ANSWERS TO ODD-NUMBERED PROBLEMS

Chapter 1

1.1 a) 1.61 km b) 3.28×10^3 ft
1.3 1.02 ns
1.5 5.36 L
1.7 31.7 y
1.9 a) 23.4 km/L b) 1.42 tanks
1.11 9.0 cm
1.13 a) $1.1 \times 10^{-3}\%$ b) no
1.15 a) 0.1% b) 0.008% c) 0.03%
1.17 a) 28 ± 0.3 cm^3 b) 170 ± 20
1.19 a) no b) no c) no d) no e) no
1.21 10^6
1.23 10^9
1.25 $70 million
1.29 $\$9 \times 10^{14}$; about $\$3 \times 10^6$
1.31 7.8 km, 38° north of east
1.33 144 m, 41° south of west
1.35 $A_x = 0$, $A_y = -8.00$ m; $B_x = 7.50$ m, $B_y = 13.0$ m; $C_x = -10.9$ m, $C_y = -5.07$ m; $D_x = -7.99$ m, $D_y = 6.02$ m
1.37 1190 N; 13.4° above forward direction
1.39 a) 9.01 m, 33.7° b) 9.01 m, 33.7° c) 22.3 m, 250.3° d) 22.3 m, 70.3°
1.41 5.06 km, 20.2° north of west
1.43 a) 2.48 cm, 18.3° b) 4.10 cm, 83.7° c) 4.10 cm, 263.7°
1.45 781 N, 166°
1.47 $\vec{A} = -(8.00\text{ m})\hat{j}$; $\vec{B} = (7.50\text{ m})\hat{i} + (13.0\text{ m})\hat{j}$; $\vec{C} = -(10.9\text{ m})\hat{i} + (-5.07\text{ m})\hat{j}$; $\vec{D} = (-7.99\text{ m})\hat{i} + (6.02\text{ m})\hat{j}$
1.49 a) $\vec{A} = (1.23\text{ m})\hat{i} + (3.38\text{ m})\hat{j}$; $\vec{B} = (-2.08\text{ m})\hat{i} + (-1.20\text{ m})\hat{j}$ b) $\vec{C} = (12.01\text{ m})\hat{i} + (14.94\text{ m})\hat{j}$ c) 19.17 m; 51.2°
1.51 a) no b) no; yes c) ± 0.20
1.53 a) -104 m^2 b) -148 m^2 c) 40.6 m^2
1.55 a) 165° b) 28° c) 90°
1.57 a) 63.9 m; $-\hat{k}$ b) 63.9 m; $+\hat{k}$
1.59 a) 4.61 cm^2; $-z$ b) 4.61 cm^2; $+z$
1.61 a) 1.65×10^4 km b) 2.6 earth radii
1.63 10^{28}
1.65 a) 2.94 cm b) 1.82 cm
1.67 a) 10^{50} b) 10^{57} c) 10^{79}
1.69 149 N; 32.2° north of east
1.71 b) $A_x = 3.03$ cm, $A_y = 8.10$ cm c) 8.65 cm; 69.5° from the $+x$-axis toward the $+y$-axis
1.73 144 m, 41° south of west
1.75 a) 46 N, 139°
1.77 a) (87, 258) b) 136 pixels, 25° below straight left
1.79 380 km, 28.8° south of east
1.81 160 N, 13° below horizontal
1.83 a) 911 m; 8.9° west of south
1.87 b) 90°
1.89 a) $A = 5.39$, $B = 4.36$ b) $-5.00\hat{i} + 2.00\hat{j} + 7.00\hat{k}$ c) 8.83; yes
1.93 a) 54.7° b) 35.3°
1.95 $C_x = 8.0$, $C_y = 6.1$
1.97 b) 72.2
1.99 38.5 yd, 24.6° to right of downfield
1.101 a) 76 ly b) 129°

Chapter 2

2.1 a) 197 m/s b) 169 m/s
2.3 1 h 10 min
2.5 a) 17.1 s b) faster: 106 m; slower: 94 m
2.7 250 km
2.9 a) 12.0 m/s b) 0 m/s, 15.0 m/s, 12.0 m/s c) 13.3 s
2.11 a) 2.3 m/s, 2.3 m/s b) 2.3 m/s, 0.33 m/s
2.13 a) no b) (i) 12.8 m/s^2 (ii) 3.5 m/s^2 (iii) 0.72 m/s^2; yes
2.15 a) 2.00 cm/s, 50.0 cm, -0.125 cm/s^2 b) 16.0 s c) 32.0 s d) 6.20 s, 1.22 cm/s; 25.8 s, -1.22 cm/s; 36.4 s, -2.55 cm/s
2.17 a) 3 m/s^2 b) 10 m/s^2 c) depends on positive coordinate direction
2.21 a) 5.0 m/s b) 1.43 m/s^2
2.23 a) 675 m/s^2 b) 0.067 s
2.25 1.70
2.27 a) (i) 5.59 m/s^2 (ii) 7.74 m/s^2 b) (i) 179 m (ii) 12,800 m
2.29 a) +2.7 cm/s, -1.3 cm/s b) -1.3 cm/s^2 c) 22.5 cm; 25.5 cm
2.31 a) 0, 6.3 m/s^2, -11.2 m/s^2 b) 100 m, 230 m, 320 m
2.33 a) 1.80×10^4 m/s b) 0.957 c) 6 h 11 min
2.35 b) 1 s, 3 s d) 2 s e) 3 s f) 1 s
2.37 a) *A:* 20.5 m/s^2; *B:* 3.8 m/s^2; *C:* 53 m/s^2 b) 721 km
2.39 a) 2.94 m/s b) 0.599 s
2.41 a) $t = \sqrt{2d/g}$ b) 0.190 s
2.43 a) 646 m b) 16.4 s, 112 m/s
2.45 a) 25.6 m/s b) 31.6 m c) 15.2 m/s
2.47 a) 249 m/s^2 b) 25.4 c) 101 m d) no
2.49 0.0868 m/s^2
2.51 a) $x(t) = (0.250\text{ m/s}^3)t^3 - (0.0100\text{ m/s}^4)t^4$; $v_x(t) = (0.750\text{ m/s}^3)t^2 - (0.0400\text{ m/s}^4)t^3$ b) 39.1 m/s
2.53 a) 30.0 cm/s
2.55 b) 0.627 s, 1.60 s c) negative at 0.627 s, positive at 1.60 s d) 1.11 s e) 2.45 m f) 2.00 s, 0 s
2.57 a) 82 km/h b) 31 km/h
2.59 a) 3.5 m/s^2 b) 0 c) 1.5 m/s^2
2.61 a) 92.0 m b) 92.0 m
2.63 a) 464 m/s b) 2.99×10^4 m/s c) 7.48
2.65 50.0 m
2.67 4.6 m/s^2
2.69 a) 6.17 s b) 24.8 m c) $v_{truck} = 13.0$ m/s, $v_{auto} = 21.0$ m/s
2.71 a) 7.85 cm/s b) 5.00 cm/s, horizontal from the initial to final position
2.73 a) 15.9 s b) 393 m c) 29.5 m/s
2.75 a) -4.00 m/s b) 12.0 m/s
2.77 a) $2.64H$ b) $2.64T$
2.79 a) no b) yes; 14.4 m/s; not physically attainable
2.81 a) $6.79 \times 10^4 g$ b) 1.45 m/s c) $H/4$
2.83 a) 7.59 m/s b) 5.14 m c) 1.60 s
2.85 a) 7.7 m/s b) 0.78 s c) 0.59 s d) 1.3 m
2.87 270 m
2.89 a) 20.5 m/s b) yes
2.91 a) 947 m b) 393 m
2.93 a) *A* b) 2.27 s, 5.73 s c) 1.00 s, 4.33 s d) 2.67 s
2.95 a) 9.55 s, 4.78 m b) 1.62 m/s d) 8.38 m/s e) no f) 3.69 m/s, 21.7 s, 80.0 m
2.97 a) 8.18 m/s b) (i) 0.411 m (ii) 1.15 km c) 9.80 m/s d) 4.90 m/s

Chapter 3

3.1 a) $v_{av\text{-}x} = 1.4$ m/s, $v_{av\text{-}y} = -1.3$ m/s b) 1.9 m/s, $-43°$
3.3 a) 7.1 cm/s, 45° b) 5.0 cm/s, 90°; 7.1 cm/s; 45°; 11 cm/s, 27°
3.5 b) $a_{av\text{-}x} = -8.67$ m/s^2, $a_{av\text{-}y} = -2.33$ m/s^2 c) 8.98 m/s^2, 195°
3.7 b) $\vec{v} = \alpha\hat{i} + (-2\beta)\hat{j}$; $\vec{a} = -2\beta\hat{j}$ c) $v = 5.4$ m/s, $-63°$; $a = 2.4$ m/s^2, $-90°$ d) speeding up and turning right
3.9 b) 0.600 m b) 0.385 m c) $v_x = 1.10$ m/s, $v_y = -3.43$ m/s; $v = 3.60$ m/s, 72.2° below the horizontal
3.11 3.32 m
3.13 a) 30.6 m/s b) 36.3 m/s
3.15 1.29 m/s^2
3.17 a) 40.0 m/s, 69.3 m/s b) 7.07 s c) 245 m d) 565 m e) $a_x = 0$, $a_y = -9.80$ m/s^2; $v_x = 40.0$ m/s, $v_y = 0$
3.19 a) 0.682 s, 2.99 s b) 24.0 m/s, 11.3 m/s; 24.0 m/s, -11.3 m/s c) 30.0 m/s, $-36.9°$
3.21 a) 1.5 m b) -0.89 m/s
3.23 a) 13.6 m b) 34.6 m/s c) 103 m
3.25 a) 296 m b) 176 m c) 198 m d) horizontal: 15 m/s; vertical: 58.8 m/s e) horizontal: 15 m/s; vertical: 78.8 m/s
3.27 795 m
3.29 a) 0.034 m/s^2, $0.0034g$ b) $1.4h$
3.31 a) 3.07 s b) 1.68 s
3.33 a) 3.50 m/s^2, upward b) 3.50 m/s^2, downward c) 12.6 s
3.35 a) 32.9 m/s b) 27.7 m/s^2 c) 35.5 rpm
3.37 a) 14 s b) 70 s
3.39 0.36 m/s, 38° west of south
3.41 a) 4.7 m/s, 25° south of east b) 190 s c) 380 m
3.43 b) -7.1 m/s, -42 m/s c) 43 m/s, 9.5° west of south
3.45 a) $A = 0$, $B = 2.00$ m/s^2, $C = 50.0$ m, $D = 0.50$ m/s^3 b) $\vec{a} = (4.00\text{ m/s}^2)\hat{i}$, $v = 0$ c) $v_x = 40.0$ m/s, $v_y = 150$ m/s, $v = 155$ m/s c) $\vec{r} = (200\text{ m})\hat{i} + (550\text{ m})\hat{j}$
3.47 a) 124 m b) 280 m
3.49 22 m/s
3.51 40 m/s
3.53 274 m
3.55 a) 42.8 m/s b) 42.0 m
3.57 a) $\sqrt{2gh}$ b) 30.0° c) $6.93h$
3.59 c) less than 45°
3.61 b) 15°, 75°
3.63 a) 17.8 m/s b) in river, 28.4 m from the near bank
3.65 a) 81.6 m b) in cart c) 245 m d) 53.1°
3.67 a) 49 m/s b) 50 m
3.69 a) 2000 m b) 2180 m
3.71 a) 38.5 m/s b) (i) 25.0 m/s, 0 (ii) 25.0 m/s, 38.5 m/s c) (i) 0° (ii) 57.0° d) 499 m
3.73 $\pm 25.4°$
3.77 b) $v_x = R\omega(1 - \cos\omega t)$, $v_y = R\omega\sin\omega t$, $a_x = R\omega^2\sin\omega t$, $a_y = R\omega^2\cos\omega t$ c) $t = 0$, $2\pi/\omega$, $4\pi/\omega$, . . . ; $x = 0$, $2\pi R$, $4\pi R$, . . . ; $y = 0$; $a = R\omega^2$ in the $+y$ direction d) no
3.79 a) $2.50g$ b) $0.614n$
3.81 a) 44.7 km/h, 26.6° west of south b) 10.5° north of west
3.83 a) 0.659 s b) (i) 9.10 m/s (ii) 6.46 m/s c) 3.00 m, 2.13 m
3.85 7.39 m/s, 12.4° north of east
3.87 a) 80 m b) 1.6×10^{-3} c) overall effect is to reduce radius
3.89 a) $\left(\frac{2v_0^2}{g}\right)[\tan(\theta + \phi) - \tan\theta]\frac{\cos^2(\theta + \phi)}{\cos\theta}$ b) $\frac{\pi}{4} - \frac{\theta}{2}$
3.91 $\Delta t = 0.5$ s: 9.589 m/s^2, 118.6°; $\Delta t = 0.1$ s: 9.983 m/s^2, 95.73°; $\Delta t = 0.05$ s: 9.996 m/s^2, 92.86°
3.93 a) 1.5 km/h b) 3.5 km/h

Chapter 4

4.1 a) 0° b) 90° c) 180°
4.3 7.1 N to the right, 7.1 N downward
4.5 494 N, 31.7°
4.7 2.2 m/s^2
4.9 16.0 kg
4.11 a) 3.13 m, 3.13 m/s b) 21.9 m, 6.25 m/s
4.13 a) 45.0 N; $t = 2$ s to 4 s b) 2 s to 4 s c) 0, 6 s
4.15 a) $A = 100$ N, $B = 12.5$ N/s^2 b) (i) 21.6 N, 2.70 m/s^2 (ii) 134 N, 16.8 m/s^2 c) 26.6 m/s^2
4.17 2.94×10^3 N
4.19 a) 4.49 kg b) 4.49 kg, 8.13 N
4.21 825 N, blocks

4.23 a) gravity exerted by earth on bottle; force of air on bottle b) gravity exerted by bottle on earth; force of bottle on air
4.25 $7.4 \times 10^{-23}\ \text{m/s}^2$
4.27 b) yes
4.29 yes, in part (a)
4.31 b) 142 N
4.33 c) force exerted by the ground on the truck
4.35 1840 N, 135°
4.37 a) 17 N, 90° clockwise from $+x$-direction b) 840 N
4.39 a) 4.8 m/s b) 16 m/s² c) 2360 N
4.41 b) 5.83 m/s²
4.43 a) 2.50 m/s² b) 10.0 N c) to the right; F d) 25.0 N
4.45 a) 2.93 m/s² b) 11.1 m/s²
4.47 b) 79.6 N
4.49 a) mg b) mg c) $m(g + |\vec{a}|)$ d) $m(g - |\vec{a}|)$
4.51 a) 7.80 m/s b) 50.6 m/s² c) 4532 N, $6.16mg$
4.53 a) w b) 0 c) $w/2$
4.55 b) 1390 N
4.57 b) (i) 3.5 m/s² (ii) 8.0 N
4.59 $-6mBt$

Chapter 5

5.1 a) 25.0 N b) 50.0 N
5.3 a) 990 N, 735 N b) 926 N
5.5 48°
5.7 4.10×10^3 N
5.9 a) *A:* 0.732w; *B:* 0.897w; *C:* w b) *A:* 2.73w; *B:* 3.35w; *C:* w
5.11 a) 337 N b) 343 N
5.13 a) 470 N b) 163 N
5.15 b) 1.22mg c) 0.70mg
5.17 a) 4610 m/s², 470g b) 9.70×10^5 N, 471w c) 18.7 ms
5.19 b) 2.96 m/s² c) 191 N; more than the bricks, less than the counterweight
5.21 b) 2.50 m/s² c) 1.37 kg d) $T = 0.745w$
5.23 a) 0.832 m/s² b) 17.3 s
5.25 1.38°
5.29 a) 22 N b) 3.1 m
5.31 a) 0.710, 0.472 b) 258 N c) (i) 51.8 N (ii) 4.97 m/s²
5.33 a) 57.1 N b) 146 N, up the ramp
5.35 11 times farther
5.37 a) $\mu_k(m_A + m_B)g$ b) $\mu_k m_A g$
5.39 3.82 m/s²
5.41 a) 0.218 m/s b) 11.7 N
5.43 a) $\mu_k mg/(\cos\theta - \mu_k \sin\theta)$ b) $1/\tan\theta = \mu_k$
5.45 b) 8.75 N c) 30.8 N d) 1.54 m/s²
5.47 a) 0.44 kg/m b) 42 m/s
5.49 a) 3.61 m/s b) bottom c) 3.33 m/s
5.51 a) 21.0°; no b) car: 1.18×10^4 N; truck: 2.36×10^4 N
5.53 upper cable: 1410 N; horizontal cable: 8360 N
5.55 a) 1.49 rev/min b) 0.918 rev/min
5.57 a) 138 km/h b) 3580 N
5.59 2.43 m/s
5.61 a) rope making 60° angle b) 6400 N
5.63 a) $Mg/(2\sin\theta)$ b) $Mg/(2\tan\theta)$ c) $T \to \infty$
5.65 a) $m_1(\sin\alpha + \mu_k\cos\alpha)$
b) $m_1(\sin\alpha - \mu_k\cos\alpha)$
c) $m_1(\sin\alpha - \mu_s\cos\alpha) < m_2 < m_1(\sin\alpha + \mu_s\cos\alpha)$
5.67 a) 1.44 N b) 1.80 N
5.69 a) 1.3×10^{-4} N; 62.5w b) 2.9×10^{-4} N at 1.2 ms c) 1.2 m/s
5.71 1040 N
5.73 a) 11 m/s b) 7.5 m/s
5.75 0.40
5.77 a) $g\left(\dfrac{m_B + m_{\text{rope}}d/L}{m_A + m_B + m_{\text{rope}}}\right)$; increases b) 0.63 m c) will not work for any value of d
5.79 a) 66 N, northward b) 59 N, southward
5.81 a) 294 N, 152 N, 152 N b) 40.0 N
5.83 2.52 N
5.85 a) 12.9 kg b) 47.2 N in left-hand cord, 101 N in right-hand cord
5.87 $a_1 = 2m_2g/(4m_1 + m_2)$; $a_2 = 2m_2g/(4m_1 + m_2)$
5.89 1.46 m above the floor
5.91 g/μ_s
5.93 b) 0.450
5.95 0.34
5.97 a) 170 m b) 18 m/s, 41 mi/h c) 25 m/s, 56 mi/h
5.99 a) move up b) remains constant c) remains constant d) stop
5.101 a) 6.00 m/s² b) 0.380 m/s² c) 7.36 m/s d) 8.18 m/s e) 7.78 m, 6.29 m/s, 1.38 m/s² f) 3.14 s
5.103 1/3
5.105 a) $v_y(t) = v_t + (v_0 - v_t)e^{-kt/m}$
b) $v_y(t) = v_t(\sin\beta - 0.015\cos\beta)^{1/2}$
5.107 a) 0.015; 0.036 N · s²/m² b) 29 m/s c) ratio is $(\sin\beta - 0.015\cos\beta)^{1/2}$
5.109 a) 120 N b) 3.79 m/s
5.111 b) 0.28 c) no
5.113 a) right b) 120 m
5.115 a) 81.1° b) no c) bead rides at bottom of hoop ($\beta = 0$)
5.119 $T_{\max} = 2\pi\sqrt{\left(\dfrac{h\tan\beta}{g}\right)\left(\dfrac{\sin\beta + \mu_s\cos\beta}{\cos\beta - \mu_s\sin\beta}\right)}$;
$T_{\min} = 2\pi\sqrt{\left(\dfrac{h\tan\beta}{g}\right)\left(\dfrac{\sin\beta - \mu_s\cos\beta}{\cos\beta + \mu_s\sin\beta}\right)}$
5.121 $(M + m)g\tan\alpha$
5.123 a) $F = \dfrac{\mu_k w}{\cos\theta + \mu_k\sin\theta}$
b) $\theta = \tan^{-1}(\mu_k) = 14.0°$
5.125 a) $a_3 = g\left(\dfrac{-4m_1m_2 + m_2m_3 + m_3m_1}{4m_1m_2 + m_2m_3 + m_3m_1}\right)$
b) $a_B = -a_3$
c) $a_1 = g\left(\dfrac{4m_1m_2 - 3m_2m_3 + m_3m_1}{4m_1m_2 + m_2m_3 + m_3m_1}\right)$
d) $a_2 = g\left(\dfrac{4m_1m_2 + m_2m_3 - 3m_3m_1}{4m_1m_2 + m_2m_3 + m_3m_1}\right)$
e) $T_A = \frac{1}{2}T_C$
f) $T_C = \dfrac{8gm_1m_2m_3}{4m_1m_2 + m_2m_3 + m_3m_1}$
g) $a_1 = a_2 = a_3 = a_B = 0$, $T_C = 2m_2g$, $T_A = m_2g$; yes
5.127 $\cos^2\beta$

