Halliday, Resnick, and Walker *Fundamentals of Physics 10e* Problem Answers
Volume 1

Chapter 1 Answers

1	(a) 4.00×10^4 km; (b) 5.10×10^8 km^2; (c) 1.08×10^{12} km^3
2	0.18 points^2
3	(a) 10^9 μm; (b) 10^{-4}; (c) 9.1×10^5 μm
4	(a) 1.9 picas; (b) 23 points
5	(a) 160 rods; (b) 40 chains
6	(a) 8.33×10^{-2}, 2.08×10^{-2}, 6.94×10^{-3}, 3.47×10^{-3}; (b) 0.250, 8.33×10^{-2}, 4.17×10^{-2}; (c) 0.333, 0.167; (d) 0.500; (e) 14.0 medios; (f) 4.86×10^{-2} cahiz; (g) 3.24×10^4 cm^3
7	1.1×10^3 acre-feet
8	(a) 60.8 W; (b) 43.3 Z
9	1.9×10^{22} cm^3
10	15°
11	(a) 1.43; (b) 0.864
12	3.1 μm/s
13	(a) 495 s; (b) 141 s; (c) 198 s; (d) –245 s
14	(a) 52.6 min; (b) 4.9%
15	1.21×10^{12} μs
16	(a) 3.88×10^8 rotations; (b) 1557.806 448 872 75 s; (c) $\pm 3 \times 10^{-11}$ s
17	C, D, A, B, E; the important criterion is the consistency of the daily variation, not its magnitude
18	2.1 h
19	5.2×10^6 m

20	(a) 2.69×10^5 cm^3; (b) 0.77 y
21	9.0×10^{49} atoms
22	(a) 1.430 m^2; (b) 72.84 km
23	(a) 1×10^3 kg; (b) 158 kg/s
24	0.260 kg
25	1.9×10^5 kg
26	(a) 2×10^3 m^3, 2×10^4 m^3; (b) 2×10^6 bottles, 2×10^7 bottles; (c) 2×10^6 kg, 2×10^7 kg
27	(a) 1.18×10^{-29} m^3; (b) 0.282 nm
28	1 kilomole
29	1.75×10^3 kg
30	(a) 4.21 s; (b) 23.2 g; (c) 2.89×10^{-2} kg/min; (d) -6.05×10^{-3} kg/min
31	1.43 kg/min
32	(a) 1.0 m^3; (b) 6.0×10^{-4} m^3
33	(a) 293 U.S. bushels; (b) 3.81×10^3 U.S. bushels
34	403 L
35	(a) 22 pecks; (b) 5.5 Imperial bushels; (c) 200 L
36	(a) 0.900, 7.50×10^{-2}, 1.56×10^{-3}, 8.32×10^{-6}; (b) 1.00, 8.33×10^{-2}, 1.74×10^{-3}, 9.24×10^{-6}; (c) 12.0, 1.00, 2.08×10^{-2}, 1.11×10^{-4}; (d) 576, 48, 1.00, 5.32×10^{-3}; (e) 1.08×10^5, 9.02×10^3, 188, 1.00 (f) 1.96 m^3
37	8×10^2 km
38	(a) 14.5 roods; (b) 1.47×10^4 m^2
39	(a) 18.8 gallons; (b) 22.5 gallons
40	6.0×10^{26} atoms
41	0.3 cord
42	(a) 3.0×10^{-26} kg; (b) 5×10^{46} molecules
43	3.8 mg/s
44	1.3×10^9 kg

45	(a) yes; (b) 8.6 universe seconds
46	0.020 km^3
47	0.12 AU/min
48	10 u
49	(a) 3.88; (b) 7.65; (c) 156 ken^3; (d) 1.19×10^3 m^3
50	5.95 km
51	(a) 3.9 m, 4.8 m; (b) 3.9×10^3 mm, 4.8×10^3 mm; (c) 2.2 m^3, 4.2 m^3
52	$\approx 1 \times 10^{36}$
53	(a) 4.9×10^{-6} pc; (b) 1.6×10^{-5} ly
54	(a) 11.3 m^2/L; (b) 1.13×10^4 m^{-1}; (c) 2.17×10^{-3} gal/ft^2; (d) number of gallons to cover a square foot
55	(a) 3 nebuchadnezzars, 1 methuselah; (b) 0.37 standard bottle; (c) 0.26 L
56	4.4
57	10.7 habaneros
58	1.2 m
59	700 to 1500 oysters
60	(a) 2.5 cups, 2 teaspoons; (b) 0.5 quart; (c) 2 teaspoons; (d) 1 teaspoon

