{3} J
15. 3.0×10^{5} Pa
17. The answer is a proof.
19. 4.99×10^{-6}
21. **(a)** 0 J
(b) -6.1×10^{3} J
(c) 310 K
23. −4700 J
25. 1.81
27. 19.3
29. A to B: $\Delta U = 4990$ J, $W = 3320$ J, $Q = 8310$ J
B to C: $\Delta U = -4990$ J, $W = 0$ J, $Q = -4990$ J
C to D: $\Delta U = -2490$ J, $W = -1660$ J, $Q = -4150$ J
D to A: $\Delta U = 2490$ J, $W = 0$ J, $Q = 2490$ J
31. **(a)** -8.00×10^{4} J
(b) Heat flows out of the gas.
33. **(a)** 477 K
(b) 323 K
35. **(a)** 1.1×10^{4} J
(b) 1.8×10^{4} J
37. 45 K
39. 5/2
41. **(a)** 24.4 J
(b) 37.3 J/(mol·K)
43. 2.38×10^{4} J
45. 0.631
47. 65 J
49. 0.75
51. 256 K
53. **(a)** 1260 K
(b) 1.74×10^{4} J
55. 1090 K
57. lowering the temperature of the cold reservoir
59. **(a)** 0.360
(b) 1.3×10^{13} J
61. The answer is a proof.
63. 5.86×10^{5} J
65. 13
67. 275 K
69. 9.03
71. 0.48 K
73. **(a)** 2.0×10^{1}
(b) 1.5×10^{4} J
75. engine I: +0.4 J/K (irreversible, could exist)
engine II: 0 J/K (reversible)
engine III: −1.0 J/K (irreversible, could not exist)
77. **(a)** 3.68×10^{3} J/K
(b) 1.82×10^{4} J/K
(c) The vaporization process creates more disorder.
79. **(a)** $+8.0 \times 10^{2}$ J/K
(b) The entropy of the universe increases.
81. **(a)** +1.74 J/K
(b) 811 J
(c) 546 J
83. **(a)** -2.1×10^{2} K
(b) decrease
85. 0.24 m
87. **(a)** reversible
(b) −125 J/K
89. 21
91. **(a)** $+3.0 \times 10^{3}$ J
(b) Work is done by the system.

93. 0.264 m
95. **(a)** 2.00×10^6 J
(b) 925 K
(c) 4.40×10^6 J
97. 44.3 s
99. **(a)** 5/9
(b) 1/3

CHAPTER 16

1. 5.50×10^{14} Hz
3. **(a)** 10.0 s
(b) 0.100 Hz
(c) 32 m
(d) 3.2 m/s
(e) It is not possible to determine the amplitude.
5. 78 cm
7. 0.20 m/s
9. 5.0×10^1 s
11. **(a)** 1.09 m/s
(b) 6.55 m
13. 64 N
15. 7.7 m/s^2
17. **(a)** 2.0×10^1 m/s
(b) 1.4×10^1 m/s
19. 153 N
21. **(a)** $v = \sqrt{yg}$
(b) 2.2 m/s ($y = 0.50$ m), 4.4 m/s ($y = 2.0$ m)
23. 3.26×10^{-3} s
25. $y = (0.35\text{ m})\sin[(88\text{ rad/s})t - (17\text{ m}^{-1})x]$
27. $y = (0.37\text{ m})\sin[(8.2\text{ rad/s})t + (0.68\text{ m}^{-1})x]$
29. **(a)** 4.2 m/s
(b) 0.35 m
(c) $y = (3.6 \times 10^{-2}\text{ m})\sin[(75\text{ rad/s})t + (18\text{ m}^{-1})x]$
31. 28.8 K
33. 110 m
35. **(a)** 431 m/s
(b) 322 m/s
37. 690 rad/s
39. 6.7×10^{-4} s
41. **(a)** first in metal, second in water, third in air
(b) Second sound arrives 0.059 s later, and third sound arrives 0.339 s later.
43. 650 m
45. tungsten
47. 283 K
49. 57% argon, 43% neon
51. 0.404 m
53. 6.5 W
55. 190 m
57. 1.98%
59. 8.0×10^2 s
61. 7.6×10^3 W/m^2
63. 1.3
65. 1000
67. 1.0×10^2
69. **(a)** 7.4 dB
(b) No, since it requires an increase of 10 dB to double the loudness.
71. 79 400
73. 2.6
75. 2.39 dB
77. 3.4 m/s
79. 1.054
81. 615 Hz
83. 22 m/s
85. 1.5 m/s^2
87. **(a)** 1570 Hz
(b) 1590 Hz
89. 0.316 W/m^2
91. 2.06
93. 8.68×10^{-3} kg/m
95. 6.0
97. 0.25 m
99. 56 m/s
101. −6.0 dB
103. 0.84 s
105. $m_1 = 28.7$ kg, $m_2 = 14.3$ kg
107. **(a)** 2.20×10^2 m/s
(b) 9.19 m/s
109. 239 m/s