Chapter 6

6.1 a) 3.60 J b) −0.900 J c) 2.70 J
6.3 a) 74 N b) 330 J c) −330 J d) zero; zero e) zero
6.5 a) −1750 J b) no
6.7 a) (i) 9.00 J (ii) −9.00 J b) (i) 0 (ii) 9.00 J (iii) −9.00 J (iv) 0 c) zero for each block
6.9 a) (i) zero (ii) zero b) (i) zero (ii) −25.1 J
6.11 a) 1.0×10^{16} J b) about 2 times greater
6.13 a) 42.85V b) 1836K
6.15 a) 43.2 m/s b) 101 m/s c) 5.80 m d) 3.53 m/s e) 7.35 m
6.17 $(2gh[1 + \mu_k/\tan\alpha])^{1/2}$
6.19 a) 9D b) $D/3$
6.21 32.0 N
6.23 a) 4.48 m/s b) 3.61 m/s
6.25 a) 4.96 m/s b) a = 1.43 m/s²; v = 4.96 m/s; same
6.27 a) $v_0^2/2\mu_k g$ b) 1/2 c) 4 d) 2
6.29 a) 48.0 N, 64.0 N b) 0.360 J, 0.640 J
6.31 a) 2.8 m/s b) 3.5 m/s
6.33 8.5 cm
6.35 a) 1.76 b) 0.67 m/s
6.37 a) 4.0 J b) zero c) −1.0 J d) 3.0 J e) −1.0 J
6.39 a) 2.83 m/s b) 2.40 m/s
6.41 a) 5.65 cm b) no; 0.57 J
6.43 3.6×10^5 J; 100 m/s
6.45 $4.0 \times 10^{13}P$
6.47 743 W, 0.995 hp
6.49 a) 1.4 b) 0.38
6.51 a) 5.4×10^9 J b) 0.72 MW
6.53 2.96×10^4 W
6.55 877 J
6.57 a) 532 J b) −315 J c) zero d) −203 J e) 14.7 J f) 1.21 m/s
6.59 a) $1/\sin\alpha$ b) $W_{\text{in}} = W_{\text{out}}$
6.61 a) 2.59×10^{12} J b) 4800 J
6.63 b) $k_{\text{eff}} = k_1 + k_2 + \cdots + k_N$
6.65 a) $k\left(\dfrac{1}{x_2} - \dfrac{1}{x_1}\right)$; negative b) $k\left(\dfrac{1}{x_1} - \dfrac{1}{x_2}\right)$; positive c) same magnitude and opposite sign, since net work is zero
6.67 a) 5.11 m b) 0.304 c) 10.3 m
6.69 a) 0.15 N b) 9.4 N c) 0.44 J
6.71 a) 2.56 m/s b) 5.28 N c) 19.7 J
6.73 a) −910 J b) 3.17×10^3 J
6.75 1.0×10^5 N/m
6.77 1.1 m from where spring is released
6.79 a) 1.02×10^4 N/m, 8.16 m
6.81 a) 0.600 m b) 1.50 m/s
6.83 0.786
6.85 1.5 m
6.87 a) 1.10×10^5 J b) 1.30×10^5 J c) 3.99 kW
6.89 3.6 h
6.91 1.30×10^3 m³/s
6.93 a) 1.26×10^5 J b) 1.46 W
6.95 a) 2.4 MW b) 61 MW c) 6.0 MW
6.97 a) 513 W b) 355 W c) 52.1 W
6.99 a) 358 N b) 47.2 hp c) 4.06 hp d) 2.03%
6.101 a) $\frac{1}{2}MV^2$ b) 6.1 m/s c) 3.9 m/s d) K_{ball} = 0.40 J, K_{spring} = 0.60 J
6.103 a) 2.0×10^5 J b) 2.8×10^5 J c) 2.8×10^5 J d) 5 km/h

Chapter 7

7.1 a) 6.6×10^5 J b) -7.7×10^5 J
7.3 a) 820 N b) (i) zero (ii) 740 J
7.5 a) 24.0 m/s b) 24.0 m/s c) part (b)
7.7 2.5 m/s
7.9 a) (i) zero (ii) 0.98 J b) 2.8 m/s c) constant: gravity; not constant: normal, friction d) 5.0 N
7.11 −5400 J
7.13 a) 880 J b) −157 J c) 471 J d) 253 J e) a = 3.16 m/s²; v = 7.11 m/s; ΔK = 253 J; same
7.15 a) 80.0 J b) 5.00 J
7.17 a) (i) $4U_0$ (ii) $U_0/4$ b (i) $x_0\sqrt{2}$ (ii) $x_0/\sqrt{2}$
7.19 a) 6.32 cm b) 12 cm
7.21 ±0.092 m
7.23 a) 3.03 m/s; as mass leaves spring b) 95.9 m/s²; just after mass is released
7.25 a) 4.46×10^5 N/m b) 0.128 m
7.27 a) −308 J b) −616 J c) nonconservative
7.29 a) −3.6 J b) −3.6 J c) −7.2 J d) nonconservative
7.31 a) $\frac{1}{2}k(x_1^2 - x_2^2)$ b) $-\frac{1}{2}k(x_1^2 - x_2^2)$; zero c) $-\frac{1}{2}k(x_3^2 - x_1^2)$; $-\frac{1}{2}k(x_2^2 - x_3^2)$; $-\frac{1}{2}k(x_2^2 - x_1^2)$; same
7.33 2.46 N, $+x$-direction
7.35 c) attracts
7.37 a) $F(r) = (12a/r^{13}) - (6b/r^7)$
b) $(2a/b)^{1/6}$; stable c) $b^2/4a$
d) $a = 6.68 \times 10^{-138}$ J · m¹², $b = 6.41 \times 10^{-78}$ J · m⁶
7.39 a) zero, 637 N b) 2.99 m/s
7.41 a) no b) yes, $150
7.43 0.41
7.45 a) 15.9 J b) 4.0 J c) 3.0 J
7.47 a) 20.0 m from left-hand edge of horizontal section b) −78.4 J
7.49 a) 22.2 m/s b) 16.4 m c) no
7.51 0.602 m
7.53 15.5 m/s
7.55 4.4 m/s
7.57 a) $x_0\sqrt{k/m}$ b) kx_0/m c) $x = 0$, $x = -x_0$ d) x_0 e) system oscillates and never stops
7.59 a) 7.00 m/s b) 2.94 N
7.61 a) $mg(1 - h/d)$ b) 440 N
c) $\sqrt{2gh(1 - y/d)}$
7.63 48.2°
7.65 a) 0.392 b) −0.832 J
7.67 a) $U(x) = (30.0\ \text{N/m})x^2 + (6.00\ \text{N/m}^2)x^3$ b) 7.85 m/s
7.69 7.01 m/s
7.71 a) $m(g + a)^2/2gh$ b) $2gh/(g + a)$
7.73 119 J
7.75 a) 3.87 m/s b) 0.10 m
7.77 a) $F_x = -m\omega_0^2 x$, $F_y = -m\omega_0^2 x$, b) $\frac{1}{2}m\omega_0^2(x^2 + y^2)$ c) (i) $\frac{1}{2}m\omega_0^2(x_0^2 + y_0^2)$ (ii) $\frac{1}{2}m\omega_0^2(x_0^2 + y_0^2)$
7.79 a) 4.4×10^{12} J b) 2.7×10^3 m³; 0.90 mm
7.81 c) attracts
7.83 a) −50.6 J b) −67.5 J c) nonconservative
7.85 a) no b) $x_0 = F/k$ d) no e) $3F/k$, $-F/k$ f) $v_{\max} = 2F/\sqrt{mk}$ at $x = x_0 = F/k$
7.87 b) $v(x) = \left[\dfrac{2\alpha}{mx_0^2}\left(\dfrac{x_0}{x} - \left[\dfrac{x_0}{x}\right]^2\right)\right]^{1/2}$
c) $x = 2x_0$, $v = \sqrt{\alpha/2mx_0^2}$ d) zero
e) $v(x) = \left[\dfrac{2\alpha}{mx_0^2}\left(\dfrac{x_0}{x} - \left[\dfrac{x_0}{x}\right]^2 - \dfrac{2}{9}\right)\right]^{1/2}$
f) first case: x_0, ∞; second case: $3x_0/2$, $3x_0$

Chapter 8

8.1 a) 1.20×10^5 kg · m/s b) i) 60.0 m/s ii) 26.8 m/s
8.3 b) baseball, 0.525 c) woman, 0.643
8.5 a) 22.5 kg · m/s, to the left b) 838 J
8.7 562 N, no
8.9 a) 10.8 m/s, to the right b) 0.75 m/s, to the left
8.11 a) 500 N/s² b) 5810 kg · m/s c) 2.70 m/s
8.13 a) 2.50 N · s b) i) +6.25 m/s, to the right b) ii) 3.75 m/s, to the right
8.15 a) 6.79 m/s b) 55.2 J
8.17 a) 0.790 m/s b) −0.0023 J
8.19 0.866 kg · m/s
8.21 a) 0.0559 m/s b) 0.0313 m/s
8.23 3.65×10^5 m/s
8.25 a) 7.20 m/s b) −680 J
8.27 3.56 m/s
8.29 a) 0.846 m/s b) 2.10 J
8.31 a) 1.4×10^{-6} km/h, which is not noticeable. b) 6.7×10^{-8} km/h, which is not noticeable.
8.33 5.9 m/s at 32° east of north
8.35 a) Both cars have the same change in momentum, but the smaller car has a greater velocity change. b) 2.5 Δv c) Those in the smaller car
8.37 19.5 m/s (car), 21.9 m/s (truck)
8.39 a) 2.93 cm b) 866 J c) 1.73 J
8.41 a) 0.333 m/s, 3.33 J b) −1.33 m/s (*A*), +0.67 m/s (*B*)
8.43 a) −0.100 m/s (*A*), 0.500 m/s (*B*) b) 0.009 kg · m/s for both c) -4.5×10^{-4} J (*A*), 4.5×10^{-4} J (*B*), same magnitudes because the collision is elastic
8.45 a) 1/3 b) 1/9 c) 10
8.47 x_{cm} = 0.044 m, y_{cm} = 0.056 m
8.49 2520 km from the center of Pluto
8.51 0.700 m upward and 0.700 m to the right
8.53 0.47 m/s
8.55 $F_x = (-1.50\ \text{N/s})t$, F_y = 0.25 N, $F_z = 0$
8.57 a) 53 g b) 5.22 N
8.59 2.4 km/s
8.61 45.1
8.63 a) 0.47 N · s b) 237 N
8.65 a) $J_x = -1.14$ N · s, $J_y = 0.33$ N · s b) v_{2x} = 0.0500 m/s, v_{2y} = 1.78 m/s
8.67 2.67 m/s (convertible), 3.46 m/s (SUV)
8.69 a) v_{Cx} = 1.75 m/s, v_{Cy} = 0.26 m/s b) −0.092 J
8.71 15.0 m/s
8.73 36.4 N
8.75 a) 2.60 m/s b) 325 m/s
8.77 a) 5.28 m/s b) 5.7 m
8.79 68.8°
8.81 102 N
8.83 a) 0.222 b) −291 J c) 0.784 J
8.85 b) $M = m$ c) zero
8.87 a) 9.35 m/s b) 3.29 m/s
8.89 b) $\frac{1}{2}Mv_{\text{cm}}^2$
8.91 a) 3.56 m/s b) 5.22 m/s c) 4.67 m/s
8.93 0.00544%
8.95 1.61×10^{-22} kg · m/s, to the left
8.97 *A*: 13.6 m/s; *B*: 6.34 m/s, 65.0°
8.99 a) $(L/2)\cos(\alpha/2)$, along axis from apex b) $(L/3)$, along bisector from bottom c) $L/\sqrt{8}$ along bisector d) $L/\sqrt{12}$ from each side
8.101 0.400 m/s
8.103 a) 1.40 kg: 14.3 m/s; 0.28 kg: 71.6 m/s b) 347 m
8.105 222 m/s, 1.01×10^3 m/s; $v_{\text{Kr}} = 1.5v_{\text{Ba}}$
8.107 a) zero b) 1 d) 0.87 m f) 0.089 m
8.109 a) yes b) no; kinetic energy decreases by 4.8×10^3 J
8.111 a) $1.37v_{\text{ex}}$ b) $1.18v_{\text{ex}}$ c) $2.38v_{\text{ex}}$ d) 2.94 km/s
8.113 b) $2L/3$
8.115 a) $l^2\lambda g/32$ b) $l^2\lambda g/32$

Chapter 9

9.1 a) 34.4° b) 6.27 cm c) 1.05 m
9.3 a) *A:* rad/s; *B:* rad/s³ b) (i) 0 (ii) 15.0 rad/s² c) 9.50 rad
9.5 a) $\omega_z(t) = (0.400\ \text{rad/s}) + (0.0360\ \text{rad/s}^3)t^2$ b) 0.400 rad/s c) ω_z = 1.30 rad/s; $\omega_{\text{av-}z}$ = 0.700 rad/s
9.7 a) $a = \pi/4$ rad, b = 2.00 rad/s, $c = -0.139$ rad/s³ b) zero c) 19.5 rad; 9.35 rad/s
9.9 a) 2.25 rad/s b) 4.69 rad
9.11 a) 24.0 s b) 68.8 rev
9.13 10.5 rad/s
9.15 a) 300 rpm b) 75.0 s; 312 rev
9.17 9.00 rev
9.19 a) 540 rad b) 12.3 s c) −8.17 rad/s²
9.21 a) 1.99×10^{-7} rad/s b) 7.27×10^{-5} rad/s c) 2.99×10^4 m/s d) 464 m/s e) 0.0337 m/s²; zero
9.23 a) 15.1 m/s² b) 15.1 m/s²
9.25 a) 0.180 m/s²; 0; 0.180 m/s² b) 0.180 m/s²; 0.377 m/s²; 0.418 m/s² c) 0.180 m/s²; 0.754 m/s²; 0.775 m/s²
9.27 10.7 cm; no
9.29 a) 0.831 m/s b) 109 m/s²
9.31 a) 2.29 b) 1.51 c) 15.7 m/s, 108g
9.33 2.99 cm
9.35 a) (i) 0.469 kg · m² (ii) 0.117 kg · m² (iii) zero b) (i) 0.0433 kg · m² (ii) 0.0722 kg · m² c) (i) 0.0288 kg · m² (ii) 0.0144 kg · m²
9.37 a) 0.0640 kg · m² b) 0.0320 kg · m² c) 0.0320 kg · m²
9.39 0.193 kg · m²
9.41 8.52 kg · m²
9.43 a) 3.15×10^{23} J b) 158 y; no
9.45 0.600 kg · m²
9.47 7.35×10^4 J
9.49 a) 67.3 cm b) 45.5%
9.51 a) f^5 b) 6.37×10^8 J
9.53 −88.2 J
9.55 on an axis parallel to a diameter and $(2/\sqrt{15})R$ from the center of the sphere
9.57 $\frac{1}{3}M(a^2 + b^2)$
9.59 a) $ML^2/12$ b) $ML^2/12$
9.61 $MR^2/2$
9.63 a) $\gamma L^2/2$ b) $ML^2/2$; larger c) $ML^2/6$; one-third result of (b)
9.65 in 128 d
9.67 a) 0.600 m/s³ b) $\alpha = (2.40\ \text{rad/s}^3)t$ c) 3.54 s d) 17.7 rad
9.69 a) 0.050 rad/s² b) 0.300 rad/s c) 5.40 m/s² e) 6.18 m/s²; 7.66 × 10³ N f) 60.9°
9.71 a) 1.70 m/s b) 84.8 rad/s
9.73 b) 2.00 m/s² d) 0.208 kg · m²
9.77 a) 7.36 m b) 327 m/s²
9.79 a) 2.14×10^{29} J b) 2.66×10^{33} J
9.81 a) $Mb^2/6$ b) 182 J
9.83 a) −0.784 J b) 5.42 rad/s c) 5.42 rad/s d) particle speed = 4.43 m/s
9.85 $\sqrt{(2gd)(m_B - \mu_k m_A)/(m_A + m_B + I/R^2)}$
9.87 $\sqrt{(g/R)(1 - \cos\beta)}$
9.89 a) 2.25×10^{-3} kg · m² b) 3.40 m/s c) 4.95 m/s
9.91 7.23 m
9.93 a) $(247/512)MR^2$ b) $(383/512)MR^2$
9.95 b) $\frac{1}{4}M(R_1^2 + R_2^2)$
9.97 a) $\frac{3}{5}MR^2$ b) larger
9.99 b) 5.97×10^{24} kg c) $0.334MR^2$
9.101 a) $s = r_0\theta + \beta\theta^2/2$
b) $\theta = (1/\beta)[\sqrt{r_0^2 + 2\beta vt} - r_0]$
c) $\omega_z = \dfrac{v}{\sqrt{r_0^2 + 2\beta vt}}$, $\alpha_z = \dfrac{\beta v^2}{(r_0^2 + 2\beta vt)^{3/2}}$; no d) r_0 = 2.50 cm, β = 0.247 μm/rad; 2.13×10^4 rev