Chapter 2 Answers

1	13 m
2	(a) 1.74 m/s; (b) 2.14 m/s
3	(a) +40 km/h; (b) 40 km/h
4	48 km/h

5	(a) 0; (b) –2 m; (c) 0; (d) 12 m; (e) +12 m; (f) +7 m/s
6	5.554 s
7	60 km
8	(a) 0.50 m/s; (b) 10 s
9	1.4 m
10	(a) method 1; (b) 5.76×10^{-4}
11	128 km/h
12	(a) 48.0 m; (b) 2.5 m/s; (c) downstream
13	(a) 73 km/h; (b) 68 km/h; (c) 70 km/h; (d) 0
14	5.9 m
15	(a) –6 m/s; (b) -*x* direction; (c) 6 m/s; (d) decreasing; (e) 2 s; (f) no
16	(a) 0; (b) 4.0 m; (c) -0.82 s; (d) 0.82 s; (f) +20*t*; (g) increase
17	(a) 28.5 cm/s; (b) 18.0 cm/s; (c) 40.5 cm/s; (d) 28.1 cm/s; (e) 30.3 cm/s
18	(a) 54 m; (b) 18 m/s; (c) -12 m/s^2; (d) 64 m; (e) 4.0 s; (f) 24 m/s; (g) 2.0 s; (h) –24 m/s^2; (i) 18 m/s
19	-20 m/s^2

20	(a) 1.2 s; (b) 0; (c) positive; (d) negative
21	(a) 1.10 m/s; (b) 6.11 mm/s^2; (c) 1.47 m/s; (d) 6.11 mm/s^2
22	(a) m/s^2; (b) m/s^3; (c) 1.0 s; (d) 82 m; (e) –80 m; (f) 0; (g) –12 m/s; (h) –36 m/s; (i) -72 m/s; (j) –6 m/s^2; (k) –18 m/s^2; (l) –30 m/s^2; (m) -42 m/s^2
23	1.62×10^{15} m/s^2
24	(a) $(2.6 \times 10^4)g$; (b) $(1.3 \times 10^2)g$
25	(a) 30 s; (b) 300 m
26	(a) 0.100 m
27	(a) +1.6 m/s; (b) +18 m/s
28	(a) 5.00 s; (b) 61.5 m
29	(a) 10.6 m; (b) 41.5 s
30	(a) 2.5 s
31	(a) 3.1×10^6 s; (b) 4.6×10^{13} m
32	$21g$
33	(a) 3.56 m/s^2; (b) 8.43 m/s
34	(a) -50 km/h; (b) –2.0 m/s^2
35	0.90 m/s^2
36	(a) 56.6 s; (b) 31.8 m/s
37	(a) 4.0 m/s^2; (b) $+x$

38	(a) 32.9 m/s; (b) 49.1 s; (c) 11.7 m/s
39	(a) $-2.5\ \text{m/s}^2$; (b) 1; (d) 0; (e) 2
40	(a) either; (b) neither
41	40 m
42	(a) 15.0 m; (b) 94 km/h
43	(a) $0.994\ \text{m/s}^2$
44	(a) 3.70 m/s; (b) 1.74 m/s; (c) 0.154 m
45	(a) 31 m/s; (b) 6.4 s
46	(a) 183 m/s; (b) no
47	(a) 29.4 m; (b) 2.45 s
48	(a) 1.54 s; (b) 27.1 m/s
49	(a) 5.4 s; (b) 41 m/s
50	9.6 m/s
51	(a) 20 m; (b) 59 m
52	(a) 0.45 s; (b) 38 m/s; (c) 42 m/s
53	4.0 m/s
54	(a) 12.3 m/s
55	(a) $857\ \text{m/s}^2$; (b) up
56	3.0 m/s
57	(a) $1.26 \times 10^3\ \text{m/s}^2$; (b) up
58	(a) 3.41 s; (b) 57 m
59	(a) 89 cm; (b) 22 cm
60	26 m
61	20.4 m

62	(a) 350 ms; (b) 82 ms
63	2.34 m
64	(a) 8.0 m/s^2; (b) 20 m/s
65	(a) 2.25 m/s; (b) 3.90 m/s
66	(a) 0.13 m; (b) 0.50 m
67	0.56 m/s
68	5.0 m/s
69	100 m
70	15.6 m/s
71	(a) 2.00 s; (b) 12 cm; (c) -9.00 cm/s^2; (d) right; (e) left; (f) 3.46 s
72	(a) 15.7 m/s; (b) 12.5 m; (c) 82.3 m
73	(a) 82 m; (b) 19 m/s
74	1.3 s
75	(a) 0.74 s; (b) 6.2 m/s^2
76	(a) D_{23}/v_p; (b) $t_r + v_p/2a + (D_{12} - d)/v_p$
77	(a) 3.1 m/s^2; (b) 45 m; (c) 13 s
78	yes, 0, 10 m/s
79	17 m/s
80	(a) 5.0 m/s^2; (b) 4.0 s; (c) 6.0 s; (d) 90 m
81	+47 m/s
82	39 m/s
83	(a) 1.23 cm; (b) 4 times; (c) 9 times; (d) 16 times; (e) 25 times
84	(a) 25g; (b) 400 m