CHAPTER 17

1. 8.42 m
3. The answer is a series of drawings.
5. 107 Hz
7. 3.89 m
9. **(a)** destructive interference
(b) constructive interference
11. 3.90 m, 1.55 m, 6.25 m
13. **(a)** 44°
(b) 0.10 m
15. **(a)** 53.8°
(b) 23.8°
17. 3.7°
19. 8 Hz
21. 263 Hz
23. 437 Hz
25. 8 Hz
27. 2.4 m/s
29. 171 N
31. 1.10×10^2 Hz
33. **(a)** 180 m/s
(b) 1.2 m
(c) 150 Hz
35. 0.485
37. 0.077 m
39. 20.8° and 53.1°
41. 0.50 m
43. 1.96 m
45. 0.35 m
47. **(a)** $f_2 = 800$ Hz, $f_3 = 1200$ Hz, $f_4 = 1600$ Hz
(b) $f_2 = 800$ Hz, $f_3 = 1200$ Hz, $f_4 = 1600$ Hz
(c) $f_3 = 1200$ Hz, $f_5 = 2000$ Hz, $f_7 = 2800$ Hz
49. 0.557 m
51. 6.1 m
53. 1.95×10^{-3} s
55. 5.06 m
57. **(a)** 3
(b) 0.57 m
59. 3.93×10^{-3} kg/m
61. 28 Hz and 42 Hz
63. 12 Hz

CHAPTER 18

1. $-1.6\ \mu$C
3. **(a)** $-1.6\ \mu$C
(b) 1.0×10^{13}
5. **(a)** $+1.5\ q$
(b) $+4\ q$
(c) $+4\ q$
7. **(a)** 3.35×10^{26} electrons
(b) -5.36×10^7 C
9. 8
11. **(a)** 0.83 N
(b) attractive
13. 0.38 N, 49° below the $-x$ axis
15. **(a)** both positive or both negative
(b) 1.7×10^{-16} C
17. 3.8×10^{12}
19. 7.19×10^{23} m/s^2
21. **(a)** +0.166 N (directed along the $+y$ axis)
(b) +111 m/s^2 (directed along the $+y$ axis)
23. 1.96×10^{-17} J
25. -3.3×10^{-6} C
27. **(a)** 15.4°
(b) 0.813 N
29. 1.8 N due east
31. 1.37
33. 54 N/C
35. **(a)** 3.0 m from the positive charge (not between the charges)
(b) 0 N
37. **(a)** -6.2×10^7 N/C (directed along the $-x$ axis)
(b) $+2.9 \times 10^8$ N/C (directed along the $+x$ axis)
39. **(a)** positive
(b) 2.53×10^7 protons
41. 3.11×10^2 N/C
43. 2.5×10^4 N/C
45. $|q_1| = 0.716\ q$, $|q_2| = 0.0895\ q$
47. 0.577
49. $+1.9 \times 10^{-2}$ m
51. 61°
53. 3.25×10^{-8} C
55. **(a)** 350 N·m^2/C
(b) 460 N·m^2/C
57. 1.8×10^3 N·m^2/C
59. **(a)** The flux through the face in x, z plane at $y = 0$ m is -6.0×10^1 N·m^2/C. The flux through the face parallel to the x, z plane at $y = 0.20$ m is $+6.0 \times 10^1$ N·m^2/C. The flux through each of the remaining four faces is zero.
(b) 0 N·m^2/C
61. The answer is a proof.
63. The answer is a drawing.
65. $-q$ on the interior surface and $+3\ q$ on the exterior surface
67. 0.16 N·m