Chapter 10

10.1 a) 40.0 N · m, out of the page b) 34.6 N, out of the page c) 20.0 N · m, out of the page d) 17.3 N · m, into the page e) zero f) zero
10.3 2.50 N · m, counterclockwise
10.5 b) into page c) $(-1.05\ \text{N} \cdot \text{m})\hat{\boldsymbol{k}}$
10.7 13.1 N · m
10.9 a) 14.8 rad/s² b) 1.52 s
10.11 7.47 N
10.13 0.482
10.15 a) 7.5 N in horizontal part, 18.2 N in hanging part b) 0.0160 kg · m²
10.17 a) 2.65 rad/s² b) no c) 3.31 m/s²; no
10.19 a) 1.80 m/s b) 7.13 J c) (i) 3.60 m/s, to the right (ii) 0 (iii) 2.55 m/s, 45° below horizontal d) (i) 1.80 m/s, to the right (ii) 1.80 m/s, to the left (iii) 1.80 m/s, downward
10.21 a) 1/3 b) 2/7 c) 2/5 d) 5/13
10.23 a) 0.613 b) no, requires $\mu_s = 0.858$ c) no slipping
10.25 11.7 m
10.27 a) 0.309 rad/s b) 100 J c) 6.67 W
10.29 a) 0.38 N · m b) 160 rad c) 59 J d) 59 J
10.31 b) 65.6 N
10.33 a) 358 N · m b) 1.79×10^3 N c) 83.8 m/s
10.35 a) 115 kg · m²/s, into the page b) 125 kg · m²/s², out of the page
10.37 4.71×10^{-6} kg · m²/s
10.39 4.6×10^3 rad/s
10.41 1.14 rev/s
10.43 0.60 rev
10.45 a) 0.120 rad/s b) 3.20×10^{-4} J; work done by bug
10.47 a) 5.88 rad/s
10.49 a) 1.62 N b) 1.80×10^3 rev/min
10.51 a) halved b) doubled c) halved d) doubled e) unchanged
10.53 a) 67.6 N b) 62.9 N c) 3.27 s
10.55 a) 840 rpm b) 75 mph c) 60 mph
10.57 a) 16.3 rad/s² b) no; decreases c) 5.70 rad/s
10.59 a) at $x = l$ b) at $x = l$ c) at $x = (l/2)(1 + [2h/l]^2)$ for $l > 2h$; at $x = l$ for $l < 2h$
10.61 a) FR b) FR; yes c) $\sqrt{4F/MR}$ d) $2F/M$ e) $4F/M$
10.63 a) 266 N b) 4.71 rad/s²
10.65 a) 2.88 m/s² b) 6.13 m/s²; greater in case (b)
10.67 239 N
10.69 $a = \dfrac{2g}{2 + (R/b)^2}$; $\alpha = \dfrac{2g}{2b + R^2/b}$; $T = \dfrac{2mg}{2(b/R)^2 + 1}$
10.71 clockwise; clockwise; clockwise
10.73 a) 1.41 s; 70.5 m/s b) t larger, v smaller
10.75 29.0 m/s
10.77 a) 26.0 m/s b) unchanged
10.79 a) $\sqrt{20hy/7}$ b) no c) rolling friction d) $\sqrt{8hy/3}$

10.81 b) R = radius of wheel, T = period of wheel's rotation
c) $v_x = \frac{2\pi R}{T}\left[1 - \cos\left(\frac{2\pi t}{T}\right)\right]$, $v_y = \frac{2\pi R}{T}\sin\left(\frac{2\pi t}{T}\right)$; $a_x = \left(\frac{2\pi R}{T}\right)^2 R\sin\left(\frac{2\pi t}{T}\right)$, $a_y = \left(\frac{2\pi R}{T}\right)^2 R\cos\left(\frac{2\pi t}{T}\right)$
d) $t = 0, T, 2T, \ldots$; $a_x = 0$, $a_y = \frac{4\pi^2 R}{T^2}$
e) $\frac{4\pi^2 R}{T^2}$, independent of time
10.83 $g/3$
10.85 1.87 m
10.87 a) $6v/19L$ b) $3/19$
10.89 a) 5.46 rad/s b) 3.17 cm
c) 1.01×10^3 m/s
10.91 a) 2.00 rad/s b) 6.57 rad/s
10.93 0.30 rad/s, clockwise
10.97 -4.2×10^{-16} rad/s per year; decreasing
10.101 a) $a = +\mu_k g$, $\alpha = -2\mu_k g/R$
b) $\omega_0^2 R^2/18\mu_k g$ c) $-M\omega_0^2 R^2/6$
10.103 a) $mv_1^2 r_1^2/r^3$ b) $(mv_1^2/2)[(r_1/r_2)^2 - 1]$
c) same

Chapter 11

11.1 29.8 cm
11.3 20.0 kg
11.5 5450 N
11.7 a) 1000 N, 1.20 m from end where 400-N force is applied b) 800 N, 1.25 m from end where 400-N force is applied
11.9 a) 550 N b) 0.614 m from A
11.11 a) 1920 N b) 1140 N
11.13 a) $T = 2.60w$; $F_{\text{pivot}} = 3.28w$ at 37.6°
b) $T = 4.10w$; $F_{\text{pivot}} = 5.38w$ at 48.8°
11.15 140 N by each hinge
11.17 246 N; 0.34 m behind front feet
11.19 $T_{\text{left}} = 270$ N, $T_{\text{right}} = 304$ N, $\theta = 40°$
11.21 a) 0.800 m b) clockwise c) 0.800 m, clockwise
11.23 1.4 mm
11.25 2.00×10^{11} Pa
11.27 a) upper: 3.1×10^{-3}; lower: 2.0×10^{-3}
b) upper: 1.6 mm; lower: 0.98 mm
11.29 9.1×10^6 N
11.31 a) 3.33×10^6 Pa b) 1.33×10^5 Pa
11.33 a) 4.8 × 10^9 Pa; 2.1 × 10^{-10} Pa^{-1}
11.35 b) 6.60×10^5 N c) 1.8 mm
11.37 3.41×10^7 Pa
11.39 10.2 m/s²
11.41 a) 525 N b) 222 N, 328 N c) 1.48
11.43 wing force: 7300 N upward; tail force: 600 N downward
11.45 a) 140 N b) 6 cm to the right
11.47 a) 424 N b) 170 N
11.49 120 N to the right, 160 N upward
11.53 b) $(Mg/2)\sin\theta$
11.55 a) $V = mg + w$, $H = T = (w + mg/4)\cot\theta$
b) 950 N c) 4.00°
11.57 7600 N
11.59 a) 2700 N b) 19
11.61 a) 4.90 m b) 60 N
11.63 a) $\theta = \arctan(h/d)$; $T = (Wd/2)\sqrt{h^2 + d^2}$
b) $\frac{Whd}{2(h^2 + d^2)}$; $W\frac{2h^2 + d^2}{2(h^2 + d^2)}$
11.65 a) 1150 N b) 1940 N c) 918 N d) 0.473
11.67 person above: 590 N; person below: 1370 N; above
11.69 a) $w_{\max} = T_{\max}hD/(L\sqrt{h^2 + D^2})$
11.71 a) 7140 N; tall walls b) 7900 N
11.73 a) 268 N b) 232 N c) 366 N
11.75 a) A: 0.424 N; B: 1.47 N; C 0.424 N
b) 0.848 N
11.77 a) tips at 27°, slips at 31°; the bale tips before it slips b) tips at 27° slips at 22° the bale slips before it tips
11.79 a) $F_A = 80$ N, $F_B = 870$ N b) 1.92 m
11.81 a) 3.7 kN, 2.0 kN vertically upward
11.83 a) $0.012w$ b) less c) 25.0°; tips
11.85 a) 5.4 mm b) 4.2 mm
11.87 a) 0.70 m from wire A b) 0.45 m from wire B
11.89 a) 1.63 m b) brass: 2.00×10^8 Pa; nickel: 4.00×10^8 Pa c) brass: 2.2×10^{-3}; nickel: 1.9×10^{-3}
11.91 a) 0.36 mm b) 0.045 mm c) 0.33 mm
11.93 a) $(F\cos^2\theta)/A$ b) $(F\sin 2\theta)/2A$ c) 0
d) 45°
11.95 a) 600 N b) 13.5 kN
c) slide: $\mu_s w/(\sin\theta - \mu_s\cos\theta)$; tip: $w/[(\frac{1}{9})\cos\theta + 2\sin\theta]$; 66°
11.97 the lesser of $h^2/L + L/2$ and L
11.99 $[(A^2x/F) - k_O V_O]/V_S$
11.101 a) 0.662 mm b) 2.20×10^{-2} J
c) 8.33×10^{-3} J d) -3.04×10^{-2} J
e) 3.04×10^{-2} J

Chapter 12

12.1 2.18
12.3 0.026 mm
12.5 a) 2.59×10^8 m b) no
12.7 a) 2.40 × 10^{-3} N b) 3.6×10^{-6}
12.9 a) 6.30×10^{20} N, toward sun
b) 4.77 × 10^{20} N, 24.6° toward earth from sun
c) 2.37×10^{20} N, toward sun
12.11 a) 0.366 m from mass m b) (i) unstable (ii) stable
12.13 2.1×10^{-9} m/s², down
12.15 1.38×10^7 m
12.17 a) 0.37 m/s² b) 1700 kg/m³
12.19 610 N; 83% of weight at surface
12.21 5.98×10^{24} kg
12.23 0.83 m/s; yes
12.25 a) 5.02×10^3 m/s b) 6.06×10^4 m/s
12.27 a) 7.46×10^3 m/s b) 1.68 h
12.29 2.01×10^{30} kg
12.31 a) 4.7 m/s; yes b) 2.2 h
12.33 a) 8.3×10^4 m/s b) 1.3×10^6 s
12.35 a) 4.45×10^{12} m, 4.55×10^{12} m b) 248 y
12.39 a) (i) 5.31×10^{-9} N (ii) 2.67×10^{-9} N
12.41 a) $-GMm/\sqrt{a^2 + x^2}$
c) $GMmx/(a^2 + x^2)^{3/2}$ toward center of ring
e) $-GMm/a$, zero
12.43 a) 53 N b) 52 N
12.45 1.39×10^{-9}
12.47 a) 4.3×10^{37} kg, $2.1 \times 10^7 M_{\text{sun}}$ b) no
c) 6.3×10^{10} m; yes
12.49 a) 9.67×10^{-12} N, midway between x and y axes b) 3.02×10^{-5} m/s
12.51 b) 5.39×10^{-13} N · m, clockwise
12.53 b) (i) 1.63×10^{-5} m/s, 4.08×10^{-6} m/s (ii) 2.04×10^{-5} m/s c) 31.9 m
12.55 a) 3.58×10^7 m
12.57 1.8×10^2 m/s
12.59 a) 1.39×10^7 m b) 3.59×10^7 m
12.61 $0.01R_E = 64$ km
12.63 0.28%
12.65 6.06×10^3 km/h
12.67 $\sqrt{2Gm_E h/(R_E^2 + hR_E)}$
12.69 a) 13.7 km/s b) 13.3 km/s c) 13.2 km/s
12.71 a) (i) 2.8 y (ii) 6.1 y b) 4.90×10^8 km
c) 4.22×10^8 km
12.73 a) $GM^2/4R^2$ b) $\sqrt{GM/4R}$, $4\pi\sqrt{R^3/GM}$
c) $GM^2/4R$
12.75 6.8×10^4 m/s
12.77 a) 7.91×10^3 s b) 1.53
c) 8.43×10^3 m/s, 5.51×10^3 m/s
d) 2.41×10^3 m/s, 3.26×10^3; perigee
12.79 3.22×10^9 J
12.81 9.36 m/s²
12.83 $\frac{GmM}{x(x + L)}$
12.85 a) $U(r) = \frac{Gm_E m}{2R_E^3}r^2$ b) 7.90×10^3 m/s
12.87 a) against the direction of motion in all cases
b) 2.24×10^7 s c) 44.1°
12.89 $F = \frac{2GMm}{a^2}\left[1 - \frac{x}{\sqrt{a^2 + x^2}}\right]$, toward the center of the disk

Chapter 13

13.1 a) 4.54×10^{-3} s, 1.38×10^3 rad/s
b) 2.27×10^{-3} s, 2.76×10^3 rad/s
13.3 5.53×10^3 rad/s, 1.14×10^{-3} s
13.5 0.0500 s
13.7 a) 0.167 s b) 37.7 rad/s c) 8.44×10^{-2} kg
13.9 a) 0.375 s b) 2.66 Hz c) 16.7 rad/s
13.11 a) 0.98 m b) $\pi/2$ rad
c) $x(t) = (-0.98\text{ m})\sin([12.2\text{ rad/s}]t)$
13.13 a) -2.71 m/s²
b) $x(t) = (1.46\text{ cm})\cos([15.7\text{ rad/s}]t + 0.715\text{ rad})$,
$v_x(t) = (-22.9\text{ cm/s})\sin([15.7\text{ rad/s}]t + 0.715\text{ rad})$,
$a_x(t) = (-359\text{ cm/s}^2)\cos([15.7\text{ rad/s}]t + 0.715\text{ rad})$
13.15 120 kg
13.17 a) 0.253 kg b) 1.22 cm c) 3.05 N
13.19 a) 1.51 s b) 26.0 N/m c) 0.308 m/s
d) 1.92 N e) −0.0125 m; 0.303 m/s; 0.216 m/s²
13.21 a) 1.48 m/s b) 2.96×10^{-5} J
13.23 a) 1.20 m/s b) 1.11 m/s c) 36 m/s²
d) 13.5 m/s² e) 0.36 J
13.25 $m = 3M$; $\frac{1}{3}$
13.27 0.240 m
13.29 a) 0.0778 m b) 1.28 Hz c) 0.624 m/s
13.31 a) 4.06 cm b) 1.21 m/s c) 29.8 rad/s
13.33 b) 23.9 cm; 1.45 Hz
13.35 a) 2.7×10^{-8} kg · m²
b) 4.3×10^{-6} N · m/rad
13.37 5.12×10^{-2} kg · m²
13.41 a) 0.25 s b) 0.25 s
13.43 0.407 swings/s
13.45 2.00 m
13.47 10.7 m/s²
13.49 0.129 kg · m²
13.53 A: $2\pi\sqrt{L/g}$; B: $(4\pi\sqrt{2}/3)\sqrt{L/g} = 0.943T_A$; pendulum A
13.55 A: $2\pi\sqrt{L/g}$; B: $2\pi\sqrt{\frac{11L}{10g}} = 1.05T_A$; pendulum B
13.57 a) 0.393 Hz b) 1.73 kg/s
13.59 a) A b) magnitude = $bA/2m$, in $-x$-direction; slope is negative
c) $a_x(0) = A\left(\frac{b^2}{2m^2} - \frac{k}{m}\right)$; if $b < \sqrt{2mk}$, $a(0) < 0$; if $b = \sqrt{2mk}$, $a(0) = 0$; if $b > \sqrt{2mk}$, $a(0) > 0$
13.61 a) kg/s b) (i) $5.0F_{\max}/k$ (ii) $2.5F_{\max}/k$
13.63 a) 6.72 × 10^3 m/s² b) 3.02 kN
c) 18.3 m/s, 75.6 J d) 17.6 kW e) 12.1 kN, 36.7 m/s, 302 J, 141 kW
13.65 a) all unchanged b) $1/4$ as large c) halved
d) $1/\sqrt{5}$ as great e) U: unchanged; K: $1/5$ as large
13.67 a) 24.4 cm b) 0.220 s c) 1.19 m/s
13.69 a) 0.318 Hz, 0.500 m, 3.14 s b) 1.57 s
13.71 $\frac{1}{2\pi}\sqrt{\frac{3\sqrt{2}}{5}}\sqrt{\frac{g}{L}} = 0.921\left(\frac{1}{2\pi}\sqrt{\frac{g}{L}}\right)$
13.73 a) 1.49 s b) -2.12×10^{-4} s per s; shorter
c) 0.795 s
13.75 a) 0.150 m/s b) 0.112 m/s², downward
c) 0.700 s d) 4.38 m
13.77 a) 2.6 m/s b) 0.21 m c) 0.49 s
13.79 9.08×10^{24} kg
13.81 1.17 s
13.83 a) yes c) 2.40×10^3 s d) no
13.87 c) -7.57×10^{-19} J e) 8.39×10^{12} Hz
13.89 0.705 Hz; 14.5°
13.91 $2\pi\sqrt{M/3k}$
13.93 $\frac{1}{4\pi}\sqrt{\frac{3g}{\sqrt{2}L}}$
13.95 c) 0.430 m
13.97 a) $k_{\text{eff}} = k_1 + k_2$ b) $k_{\text{eff}} = k_1 + k_2$
c) $k_{\text{eff}} = \frac{k_1 k_2}{k_1 + k_2}$ d) $\sqrt{2}$

13.99 a) $Mv^2/6$ c) $\omega = \sqrt{3k/M}$; $M' = M/3$
13.101 579 N/m

Chapter 14

14.1 $w = 41.8$ N; no
14.3 7.02×10^3 kg/m³; yes
14.5 1.6
14.7 61.7 N
14.9 a) 1.86×10^6 Pa b) 184 m
14.11 0.581
14.13 a) absolute:
46.7 lb/in.² = 3.22×10^5 Pa = 3.18 atm;
gauge:
32.0 lb/in.² = 2.21×10^5 Pa = 2.18 atm
b) no c) 432 cm²
14.15 6.27×10^6 Pa = 61.9 atm
14.17 6.0×10^4 Pa
14.19 1.41×10^5 Pa; 4.03×10^4 Pa
14.21 2.3×10^5 N
14.23 a) 637 Pa b) (i) 1170 Pa (ii) 1170 Pa
14.25 1.66×10^5 Pa = 1.64 atm
14.27 6.43×10^{-4} m³, 2.78×10^3 kg/m³
14.29 a) $\rho < \rho_{\text{fluid}}$ c) submerged: ρ/ρ_{fluid}; above: $(\rho_{\text{fluid}} - \rho)/\rho_{\text{fluid}}$ d) 32%
14.31 a) 116 Pa b) 921 Pa c) 0.822 kg, 822 kg/m³
14.33 1.91×10^3 kg/m³
14.35 9.6 m/s
14.37 a) 17.0 m/s b) 0.317 m
14.39 28.4 m/s
14.41 1.47×10^5 Pa
14.43 12,600 N
14.45 2.03×10^4 Pa
14.47 a) $(p_0 - p)\pi D^2/4$ b) 776 N
14.49 a) 5.9×10^5 N b) 1.76×10^5 N
14.51 c) independent of surface area
14.53 $(p - p_0)VR^2/Gmd$
14.55 a) 12,700 kg/m³, 3140 kg/m³
14.57 a) 1470 Pa b) 13.9 cm
14.59 9.8 × 10^6 kg; yes
14.61 a) 30% b) 70%
14.63 4.66×10^{-4} m³; 5.27 kg
14.65 a) 1.10×10^4 m³ b) 112 kN
14.67 a) 0.107 m b) 2.42 s
14.69 a) $H/2$ b) H
14.71 0.0958 kg
14.73 33.5 N
14.75 b) 12.2 N c) 11.8 N
14.77 b) 2.52×10^{-4} m³, 0.124
14.79 risen by 5.57×10^{-4} m
14.81 a) $1 - \rho_B/\rho_L$ b) $(\rho_L - \rho_B)L/(\rho_L - \rho_W)$
c) 4.60 cm
14.83 a) la/g b) $\omega^2 l^2/2g$
14.87 a) $2\sqrt{h(H - h)}$ b) h
14.89 a) 0.200 m³/s b) 6.97×10^4 Pa
14.91 $3h_1$
14.93 a) $r = r_0(1 + 2gy/v_0^2)^{-1/4}$ b) 1.10 m
14.95 a) 80.4 N
14.97 a) $\sqrt{2gh}$ b) $(p_a/\rho g) - h$