85	25 km/h
86	(a) 18 m/s; (b) 83 m
87	1.2 h
88	(a) 5.00 m/s; (b) 1.67 m/s^2; (c) 7.50 m
89	4H
90	(a) 15 m; (b) 2.0 m/s; (c) –2.0 m/s^2; (d) 3.5 m/s; (e) 0
91	(a) 3.2 s; (b) 1.3 s
92	(a) 60.6 s; (b) 36.3 m/s
93	(a) 8.85 m/s; (b) 1.00 m
94	34 m
95	(a) 2.0 m/s^2; (b) 12 m/s; (c) 45 m
96	(a) 38.1 m; (b) 9.02 m/s; (c) down; (d) 14.5 m/s; (e) up
97	(a) 48.5 m/s; (b) 4.95 s; (c) 34.3 m/s; (d) 3.50 s
98	1.5 s
99	22.0 m/s
100	(a) 17 s; (b) 290 m
101	(a) $v = (v_0^2 + 2gh)^{0.5}$; (b) $t = [(v_0^2 + 2gh)^{0.5} – v_0]/g$; (c) same as (a); (d) $t = [(v_0^2 + 2gh)^{0.5} + v_0]/g$, greater
102	8.4 m
103	414 ms
104	(a) 80 m/s; (b) 110 m/s; (c) 20 m/s^2
105	90 m

106	(a) 3.0 s; (b) 9.0 m
107	0.556 s
108	2.78 m/s^2
109	(a) 0.28 m/s^2; (b) 0.28 m/s^2
110	94 m
111	(a) 10.2 s; (b) 10.0 m
112	3.75 ms
113	(a) 5.44 s; (b) 53.3 m/s; (c) 5.80 m
114	(a) 9.08 m/s^2; (b) 0.926*g*; (c) 6.12 s; (d) 15.3T_r; (e) braking; (f) 5.56 m
115	2.3 cm/min
116	217 m/s
117	0.15 m/s
118	(a) 3.5; (b) (5.0 m)/v_s
119	(a) 1.0 cm/s; (b) 1.6 cm/s, 1.1 cm/s, 0; (c) -0.79 cm/s^2; (d) 0, -0.87 cm/s^2, -1.2 cm/s^2

Chapter 3 Answers

1	(a) –2.5 m; (b) -6.9 m
2	(a) 13 m; (b) 7.5 m
3	(a) 47.2 m; (b) 122°
4	(a) 0.349 rad; (b) 0.873 rad; (c) 1.75 rad; (d) 18.9°; (e) 120°; (f) 441°
5	(a) 156 km; (b) 39.8° west of due north
6	(a) 4.28 m; (b) 11.7 m

7	(a) parallel; (b) antiparallel; (c) perpendicular
8	(b) 3.2 km; (c) 41° south of due west
9	(a) $(3.0\text{ m})\hat{i} - (2.0\text{ m})\hat{j} + (5.0\text{ m})\hat{k}$; (b) $(5.0\text{ m})\hat{i} - (4.0\text{ m})\hat{j} - (3.0\text{ m})\hat{k}$; (c) $(-5.0\text{ m})\hat{i} + (4.0\text{ m})\hat{j} + (3.0\text{ m})\hat{k}$
10	(a) 12 m; (b) –5.8 m; (c) –2.8 m
11	(a) $(-9.0\text{ m})\hat{i} + (10\text{ m})\hat{j}$; (b) 13 m; (c) 132°
12	(a) 81 km; (b) 40° north of due east
13	4.74 km
14	(a) –80 m; (b) 110 m; (c) 143 m; (d) 168°
15	(a) 1.59 m; (b) 12.1 m; (c) 12.2 m; (d) 82.5°
16	(a) $(8.0\text{ m})\hat{i} + (2.0\text{ m})\hat{j}$; (b) 8.2 m; (c) 14°; (d) $(2.0\text{ m})\hat{i} - (6.0\text{ m})\hat{j}$; (e) 6.3 m; (f) –72°
17	(a) 38 m; (b) –37.5°; (c) 130 m; (d) 1.2°; (e) 62 m; (f) 130°
18	(a) 26.6 m; (b) –151°
19	5.39 m at 21.8º left of forward
20	(a) 5.0 km; (b) 4.3º south of due west

21	(a) –70.0 cm; (b) 80.0 cm; (c) 141 cm; (d) –172°
22	(a) (1.28 m)$\hat{i}$ + (6.60 m)$\hat{j}$; (b) 6.72 m; (c) 79.0°; (d) 1.38 rad
23	3.2
24	2.2 m
25	2.6 km
26	(a) (-3.18 m)$\hat{i}$ + (4.72 m)$\hat{j}$; (b) 5.69 m; (c) +124°
27	(a) 8$\hat{i}$ + 16$\hat{j}$; (b) 2$\hat{i}$ + 4$\hat{j}$
28	(a) 0.84 m; (b) 79° south of due east
29	(a) 7.5 cm; (b) 90º; (c) 8.6 cm; (d) 48º
30	(a) 5.0 m; (b) –37°; (c) 10 m; (d) 53°; (e) 11 m; (f) 27°; (g) 11 m; (h) 80°; (i) 11 m; (j) 260°; (k) 180°
31	(a) 9.51 m; (b) 14.1 m; (c) 13.4 m; (d) 10.5 m
32	(a) $a\hat{i} + a\hat{j} + a\hat{k}$; (b) $-a\hat{i} + a\hat{j} + a\hat{k}$; (c) $a\hat{i} - a\hat{j} + a\hat{k}$; (d) $-a\hat{i} - a\hat{j} + a\hat{k}$; (e) 54.7°; (f) $3^{0.5}a$