69. **(a)** 4.56×10^{-8} C
(b) 3.25×10^{-6} kg
71. 3.9×10^{6} N/C, in the $+y$ direction
73. 2.2×10^{5} N/C, in the $-x$ direction
75. 92.0 N/m

CHAPTER 19

1. -2.1×10^{-11} J
3. 5.40×10^{-5} C
5. 67 hp
7. 19 m/s
9. **(a)** 3.0×10^{10} J
(b) 7.4×10^{3} m/s
(c) 7.2×10^{4} kg
11. 339 V
13. -4.05×10^{4} V
15. 2.4
17. -4.7×10^{-2} J
19. $+7.8 \times 10^{6}$ V
21. -3.1×10^{-6} C
23. 0.0342 m
25. 1.53×10^{-14} m
27. -0.746 J
29. Each particle is moving at a speed of 9.7 m/s.
31. 1.1 m
33. 3.5×10^{4} V
35. 8.8×10^{6} V/m
37. **(a)** 179 V
(b) 143 V
(c) 155 V
39. 1.7×10^{3} V/m, to the left
41. **(a)** 0 V
(b) $+290$ V
(c) -290 V
43. 1.1×10^{3} V
45. **(a)** 33 J
(b) 8500 W
47. 5.3
49. 7.0×10^{13}
51. 52 V
53. 1.3×10^{-4} C
55. The answer is a proof.
57. **(a)** 1.3×10^{-12} C
(b) 8.1×10^{6}
59. -4.35×10^{-18} J
61. 1.1×10^{-20} J
63. 8.0×10^{-5} C
65. **(a)** 0 V/m
(b) 1.0×10^{1} V/m
(c) 5.0 V/m
67. 2.77×10^{6} m/s

CHAPTER 20

1. **(a)** 3.6×10^{-2} C
(b) 2.3×10^{17}
3. **(a)** 2.6 C
(b) 310 J
5. 22 A
7. 16 Ω
9. **(a)** 4.7×10^{13}
(b) 17 C°
11. 0.12 Ω
13. $-34.6°$ C
15. 1.64
17. 9.3%
19. 189 Ω
21. 9.7×10^{2} kg
23. **(a)** 4.4 Ω
(b) 2.8 A
25. $\$5.9 \times 10^{6}$
27. 8.9 h
29. 190 s
31. 250° C
33. **(a)** 786 W
(b) 1572 W
35. 21 V
37. 1.3×10^{-3} m
39. **(a)** 50.0 Hz
(b) 2.40×10^{2} Ω
(c) 60.0 W
41. 32 Ω
43. **(a)** 145 Ω
(b) 74 V
45. 9.0 V
47. **(a)** 1.2 Ω
(b) 110 V
49. **(a)** 35 Ω
(b) 5.0×10^{1} Ω
51. 5.3 Ω
53. **(a)** 65.0 Ω
(b) 38.8 Ω
(c) 1.25 W
(d) 2.09 W
55. **(a)** 4.57 A
(b) 1450 W
57. 190 Ω
59. **(a)** 3.6 Ω
(b) 33 A. The breaker will open.
61. 3.58×10^{-8} m^2
63. 9.2 A
65. 4.6 Ω
67. **(a)** 8.33×10^{-2} A
(b) 0.833 W
69. 6.00 Ω, 0.545 Ω, 3.67 Ω, 2.75 Ω, 2.20 Ω, 1.50 Ω, 1.33 Ω, 0.833 Ω
71. **(a)** 0.750 A
(b) 2.11 A
73. 30
75. 8.3 A
77. 24.0 V
79. **(a)** 0.38 A
(b) 2.0×10^{1} V
(c) B
81. $I = 5.00$ A, $V = 46.0$ V
83. 6.0 A (left to right) in the 2.0-Ω resistor, 2.0 A (left to right) in the 8.0-Ω resistor
85. 0.75 V. Left end is at higher potential.
87. 0.0835 Ω
89. 30.0 V
91. 820 Ω, 8.00×10^{-3} A
93. 9.0 V
95. 1.54
97. 2.0 μF
99. **(a)** 3.60×10^{-4} C
(b) 8.00×10^{-5} C
101. C_0
103. 4.1×10^{-7} F
105. 2.0×10^{4} Ω
107. 0.29 s
109. The answer is a proof.
111. 82 Ω
113. $0.0050\ (\text{C}°)^{-1}$
115. 5.01 A
117. 25 Ω
119. **(a)** 15.5 V
(b) 14.2 W
121. $L_{\text{tungsten}}/L_{\text{carbon}} = 70$
123. 11 V