Chapter 15

15.1 a) 0.439 m; 1.28 ms b) 0.219 m
15.3 220 m/s = 800 km/h
15.5 a) 4.3×10^{14} Hz to 7.5×10^{14} Hz; 1.3×10^{-15} s to 2.3×10^{-15} s b) no
15.7 a) $f = 25.0$ Hz, $T = 0.0400$ s, $k = 19.6$ rad/m
b) $y(x, t) = (0.0700\text{ m})\cos 2\pi\left(\frac{x}{0.320\text{ m}} + \frac{t}{0.0400\text{ s}}\right)$ c) +0.0495 m d) 0.0050 s
15.9 c) $-x$-direction for both
d) $v_y(x, t) = \omega A\cos(kx + \omega t)$,
$a_y(x, t) = -\omega^2 A\sin(kx + \omega t)$
15.11 a) 4.0 mm b) 0.040 s c) 0.14 m, 3.6 m/s
d) 0.24 m, 6.0 m/s e) no
15.13 b) $+x$-direction
15.15 a) 16.3 m/s b) 0.136 m c) both increase by factor of $\sqrt{2}$
15.17 0.390 s
15.19 a) 10.0 m/s b) 0.250 m
c) $y(x, t) = (3.00\text{ cm})\cos[(8.00\pi\text{ rad/s})x - (80.0\pi\text{ rad/s})t]$ d) 1890 m/s² e) yes
15.21 a) 95 km b) 2.5×10^{-7} W/m²
c) 1.1×10^5 W
15.23 a) 0.050 W/m² b) 2.2×10^4 J
15.25 707 W
15.33 a) $(1.33\text{ m})n$, $n = 0, 1, 2, 3, \ldots$
b) $(1.33\text{ m})(n + \frac{1}{2})$, $n = 0, 1, 2, 3, \ldots$
15.39 a) 96.0 m/s b) 461 N c) 1.13 m/s, 426 m/s²
15.41 a) 2.80 cm c) 277 cm d) 185 cm, 0.126 s, 1470 cm/s e) 280 cm/s
f) $y(x, t) = (5.60\text{ cm})\sin[(0.0907\text{ rad/cm})x]\sin([133\text{ rad/s}]t)$
15.43 a) $y(x,t) = (4.60\text{ mm})\sin[(6.98\text{ rad/m})x]\sin([742\text{ rad/s}]t)$ b) 3rd c) 39.4 Hz
15.45 a) 45.0 cm b) no
15.47 a) 311 m/s b) 246 Hz c) 245 Hz, 1.40 m
15.49 a) 20.0 Hz, 126 rad/s, 3.49 rad/m
b) $y(x,t) = (2.50\text{ mm})\cos[(3.49\text{ rad/m})x - (126\text{ rad/s})t]$
c) $y(t) = (2.50\text{ mm})\cos[(126\text{ rad/s})t]$
d) $y(t) = (2.50\text{ mm})\cos[3\pi/2 - (126\text{ rad/s})t]$ e) 0.314 m/s
f) −2.50 mm, 0
15.51 a) $(7L/2)\sqrt{\mu_1/F}$ b) no
15.53 a) $(2\pi A/\lambda)\sqrt{FL/M}$ b) increase by a factor of 4
15.55 a) $4\pi^2 F\Delta x/\lambda^2$
15.57 a) 1, 0; 2, +; 3, −; 4, 0; 5, −; 6, + b) 1, −; 2, +; 3, −; 4, +; 5, −; 6, 0 c) (a): answers would reverse sign; (b): no change
15.61 c) C/B
15.63 b) k decreases by a factor of $2\sqrt{2}$; ω decreases by a factor of $\sqrt{2}$
15.65 a) 7.07 cm b) 400.0 W
15.67 $\alpha = (v_1^2 - v_2^2)\rho/Y\Delta T$
15.69 $n(0.800\text{ Hz})$, $n = 1, 2, 3, \ldots$
15.71 c) yes
15.73 c) $2A$, $2A\omega$, $2A\omega^2$
15.75 230 N
15.77 a) 0, L b) 0, $L/2$, L d) no
15.79 a) 148 N b) 26%
15.81 b) $\frac{1}{2}\mu\omega^2 A^2\sin^2(kx - \omega t)$
e) $\frac{1}{2}Fk^2A^2\sin^2(kx - \omega t)$
15.83 $\pi/\omega\sqrt{2}$
15.85 a) 99.4 N c) −4.25 Hz, falls

Chapter 16

16.1 a) 0.344 m b) 1.2×10^{-5} m
c) 6.9 m, 50 Hz
16.3 a) 7.78 Pa b) 77.8 Pa c) 778 Pa
16.5 a) 1.33×10^{10} Pa b) 9.47×10^{10} Pa
16.7 90.8 m
16.9 81.5°C
16.11 0.208 s
16.13 $Y/900$
16.15 a) 9.44×10^{-11} m; 0.434 m
b) 5.66×10^{-9} m; 0.101 m
c) air; $A_{\text{air}}/A_{\text{water}} = 60.0$
16.17 a) 1.94 Pa b) 4.58×10^{-3} W/m²
c) 96.6 dB
16.19 a) 4.4×10^{-12} W/m² b) 6.39 dB
c) 5.8×10^{-11} m
16.21 14.0 dB
16.23 a) 20.0
16.25 a) *fundamental:* displacement node at 0.60 m, pressure nodes at 0 and 1.20 m; *first overtone:* displacement nodes at 0.30 m and 0.90 m, pressure nodes at 0. 0.60 m, and 1.20 m; *second overtone:* displacement nodes at 0.20 m, 0.60 m, and 1.00 m, pressure nodes at 0, 0.40 m, 0.80 m, and 1.20 m b) *fundamental:* displacement node at 0, pressure node at 1.20 m; *first overtone:* displacement nodes at 0 and 0.80 m, pressure nodes at 0.40m and 1.20 m, and; *second overtone:* displacement nodes at 0, 0.48 m, and 0.96 m, pressure nodes at 0.24 m, 0.72 m, 1.20 m
16.27 506 Hz, 1520 Hz, 2530 Hz
16.29 a) 267 Hz b) no
16.31 a) 614 Hz b) 1.23 kHz
16.33 a) 172 Hz b) 86 Hz
16.35 0.125 m
16.37 a) 4 beats/s b) 3.0×10^{-8} m, 0
16.39 1.3 Hz
16.41 780 m/s
16.43 a) 375 Hz b) 371 Hz c) 4 Hz
16.45 a) 0.25 m/s b) 0.91 m
16.47 19.8 m/s
16.49 26.8 Hz
16.51 0.095c; toward us
16.53 a) 36.0° b) 2.23 s
16.55 a) 1.00 b) 8.00 c) 47.3 nm
16.57 b) $3f_0$ c) $v = 4Lf_0$
16.59 flute harmonic $3N$($N = 1, 3, \ldots$) resonates with string harmonic $4N$
16.61 a) stopped b) $n = 7$, $n = 9$ c) 43.9 cm
16.63 a) $v/(2L)$, v/L, $3v/(2L)$
16.65 a) 375 m/s b) 1.39 c) 0.8 cm
16.67 a) $n(77.3\text{ Hz})$, $n = 1, 2, 3, \ldots$
16.69 1.27
16.71 a) 548 Hz b) 652 Hz
16.73 a) $I = 2\pi^2\sqrt{\rho B f}^2(\Delta R)^2$
b) $P = 8\pi^3\sqrt{\rho B f}^2 R^2(\Delta R)^2$
c) $A = (R/d)\Delta R$, $p_{\max} = 2\pi\sqrt{\rho B}(Rf/d)\Delta R$, $I = 2\pi^2\sqrt{\rho B}(fR/d)^2(\Delta R)^2$
16.75 a) 6.74 cm b) 147 Hz
16.77 b) 2.0 m/s
16.79 a) 1.2 × 10^6 m/s b) 3.6×10^{16} m = 3.8 ly
c) 5.2×10^3 ly; 4100 BCE
16.81 a) $f_0\left(\frac{2v_W}{v - v_W}\right)$ b) $f_0\left(\frac{2v_W}{v + v_W}\right)$
16.83 d) 9.69 cm/s; 6.67×10^2 m/s²

Chapter 17

17.1 −81.0°F b) 134.1°F c) 88.0°F
17.3 38 F°
17.5 a) −18.0 F° b) −10.0 C°
17.7 a) 104.4°F; yes b) 54°F
17.9 a) 216.5 K b) 325.9 K c) 205.4 K
17.11 a) −210°C b) 63 K
17.13 0.964 atm
17.15 a) −282°C b) no, 4.76×10^4 Pa
17.17 0.39 m
17.19 a) 1.9014 cm b) 1.8964 cm
17.21 2.3×10^{-5} (C°)$^{-1}$
17.23 11 L
17.25 1.7×10^{-5} (C°)$^{-1}$
17.27 a) 1.431 cm² b) 1.437 cm²
17.29 0.261 mm
17.31 a) 3.2×10^{-5} (C°)$^{-1}$ b) 2.5×10^9 Pa
17.33 5.79×10^5 J
17.35 240 J/kg · K
17.37 1.4×10^3 s
17.39 1.21×10^{-2} C°
17.41 45.1 C°
17.43 a) 114 C° b) 6.35 C°
17.45 a) 215 J/kg · K b) water c) too small
17.47 8 min
17.49 3.64×10^4 J = 8.69×10^3 cal = 34.5 Btu
17.51 2.39×10^4 Btu/h = 7.01×10^3 W
17.53 357 m/s
17.55 3.45 L
17.57 5.50×10^5 J
17.59 0.0940 kg
17.61 2.10 kg
17.63 190 g
17.65 a) 222 K/m b) 10.7 W c) 73.3°C
17.67 a) −5.8°C b) 11 W/m²
17.69 7.1×10^2 Btu = 7.5×10^5 J
17.71 105.5°C
17.73 a) 21.3 kW b) 6.44 kW
17.75 167 W
17.77 2.1 cm²
17.79 a) 35.2°M b) 39.6 C°
17.81 b) 5.0 × 10^{-3} cm³, −23 kg/m³
17.83 37.5°C
17.85 35.0°C
17.87 23.0 cm, 7.0 cm

17.89 b) 1.9×10^8 Pa
17.91 a) 87°C b) −80°C
17.93 20.2°C
17.95 a) 54.3
17.97 a) 83.6 J b) 1.86 J/mol · K
c) 5.60 J/mol · K
17.99 a) 2.7×10^7 J b) 6.89 K c) 19.3 K
17.101 2.53 cm
17.103 a) 86.1°C b) no ice, 0.130 kg liquid water, no steam
17.105 a) 100°C b) 0.0214 kg steam, 0.219 kg liquid water
17.107 1.743 kg
17.109 a) 94 W b) 1.3
17.111 2.9
17.113 a) 6.0×10^5 s (about 170 h) d) 1.5×10^{10} s (about 500 y); no
17.115 0.106 W/m · K
17.117 5.82×10^{-3} kg
17.119 a) 69.6°C
17.121 1.76 C°
17.123 a) 103°C b) 27 W
17.125 a) the reverse b) 1.2×10^{-4} c) 5.2 s
d) to within 1.93 C°
17.127 a) (i) 280 W (ii) 0.248 W
(iii) 2.10×10^3 W (iv) 116 W; radiation from the sun b) 3.72 L/h c) 1.4 L/h

Chapter 18

18.1 a) 56.2 mol b) 6.81×10^6 Pa = 67.2 atm
18.3 0.959 atm
18.5 a) 3×10^{27} molecules
b) 3×10^{19} molecules/cm^3
18.7 503.0°C
18.9 3.36×10^5 Pa
18.11 0.159 L
18.13 1.05 atm
18.15 a) 70.2°C b) yes
18.17 850 m
18.19 density at sea level is 1.2% larger
18.21 2.28×10^4 Pa
18.23 a) $8720 b) 3.88 cm
18.25 a) 8.2×10^{-17} atm b) no
18.27 55.6 mol, 3.35×10^{25} molecules
18.29 a) 9.00×10^{-5} m^3 b) 3.10×10^{-10} m
c) about the same
18.31 b) 1.004
18.33 a) could be true b) could be true
c) not true d) must be true e) could be true
18.35 a) 1.9×10^6 m/s; no, 0.64% of c
b) 7.3×10^{10} K
18.37 a) 6.21×10^{-21} J b) 2.34×10^5 m^2/s^2
c) 484 m/s d) 2.57×10^{-13} kg · m/s
e) 1.24×10^{-19} N f) 1.24×10^{-17} Pa
g) 8.15×10^{21} molecules
h) 2.45×10^{22} molecules
18.39 3800°C
18.41 a) 1560 J b) 935 J
18.43 a) 741 J/kg · K b) 5.65 kg; 4850 L
18.45 a) 924 J/kg · K b) Table 17.3 gives 910 J/kg · K
18.49 a) 337 m/s b) 380 m/s c) 412 m/s
18.51 a) 610 Pa; solid → vapor b) 2.21 × 10^7 Pa; solid → liquid → vapor
18.53 no; no
18.55 0.213 kg
18.57 a) −178°C b) 1.17×10^{26} molecules/m^3
c) Titan's is 4.7 times Earth's
18.59 1.92 atm
18.61 a) 31 b) 8.41 × 10^3 N c) 7.8 × 10^3 N
18.63 a) 26.2 m/s b) 16.1 m/s, 5.44 m/s
c) 1.74 m
18.65 5.0×10^{27}
18.67 a) same translational kinetic energy; A has greater rms speed b) B c) 4250°C d) B
18.69 b) 303 mol/m^3 c) van der Waals
18.71 a) 4.65×10^{-26} kg b) 6.11×10^{-21} J
c) 2.04×10^{24} molecules d) 1.24×10^4 J
18.73 b) r_2 c) $r_1 = R_0/2^{16}$, $r_2 = R_0$, $r_1/r_2 = 2^{-16}$
d) U_0
18.75 a) 517 m/s b) 299 m/s
18.77 b) 1.40×10^5 K, 1.01×10^4 K
c) 6.37×10^3 K, 4.59×10^2 K
18.79 a) 1.24×10^{-14} kg b) 4.16×10^{11}
c) 2.95×10^{-6} m, no
18.81 a) $2R$ b) less
18.83 CO_2: 20.79 J/mol · K, 0.270; SO_2: 24.94 J/mol · K, 0.205; H_2S: 24.94 J/mol · K, 0.039
18.87 b) $0.0420N$ c) $(2.94 \times 10^{-21})N$
d) $0.0297N$, $(2.08 \times 10^{-21})N$ e) $0.0595N$, $(4.15 \times 10^{-21})N$
18.89 42.6%
18.91 a) 4.5×10^{11} m b) 703 m/s, 6.4×10^8 s (about 20 y). no c) 1.4×10^{-14} Pa
d) about 650 m/s; evaporate
f) 2×10^5 K; no
18.93 d) $T_c = 8a/27Rb$, $(V/n)_c = 3b$
e) $p_c = a/27b^2$ f) 8/3 g) 3.28, 3.44, 4.35

Chapter 19

19.1 b) 1330 J
19.3 b) −6540 J
19.5 a) 0.88 atm
19.7 a) $(p_1 - p_2)(V_2 - V_1)$ b) negative of work done in reverse direction
19.9 a) 3.78×10^4 J b) 7.72×10^4 J c) no
19.11 a) 410 J b) rises
19.13 a) 16.4 min b) 139 m/s = 501 km/h
19.15 a) internal energy b) ab c) none
19.17 a) positive b) I: positive; II: negative
c) into d) I: into; II: out of
19.19 a) 1.67×10^5 J b) 2.03×10^6 J
19.21 b) 208 J c) on the piston d) 712 J
e) 920 J f) 208 J
19.23 a) 948 K b) 900 K
19.25 2/5
19.27 a) 25.0 C° b) 17.9 C° c) a
19.29 a) −605 J b) 0 c) yes, 605 J, liberates
19.31 a) 747 J b) 1.30
19.33 a) 4.76×10^5 Pa b) -1.06×10^4 J
c) 1.59; heated
19.35 5.1×10^3 J; increases; increases
19.37 b) 224 J c) $Q = 0$ d) −224 J
19.39 11.6°C
19.41 a) increases b) 4800 J
19.43 a) 45.0 J b) liberates 65.0 J
c) $Q_{ad} = 23.0$ J, $Q_{ab} = 22.0$ J
19.45 a) same b) absorbs 4000 J
c) absorbs 8000 J
19.47 b) −2460 J
19.49 a) 1173 K b) 1.22×10^4 J
c) 4.26×10^4 J d) 4.57×10^4 J
19.51 −0.226 m^3
19.53 a) 4.32×10^{-4} m^3 b) 648 J
c) 7.15×10^5 J d) 7.14×10^5 J
e) no substantial difference
19.55 3.4×10^5 J/kg
19.57 b) 11.9 C°
19.59 a) 0.173 m b) 206°C c) 7.46×10^4 J
19.61 a) $Q = 300$ J, $\Delta U = 0$ b) $Q = 0$, $\Delta U = -300$ J c) $Q = 750$ J, $\Delta U = 450$ J
19.63 a) $W = 738$ J, $Q = 2588$ J, $\Delta U = 1850$ J
b) $W = 0$, $Q = -1850$ J, $\Delta U = -1850$ J
c) 0
19.65 a) $W = -187$ J, $Q = -654$ J, $\Delta U = -467$ J
b) $W = 113$ J, $Q = 0$, $\Delta U = -113$ J
c) $W = 0$, $Q = 580$ J, $\Delta U = 580$ J
19.67 a) 360 K, 2.67×10^5 Pa b) 1.14 L