33	(a) 12; (b) +z; (c) 12; (d) -z; (e) 12; (f) +z
34	(a) $2.0\hat{k}$; (b) 26; (c) 46; (d) 5.8
35	(a) –18.8 units; (b) 26.9 units, +z direction
36	0
37	(a) –21; (b) –9; (c) $5\hat{i} - 11\hat{j} - 9\hat{k}$
38	540
39	70.5°
40	(a) 2.81 m^2; (b) $(1.43\ m^2)\hat{i} + (4.86\ m^2)\hat{j} - (2.48\ m^2)\hat{k}$; (c) 63.5°
41	22°
42	(a) $31\hat{k}$; (b) 8.0; (c) 33; (d) 1.6
43	(a) 3.00 m; (b) 0; (c) 3.46 m; (d) 2.00 m; (e) –5.00 m; (f) 8.66 m; (g) –6.67; (h) 4.33
44	$-3.0\hat{i} - 3.0\hat{j} - 4.0\hat{k}$
45	(a) –83.4; (b) $(1.14 \times 10^3)\hat{k}$; (c) 1.14×10^3, θ not defined, $\phi = 0°$; (d) 90.0°; (e) $-5.14\hat{i} + 6.13\hat{j} + 3.00\hat{k}$; (f) 8.54, $\theta = 130°$, $\phi = 69.4°$
46	(a) 4.2 m; (b) 50° north of due east; (c) 8.0 m; (d) 24° north of due west

47	(a) 140°; (b) 90.0°; (c) 99.1°
48	(a) 57°; (b) 2.2 m; (c) –4.5 m; (d) –2.2 m; (e) 4.5 m
49	(a) 103 km; (b) 60.9° north of due west
50	(a) +*x* direction; (b) +*y* direction; (c) 0; (d) 0; (e) +*z* direction; (f) –*z* direction; (g) d_1d_2; (h) d_1d_2; (i) $d_1d_2/4$; (j) +*z* direction
51	(a) 27.8 m; (b) 13.4 m
52	(a) $(9.0\text{ m})\hat{i} + (6.0\text{ m})\hat{j} - (7.0\text{ m})\hat{k}$; (b) 123°; (c) –3.2 m; (d) 8.2 m
53	(a) 30; (b) 52
54	(a) 0; (b) –16; (c) –9
55	(a) –2.83 m; (b) –2.83 m; (c) 5.00 m; (d) 0; (e) 3.00 m; (f) 5.20 m; (g) 5.17 m; (h) 2.37 m; (i) 5.69 m; (j) 25° north of due east; (k) 5.69 m; (l) 25° south of due west

56	(a) $(10.0\ \text{m})\hat{i} + (1.63\ \text{m})\hat{j}$; (b) 10.2 m; (c) 9.24°
57	4.1
58	(a) 10 m; (b) north; (c) 7.5 m; (d) south
59	(a) $(9.19\ \text{m})\hat{i}' + (7.71\ \text{m})\hat{j}'$; (b) $(14.0\ \text{m})\hat{i}' + (3.41\ \text{m})\hat{j}'$
60	(a) $9\hat{i} + 12\hat{j}$; (b) $3\hat{i} + 4\hat{j}$
61	(a) $11\hat{i} + 5.0\hat{j} - 7.0\hat{k}$; (b) 120°; (c) –4.9; (d) 7.3
62	(a) 1.8 m; (b) 69° north of due east
63	(a) 3.0 m^2; (b) 52 m^3; (c) $(11\ m^2)\hat{i} + (9.0\ m^2)\hat{j} + (3.0\ m^2)\hat{k}$
64	(a) 6.42 m; (b) no; (c) yes; (d) yes; (e) a possible answer: $(4.30\ \text{m})\hat{i} + (3.70\ \text{m})\hat{j} + (3.00\ \text{m})\hat{k}$; (f) 7.96 m
65	(a) $(-40\hat{i} - 20\hat{j} + 25\hat{k})$ m; (b) 45 m
66	(a) $+y$; (b) $-y$; (c) 0; (d) 0; (e) $+z$; (f) $-z$; (g) ab (h) ab; (i) ab/d; (j) $+z$
67	(a) 0; (b) 0; (c) –1; (d) west; (e) up; (f) west

68	Walpole (where the state prison is located)
69	(a) 168 cm; (b) 32.5°
70	(a) 370 m; (b) 36° north of due east; (c) 425 m; (d) the distance
71	(a) 15 m; (b) south; (c) 6.0 m; (d) north
72	(a) –28 cm; (b) –28 cm; (c) 50 cm; (d) 0; (e) 30 cm; (f) 52 cm; (g) 52 cm; (h) 24 cm; (i) 57 cm; (j) 25° north of east; (k) 57 cm; (l) 25° south of west
73	(a) $2\hat{k}$; (b) 26; (c) 46; (d) 5.81
74	(a) 2.97; (b) $1.51\hat{i} + 2.67\hat{j} - 1.36\hat{k}$; (c) 48.5°
75	(a) up; (b) west; (c) south; (d) 1; (e) 0
76	3.6 m
77	(a) $(1300\text{ m})\hat{i} + (2200\text{ m})\hat{j} - (410\text{ m})\hat{k}$; (b) 2.56×10^3 m
78	36.6
79	8.4