CHAPTER 21

1. **(a)** 5.7×10^{-5} N, into the paper
(b) 1.1×10^{-4} N, into the paper
(c) 5.7×10^{-5} N, into the paper
3. 4.1×10^{-3} m/s
5. 58°
7. 1.7×10^{-3} N
9. 1.3×10^{-10} N, directed out of the page
11. **(a)** due south
(b) 2.55×10^{14} m/s^2
13. **(a)** 7.2×10^{6} m/s
(b) 3.5×10^{-13} N
15. **(a)** negatively charged
(b) 2.7×10^{-3} kg
17. **(a)** 4.3×10^{2} m
(b) 7.8×10^{5} m
19. 1.63×10^{-2} m
21. **(a)** 1.08×10^{7} m/s
(b) 7.60×10^{-12} N
(c) 0.102 m
23. 0.16 T
25. **(a)** 0°
(b) 0.29 m
27. **(a)** 4.4×10^{-3} N
(b) 1.7×10^{-4} C
29. 9.6×10^{4} m/s
31. 5.1×10^{-5} T
33. top side: 0.96 N, bottom side: 0.96 N, each of the other two sides: 0 N
35. 2.7 m
37. 0.19 N
39. 44°
41. 14 A
43. 0.062 m
45. 4.19×10^{-3} N·m
47. **(a)** 170 N·m
(b) The angle will increase.
49. 1.27
51. 8.3 N
53. **(a)** down
(b) 3.1×10^{-4} T
55. 2.8×10^{4} turns/m
57. 3.8×10^{-5} T
59. **(a)** 4.3×10^{-5} T
(b) 5.3×10^{-5} T
61. 8.6 A. The current in the outer coil must have an opposite direction to the current in the inner coil.
63. 0.800 m, to the right of wire 1
65. 1.04×10^{-2} T

67. The current in wire 3 is directed out of the plane of the paper. $I_3/I = 2$
69. The answer is a proof.
71. The answer is a proof.
73. 0.12 m
75. 2.2 A
77. 8.0×10^{-5} T
79. 1.1×10^{-2} N
81. 8.7×10^{-3} s
83. **(a)** 6.8×10^{-3} N
(b) 36°
85. 9.3×10^{-24} A · m^2

CHAPTER 22

1. 0.065 V
3. 7800 V
5. rod A: emf = 0 V; rod B: emf = 1.6 V, with end 2 being positive; rod C: emf = 0 V
7. 0.15 W
9. 250 m
11. 2.2×10^{-3} Wb
13. 70.5°
15. 0.70
17. both triangular ends: 0 Wb; bottom surface: 0 Wb; 1.2 m × 0.30 m surface: 0.090 Wb; 1.2 m × 0.50 m surface: 0.090 Wb
19. 1.5 m^2/s
21. 8.6×10^{-5} T
23. **(a)** 0.38 V
(b) 0.43 m^2/s
25. 0.050 V
27. 6.6×10^{-2} J
29. 2.4×10^{-3} A
31. 1.6×10^{-5} A
33. Figure 22.1*b*: right to left
Figure 22.1*c*: left to right
35. **(a)** clockwise
(b) clockwise
37. There is no induced current.
39. **(a)** location I: $x \rightarrow y \rightarrow z$
location II: $z \rightarrow y \rightarrow x$
(b) location I: $z \rightarrow y \rightarrow x$
location II: $x \rightarrow y \rightarrow z$
41. **(a)** 2.4 Hz
(b) 15 rad/s
(c) 0.62 T
43. 3.0×10^5
45. 38 m
47. 15.4 V
49. 1.5×10^9 J
51. 2.5×10^{-2} H
53. 1.4 V
55. 220
57. 3.6×10^9 N/C
59. $M = \mu_0 \pi N_1 N_2 R_2^2/(2R_1)$
61. 1.0×10^1 W
63. 0.20 A
65. 0.25
67. **(a)** 7.0×10^5 W
(b) 7.0×10^1 W
69. The answer is a proof.
71. 0.150 m
73. **(a)** clockwise
(b) counterclockwise
75. 12 V
77. 0.14 V
79. **(a)** 3.6×10^{-3} V
(b) 2.0×10^{-3} m^2/s. Area must be shrunk.
81. 2100 rad/s