Chapter 20

20.1 a) 6500 J b) 34%
20.3 a) 23% b) 12,400 J c) 0.350 g
d) 222 kW = 298 hp
20.5 a) 25% b) 970 MW
20.7 13.8
20.9 a) 1.62×10^4 J b) 5.02×10^4 J
20.11 a) 767 W b) 7.27
20.13 a) 215 J b) 378 K c) 39.1%
20.15 a) 4.2×10^4 J b) 715 K
20.17 a) 492 J b) 212 W c) 5.4
20.19 a) 400 W b) 10.7 c) 36.9 kg
20.21 4500 J
20.23 37.1 hp
20.25 a) 428 J/K b) −392 J/K c) 36 J/K
20.27 a) irreversible b) $+1.25 \times 10^4$ J/K; it is consistent
20.29 6.31 J/K
20.31 a) 6.05×10^3 J/K b) five time greater for vaporization
20.33 gallium: +6.63 J/K; hand: −6.48 J/K; greater for gallium
20.35 a) no b) 18.3 J/K c) 18.3 J/K
20.37 a) 0.200 b) 8000 J
20.39 a) 27.8 K b) 15.3 K
20.41 b) absorbed: *bc;* rejected: *ab, ca*
c) $T_a = T_b = 241$ K, $T_c = 481$ K
d) $Q_{net} = W_{net} = 610$ J e) 8.7%
20.43 a) enters: 2.10×10^4 J; leaves: 1.66×10^4J
b) 4.4×10^3 J; 21% c) maximum is $e = 67\%$
20.45 a) 7.0% b) 3.0×10^6 J/s; 2.8×10^6 J/s
c) 6×10^5 kg/h = 6×10^5 L/h
20.47 a) $p_1 = 2.00$ atm, $V_1 = 4.00$ L; $p_2 = 2.00$ atm, $V_2 = 6.00$ L; $p_3 = 1.11$ atm, $V_3 = 6.00$ L; $p_4 = 1.67$ atm, $V_4 = 4.00$ L
b) (i) $Q = 1422$ J, $W = 405$ J
(ii) $Q = -1355$ J, $W = 0$
(iii) $Q = W = -274$ J (iv) $Q = 339$ J, $W = 0$ c) 131 J d) 7.5%; $e_{Carnot} = 44\%$
20.49 a) $a \to b$: $Q = 2.25 \times 10^5$ J, $W = 0.90 \times 10^5$ J, $\Delta U = 1.35 \times 10^5$ J; $b \to c$: $Q = -2.40 \times 10^5$ J, $W = 0$, $\Delta U = -2.40 \times 10^5$ J; $c \to a$: $Q = 0.45 \times 10^5$ J, $W = -0.60 \times 10^5$ J, $\Delta U = 1.05 \times 10^5$ J b)
$Q = W = 0.30 \times 10^5$ J, $\Delta U = 0$ c) 11.1%
20.51 $\left(\frac{T_H - T'}{T_H}\right)\left(\frac{T' - T_C}{T'}\right)$; less
20.53 a) 122 J, 78 J b) 5.10×10^{-4} m^3
c) $p_b = 2.32 \times 10^6$ Pa, $V_b = 4.81 \times 10^{-5}$ m^3, $T_b = 771$ K; $p_c = 4.00 \times 10^6$ Pa, $V_c = 4.81 \times 10^{-5}$ m^3, $T_c = 1333$ K; $p_d = 1.47 \times 10^5$ Pa, $V_d = 5.10 \times 10^{-4}$ m^3, $T_d = 518$ K d) $e = 61.1\%$; $e_{Carnot} = 77.5\%$
20.55 b) 6.20×10^4 J c) 3.42×10^4 J
d) before: 6.20×10^4J; after: 3.42×10^4 J
20.57 a) 88.5 J b) 17.7 J
20.59 a) $b \to c$: $nC_V \ln(T_c/T_b)$; $d \to a$: $nC_V \ln(T_a/T_d)$
b) $nC_V \ln\left(\frac{T_c T_a}{T_b T_d}\right)$
20.61 a) −143 J/K b) +196 J/K c) zero
d) +53 J/K

Chapter 21

21.1 a) 2.0×10^{10} b) 8.58×10^{-13}
21.3 2.10×10^{28} electrons, 3.35×10^9 C
21.5 3.71×10^3 m
21.7 a) 7.42×10^{-7} C on each sphere
b) 3.71×10^{-7} C on one and 1.48×10^{-6} C on the other
21.9 1.43×10^{13}, away from each other
21.11 a) 2.20 × 10^4 m/s
21.13 +0.750 nC
21.15 1.8×10^{-4} N, +x-direction
21.17 $x = -0.144$ m
21.19 2.58×10^{-6} N, −y-direction
21.21 b) $F_x = 0, F_y = +2kqQa/(a^2 + x^2)^{3/2}$
c) $2kqQ/a^2$, +y-direction
21.23 b) $kq^2(1 + 2\sqrt{2})/2L^2$
21.25 a) 4.40×10^{-16} N b) 2.63×10^{11} m/s^2
c) 2.63×10^5 m/s
21.27 a) 3.31×10^6 N/C, to the left
b) 1.42×10^{-8} s c) 1.80×10^3 N/C, to the right
21.29 a) $-21.9\mu C$ b) 1.02×10^{-7} N/C
21.31 a) 8.75×10^3 N/C,to the right
b) 6.54×10^3 N/C,to the right
c) 1.40×10^{-15} N,to the right
21.33 a) 364 N/C b) no, 2.73 μm downward
21.35 1.79×10^6 m/s
21.37 a) $mg = 8.93 \times 10^{-30}$ N; $F_e = 1.60 \times 10^{-15}$ N; yes
b) 1.63×10^{-16} kg = $1.79 \times 10^{14} m_e$ c) no
21.39 a) $-\hat{j}$ b) $(\hat{i} + \hat{j})/\sqrt{2}$ c) $-0.390\hat{i} + 0.921\hat{j}$
21.41 a) 6.33×10^5 m/s b) 1.59×10^4 m/s
21.43 a) 0 b) $E_x = -2kq(x^2 + a^2)/(x^2 - a^2)^2$, for $x < -a$; $E_x = +2kq(x^2 + a^2)/(x^2 - a^2)^2$, for $x > +a$
21.45 a) (i) 574 N/C, +x-direction
(ii) 268 N/C, −x-direction
(iii) 404 N/C, −x-direction
b) (i) 9.20×10^{-17} N, −x-direction
(ii) 4.30×10^{-17} N, +x-direction
(iii) 6.48×10^{-17} N, +x-direction
21.47 1.04×10^7 N/C, to the left
21.49 a) $E_x = E_y = E = 0$
b) $E_x = +2.66 \times 10^3$ N/C, $E_y = 0$;
$E = 2.66 \times 10^3$ N/C,+x-direction
c) $E_x = +129$ N/C, $E_y = -510$ N/C;
$E = 526$ N/C, 284° clockwise from +x-axis
d) $E_x = 0$, $E_y = E = +1.38 \times 10^3$ N/C, +y-direction
21.51 a) $E_x = -4.79 \times 10^3$ N/C, $E_y = 0$;
$E = 4.79 \times 10^3$ N/C, −x-direction
b) $E_x = +2.13 \times 10^3$ N/C, $E_y = 0$;
$E = 2.13 \times 10^3$ N/C,+x-direction
21.53 a) $\vec{E} = \frac{2k\lambda}{x\sqrt{x^2/a^2 + 1}}\hat{i}$ b) $\vec{E} = \frac{2k\lambda}{x}\hat{i}$
21.55 a) (7.0 N/C)$\hat{i}$ b) $(1.75 \times 10^{-5}\,\text{N})\hat{i}$
21.57 a) 0 b) 0 c) σ/ϵ_0 directed downward
21.59 a) yes b) no
21.61 An infinite line of charge has a radial field in the plane through the wire, and constant in the plane of the wire, mirror-imaged about the wire
21.63 a) 1.4×10^{-11} C · m from q_1 toward q_2
b) 860 N/C
21.65 b) This also gives the correct expression for E_y since y appears in the full expression's denominator squared, so the signs carry through correctly.
21.67 b) Opposite charges are closest so the dipoles attract.
21.69 a) The torque is zero when $\vec{p}$ is aligned either in the *same* direction as $\vec{E}$ or in the *opposite* directions
b) The stable orientation is when $\vec{p}$ is aligned in the *same* direction as $\vec{E}$
21.71 1680 N, from + 5.00 μC charge toward −5.00 μC charge
b) 22.3 N · m, clockwise
21.73 a) $\sqrt{\frac{kqQ}{m\pi^2 a^3}}$ b) accelerating along the y-axis away from origin
21.75 b) 2.80 × 10^{-6}C c) 39.5°
21.77 a) 2.09×10^{21} N b) 5.90×10^{23} m/s^2 c) no
21.79 a) $6kq^2/L^2$, away from vacant corner
b) $(3kq^2/2L^2)(1 + 2\sqrt{2})$, toward center of square
21.81 a) 6.0×10^{23}
b) $F_g = 4.1 \times 10^{-31}$ N, $F_e = 5.1 \times 10^5$ N
c) yes for F_e and no for F_g
21.83 a) $(2kq/x^2)[1 - (1 + a^2/x^2)^{-3/2}]$, −$x$-direction
b) $3kqa^2/x^4$
21.85 a) 3.5 × 10^{20} b) 1.6 C; 2.4×10^{10} N
21.87 a) $(mv_0^2 \sin^2\alpha)/2eE$ b) $(mv_0^2 \sin^2 2\alpha)/eE$
c) $h_{max} = 0.418$ m, $d = 2.89$ m
21.89 a) $E_x = \frac{kQ}{a}\left(\frac{1}{r} - \frac{1}{a + r}\right)$, $E_y = 0$
b) $\frac{kqQ}{a}\left(\frac{1}{x - a} - \frac{1}{x}\right)\hat{i}$
21.91 a) $-(7850\,\text{N/C})\hat{i}$ b) smaller c) 18 cm
21.93 a) + (0.89 N/C)$\hat{i}$ b) smaller c) (i) 1.2%
(ii) 4.5%
21.95 a) $F = \frac{2kqQ}{a}\left(\frac{1}{y} - \frac{1}{\sqrt{a^2 + y^2}}\right)$, −$x$-direction
b) $F = \frac{kqQ}{a}\left(\frac{1}{x - a} - \frac{1}{x + a} - \frac{2}{x}\right)$, +$x$-direction
21.97 $E_x = E_y = 2kQ/a^2$
21.99 a) 6.25×10^4 N/C, 225° measured counterclockwise from +x-axis
b) 1.00×10^{-14} N, 45° measured counterclockwise from +x-axis
21.101 a) 1.19×10^6 N/C, to the left
b) 1.19×10^5 N/C, to the left
c)1.19×10^5 N/C, to the right
21.103 $\vec{E} = \frac{\sigma}{2\epsilon_0}\left[-\frac{x}{|x|}\hat{i} + \frac{z}{|z|}\hat{k}\right]$
21.105 b) $q_1 < 0, q_2 > 0$ c) 0.844 μC d) 56.2 N
21.107 a) $\frac{kQ}{L}\left[\frac{1}{x + a/2} - \frac{1}{x + L + a/2}\right]$

Chapter 22

22.1 a) 1.75 N · m^2/C b) no c) i) 0 ii) 90°
22.3 a) 3.53×10^5 N · m^2/C b) 3.13×10^{-6} C
22.5 $\Phi = E\pi r^2$
22.7 a) 2.71×10^5 N · m^2/C
b) 2.71×10^5 N · m^2/C
c) 5.42×10^5 N · m^2/C
22.9 a) zero b) 3.75×10^7 N/C radially inward
c) 1.11×10^7 N/C radially inward
22.11 b) no
22.13 a) 1.81×10^5 N · m^2/C b) no change
22.15 a) 4.50×10^4 N/C b) 9.18×10^2 N/C
22.17 a) 3.00×10^{-7} C b) 1.20×10^5 N/C
22.19 a) $q = 3.27 \times 10^{-9}$ C b) $n_e = 2.04 \times 10^{10}$
22.21 8.06×10^5 N/C, toward negatively charged sphere
22.23 a) 5.73×10^{-6} C/m^2 b) 6.48×10^5 N/C
c) -5.65×10^4 N · m^2/C
22.25 a) 2.59×10^{-7} C/m^3 b) 1.96×10^3 N/C
22.27 a) $E = \sigma/\epsilon_0$ b) 0
22.29 a) $\lambda = 2\pi r\sigma$ b) $\sigma R/r\epsilon_0$
22.31 a) yes; + Q b) no c) yes d) no; no
e) no; yes; no
22.33 a) 750 N · m^2/C b) 0 c) 577 N/C
22.35 a) -5.98×10^{-10} C
22.37 a) $\lambda/2\pi\epsilon_0 r$, radially outward
b) $\lambda/2\pi\epsilon_0 r$, radially outward
d) inner: $-\lambda$; outer: $+\lambda$
22.39 a) i) $\alpha/2\pi\epsilon_0 r$, radially outward ii) 0 iii) 0
b) i) $-\alpha$ ii) 0
22.41 $\theta = 19.8°$
22.43 a) $0 < r < R$, $E = 0$
$R < r < 2R$, $E = Q/4\pi\epsilon_0 r^2$, radially outward;
$r > 2R$, $E = 2Q/4\pi\epsilon_0 r^2$, radially outward
22.45 a) i) 0 ii) 0 iii) $q/2\pi\epsilon_0 r^2$, radially outward
iv) 0 v) $3q/2\pi\epsilon_0 r^2$, radially outward b) i) 0
ii) $+2q$ iii) $-2q$ iv) $+6q$
22.47 a) i) 0 ii) 0 iii) $q/2\pi\epsilon_0 r^2$, radially outward
iv) 0 v) $q/2\pi\epsilon_0 r^2$, radially inward b) i) 0
ii) $+2q$ iii) $-2q$ iv) $-2q$
22.49 a) $Qq/4\pi\epsilon_0 r^2$, toward the center of the shell
b) 0
22.51 a) The given σ is on both sides, so E is twice as great b) $\Phi = (\sigma A)/\epsilon_0$, but $E_{out} = \sigma/\epsilon_0$, so $E_{in} = 0$
22.53 $d = R/2$
22.55 b) for $|x| \le d$: $\vec{E} = (\rho_0 x^3/3\epsilon_0 d^2)\hat{i}$;
for $|x| \ge d$: $\vec{E} = (\rho_0 d/3\epsilon_0)(x/|x|)\hat{i}$
22.57 c) $E(r) = \frac{Q}{\pi\epsilon_0 R^2}\left(\frac{r}{R} - \frac{3r^2}{4R^2}\right)$
e) $E_{max} = Q/3\pi\epsilon_0 R^2$ *at* $r = 2R/3$
22.59 a) $\Phi = 4\pi Gm$ b) $\Phi = -4\pi G M_{encl}$
22.61 $\rho\vec{b}/3\epsilon_0$
22.63 a) $-(Q/16\pi\epsilon_0 R^2)\hat{i}$ b) $(Q/72\pi\epsilon_0 R^2)\hat{i}$
22.65 a) $Q(r) = Qe^{-2r/a_0}[2(r/a_0)^2 + 2(r/a_0) + 1]$
b) $E = \frac{kQe^{-2r/a_0}}{r^2}[2(r/a_0)^2 + 2(r/a_0) + 1]$
22.67 c) 0.807

Chapter 23

23.3 3.46×10^{-13} J
23.5 a) 12.5 m/s b) 0.323 m
23.7 a) 0.198 J b) i) 26.6 m/s ii) 36.7 m/s
iii) 37.6 m/s
23.9 a) -3.60×10^{-7} J b) $x = 0.0743$ m
23.11 $-q/2$
23.13 B: larger C: smaller D: same
23.15 7.42 m/s; faster
23.17 a) 0 b) +7.50 × 10^{-4} J
c) -2.06×10^{-3} J
23.19 a) 2.50 mm b) 7.49 mm
23.21 a) −737 V b) −704 V c) $+8.2 \times 10^{-8}$ J
23.23 b) 0 d) 0
23.25 b) $V = \frac{q}{4\pi\epsilon_0}\left(\frac{1}{|x|} - \frac{2}{|x - a|}\right)$
23.27 1.02×10^7m/s
23.29 a) b b) 800 V/m c) -4.8×10^{-5} J
23.31 a) increase of 156 V b) decrease of 182 V
23.33 a) oscillatory b) 1.67×10^7 m/s
23.35 a) $\lambda = 9.51$ C/m b) no. less.
V decreases in direction of $\vec{E}$.
$\lambda > 0$: V inversely proportional to r c) 0
23.37 a) 7.81×10^4 V b) 0
23.41 a) 8.00 kV/m b) 1.92×10^{-7} N
c) 8.64×10^{-7} J d) -8.64×10^{-7} J
23.43 b) −20 nC c) no
23.47 a) $E_x = -Ay + 2Bx$, $E_y = -Ax - C$, $E_z = 0$
b) $x = -C/A$, $y = -2BC/A^2$, any value of z
23.49 a) i) for $r < r_a$, $V = \frac{q}{4\pi\epsilon_0}\left(\frac{1}{r_a} - \frac{1}{r_b}\right)$
ii) for $r_a < r < r_b$, $V = \frac{q}{4\pi\epsilon_0}\left(\frac{1}{r} - \frac{1}{r_b}\right)$
iii) for $r > r_b$, $V = 0$
b) $V_{ab} = \frac{q}{4\pi\epsilon_0}\left(\frac{1}{r_a} - \frac{1}{r_b}\right)$
c) for $r_a < r < r_b$, $E = \frac{V_{ab}}{\left(\frac{1}{r_a} - \frac{1}{r_b}\right) r^2}$
d) $E = 0$
23.51 a) concentric cylinders
b) 10 V: 2.90×10^{-2} m; 20 V: 4.20×10^{-2} m
23.53 a) -2.15×10^{-5} J b) $W_E = +2829$ V
c) $E = 3.54 \times 10^4$ V/m
23.55 a) 7.85×10^4 V/m$^{4/3}$
b) $\vec{E} = (-1.0 \times 10^5\,\text{V/m}^{4/3})x^{1/3}\hat{i}$
c) $\vec{F} = (3.13 \times 10^{-15}\,\text{N})\hat{i}$
23.57 a) $-1.46q^2/\pi\epsilon_0 d$
23.59 a) -8.62×10^{-18} J b) 2.87×10^{-11} m
23.61 a) i) $V = (\lambda/2\pi\epsilon_0)\ln(b/a)$
ii) $V = (\lambda/2\pi\epsilon_0)\ln(b/r)$ iii) $V = 0$
d) $(\lambda/2\pi\epsilon_0)\ln(b/a)$
23.63 a) 1.76×10^{-16} N, downward
b) 1.93×10^{14} m/s, downward c) 8.24 mm
d) 15.4° e) 4.12 cm
23.65 a) 9.71×10^4 V/m b) 3.03×10^{-11} C
23.67 a) $r \le R$: $V = \left(\frac{\lambda}{4\pi\epsilon_0}\right)[1 - (r/R)^2]$;
$r \ge R$: $V = -\left(\frac{\lambda}{2\pi\epsilon_0}\right)\ln(r/R)$
23.69 $Q/4\pi\epsilon_0\sqrt{x^2 + a^2}$
23.71 $Q^2/8\pi\epsilon_0 R$
23.73 a) $Q/8\pi\epsilon_0 R$ b) i) center c) ii) surface
23.75 b) yes c) no
23.77 $Q/8\pi\epsilon_0 R$
23.79 a) $(Q/4\pi\epsilon_0 a)\ln[1 + (a/x)]$
b) $(Q/4\pi\epsilon_0 a)\ln\left[(a/y) + \sqrt{1 + (a/y)^2}\right]$
c) in (a), $(Q/4\pi\epsilon_0 x)$ in (b), $(Q/4\pi\epsilon_0 y)$
23.81 a) 1/3 b) 3
23.83 a) $E = Q_1/4\pi\epsilon_0 R_1^2$; $V = Q_1/4\pi\epsilon_0 R_1$
b) sphere 1: $Q_1 R_1/(R_1 + R_2)$;
sphere 2: $Q_1 R_2/(R_1 + R_2)$
c) $V = Q_1/4\pi\epsilon_0(R_1 + R_2)$ for either sphere
d) sphere 1: $E = Q_1/4\pi\epsilon_0 R_1(R_1 + R_2)$;
sphere 2: $E = Q_1/4\pi\epsilon_0 R_2(R_1 + R_2)$
23.85 a) 7.6×10^6 m/s b) 7.3×10^6 m/s
c) 2.3×10^9 K; 6.9×10^9 K
23.87 a) 5.9×10^{-15} m b) 4.14×10^{-11} J
c) 2.55×10^{25} nuclei
23.89 a) 1.01×10^{-12} m, 1.11×10^{-13} m, 2.54×10^{-14} m
23.91 c) 3 electrons, 0.507 μm