Chapter 4 Answers

1	(a) 6.2 m
2	(a) $(-5.0\text{ m})\hat{i} + (8.0\text{ m})\hat{j}$; (b) 9.4 m; (c) 122°; (e) $(8.0\text{ m})\hat{i} - (8.0\text{ m})\hat{j}$; (f) 11 m; (g) –45°
3	$(-2.0\text{ m})\hat{i} + (6.0\text{ m})\hat{j} - (10\text{ m})\hat{k}$

4	(a) 14 cm; (b) –135°; (c) 20 cm; (d) 90°; (e) 0; (f) 0
5	(a) 7.59 km/h; (b) 22.5° east of due north
6	(a) $(3.00\ \text{m/s})\hat{\mathbf{i}} - (8.00\ \text{m/s}^2)t\hat{\mathbf{j}}$; (b) $(3.00\ \text{m/s})\hat{\mathbf{i}} - (16.0\ \text{m/s})\hat{\mathbf{j}}$; (c) 16.3 m/s; (d) –79.4°
7	$(-0.70\ \text{m/s})\hat{\mathbf{i}} + (1.4\ \text{m/s})\hat{\mathbf{j}} - (0.40\ \text{m/s})\hat{\mathbf{k}}$
8	(a) 1.08×10^3 km; (b) 26.6° east of due south; (c) 480 km/h; (d) 26.6° east of due south; (e) 644 km/h
9	(a) 0.83 cm/s; (b) 0°; (c) 0.11 m/s; (d) -63°
10	(a) 3.50 m/s; (b) $-0.125\ \text{m/s}^2$
11	(a) $(6.00\ \text{m})\hat{\mathbf{i}} - (106\ \text{m})\hat{\mathbf{j}}$; (b) $(19.0\ \text{m/s})\hat{\mathbf{i}} - (224\ \text{m/s})\hat{\mathbf{j}}$; (c) $(24.0\ \text{m/s}^2)\hat{\mathbf{i}} - (336\ \text{m/s}^2)\hat{\mathbf{j}}$; (d) –85.2°
12	(a) 56.6 m; (b) 45° north of due west (NW); (c) 1.89 m/s; (d) 45° north of due west (NW); (e) $0.471\ \text{m/s}^2$; (f) 45° north of due east (NE)
13	(a) $(8\ \text{m/s}^2)t\hat{\mathbf{j}} + (1\ \text{m/s})\hat{\mathbf{k}}$; (b) $(8\ \text{m/s}^2)\hat{\mathbf{j}}$
14	(a) $(-1.5\ \text{m/s}^2)\hat{\mathbf{i}} + (0.50\ \text{m/s}^2)\hat{\mathbf{k}}$; (b) $1.6\ \text{m/s}^2$; (c) 162°
15	(a) $(-1.50\ \text{m/s})\hat{\mathbf{j}}$; (b) $(4.50\ \text{m})\hat{\mathbf{i}} - (2.25\ \text{m})\hat{\mathbf{j}}$
16	(a) $(-18\ \text{m/s}^2)\hat{\mathbf{i}}$; (b) 0.75 s; (c) never; (d) 2.2 s

17	$(32\ \text{m/s})\hat{i}$
18	(a) 15.8 m/s; (b) 42.6°
19	(a) $(72.0\ \text{m})\hat{i} + (90.7\ \text{m})\hat{j}$; (b) 49.5°
20	60°
21	(a) 18 cm; (b) 1.9 m
22	(a) 0.495 s; (b) 3.07 m/s
23	(a) 3.03 s; (b) 758 m; (c) 29.7 m/s
24	25.9 cm
25	43.1 m/s (155 km/h)
26	(a) 16.9 m; (b) 8.21 m; (c) 27.6 m; (d) 7.26 m; (e) 40.2 m; (f) 0
27	(a) 10.0 s; (b) 897 m
28	(a) 51.8 m; (b) 27.4 m/s; (c) 67.5 m
29	78.5°
30	5.8 m/s
31	3.35 m
32	(a) 12.0 m; (b) 19.2 m/s; (c) 4.80 m/s; (d) no
33	(a) 202 m/s; (b) 806 m; (c) 161 m/s; (d) –171 m/s
34	(a) 21.4 m/s; (b) 24.9 m/s; (c) 16.3%
35	4.84 cm
36	(a) yes; (b) 20 cm; (c) no; (d) 86 cm