CHAPTER 23

1. 5.00×10^{-2} s
3. 2.7×10^{-6} F
5. 36 Ω
7. **(a)** 6.4×10^{-6} F
(b) 9.0×10^{-4} C
9. 8.0×10^1 Hz
11. 75 V
13. 176 mH
15. **(a)** 1.11×10^4 Hz
(b) 6.83×10^{-9} F
(c) 6.30×10^3 Ω
(d) 7.00×10^2 Ω
17. resistor: 10.5 V, capacitor: 19.0 V, inductor: 29.6 V
19. 83.9 V
21. **(a)** 0.925 A
(b) 31.8°
23. **(a)** 10.7 V
(b) −29.8°
25. 270 Hz
27. **(a)** 29.0 V
(b) −0.263 A
29. 0.651 W
31. 2.7×10^{-5} H
33. **(a)** 352 Hz
(b) 15.5 A
35. 0.81 W
37. **(a)** 1.3×10^{-3} H
(b) 8.7×10^{-6} F
39. **(a)** 2.94×10^{-3} H
(b) 4.84 Ω
(c) 0.163
41. 0.707
43. 1.9 V
45. 38 V
47. 0.44 A
49. **(a)** 0.50 A
(b) 0.34 A
(c) Yes. 0.704 H
51. 8

CHAPTER 24

1. 8.33 min
3. 4.1×10^{16} m
5. The answers are in graphical form.
7. **(a)** 473 nm
(b) 606 nm
9. 1.25 m
11. 3.7×10^4
13. 4.500×10^7 Hz
15. 1.3×10^6 m
17. 42.3 m/s
19. 6.4×10^{18} m
21. 0.24 s
23. **(a)** 6.81×10^5 N/C
(b) 2.27×10^{-3} T
25. **(a)** 183 N/C
(b) 6.10×10^{-7} T
27. 5.6×10^9 J
29. 3.93×10^{26} W
31. 5600 W
33. 4.44×10^{-10}
35. **(a)** receding
(b) 3.1×10^6 m/s
37. **(a)** 6.175×10^{14} Hz
(b) 6.159×10^{14} Hz
39. **(a)** 0.55 W/m^2
(b) 3.7×10^{-2} W/m^2
41. 71.6°
43. 14 W/m^2
45. 9.3°. The angle θ is increased.
47. 20
49. 11.118 m
51. 1.5×10^{-4} H
53. 0.07 N/C
55. 206 W/m^2
57. **(a)** 2.4×10^9 Hz
(b) 0.063 m
59. 920 W
61. 6.25×10^{-9} J

CHAPTER 25

1. 10°
3. 7.2 m
5. 55°
7. arrow A
9. **(a)** 30°
(b) 30°
11. 1.2 m/s, in the $-x$ direction
13. The image is located 6.0 cm behind the mirror.
15. **(a)** The image is located 16.7 cm behind the mirror.
(b) 6.67 cm
17. **(a)** The image is located 20.0 cm behind the mirror.
(b) 6.0 cm
19. 22 cm
21. **(a)** 290 cm
(b) −8.9 cm
(c) upside down
23. 9.62 cm, concave
25. **(a)** −4.3 m
(b) 0.39
27. **(a)** convex
(b) 24.0 cm
29. 42.0 cm
31. 0.533 m
33. $-\frac{1}{2}$
35. **(a)** 1.07×10^5 m
(b) 1420 m/s
37. **(a)** +62 cm
(b) +0.35
(c) upright
(d) smaller
39. 1.67 m