Chapter 24

24.1 1.82×10^{-4} C
24.3 a) 604 V b) 9.1×10^{-3} m^2
c) 1.84×10^6 V/m d) 1.63×10^{-5} C/m^2
24.5 a) 120 μC b) $C = \epsilon_0 A/d$ c) 480 μC
24.7 2.8 mm
24.9 a) 4.35×10^{-12} F b) 2.30 V

24.11 a) $6.56 \times 10^{-11}\ \text{F/m}$ b) $6.43 \times 10^{-11}\ \text{C}$
24.13 a) $1.50 \times 10^{-11}\ \text{F}$ b) 3.08 cm c) $3.13 \times 10^{4}\ \text{N/C}$
24.15 a) $C_{eq} = 2.40\ \mu\text{F}$; $Q_{total} = 6.72 \times 10^{-5}\ \text{C}$; $Q_{12} = 2.24 \times 10^{-5}\text{C}$; $Q_3 = 4.48 \times 10^{-5}\ \text{C}$; $Q_1 = Q_2 = Q_{12} = 2.24 \times 10^{-5}\ \text{C}$
24.17 a) $Q_1 = 1.56 \times 10^{-5}\ \text{C}$; $Q_1 = 2.6 \times 10^{-4}\ \text{C}$ b) 52.0 V
24.19 $V_2 = 50\ \text{V}$; $V_3 = 70\ \text{V}$
24.21 $C_{eq} = \dfrac{\epsilon_0 A}{d_1 + d_2}$
24.23 57 μF
24.25 $0.0283\ \text{J/m}^3$
24.27 19.6 J
24.29 a) $Q^2x/2\epsilon_0 A$ b) $(Q^2/2\epsilon_0 A)dx$ c) $Q^2/2\epsilon_0 A$
24.31 b) yes c) flat sheets parallel to the plates
24.33 a) 24.2 μC b) $V = 220\ \text{V}$: $Q_{35} = 7.7\ \mu\text{C}$, $Q_{75} = 16.5\ \mu\text{C}$ c) 2.66 mJ d) 35 nF: 0.85 mJ; 75 nF: 1.81 mJ e) 220V for each capacitor
24.35 a) 1.60 nC b) 8.0
24.37 a) $U_{\text{parallel}} = 4U_{\text{series}}$ b) $Q_{\text{parallel}} = 2Q_{\text{series}}$ c) $E_{\text{parallel}} = 2E_{\text{series}}$
24.39 a) $6.20 \times 10^{-7}\ \text{C/m}^2$ b) 1.28
24.41 $0.0135\ \text{m}^2$
24.43 a) $2.3 \times 10^{-11}\ \text{C}^2/\text{N}\cdot\text{m}^2$ b) 40 kV c) $\sigma = 4.6 \times 10^{-4}\ \text{C/m}^2$, $\sigma_i = 2.8 \times 10^{-4}\ \text{C/m}^2$
24.45 a) 10.1 V b) 2.25
24.47 a) 3.6 mJ; 13.5 mJ b) increased by 9.9 mJ
24.49 a) $Q/k\epsilon_0 A$ b) $Qd/k\epsilon_0 A$ c) $k\epsilon_0 A/d$
24.51 a) $2.4 \times 10^{-11}\ \text{F}$ b) $2.9 \times 10^{-10}\ \text{C}$ c) 1.3×10^{3} d) $1.7 \times 10^{-9}\ \text{J}$
24.53 a) 421 J b) $5.39 \times 10^{-9}\ \text{F}$
24.55 for $d \ll r_a$: $C \approx \dfrac{\epsilon_0 A}{d}$
24.57 a) $U_{\text{tot}} = 158\ \mu\text{J}$ b) $U_{4.5} = 72.1\ \mu\text{J}$
24.59 a) 2.5 μF b) $Q_1 = 5.5 \times 10^{-4}\ \text{C}$, $V_1 = 66\ \text{V}$; $Q_2 = 3.7 \times 10^{-4}\ \text{C}$, $V_2 = 88\ \text{V}$; $Q_3 = 1.8 \times 10^{-4}\ \text{C}$, $V_3 = 44\ \text{V}$; $Q_4 = 1.8 \times 10^{-4}\ \text{C}$, $V_4 = 44\ \text{V}$; $Q_5 = 5.5 \times 10^{-4}\ \text{C}$, $V_5 = 66\ \text{V}$
24.61 a) 76 μC b) 1.4×10^{-3} J c) 11 V d) 1.2×10^{-3} J
24.63 a) 2.3 μF b) $C_1 = 9.7 \times 10^{-4}\ \text{C}$; $C_2 = 6.4 \times 10^{-4}\ \text{C}$ c) 47 V
24.65 a) 3.91 b) 22.8 V
24.67 c) 710 μF
24.69 a) $6.5 \times 10^{-2}\ \text{F}$ b) $Q = 2.3 \times 10^{4}\ \text{C}$ c) 4.0×10^{9} J
24.71 $C_{\text{eq}} = \dfrac{2\epsilon_0 A}{d}\left(\dfrac{K_1 K_2}{K_1 + K_2}\right)$
24.73 b) 14 μF c) 72.0 μF: 505 μC, 7.02 V; 28.0 μF: 259 μC, 9.24 V; 18.0 μF: 229 μC, 12.7 V; 27.0 μF: 276 μC, 10.2 V; 6.0 μF: 14.9 μC, 2.49 V
24.75 a) $(\epsilon_0 L/D)[L + (K-1)x]$
24.77 b) $2.38 \times 10^{-9}\ \text{F}$

Chapter 25

25.1 $3.89 \times 10^{4}\ \text{C}$
25.3 a) 3.13×10^{19} b) $J = 1.51 \times 10^{6}\ \text{A/m}^2$ c) $v_d = 1.11 \times 10^{-4}\text{m/s}$ d) J would decrease; v_d would decrease
25.5 a) 110 min b) 442 min c) $v_d \propto 1/d$
25.7 a) 329 C b) 41.1 A c) 1333 min
25.9 $5.86 \times 10^{28}\ \text{e}^-/m^3$
25.11 a) $1.216\Omega\cdot\text{m}$ @ 20 °C
25.13 a) tungsten $E = 5.16 \times 10^{-3}\ \text{V/m}$ b) aluminum $E = 2.70 \times 10^{-3}\ \text{V/m}$
25.15 a) $E_{\max} = 1.21\ \text{V/m}$ b) $R = 1.45 \times 10^{-2}\ \Omega$ c) $V_{\max} = 1.82 \times 10^{-1}\ \text{V} = 0.182\ V$
25.17 0.125 Ω
25.19 15 g
25.21 $1.53 \times 10^{-8}\ \Omega$
25.23 a) $1.53 \times 10^{-8}\ \Omega$ b) $R = 2.4\ \Omega$
25.25 a) 11.1 A b) 3.13 V c) 0.28 Ω
25.27 a) 99.54 Ω b) 0.0158 Ω
25.29 a) $4.67 \times 10^{-8}\ \Omega$ b) $6.74 \times 10^{-4}\ \Omega$
25.31 a) 0.219 Ω b) $P = 3422\ \text{J/s}$, $E = 1.23 \times 10^{7}$ J
25.33 a) $\mathcal{E} = 9.0\ \text{V}$ b) $r = 4.5\ \Omega$
25.35 a) $I = 0$ b) $\mathcal{E} = 5.0\ V$ c) 5.0 V
25.37 a) $\mathcal{E} = 3.08\ \text{V}$ b) $r = 0.067\ \Omega$ c) 1.8 Ω
25.39 a) 1.41 A b) −13.7 V c) −1.0 V
25.41 b) yes; linear
25.43 a) 144 Ω b) $2.40 \times 10^{2}\ \Omega$ c) 100 W bulb, $I = 0.833$ A d) 120 W bulb, $I = 0.500$ A
25.45 a) 29.8 W b) 0.248 A
25.47 a) $P = JE$ b) $p = J^2\rho$ c) $p = E^2/\rho$
25.49 a) 2.59×10^{6} J b) 0.062 L c) 1.6 h
25.51 12.3%
25.53 a) 24 W b) 4.0 W c) 20 W
25.55 a) 26.7 Ω b) 4.5 A c) 454 W
25.57 a) $3.65 \times 10^{-8}\ \Omega\cdot\text{m}$ b) 172 A c) $2.58 \times 10^{-3}\ \text{m/s}$
25.59 0.060 Ω
25.61 a) 2.5 mA b) $2.14 \times 10^{-5}\ \text{V/m}$ c) $8.55 \times 10^{-5}\ \text{V/m}$ d) 1.80×10^{-4} V
25.63 a) $R = \dfrac{\rho h}{\pi r_1 r_2}$ b) $R = \dfrac{\rho L}{A}$
25.65 $I = \dfrac{Q}{\kappa\epsilon_0\rho}$
25.67 a) 0.057 Ω b) $3.34 \times 10^{-8}\Omega\cdot\text{m}$ c) 0.86 mm d) 2.40 $\times 10^{-3}\ \Omega$ e) $1.1 \times 10^{-3}\ (^\circ\text{C})^{-1}$
25.69 a) 0.2 Ω b) 8.7 V
25.71 a) 1000 Ω b) 100 V c) 10 W
25.73 1.42 A
25.75 a) $I_A\left(1 + \dfrac{R_A}{r + R}\right)$ b) 0.0425 Ω
25.77 b) 8-gauge c) 106 W d) 66 W, 175 kWh, $19.25
25.79 a) 0.40 A b) 1.6 W c) 4.8 W d) 3.2 W
25.81 a) $\dfrac{a}{E}$ b) 2.59×10^{6} J c) 4.32×10^{5} J d) 0.96 Ω e) 1.73×10^{6} J
25.83 a) $I = \dfrac{v_0 A}{\rho_0 L(1 - e^{-1})}$
b) $E(x) = \dfrac{v_0 e^{-x/L}}{L(1 - e^{-1})}$
c) $V(x) = V_0\dfrac{(e^{-x/L} - e^{-1})}{(1 - e^{-1})}$

Chapter 26

26.1 $\dfrac{3R}{4}$
26.3 a) $R_q < R_1$ b) $R_{eq} < R_1$
26.5 a) $I = 3.50$ A b) $I = 4.50$ A c) $I = 3.15$ A d) $I = 3.25$ A
26.7 0.769 A
26.9 a) 8.8 Ω b) 3.18 A c) 3.18 A d) $V_{2.4} = 7.64\ \text{V}$; $V_{1.6} = 5.09\ \text{V}$; $V_{4.8} = 15.3\ \text{V}$
26.11 $R_{eq} = 5.00\ \Omega$; $I_{\text{total}} = 12.0$ A; $I_{12} = 3.00$ A; $I_4 = 9.00$ A; $I_3 = 8.00$ A; $I_6 = 4.00$ A
26.13 a) $I_1 = 1.50$ A, $I_2 = I_3 = I_4 = 0.50$ A b) $P_1 = 10.1\ \text{W}$, $P_2 = P_3 = P_4 = 1.12\ \text{W}$; c) $I_1 = 1.33$ A, $I_2 = I_3 = 0.667$ A d) $P_1 = 8.00\ \text{W}$, $P_2 = P_3 = 2.00\ \text{W}$ e) $R_2 + R_3$ is brighter; R_1 is dimmer
26.15 a) 18.0 V; 3.00 A
26.17 a) 0.100 A for each b) 400-Ω bulb: 4.00 W; 800-Ω bulb: 8.00 W c) 400-Ω bulb: 0.300 A; 800-Ω bulb: 0.150 A d) 400-Ω bulb: 36.0 W; 800-Ω bulb: 18.0 W; total: 54.0 W e) in series, 800-Ω bulb is brighter; in parallel, 400-Ω bulb is brighter and total light output is greater
26.19 1010 s
26.21 a) 2.00 A b) 5.00 Ω c) 42.0 V d) 3.50 A
26.23 a) 8.00 A b) $\mathcal{E}_1 = 36.0\ \text{V}$, $\mathcal{E}_2 = 54.0\ \text{V}$ c) 9.00 Ω
26.25 a) 1.60 A, 1.40 A, 0.20 A b) 10.4 V
26.27 a) $\mathcal{E} = 36.40\ \text{V}$ b) 0.500 A
26.29 a) $-2.14\ \text{V}$, a is at a higher potential b) $I_{100} = 0.250$ A; $I_{75} = 0.200$ A; $I_A = 0.500$ A downward; V = 0
26.31 a) 0.641 Ω b) 975 Ω
26.33 a) 17.8 V b) 22.7 V c) 27.5%
26.35 c) 3.34 V
26.37 a) 543 Ω b) 1.88 mA c) 203 Ω
26.39 a) $C = 8.49 \times 10^{-3}\ \text{F}$ b) $\tau = 2.89$ s
26.41 a) $t = 4.21 \times 10^{-3}$ s b) $I = 0.125$ A
26.43 190 μC
26.45 $I = 13.6$ A
26.47 a) 0.938 A b) 0.606 A
26.49 a) 1.33×10^{-4} C b) $v_R = 9.12\ \text{V}$, $v_C = 8.88\ \text{V}$ c) $v_R = v_C = 8.88\ \text{V}$ d) 6.75×10^{-5} C
26.51 900 W
26.53 a) 6.0 A, 720 W b) 3.5 A, 420 W
26.55 a) $13.6\ \mu\Omega = 1.36 \times 10^{-5}\ \Omega$ b) $2.14 \times 10^{-8}\ \Omega$
26.57 a) 9.9 W b) 16.3 W, brighter
26.59 a) 18.7 Ω b) 7.5 Ω
26.61 $I_1 = 0.848$ A, $I_2 = 2.14$ A, $I_3 = 0.171$ A
26.63 2.00-Ω resistor: 5.21 A; 4-Ω resistor: 1.11 A; 5-Ω resistor: 6.32 A
26.65 a) 0.222 V b) 0.464 A
26.67 12.7 V
26.69 a) 186 V, upper terminal + b) 3.00 A from − to + terminal c) 20.0 Ω
26.71 a) $P_1 + P_2$ b) $\dfrac{P_1 P_2}{(P_1 + P_2)}$
26.73 a) −12.0 V b) 1.71 V c) 4.20 V
26.75 $R_3 = 10.8\ \Omega$, $R_2 = 1.08\ \Omega$, $R_1 = 0.12\ \Omega$
26.77 a) 114.4 V b) 263 V c) 266 V
26.79 b) 1897 Ω
26.81 a) 224-Ω resistor: 24.8 V; 589-Ω: 65.2 V b) 3.87 kΩ c) 62.6 V d) no

Chapter 27

27.1 a) $(-6.68 \times 10^{-4}\ \text{N})\hat{k}$ b) $(+6.68 \times 10^{-4}\ \text{N})\hat{i} + (7.27 \times 10^{-4}\ \text{N})\hat{j}$
27.3 a) positive b) 5.05×10^{-2}N
27.5 $9.47 \times 10^{6}\ \text{m/s}$
27.7 a) $\vec{B}_x = -0.175\ \text{T}$, $\vec{B}_z = -0.256\ \text{T}$ b) yes, $\vec{B}_y$ d) zero, 90°
27.9 a) $\vec{B} = 1.46$ T at 40.0° from the $+x$-axis, toward the z-axis in the xz plane b) $\vec{F} = 7.48 \times 10^{-16}$ N, at 50° from the $+x$-axis toward the $+z$-axis
27.11 a) 3.05×10^{-3} Wb b) 1.83×10^{-3} Wb c) 0
27.13 -7.79×10^{-4} Wb
27.15 a) 1.60×10^{-4} T, into the page b) 1.11×10^{-7} s
27.17 7.93×10^{-10} N, south
27.19 a) $1.2 \times 10^{7}\ \text{m/s}$ b) 0.10 T
27.21 a) $8.35 \times 10^{5}\ \text{m/s}$ b) 2.62×10^{-8} s c) 7.26 kV
27.23 a) 107 T b) no
27.25 a) 8.38×10^{-4} T
27.27 a) no b) 1.40 cm
27.29 $B = 4.45 \times 10^{-2}$ T
27.31 1.29×10^{-25} kg, 78
27.33 a) 1.34×10^{4} A b) horizontal
27.35 $F = 0.724$ N, at 63.4° below the $+x$-axis
27.37 9.7 A
27.39 a) 817 V b) $113\ \text{m/s}^2$
27.41 a) $-(ILB)\hat{j}$ b) yes
27.43 a) 1.5×10^{-16} s b) 1.1 mA c) $9.3 \times 10^{-24}\text{A}\cdot\text{m}^2$
27.45 a) rotates about axis A_z b) $\alpha = 294\ \text{rad/s}^2$
27.47 −2.42 J
27.49 a) 1.13 A b) 3.69 A c) 98.2 V d) 362 W
27.51 a) 4.7 mm/s b) $4.5 \times 10^{-3}\ \text{V/m}$ in the $+z$-direction c) 53 μV
27.53 a) F_2/qv_1 in the $-y$-direction b) $F_2/\sqrt{2}$
27.55 $\vec{B} = 3.68$ T at a right angle to v_i
27.57 a) $8.9 \times 10^{-17}\ \text{J} = 5.5 \times 10^{5}\ \text{eV}$ b) 7.7×10^{-8} s c) 1.2 T d) same as in (a)
27.59 4.46 A
27.61 a) -1.98×10^{-6} C b) $(9.69 \times 10^{14}\ \text{m/s})(4\hat{i} + 3\hat{j})$ c) $R = 5.69$ cm d) 1.47×10^{7} Hz e) $(R, 0, 1.72\ \text{m})$
27.63 9τ
27.65 1.6 mm
27.67 $(Mg\tan\theta/LB)$, right to left
27.71 a) 8.46×10^{-3} T b) 0.271 m c) 2.14×10^{-2} m
27.73 1.80 N to the left
27.75 0.0242 T, in the $+y$-direction
27.77 a) 0.0442 N · m clockwise b) stretched c) 7.98×10^{-3} J
27.79 0.444 N, in the $-y$-direction
27.81 b) side (0, 0) to (0, L): $(B_0 IL/2)\hat{i}$; side (0, L) to (L, L): $(-B_0 IL)\hat{j}$; side (L, L) to (L, 0): $(-B_0 IL/2)\hat{i}$; side (L, 0) to (0, 0): 0 c) $(-B_0 IL)\hat{j}$
27.83 2.52 m/s b) 7.60 A c) 0.197 Ω
27.85 a) $\vec{\mu} = -IA\hat{k}$ b) $B_x = 3D/IA$, $B_y = 4D/IA$, $B_z = -12D/IA$
27.87 $-\beta r/2$
27.89 a) 5.14 m b) 1.72×10^{-6} s c) 6.09 mm d) 3.04 cm