37	(a) 1.60 m; (b) 6.86 m; (c) 2.86 m
38	(a) 95 m; (b) 31 m
39	(a) 32.3 m; (b) 21.9 m/s; (c) 40.4°; (d) below
40	(a) 24.95 m; (b) 25.02 m
41	56.4º error. This should be 55.5º
42	(a) 5.3 m; (b) 7.9 m; (c) 69 m
43	(a) 11 m; (b) 23 m; (c) 17 m/s; (d) 63°
44	(a) 0.205 s; (b) 0.205 s; (c) 20.5 cm; (d) 61.5 cm
45	(a) ramp; (b) 5.82 m; (c) 31.0°
46	70.7%
47	(a) yes; (b) 2.56 m
48	(a) 33.7 m; (b) 26.0 m/s; (c) 71.1°
49	(a) 31°; (b) 63°
50	(a) 20 m/s; (b) 36 m/s; (c) 74 m
51	(a) 2.3°; (b) **1.1** m; (c) 18°
52	14°
53	(a) 75.0 m; (b) 31.9 m/s; (c) 66.9°; (d) 25.5 m
54	42 m/s
55	the third
56	(a) 7.49 km/s; (b) 8.00 m/s^2

57	(a) 7.32 m; (b) west; (c) north
58	(a) 0.94 m; (b) 19 m/s; (c) 2.4 km/s^2; (d) 50 ms
59	(a) 12 s; (b) 4.1 m/s^2; (c) down; (d) 4.1 m/s^2; (e) up
60	(a) 0; (b) 0
61	(a) 1.3×10^5 m/s; (b) 7.9×10^5 m/s^2; (c) increase
62	4.0 m/s^2
63	2.92 m
64	(a) 4.00 m; (b) 6.00 m
65	(3.00 m/s^2)$\hat{i}$ + (6.00 m/s^2)$\hat{j}$
66	(a) 8.82 m; (b) 6.00 m
67	160 m/s^2
68	(a) 5.24 m/s^2; (b) 3.33 m/s^2
69	(a) 13 m/s^2; (b) eastward; (c) 13 m/s^2; (d) eastward
70	(a) 5 km/h; (b) +x; (c) 1 km/h; (d) –x
71	1.67
72	130°
73	(a) (80 km/h)$\hat{i}$ - (60 km/h)$\hat{j}$; (b) 0°; (c) answers do not change
74	240 km/h
75	32 m/s
76	(a) 185 km/h; (b) 22° south of due west
77	60°

78	(a) 24.8 m/s; (b) 83.8° north of due east; (c) 0.40 m/s^2; (d) 60.0° north of due east
79	(a) 38 knots; (b) 1.5° east of due north; (c) 4.2 h; (d) 1.5° west of due south
80	(a) 7.2 m/s; (b) 16° west of due north; (c) 29 s (not 28 s)
81	(a) (-32 km/h)$\hat{i}$ - (46 km/h)$\hat{j}$; (b) [(2.5 km) – (32 km/h)t]$\hat{i}$ + [(4.0 km) – (46 km/h)t]$\hat{j}$; (c) 0.084 h; (d) 2×10^2 m
82	(a) 37° west of due north; (b) 62.6 s
83	(a) –30°; (b) 69 min; (c) 80 min; (d) 80 min; (e) 0°; (f) 60 min
84	(a) 10 m/s; (b) 19.6 m/s; (c) 40 m; (d) 40 m
85	(a) 2.7 km; (b) 76° clockwise
86	(a) 1030 m; (b) west
87	(a) 44 m; (b) 13 m; (c) 8.9 m
88	143 km/h
89	(a) 45 m; (b) 22 m/s
90	23 ft/s
91	(a) 2.6×10^2 m/s; (b) 45 s; (c) increase
92	(a) 19 m/s; (b) 35 rev/min; (c) 1.7 s

93	(a) 63 km; (b) 18° south of due east; (c) 0.70 km/h; (d) 18° south of due east; (e) 1.6 km/h; (f) 1.2 km/h; (g) 33° north of due east
94	(a) A: 10.1 km, 0.556 km; B: 12.1 km, 1.51 km; C: 14.3 km, 2.68 km; D: 16.4 km, 3.99 km; E: 18.5 km, 5.53 km; (b) the rocks form a curtain that curves upward and away from you
95	(a) 1.5; (b) (36 m, 54 m)
96	(a) 20.3 m/s; (b) 21.7 m/s
97	(a) 62 ms; (b) 4.8×10^2 m/s
98	$(-2.69 \text{ m/s})\hat{i} + (-1.80 \text{ m/s})\hat{j}$
99	2.64 m
100	$(-2.1 \text{ m/s}^2)\hat{i} + (2.8 \text{ m/s}^2)\hat{j}$
101	(a) 2.5 m; (b) 0.82 m; (c) 9.8 m/s^2; (d) 9.8 m/s^2
102	(a) 6.7×10^6 m/s; (b) 1.4×10^{-7} s
103	(a) 6.79 km/h; (b) 6.96°
104	7.0 m/s
105	(a) 16 m/s; (b) 23°; (c) above; (d) 27 m/s; (e) 57°; (f) below
106	(a) $(-7.0 \text{ m})\hat{i} + (12 \text{ m})\hat{j}$; (b) *xy* plane