41. **(a)** R
(b) -1
(c) inverted
43. 0.67
45. -3
47. 33.7°

CHAPTER 26

1. ethyl alcohol
3. 1.66×10^{8} m/s
5. 2.0×10^{-11} s
7. 1.82
9. **(a)** 43°
(b) 31°
11. 0.9°
13. 1.92×10^{8} m/s
15. 38.7°
17. 1.65
19. The answer is a derivation.
21. 1.19 mm
23. 2.7 m
25. 21.4 cm
27. 1.54
29. 1.51
31. **(a)** B
(b) A
33. 3.36×10^{-8} s
35. 1.35
37. 1.52
39. 25.0°
41. The answer is a proof.
43. 0.86°
45. 0.35°
47. red ray: 52.7°, violet ray: 56.2°
49. **(a)** $d_i = -75$ cm, $m = +2.5$
(b) $d_i = -75.0$ cm, $m = +2.50$
51. **(a)** -24 cm
(b) 6.0 mm
53. **(a)** 3.78 m
(b) width $= 8.40 \times 10^{2}$ mm,
height $= 1.26 \times 10^{3}$ mm
55. **(a)** -15 cm
(b) virtual
57. **(a)** 6.74×10^{-7} m^2
(b) 7.86×10^{5} W/m^2
59. **(a)** converging lens
(b) $2f$
(c) $2f$
61. 48 cm
63. +35 cm and +90.5 cm
65. 5.6 cm to the left of the right-hand lens
67. -12 cm
69. **(a)** 4.00 cm to the left of the diverging lens
(b) -0.167
(c) virtual
(d) inverted
(e) smaller
71. **(a)** 18.1 cm
(b) real
(c) inverted
73. 160.0 cm
75. **(a)** 35.2 cm
(b) 32.9 cm
77. 28.0 cm
79. **(a)** converging
(b) farsighted
(c) 96.3 cm
81. **(a)** -4.5 m
(b) 0.50 m
83. 3.7
85. **(a)** 6.88 cm
(b) 3.63
87. 13.7 cm
89. 15.4
91. 0.81 cm
93. 4.8×10^{-3} rad
95. **(a)** -30.0
(b) 4.27 cm
(c) -4.57
97. 1.1 m
99. 0.261 cm
101. **(a)** 1.482 m
(b) 0.018 m
103. **(a)** -194
(b) -7.8×10^{-5} m
(c) 1.94×10^{6} m
105. $d_i = 18$ cm
107. **(a)** 1.50
(b) 1.27
109. right eye: -0.20 diopters
left eye: -0.15 diopters
111. 61.1 mm
113. 2.46×10^{8} m/s
115. -9.2 m
117. **(a)** -0.00625 m
(b) -0.0271 m
119. **(a)** 4.52×10^{-4} m
(b) 6.12×10^{-2} m
121. **(a)** 11.8 cm
(b) 47.8 cm
123. -31
125. **(a)** 31.3 cm
(b) 2.43 m

CHAPTER 27

1. Constructive interference occurs.
3. **(a)** Destructive interference occurs.
(b) 3.25 m and 0.75 m from one of the sources
5. 4.9×10^{-7} m
7. 403 nm
9. 0.0248 m
11. 487 nm
13. 1.30×10^{2} nm and 3.90×10^{2} nm
15. 6.12×10^{-7} m
17. 1.18
19. 115 nm
21. 0.0256 m
23. **(a)** 1.1°
(b) 3.0×10^{-5} m
25. **(a)** 0.21°
(b) 22°
27. 1.2×10^{-5} m
29. 0.012 m
31. 2.0×10^{-5} m
33. **(a)** 3.53 m
(b) 2.15 m
35. 1.0×10^{4} m
37. 1.9 mm
39. 2.3 m
41. **(a)** 1.22λ
(b) shorter wavelength
43. **(a)** 37°
(b) 22°
45. 4.0×10^{-6} m
47. 630 nm
49. 640 nm and 480 nm
51. $\frac{3}{4}$
53. 1.95 m
55. **(a)** 11°
(b) 22°
(c) 34°
(d) 48°
57. 6.0×10^{-5} m
59. **(a)** 9.7×10^{-3} m
(b) The hunter's claim is not reasonable.
61. **(a)** violet light: $\theta = 7.9°$
red light: $\theta = 13°$
(b) violet light: $\theta = 16°$
red light: $\theta = 26°$
(c) violet light: $\theta = 24°$
red light: $\theta = 41°$
(d) The second and third orders overlap.
63. 8
65. **(a)** 2
(b) $m_B = 4$, $m_A = 2$ and $m_B = 6$, $m_A = 3$