Chapter 28

28.1 $(-1.92 \times 10^{-5}\ \text{T})\hat{k}$ b) 0
28.3 a) $\vec{B} = 6.00 \times 10^{-10}$ T out of the paper b) $\vec{B} = 1.20 \times 10^{-9}$ T out of the paper c) 0
28.5 a) 0 b) $(-1.31 \times 10^{-6}\ \text{T})\hat{k}$ out of the paper c) $(-4.62 \times 10^{-7}\ \text{T})\hat{k}$ d) $(1.31 \times 10^{-6}\ \text{T})\hat{j}$
28.7 a) attractive b) 1.00×10^{-6}
28.9 a) 4.00×10^{-7} T out of the paper b) 1.52×10^{-8} T out of the paper c) 0
28.11 a) $(5.00 \times 10^{-11}\ \text{T})\hat{j}$ b) $(-5.00 \times 10^{-11}\ \text{T})\hat{i}$ c) $(-1.77 \times 10^{-11}\ \text{T})\hat{k}$ d) 0
28.13 1.76×10^{-5} T into the paper
28.15 a) 8.0×10^{-4} T b) 4.00×10^{-5} T, 20 times larger
28.17 a) 10.0 A b) above the wire c) directly east of the wire.
28.19 a) $(-1.0 \times 10^{-7}\ \text{T})\hat{i}$ b) $(2.19 \times 10^{-6}\ \text{T})$, $\theta = 46.8°$ from x toward z c) $(7.9 \times 10^{-6}\ \text{T})\hat{i}$
28.21 a) 0 b) 6.67×10^{-6} T c) 7.53×10^{-6} T to the left
28.23 a) 0 b) 0 c) 4.0×10^{-4} T to the left
28.25 a) 6.00×10^{-6} N, repulsive b) 2.40×10^{-5} N
28.27 $4.6 \times 10^{-5}\ \text{N/m}$, repulsive but negligible
28.29 $\mu_0 I^2/2\pi\lambda g$
28.31 $m_0|I_1 - I_2|/4R$,0
28.33 a) 9.42×10^{-3} T b) 1.34×10^{-4} T
28.35 a) 305 A b) $-3.83 \times 10^{-4}\ \text{T}\cdot\text{m}$
28.37 a) $\dfrac{\mu_0 I}{2\pi r}$ b) 0
28.39 $B = \dfrac{\mu_0 I}{2\pi r}$; $r = R/2$; $r = 2R$
28.41 a) 1790 turns/m b) 63.0 m
28.43 a) 3.72×10^{6} A b) 2.49×10^{5} A c) 237 A
28.45 1.11×10^{-3} T
28.47 a) 0.0725 A b) 0.0195 A
28.49 a) i) 1.1×10^{-3} T ii) $4.7 \times 10^{-6}\ \text{A/m}$ iii) 5.9 T
28.51 a) 1.00×10^{-6} T into the paper b) $(7.49 \times 10^{-8}\ \text{N})\hat{j}$
28.53 a) $1.1 \times 10^{13}\ \text{m/s}^2$, away from the wire b) 62.5 N/C, away from the wire c) $mg \approx 10^{-29}$ N, negligible
28.55 5.75×10^{-6} T; 2.21×10^{-21} N perpendicular to line ab and to velocity
28.57 a) $\pm 607\ \text{m/s}$ b) 9.2×10^{-6} T
28.59 a) 2.00 A out of the paper b) 2.13 $\times 10^{-6}$ T, to the right c) 2.06×10^{-6} T
28.61 a) $1.11 \times 10^{-5}\ \text{N/m}$ b) out of page: $1.11 \times 10^{-5}\ \text{N/m}$ upward
28.63 23.2 A
28.65 a) $\mu_0\pi NN'II'a^2a'^2(\sin\theta)/2x^3$ b) $-\mu_0\pi NN'II'a^2a'^2(\cos\theta)/2x^3$
28.67 a) $(\mu_0 NIa^2/2)[((x + a/2)^2 + a^2)^{-3/2} + ((x - a/2)^2 + a^2)^{-3/2}]$ c) $(\mu_0 NI/a)(4/5)^{3/2}$

28.69 $\mu_0 I/8R$, out of the paper
28.71 a) $3I/2\pi R^3$ b) i) $\mu_0 Ir^2/2\pi R^3$ ii) $\mu_0 I/2\pi r$
28.73 zero
28.75 $16a/3$
28.77 b) $\mu_0 I_0/2\pi r$ c) $(I_0 r^2/a^2)(2 - r^2/a^2)$ d) $(\mu_0 I_0 r/2\pi a^2)(2 - r^2/a^2)$
28.79 $\mu_0 I$
28.81 a) $\mu_0 nI/2$, in the $+x$-direction b) $\mu_0 nI/2$, in the $-x$-direction
28.83 $7.73 \times 10^{-23}\ \text{J/T} = 0.0833\ \mu_B$
28.85 c) 6.15 mm
28.87 $\mu_0 Qn/a$

Chapter 29

29.1 a) 4.50 Wb b) 20.3 V
29.3 a) $Q = NBA/R$ b) no
29.5 a) +34 V b) counterclockwise
29.7 a) $I = i{:}B = \dfrac{\mu_0 i}{2\pi r}$ into the page
b) $d\Phi_B = \dfrac{\mu_0 i}{2\pi r}L\,dr$ c) $\Phi_B = \dfrac{\mu_0 iL}{2\pi}\ln(b/a)$
d) $\mathcal{E} = \dfrac{\mu_0 L}{2\pi}\ln(b/a)\dfrac{di}{dt}$
29.9 a) 5.44 mV b) clockwise
29.11 a) $\mathcal{E} = +Abv$ b) clockwise c) $\mathcal{E} = -Abv$ d) counterclockwise
29.13 10.4 rad/s
29.15 a) counterclockwise b) clockwise c) $I = 0$
29.17 a) a to b b) b to a c) b to a
29.19 a) clockwise b) 0 c) counterclockwise
29.21 a) $V_{ab} = 0.675$ V b) b at higher potential than a c) $E = 2.25\ \text{V/m}$ from b to a d) b has excess of positive charge e) i) 0 ii) 0
29.23 46.2 m/s; no
29.25 a) 3.00 V b) clockwise c) 0.800 N to the right d) 6.00 W = $P_{\text{mech}} = P_{\text{elec}}$
29.27 a) 4.23 V b) 4.23 V c) 0 d) for width $w \ll L$, it does not matter. $\mathcal{E} = 4.23$ V as long as the longitudinal axis of the rod is in the x-y plane.
29.29 a) $\pi r_1^2\dfrac{dB}{dt}$ b) $\dfrac{r_1}{2}\dfrac{dB}{dt}$ c) $\dfrac{R^2}{2r_2}\dfrac{dB}{dt}$ e) $\dfrac{\pi R^2}{4}\dfrac{dB}{dt}$ f) $\pi R^2\dfrac{dB}{dt}$ g) $\pi R^2\dfrac{dB}{dt}$
29.31 9.21 A/s
29.33 9.50×10^{-4} V
29.35 $K = 2.34$
29.37 a) 5.99×10^{-10} C b) 6.00×10^{-3} A c) 6.00×10^{-3} A
29.39 a) 0.15 V/m b) 38 V/m · s c) $3.4 \times 10^{-10}\text{A/m}^2$ d) $B_D = 2.38 \times 10^{-21}$ T, negligible; $B_C = 5.33 \times 10^{-5}$ T
29.41 For any continuous superconducting path, $R_{\text{total}} = 0$
29.43 a) $-(4.38 \times 10^{4}\ \text{A/m})\hat{i}$ b) $(15.0\ \text{T})\hat{i}$
29.45 a) 3.7 A b) 54 μA c) counterclockwise
29.47 a) $\dfrac{\mu_0 i\pi a}{2C}$ c) $i = i_0\exp(-2Rt/\mu_0\pi a)$ d) 45 μs
29.49 a) $\mu_0 Iabv/2\pi r(a + r)$ b) clockwise
29.51 191 rpm
29.53 a) 0.126 V b) a to b
29.55 b) FR/B^2L^2
29.57 1.2 V
29.59 $\dfrac{\mu_0 IW}{4\pi}$
29.61 a) $(\mu_0 IV/2\pi)\ln((L + d)/d)$ b) a c) 0
29.63 a) 0.165 V b) 0.165 V c) 0; 0.0142 V
29.65 a) B^2a^2V/R
29.67 a) $(qr/2)\dfrac{dB}{dt}$, to the left b) $(qr/2)\dfrac{dB}{dt}$, upward c) 0
29.73 a) $1.96 \times 10^{-4}\text{A/m}^2$ b) $3.00 \times 10^{-9}\text{A/m}^2$ c) 7.82×10^{6} Hz
29.75 b) $\dfrac{a}{2}\dfrac{dB}{dt}$ c) 7.37×10^{-4} A d) 1.75×10^{-4} V
29.77 a) a to b b) $v_t = \dfrac{Rmg\tan\theta}{L^2B^2\cos\theta}$ c) $\dfrac{mg\tan\theta}{LB}$ d) $\dfrac{Rm^2g^2(\tan\theta)^2}{L^2B^2}$ e) same as (d)

Chapter 30

30.1 a) 0.270 V, yes b) 0.270 V
30.5 a) 1.96 H b) 7.12×10^{-3} Wb
30.7 a) 0.250 H b) 4.5×10^{-4} Wb
30.9 a) 4.68 mV b) a
30.11 $\dfrac{\mu_0 N^2 A}{l}$
30.13 2850
30.15 a) 1.61×10^{-1} T b) $1.03 \times 10^{4}\ \text{J/m}^3$ c) 0.129 J d) 4.03×10^{-5} H
30.19 a) 2.40 A/s b) 0.800 A/s c) 0.413 A d) 0.750 A
30.21 a) 17.3μs b) 30.7μs
30.25 a) 0.250 A b) 0.137 A c) 32.9 V, c d) 4.62×10^{-4} s
30.27 a) $(4.50\ \text{W})[1 - \exp(-(3.20\ \text{s}^{-1})t)]$ b) $(4.50\ \text{W})[1 - \exp(-(3.20\ \text{s}^{-1})t)]^2$ c) $(4.50\ \text{W})[\exp(-(3.20\ \text{s}^{-1})t) - \exp(-(6.40\ \text{s}^{-1})t)]$
30.29 a) 25.0 mH b) 9.00×10^{-8} C c) 5.40×10^{-7} J d) 6.57 mA
30.31 a) 105 rad/s, 59.6 ms b) 7.20×10^{-4} C c) 4.32×10^{-3} J d) −543 μC e) −49.9 mA f) 2.45×10^{-3} J, capacitor; 1.87×10^{-3} J, inductor
30.33 a) $f = 2.13 \times 10^{3}$ Hz b) $V_E = 0.225$ J c) $V_B = 0.223$ J
30.35 a) $U_C = (Q^2/2C)\cos^2(\omega t + \phi)$; $U_L = (Q^2/2C)\sin^2(\omega t + \phi)$
30.37 $\sqrt{LC} = \sqrt{(\text{V}\cdot\text{s/A})(\text{A}\cdot\text{s/V})} = \sqrt{\text{s}^2} = \text{s}$
30.41 a) 298 rad/s b) 83.8 Ω
30.43 a) $m = 4.80 \times 10^{-6}$ H b) $\mathcal{E} = \pm 1.80 \times 10^{-4}$ V
30.49 a) $\dfrac{\mu_0 i}{2\pi r}$ b) $\left(\dfrac{\mu_0 i^2 l}{4\pi r}\right)dr$ c) $\left(\dfrac{\mu_0 i^2 l}{4\pi}\right)\ln(b/a)$
30.51 a) $L = 8.89$ H b) $l = 56.3$ m; no
30.53 a) 0.281 J b) 0.517 J c) 0.236 J
30.57 222 μF; 9.31 μH
30.59 $2 \times 10^{4}\ \text{m/s}$
30.61 a) solenoid c) 50 V d) 3.5 A e) 4.3 Ω;43 mH
30.63 a) $V_1 = 40.0$ V; $A_1 = A_4 = 0.80$ A, all others are zero b) $V_1 = 24.0$ V, $V_2 = 0$, $V_3 = V_4 = V_5 = 16.0$; $A_1 = 0.48$ A, $A_2 = 0.16$ A, $A_3 = 0.32$ A, $A_4 = 0$ c) 192 μC
30.65 a) $A_1 = A_4 = 0.45$ A, $A_2 = A_3 = 0$ b) $A_1 = 0.58$ A, $A_2 = 0.32$ A, $A_3 = 0.16$ A, $A_4 = 0.11$ A
30.67 a) 60.0 V b) a c) 60.0 V d) c e) −96.0 V f) b g) −156 V h) d
30.69 a) $i_0 = 0$, $V_{ac} = 0$, $V_{cb} = 36.0$ V b) $i_0 = 0.180$ A, $V_{ac} = 9.0$ V, $V_{cb} = 27.0$ V c) $i_0 = (0.180\ \text{A})[1 - \exp(-(50.0\text{s}^{-1})t)]$, $V_{ac} = (9.00\ \text{V})[1 - \exp(-(50.0\text{s}^{-1})t)]$, $V_{cb} = 27.0\ \text{V} + (9.00\ \text{V})\exp(-(50.0\ \text{s}^{-1})t)$
30.71 a) 0; 20 V b) 0.267 A; 0 c) 0.147 A; 9.0 V
30.75 a) $i_1 = \mathcal{E}/R_1$, $i_2 = (\mathcal{E}/R_2)[1 - \exp(-R_2 t/L)]$ b) $i_1 = \mathcal{E}/R_1$, $i_2 = \mathcal{E}/R_2$ c) $i = (\mathcal{E}/R_2)\exp(-(R_1 + R_2)t/L)$
30.77 a) $d = [(L - L_0)/(L_F - L_0)]D$ b) 0.63024 H, 0.63048 H, 0.63072 H, 0.63096 H c) 0.63000 H, 0.62999 H, 0.62999 H, 0.62998 H
30.79 a) $i_1 = (\mathcal{E}/R_1)[1 - \exp(R_1 t/L)]$, $i_2 = (\mathcal{E}/R_2)\exp(-t/R_2 C)$, $q_2 = C\mathcal{E}[1 - \exp(-t/R_2 C)]$ b) 0, 9.6 mA c) 1.9 A, 0 d) 1.6 ms e) 9.4 mA f) 0.22 s

Chapter 31

31.1 a) $I_{rms} = 0.34$ A b) $I = 0.48$ A c) 0
d) $(i^2)_{av} = 0.12$ A^2
31.3 a) 31.8 V b) 0
31.5 a) 0.0132 A b) 0.132 A c) 1.32 A
31.9 a) 1.51 kΩ b) 0.239 H c) 497 Ω d)16.6 μF
31.11 13.3 μF
31.13 a) $i = (0.0253\text{ A})\cos[(720\text{ rad/s})t]$
b) 180 Ω
c) $v_L = (-4.56\text{ V})\sin[(720\text{ rad/s})t]$
31.15 b) $v = 20.5$ V, $v_r = 7.6$ V, $v_L = 12.9$ V
c) $v = -15.2$ V, $v_R = -22.5$ V, $v_L = 7.3$ V
31.17 a) 696 Ω b) 0.0431 A
c) $v_R = 8.62$ V, $v_c = 28.7$ V d) $-73.3°$
31.19 a) 601 Ω b) 49.9 mA c) $-70.6°$, lags
d) $v_R = 9.98$ V, $v_L = 4.99$ V, $v_c = 33.3$ V
31.21 a) 113 Hz; 15 mA b) 7.61 mA; lag
31.23 50.0 V
31.25 a) $P_{max} = 40.0$ W b) $I_{rms} = 0.167$ A
c) $R = 7.20 \times 10^2$ Ω
31.29 a) $+45.8°$,0.697 b) 344 Ω c) 155 V
d) 48.6 W e) 48.6 W f) 0 g) 0
31.31 a) 150 V b) 150 V, 1290 V, 1290 V
c) 37.5 W
31.33 a) 1.00 b) 75.0 W c) 75.0 W
31.35 a) $Z = 115$ Ω b) $Z = 146$ Ω c) $Z = 146$ Ω
31.37 a) 10 b) 2.40 A c) 28.8 A d) 500 Ω
31.39 a) $N_2 = \frac{1}{2}N_1$ b) 13 A c) 9.0 Ω
31.41 0.124 H
31.43 a) $t_1 = \pi/2\omega$, $t_2 = 3\pi/2\omega$ b) $2I/\omega$
c) $I_{rav} = 2I/\omega$
31.45 a) inductor b) 0.133 H
31.47 a) $I = 1.15$ A, $V_L = 31.6$ V, $V_R = 57.5$ V, $V_C = 14.7$ V
b) $I = 0.860$ A, $V_L = 47.3$ V, $V_R = 43.0$ V, $V_C = 5.47$ V
31.49 $\sqrt{(R^2 + \omega^2L^2)/[R^2 + (\omega L - 1/\omega C)^2]}$
31.53 b) $V_B = LV^2/4[R^2 + (\omega L - 1/\omega C)^2]$, $V_E = V^2/4\omega C[R^2 + (\omega L - 1/\omega C)^2]$
d) $\omega = 0$; $U_B = 0$; $U_E = CV^2/4$; $\omega \to \infty$; both U_B and $U_E \to 0$;
$U_B = U_E$ at $\omega = \omega_0 = 1/\sqrt{LC}$
31.57 a) $I_R = V/R$, $I_L = V/\omega L$, $I_C = \omega CV$
c) $\omega = 0$: $I_L \to \infty$, $I_C \to 0$; $\omega \to \infty$: $I_L = 0$, $I_C \to \infty$ d) 159 Hz e) 0.50 A
f) $I_R = 0.50$ A, $I_L = I_C = 0.050$ A
31.59 a) 102 Ω b) 0.882 A c) 270 V
31.61 a) 0.750 A b) 160 Ω c) 619 Ω, 341 Ω
d) 341 Ω
31.63 $i_{av} = 0$, $i_{rms} = I_0/\sqrt{3}$
31.65 a) ω_0 decreases by $\frac{1}{2}$ b) X_C doubles
c) X_C decreases by $\frac{1}{2}$ d) no
31.67 a) L and C b) factor of $\frac{1}{2}$
31.69 a) $V/\sqrt{R^2 + 9L/4C}$
b) $[2V/\sqrt{R^2 + 9L/4C}]\sqrt{L/C}$
c) $[V/2\sqrt{R^2 + 9L/4C}]\sqrt{L/C}$
d) $2LV^2/(R^2 + 9L/4C)$
e) $LV^2/2(R^2 + 9L/4C)$
31.73 a) $V_RI/2$ b) 0 c) 0
31.75 a) 0.400 A b) 36.9°
c) $Z_{cpx} = (400\ \Omega) - i(300\ \Omega)$, $Z = 500$ Ω
d) $I_{cpx} = (0.320\ A) - i(240\text{ A})$