107	(a) 4.2 m, 45°; (b) 5.5 m, 68°; (c) 6.0 m, 90°; (d) 4.2 m, 135°; (e) 0.85 m/s, 135°; (f) 0.94 m/s, 90°; (g) 0.94 m/s, 180°; (h) 0.30 m/s^2, 180°; (i) 0.30 m/s^2, 270°
108	(a) 7.3 km; (b) 80 km/h
109	(a) 5.4×10^{-13} m; (b) decrease
110	36 s, no
111	(a) 0.034 m/s^2; (b) 84 min
112	longer by about 1 cm
113	(a) 8.43 m; (b) –129°
114	(a) 0, 0; 2.0 m, 1.4 m; 4.0 m, 2.0 m; 6.0 m, 1.4 m; 8.0 m, 0; (b) 2.0 m/s, 1.1 m/s; 2.0 m/s, 0; 2.0 m/s, -1.1 m/s; (c) 0, -0.87 m/s^2; 0, -1.2 m/s^2; 0, -0.87 m/s^2
115	(a) 2.00 ns; (b) 2.00 mm; (c) 1.00×10^7 m/s; (d) 2.00×10^6 m/s
116	(a) 76 m; (b) 4.2 s
117	(a) 24 m/s; (b) 65°
118	48 s
119	93° from the car’s direction of motion
120	(a) 22 m; (b) 15 s
121	(a) 4.6×10^{12} m; (b) 2.4×10^5 s
122	(a) 55.6°; (b) 6.85 m; (c) 6.78 m/s
123	(a) 6.29°; (b) 83.7°

124	(c) 2.10 s; (d) 25.7 m; (e) 25.7 m; (f) 0; (g) 1.71 s; (h) 13.5 m; (i) 4.76 m; (j) 12.6 m
125	3×10^1 m
126	(a) 14 m/s; (b) 14 m/s; (c) -10 m; (d) -4.9 m; (e) +10 m; (f) -4.9 m
127	(a) $(6.0\hat{i} + 4.2\hat{j})$ m/s; (b) $(18\hat{i} + 6.3\hat{j})$ m
128	67 km/h
129	(a) 38 ft/s; (b) 32 ft/s; (c) 9.3 ft
130	(a) from 75° east of due south; (b) 30° east of due north. For a second set of solutions, substitute west for east in both answers.
131	(a) 11 m; (b) 45 m/s
132	(a) $(10\hat{i} + 10\hat{j})$ m/s; (b) 8.0 m/s^2; (c) 2.7 s; (d) 2.2 s
133	(a) 5.8 m/s; (b) 17 m; (c) 67°
134	(a) 48 m, west of center; (b) 48 m, west of center
135	(a) 32.4 m; (b) -37.7 m
136	(a) 96.2 m; (b) 4.31 m; (c) 86.5 m, 25.1 m
137	88.6 km/h
138	(a) -30°; (b) 69 min; (c) 80 min; (d) 80 min; (e) 0°; (f) 60 min

Chapter 5 Answers

1	2.9 m/s^2
2	(a) 0; (b) $(4.0 \text{ m/s}^2)\hat{j}$; (c) $(3.0 \text{ m/s}^2)\hat{i}$

3	(a) 1.88 N; (b) 0.684 N; (c) $(1.88\ \text{N})\hat{i} + (0.684\ \text{N})\hat{j}$
4	$(-2\ \text{N})\hat{i} + (6\ \text{N})\hat{j}$
5	(a) $(0.86\ \text{m/s}^2)\hat{i} - (0.16\ \text{m/s}^2)\hat{j}$; (b) 0.88 m/s²; (c) –11°
6	241 N
7	(a) $(-32.0\ \text{N})\hat{i} - (20.8\ \text{N})\hat{j}$; (b) 38.2 N; (c) -147°
8	$(-34\hat{i} - 12\hat{j})$ N
9	(a) 8.37 N; (b) -133°; (c) -125°
10	$(-7.98\ \text{N})\hat{i}$
11	9.0 m/s^2
12	56°
13	(a) 4.0 kg; (b) 1.0 kg; (c) 4.0 kg; (d) 1.0 kg
14	(a) 2.0 N; (b) down
15	(a) 108 N; (b) 108 N; (c) 108 N
16	(a) 0.26; (b) decrease
17	(a) 42 N; (b) 72 N; (c) 4.9 m/s^2
18	0.22 m/s
19	1.2×10^5 N
20	6.8×10^3 N
21	(a) 11.7 N; (b) –59.0°
22	(a) $-9.80\hat{j}$ m/s^2; (b) $2.35\hat{j}$ m/s^2; (c) 1.37 s; (d) $(-5.56 \times 10^{-3}\ \text{N})\hat{j}$; (e) $(1.333 \times 10^{-3}\ \text{N})\hat{j}$
23	(a) $(285\ \text{N})\hat{i} + (705\ \text{N})\hat{j}$; (b) $(285\ \text{N})\hat{i} - (115\ \text{N})\hat{j}$; (c) 307 N; (d) –22.0°; (e) 3.67 m/s^2; (f) –22.0°