CHAPTER 28

1. 2.4×10^{8} m/s
3. 72 h
5. 2.28 s
7. 16
9. 2.60×10^{8} m/s
11. 530 m
13. 4.0 light-years
15. 40.2°
17. **(a)** 4.3 yr
(b) the twin traveling at 0.500 c
19. **(a)** 1.7×10^{7} kg·m/s
(b) 3.0×10^{7} kg·m/s
21. 1.0 m
23. -2.0 m/s
25. **(a)** 1.0
(b) 6.6
27. 5.3×10^{6} mi
29. 5.0×10^{-13} J
31. 1.1×10^{24} kg/s
33. 1.3×10^{7} kg·m/s
35. 0.31 c
37. +0.80 c
39. 42 m
41. **(a)** 2.82×10^{8} m/s
(b) 1.8×10^{-16} kg·m/s
43. 1.3
45. 0.999 95 c

47. $-0.406\,c$
49. 3.0 m × 1.3 m

CHAPTER 29

1. 7.7×10^{29} photons/s
3. 6.3 eV
5. 310 nm
7. 2.10 eV
9. 73 photons/s
11. 1.9×10^{-7} m
13. **(a)** 7760 N/C
(b) 2.59×10^{-5} T
15. 75°
17. **(a)** 1.0×10^{13} Hz
(b) infrared
19. 4.755×10^{-24} kg·m/s
21. 9.50×10^{-17} m
23. **(a)** 0.1819 nm
(b) 1.092×10^{-15} J
(c) 1.064×10^{-15} J
(d) 2.8×10^{-17} J
25. 7.77×10^{-13} J
27. 1.41×10^{3} m/s
29. 7.38×10^{-11} m
31. 1.9×10^{-10} m
33. 1.86×10^{4} V
35. 6.01×10^{-11} m
37. 8.3×10^{-6} m/s
39. 1.8×10^{-20} kg·m/s
41. 8.0%
43. **(a)** 4.50×10^{-36} m/s
(b) 7.05×10^{27} years
45. 1×10^{-18} m
47. 1.26 eV
49. 1.10×10^{3} m/s
51. 3.09×10^{-10} m

CHAPTER 30

1. **(a)** 6.2×10^{-31} m^3
(b) 4×10^{-45} m^3
(c) 7×10^{-13}%
3. 1.7×10^{-13} J
5. 7.3×10^{-14} m
7. **(a)** 7458 nm
(b) 2279 nm
(c) infrared region
9. 16
11. 1.98×10^{-19} J
13. 6.56×10^{-7} m and 1.22×10^{-7} m
15. −0.213 eV
17. $n_i = 6$ and $n_f = 2$
19. $6 \leq n_i \leq 19$
21. 30.39 nm
23. −0.378 eV
25. **(a)** −1.51 eV
(b) 2.58×10^{-34} J·s
(c) 2.11×10^{-34} J·s
27. 2, 3, 4, and 5
29. **(a)** Bohr model: $L = h/(2\pi)$,
quantum mechanics: $L = 0$ J·s
(b) Bohr model: $L = 3h/(2\pi)$,
quantum mechanics: $L = 0$ J·s,
$L = \sqrt{2}h/(2\pi)$, and $L = \sqrt{6}h/(2\pi)$

31. **(a)**

n	ℓ	m_ℓ	m_s
2	0	0	1/2
2	0	0	−1/2

(b)

n	ℓ	m_ℓ	m_s
2	1	1	1/2
2	1	1	−1/2
2	1	0	1/2
2	1	0	−1/2
2	1	−1	1/2
2	1	−1	−1/2

33. 50

35.

n	ℓ	m_ℓ	m_s
4	3	3	1/2
4	3	3	−1/2
4	3	2	1/2
4	3	2	−1/2
4	3	1	1/2
4	3	1	−1/2
4	3	0	1/2
4	3	0	−1/2
4	3	−1	1/2
4	3	−1	−1/2
4	3	−2	1/2
4	3	−2	−1/2
4	3	−3	1/2
4	3	−3	−1/2

37. 7.230×10^{-11} m
39. 6.83×10^{-11} m
41. **(a)** 1.08×10^{-14} J
(b) 6.75×10^{4} eV
43. 21 600 V
45. 1.9×10^{17}
47. 19
49. 2.2×10^{16}
51. $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^{10}\,4p^3$
53. **(a)** not allowed
(b) allowed
(c) not allowed
(d) allowed
(e) not allowed
55. 3
57. −0.544 eV, −0.378 eV, −0.278 eV
59. The answer is a proof.
61. **(a)** $v_n = 2\pi ke^2Z/(nh)$
(b) 2.19×10^{6} m/s
(c) 1.09×10^{6} m/s
(d) Yes.