Chapter 32

32.1 a) 1.28 s b) 8.15×10^{15} km
32.3 a) 6.0×10^4 Hz b) 6.0×10^7 Hz
c) 6.0×10^{13} Hz d) 6.0×10^{16} Hz
32.5 a) $f = 6.94 \times 10^{14}$ Hz b) $E_{max} = 375$ V/m
32.7 $\vec{E}(z,t) = (1.74 \times 10^5\text{ V/m})\hat{i} \times \cos[(1.28 \times 10^7\text{ rad/m})z - (3.83 \times 10^{15}\text{ rad/s})t]$
$\vec{B}(z,t) = (5.80 \times 10^{-4}\text{ T})\hat{j} \times \cos[(1.28 \times 10^7\text{ rad/m})z - (3.83 \times 10^{15}\text{ rad/s})t]$
32.9 a) $+y$-direction b) 7.11×10^{-4} m
c) $\vec{B}(y,t) = (-1.03 \times 10^{-2}\text{ T})\hat{i} \times \sin[(8.84 \times 10^3\text{ rad/m})y - (2.65 \times 10^{12}\text{ rad/s})t]$
32.11 a) 361 m b) 0.0174 rad/m
c) 5.22×10^6 rad/s d) 0.0144 V/m
32.13 a) 381 nm b) 526 nm c) 1.38 d) 1.91
32.15 a) 330 W/m^2 b) 500 V/m; 1.7 μT
32.17 1.33×10^{-8} T, $+y$-direction
32.19 a) 1.1×10 W/m^2 b) 3.0×10^{-10} T
c) 840 W; assuming isotropic transmission
32.21 2.5×10^{25} J
32.23 $E_{max} = 12.0$V/m, $B_{max} = 4.00 \times 10^{-8}$ T
32.25 8.5×10^5 W
32.27 a) 8.68×10^{-15} kg/m$^2 \cdot$s
b) 2.60×10^{-6} kg/m$\cdot$s^2
32.29 $S = \epsilon_0cE^2$
32.31 a) 7.10 mm b) 3.55 mm c) 1.56×10^8 m/s
32.33 a) 4.38 mm b) 1.38 mm c) 4.38 mm
32.35 a) $L = 30.5$ cm b) $f = 2.46 \times 10^9$ Hz
c) $L = 35.5$ cm: $f = 2.11 \times 10^9$ Hz
32.39 a) $I = 0.00602$ W/m^2
b) 2.13 N/C, 7.10×10^{-9} T
c) 1.20×10^{-12} N
32.41 a) $E_{max} = 701$V/m, $B_{max} = 2.34 \times 10^{-6}$ T
b) $\mu_E = \mu_B = 1.09 \times 10^{-6}$ J/m^3
c) 1.07×10^{-11} J
32.43 a) $r = R$: $I = 6.4 \times 10^7$ W/m^2, $p_{rod} = 0.21$ Pa; $r = R/2$: $I = 2.6 \times 10^8$ W/m^2, $p_{rod} = 0.85$ Pa
32.45 7.78×10^{-13} rad/s
32.47 a) $I\rho/\pi a^2$ in direction of current
b) current out of page: $\mu_0I/2\pi a$, clockwise
c) $I^2\rho/2\pi^2a^3$, radially inward
d) $I^2\rho l/\pi a^2 = I^2R$
32.49 0.0368 V
32.51 a) 23.6 h b) throw it
32.53 a) 2.66×10^7 m b) 0.0673 s
c) 6.50×10^{-23} Pa d) 0.190 m
32.55 a) $4\pi R^3\rho Gm^3/3r^2$ b) $LR^2/4r^2c$
c) 1.90^{-7} m, independent of r
32.57 b) 1.4×10^{-11} s^{-1} c) 2.6×10^{-8} s^{-1}

Chapter 33

33.1 39.4°
33.3 a) 1.55 b) 549 nm
33.5 a) 5.17×10^{-7} m b) 3.40×10^{-7} m
33.7 a) 47.5° b) 66.0°
33.9 2.51×10^8 m/s
33.13 a) frequency $= f$; wavelength $= n\lambda$; speed $= nf\lambda = nv$ b) frequency $= f$; wavelength $= \left(\frac{n}{n'}\right)\lambda$; speed $= \left(\frac{n}{n'}\right)f\lambda = \left(\frac{n}{n'}\right)v$
33.15 71.8°
33.17 a) 51.3° b) 33.8°
33.19 a) 58.1° b) 22.8°
33.21 1.77
33.23 24.4°
33.25 a) A: $I_0/2$ B: $I_0/8$ C: $3I_0/32$ b) 0
33.27 a) 1.40 b) 35.5°
33.29 $\alpha = \arccos\left(\frac{\cos\theta}{\sqrt{2}}\right) = \cos^{-1}\left(\frac{\cos\theta}{\sqrt{2}}\right)$
33.31 6.38 W/m^2
33.33 a) first: $I = I_0/2$, second: $I = 0.25I_0$, third: $I = 0.125I_0$ all linearly polarized along the axis of their respective filters.
33.35 a) $I_R = 0.374I$ b) $I_V = 2.35I$
33.39 a) $\sin\theta_3 = (n_1\sin\theta_1)/n_3$ c) yes
33.41 72.0°
33.45 1.53
33.47 1.8
33.49 a) 48.6° b) 48.6°
33.51 39.1°
33.53 a) $n = 1.11$ b) i) 9.75 ns
ii) 4.07 ns; total = 8.95 ns
33.55 b) 0.22°
33.61 b) 38.9° c) 5.0°
33.63 a) 35° b) 10.1 W/m^2, 19.9 W/m^2
33.67 a) $\Delta = 2\theta_a^A - 6\sin^{-1}\left(\frac{1}{n}\sin\theta_a^A\right) + 2\pi$
b) $\cos^2\theta_2 = (n^2 - 1)/8$
c) red: $\theta_2 = 71.9°$; $\Delta = 230.1°$;
violet: $\theta_2 = 71.6°$, $\Delta = 233.2°$; violet

Chapter 34

34.1 39.2 cm to right of mirror; 4.85 cm
34.3 image at (x_0, y_0)
34.5 b) 33.0 cm to left of vertex, 1.20 cm tall, inverted, real
34.7 0.213 mm
34.9 18.0 m from convex side of glass shell, 0.50 cm tall, erect, virtual
34.11 a) $m = \frac{f}{(f - s)}$ c) $s > f$ d) $s < f$ e) $-\infty$
f) $s = f$ g) $s' = 0$ i) $s < f$ j) $s > f$
k) $s > 2f$ l) it becomes infinite
34.13 a) concave b) $f = 2.50$ cm, $R = 5.00$ cm
34.15 2.67 cm
34.17 a) at the center of the ball, $m = +1.33$ b) no
34.19 $s = 0.395$ m
34.21 8.35 cm to left of vertex, 0.326 mm, erect
34.23 a) 1.06 m to right of lens, 17.7 mm tall, real, inverted b) all same as (a)
34.25 71.2 cm to right of lens, $m = -2.97$
34.27 $f = 3.69$ cm, object is 2.82 cm to left of lens
34.29 $n = 1.67$
34.33 Object is 26.3 cm from lens with height 1.24 cm; image is erect; same side
34.35 10.2 m
34.37 a) 1.4×10^{-4} b) 5.25×10^{-4} c) 1.50×10^{-3}
34.39 a) 85 mm b) 135 mm
34.41 a) 11 b) 2.160×10^{-3} s
34.43 a) convex b) 50 mm to 56 mm
34.45 a) 80.0 cm b) 76.9 cm
34.47 a) $+2.33$ diopters b) -1.67 diopters
34.49 a) 6.06 cm b) 4.12 mm
34.51 4.17 cm from lens; image is located on same side as ant
34.53 a) 8.37 mm b) 21.4 c) 297
34.55 19.4 m
34.57 a) -6.33 b) 1.90 cm c) 0.126 rad = 7.22°
34.59 a) 66.1 cm b) -59.1
34.61 4.80 m/s
34.63 $n/2$
34.65 a) 13.3 cm b) 26.2 cm
34.67 a) 46.2 cm from mirror, on opposite side of mirror; virtual b) 2.88 cm, erect c) no
34.69 a) -12.0 cm $< s < 0$ b) erect
34.71 $f = \pm 4.4$ cm, ± 13.3 cm
34.73 $v = 31$ m/s
34.75 b) i) 120.00 cm from mirror, 119.96 cm from mirror ii) $m = -0.600$, $m' = -0.360$
c) faces perpendicular to axis: squares with side 0.600 mm: faces parallel to axis: rectangles with sides of length 0.360 mm (parallel to axis) and 0.600 mm (perpendicular to axis)
34.77 b) image = 2.4 cm high; $m = -0.13$
34.79 a) -3.3 cm b) virtual c) 1.9 cm to right of vertex at right end of rod d) real, inverted
e) 105 mm
34.81 a) $f = 58.7$ cm, converging
b) $h = 4.47$ mm, virtual
34.83 a) 2.53 mm
34.85 a) $R = 8.8$ mm b) no. behind the retina
c) $s' = 14$ mm from the cornea. In front of the retina. Yes. The lens needs to complete the focusing.
34.87 2.00
34.89 a) 3.75 cm to left of first lens b) 332 cm
c) real d) $h = 60.0$ mm. inverted.
34.91 10.6 cm
34.93 a) 0.24 m b) 0.24 m
34.95 Inside the glass, 72.1 cm from the spherical surface
34.97 0.80 cm
34.99 -26.7 cm
34.101 1.24 cm above page
34.103 a) 46.7 m b) 35.0 m
34.105 134 cm to left of object

Chapter 35

35.1 a) 2.50 m b) 1.00 m, 4.00 m
35.3 0.75 m, 2.00 m, 3.25 m, 4.50 m, 5.75 m, 7.00 m, 8.25 m

35.5 a) 2.0 m b) constructively
c) 1.0 m; destructively
35.9 0.83 mm
35.11 590 nm
35.13 12.6 cm
35.15 1200 nm
35.17 a) $m = 19$, 39 bright fringes
b) $m = \pm 19$, $\theta = \pm 73.3°$
35.19 a) $0.750I_0$ b) 80 nm
35.21 1670 rad
35.23 a) 0.888 mm b) 0.444 mm
35.25 71.4 m
35.27 114 nm
35.29 0.0235°
35.31 a) $\Delta T = 56$ nm b) i) 2180 nm
ii) 198.5 nm; 11.0 wavelengths
35.33 a) 514 nm; green b) 603 nm; orange
35.35 0.11 μm
35.37 0.570 mm
35.39 1.82 mm
35.41 $n = 1.730$
35.43 27.3°, 66.5°
35.45 $n = 1.57$
35.47 b) constructive: $r_2 - r_1 = (m + \phi/2\pi)\lambda$, $m = 0, \pm 1, \pm 2, \pm 3, \ldots$;
destructive: $r_2 - r_1 = \left(m + \frac{1}{2} + \phi/2\pi\right)\lambda$, $m = 0, \pm 1, \pm 2, \pm 3, \ldots$
35.49 a) $\sqrt{x^2 + (y + d)^2} - \sqrt{x^2 + (y - d)^2} = m\lambda$
c) $\sqrt{x^2 + (y + d)^2} - \sqrt{x^2 + (y - d)^2} = \left(m + \frac{1}{2}\right)\lambda$
35.51 6.8×10^{-5} (C°)$^{-1}$
35.53 $\lambda/2d$, independent of m
35.55 b) 72 cm
35.57 $n = 1.42$
35.59 a) pattern moves down the screen
b) $I = I_0\cos^2[(\pi/\lambda)(d\sin\theta + (n - 1)L)]$
c) $d\sin\theta = m\lambda - (n - 1)L$
35.61 14.0

Chapter 36

36.1 506 nm
36.3 $m_{max} = 113$; 226 dark fringes
36.5 ± 45.4 cm
36.9 $\pm 16.0°$, $\pm 33.4°$, $\pm 55.6°$
36.11 0.920 μm
36.13 a) 10.8 mm b) 5.4 mW
36.15 a) 6.75 mm b) 2.43×10^{-6} W/m^2
36.17 a) 668 nm b) $9.36 \times 10^{-5}I_0$
36.19 a) $\pm 13.0°$, $\pm 26.7°$, $\pm 42.4°$, $\pm 64.1°$
b) $I = 2.08$ W/m^2
36.21 a) 3 b) 2
36.23 a) $\pm 0.0627°$ b) $0.249I_0$ c) $0.0256I_0$
36.25 cases (i), (iii): slits 1 and 3 and slits 2 and 4; case (ii): slits 1 and 2 and slits 3 and 4
36.27 $a = 1.50 \times 10^4$ nm in width;
$d = 4.50 \times 10^4$ nm in separation
36.29 a) 4790 b) 19.0°, 40.7° c) no
36.31 a) yes b) 13.3 nm
36.33 23.3°, 52.3°
36.35 10.5°, 21.3°, 33.1°
36.37 a) $R = 17{,}500$ b) yes
c) i) 587.8170 nm ii) 587.7834 nm
iii) 587.7834 nm $< \lambda <$ 587.8170 nm
36.39 0.232 nm
36.41 a) 0.461 m
36.43 1.9 m
36.45 92 cm
36.47 1.45 m
36.49 a) Hubble: 77 m; Arecibo: 1.1×10^6 m
b) 1500 km
36.51 no
36.53 a) i) 25.6° ii) 10.2° iii) 5.1° b) i) 60.0° ii) 23.1° iii) 11.5°
36.55 2.07
36.57 a) 1.80 mm b) 0.798 mm
36.59 $\Delta\theta_\pm = \frac{2\lambda}{dN}$
36.61 b) for $3\pi/2$: any two slits separated by one other slit; for the other cases: any two slits separated by three other slits
36.65 513 nm
36.67 second order
36.69 c) ± 2.6 rad
36.71 492 km

Chapter 37

37.1 Flash at AA'
37.3 2.60×10^8 m/s
37.5 a) 0.998c b) 126 m
37.7 1.12 h, clock on spacecraft
37.9 92.5 m
37.11 a) 6.6×10^2 m
b) 4.92×10^{-5} s, 1.48×10^4 m; yes c) 447 m
37.13 a) 3.57 km b) 9.00×10^{-5} s
c) 8.92×10^{-5} s
37.15 a) 0.806c b) 0.974c c) 0.997c
37.17 0.385c
37.19 0.784c
37.21 $v = 0.611c$
37.23 0.837c, away
37.25 a) 0.159c b) 1.72×10^8
37.27 b) $a = (F/m)(1 - v^2/c^2)^{1/2}$
37.29 a) $a = (\sqrt{3}/2)c = 0.866c$
b) $c\sqrt{1 - \left(\frac{1}{2}\right)^{2/3}} = 0.608c$
37.31 a) $(\sqrt{3}/2)c = 0.866c$ b) $\sqrt{35/36}c = 0.986c$
37.33 a) 4.50×10^{-10} J
b) 1.94×10^{-18} kg$\cdot$m/s
c) 0.968c
37.35 a) 3.3×10^{-14} %; no
b) 4.0×10^{-16} kg; increases; no
37.37 a) 1.1×10^2 kg b) 0.24 m
37.39 a) 8.68×10^{-10} J b) 2.71×10^{-10} J c) 0.453
37.41 a) nonrelativistic: 5.34×10^{-12} J;
relativistic: 5.65×10^{-12} J;1.06
b) nonrelativistic: 6.78×10^{-11} J;
relativistic: 3.31×10^{-10} J; 4.88
37.43 a) 2.06×10^6 V b) 3.30×10^{-13} J
c) 2.06 MeV
37.45 $v = 0.652c$
37.47 a) 4.2×10^9 kg/s; 4.6×10^6 tons
b) 1.5×10^{13} y
37.49 a) $\Delta = 2.11 \times 10^{-5}$ b) 2.15×10^4 MeV
37.51 0.700c
37.53 a) 0.995c b) 1.0%
37.55 a) $v = (1 - 9 \times 10^{-9})c$ b) $m_{rel} = 7 \times 10^3m$
37.57 1.68×10^5 eV
37.59 a) 0.800c b) 1.00c c) i) 2.33×10^{-11} J
ii) 1.00×10^{-10} J
d) i) 1.88×10^{-11} J ii) 4.81×10^{-11} J
37.65 b) $\Delta x' = \sqrt{(\Delta x)^2 - (c\Delta t)^2}$
c) 1.44×10^{-8} s
37.67 0.357c, receding
37.69 a) 140% b) 5500% c) 63000%
37.75 a) 13.1 km/s, toward
b) 5.96×10^9 m = 0.040 Earth-sun distance (AU); 5.55×10^{29} kg = $0.279m_{sun}$
37.77 a) 0.7554c b) 2.526
c) center of momentum: less energy