CHAPTER 31

1. **(a)** $+1.31 \times 10^{-17}$ C
(b) 126
(c) 208
(d) 7.1×10^{-15} m
(e) 2.3×10^{17} kg/m^3
3. **(a)** X = Pt (platinum), 117 neutrons
(b) X = S (sulfur), 16 neutrons
(c) X = Cu (copper), 34 neutrons
(d) X = B (boron), 6 neutrons
(e) X = Pu (plutonium), 145 neutrons
5. 4.4×10^{-15} m
7. $^{120}_{50}$Sn
9. 9.4×10^{3} m
11. 39.25 MeV
13. 7.90 MeV/nucleon
15. 2.28×10^{-28} kg
17. 1.003 27 u
19. **(a)** $^{18}_{9}\text{F} \rightarrow {}^{18}_{8}\text{O} + {}^{0}_{+1}\text{e}$
(b) $^{15}_{8}\text{O} \rightarrow {}^{15}_{7}\text{N} + {}^{0}_{+1}\text{e}$
21. $^{35}_{16}\text{S} \rightarrow {}^{35}_{17}\text{Cl} + {}^{0}_{-1}\text{e}$
23. 4.87 MeV
25. **(a)** X = β^-
(b) X = β^+
(c) X = γ ray
(d) X = α particle
27. 1.61×10^{7} m/s
29. $^{212}_{84}$Po
31. 1.82 MeV
33. 19.9
35. 387 yr
37. 8.00 days
39. 146 disintegrations/min
41. 3.7×10^{10} disintegrations/s
43. 1.2×10^{-7} g
45. 7.23 days
47. 0.70%
49. **(a)** 0.999
(b) 1.36×10^{-9}
(c) 0.755
51. age of fossils = 6900 yr, maximum error in the age of the fossils = 900 yr
53. **(a)** 1.741 670 u
(b) 1622 MeV
(c) 7.87 MeV/nucleon
55. 2.1×10^{13} Bq
57. 1.38 MeV
59. 4 782 969 electrons
61. energy carried away by $^{234}_{90}$Th daughter nucleus = 0.072 MeV, energy carried away by α particle = 4.2 MeV

CHAPTER 32

1. 12
3. **(a)** 460 rem
(b) 50% chance of dying
5. 2.4×10^{4} rem
7. 5.0×10^{-4} C°
9. 4.4×10^{11} s^{-1}
11. 9.2×10^{8}
13. $\gamma + {}^{17}_{8}\text{O} \rightarrow {}^{12}_{6}\text{C} + {}^{4}_{2}\text{He} + {}^{1}_{0}\text{n}$
15. **(a)** $A = 233$, $Z = 90$, thorium $^{233}_{90}$Th
(b) $A = 233$, $Z = 92$, uranium $^{233}_{92}$U
17. **(a)** $^{14}_{7}$N (n, p) $^{14}_{6}$C, where n denotes $^{1}_{0}n$ and p denotes $^{1}_{1}$H
(b) $^{238}_{92}$U (n, γ) $^{239}_{92}$U
(c) $^{24}_{12}$Mg (n, d) $^{23}_{11}$Na, where d denotes $^{2}_{1}$H
19. 13.6 MeV

21. 9.0×10^{-4}
23. 184 MeV
25. 232.7851 u
27. (a) 8.2×10^{10} J
(b) 0.48 g
29. 1200 kg
31. 3.3 MeV
33. 4.03 MeV
35. 1.0 gal
37. (a) 1.0×10^{22}
(b) 9.6×10^{9} kg
39. 33.9 MeV
41. 815 MeV
43. (a) 1.9×10^{-20} kg·m/s
(b) 3.5×10^{-14} m
45. 0.18 MeV
47. (a) The κ^- particle does not contain u, c, or t quarks.
(b) The κ^- particle does not contain $\overline{d}$, $\overline{s}$, or $\overline{b}$ antiquarks.
49. 41
51. 1.1×10^{-4} kg
53. 160 MeV