24	(a) 0; (b) (20 N)$\hat{i}$; (c) (-20 N)$\hat{i}$; (d) (-40 N)$\hat{i}$; (e) (-60 N)$\hat{i}$;
25	(a) 0.022 m/s^2; (b) 8.3×10^4 km; (c) 1.9×10^3 m/s
26	3.1×10^2 N
27	1.5 mm
28	(a) 5.5 kN; (b) 2.7 s; (c) 4.0; (d) 2.0
29	(a) 494 N; (b) up; (c) 494 N; (d) down
30	2.1×10^2 N
31	(a) 1.18 m; (b) 0.674 s; (c) 3.50 m/s
32	(a) (1.70 N)$\hat{i}$ + (3.06 N)$\hat{j}$; (b) (1.70 N)$\hat{i}$ + (3.06 N)$\hat{j}$; (c) (2.02 N)$\hat{i}$ + (2.71 N)$\hat{j}$
33	1.8×10^4 N
34	(a) 566 N; (b) 1.13 kN
35	(a) 46.7°; (b) 28.0°
36	(a) 68 N; (b) 73 N
37	(a) 0.62 m/s^2; (b) 0.13 m/s^2; (c) 2.6 m
38	(a) +68 N; (b) +28 N; (c) -12 N
39	(a) 2.2×10^{-3} N; (b) 3.7×10^{-3} N
40	47.4 N
41	(a) 1.4 m/s^2; (b) 4.1 m/s
42	(a) 6.8 kN; (b) 201°

43	(a) 1.23 N; (b) 2.46 N; (c) 3.69 N; (d) 4.92 N; (e) 6.15 N; (f) 0.250 N
44	(a) 7.3 kg; (b) 89 N
45	(a) 31.3 kN; (b) 24.3 kN
46	16.0 kN
47	6.4×10^3 N
48	176 N
49	(a) 2.18 m/s^2; (b) 116 N; (c) 21.0 m/s^2
50	(a) 36.8 N; (b) 19.1 cm
51	(a) 3.6 m/s^2; (b) 17 N
52	5.1 m/s
53	(a) 0.970 m/s^2; (b) 11.6 N; (c) 34.9 N
54	23 kg
55	(a) 1.1 N
56	(a) 2.50 m/s^2; (b) 30.0 N
57	(a) 0.735 m/s^2; (b) down; (c) 20.8 N
58	(a) 466 N; (b) 527 N; (c) 931 N; (d) 1.05 kN; (e) 931 N; (f) 1.05 kN; (g) 1.86 kN; (h) 2.11 kN
59	(a) 4.9 m/s^2; (b) 2.0 m/s^2; (c) up; (d) 120 N

60	(a) -5.90×10^{-4} m/s^3; (b) 5.90×10^{-4} m/s^3
61	$2Ma/(a + g)$
62	(a) 12.76 m/s; (b) 12.54 m/s; (c) 1.69%
63	(a) 8.0 m/s; (b) $+x$
64	(a) 3.1 N; (b) 15 N
65	(a) 0.653 m/s^3; (b) 0.896 m/s^3; (c) 6.50 s
66	18 kN
67	81.7 N
68	334.8 N
69	2.4 N
70	(a) 245 m/s^2; (b) 20.4 kN
71	16 N
72	$(3\text{ N})\hat{i} - (11\text{ N})\hat{j} + (4\text{ N})\hat{k}$
73	(a) 2.6 N; (b) 17°
74	2.2 kg
75	(a) 0; (b) 0.83 m/s^2; (c) 0
76	(b) $F/(m + M)$; (c) $FM/(m + M)$; (d) $F(m + 2M)/2(m + M)$
77	(a) 0.74 m/s^2; (b) 7.3 m/s^2
78	4.6 N
79	(a) 11 N; (b) 2.2 kg; (c) 0; (d) 2.2 kg
80	(a) 620 N; (b) 580 N
81	195 N
82	(a) $(1.0\hat{i} - 1.3\hat{j})$ m/s^2; (b) 1.6 m/s^2; (c) –50°
83	(a) 4.6 m/s^2; (b) 2.6 m/s^2
84	(a) $\cos\theta$; (b) $(\cos\theta)^{0.5}$

85	(a) rope breaks' (b) 1.6 m/s^2
86	(a) 7.4×10^2 N; (b) 2.8×10^2 N; (c) 0; (d) 75 kg
87	(a) 65 N; (b) 49 N
88	(a) 3260 N; (b) 2.7×10^3 kg; (c) 1.2 m/s^2
89	(a) 4.6×10^3 N; (b) 5.8×10^3 N
90	(a) 1.2×10^2 m/s^2; (b) 12*g*; (c) 1.4×10^8 N; (d) 4.2 y
91	(a) 1.8×10^2 N; (b) 6.4×10^2 N
92	10 m/s^2
93	(a) 44 N; (b) 78 N; (c) 54 N; (d) 152 N
94	(a) (5.0 m/s)$\hat{i}$ + (4.3 m/s)$\hat{j}$; (b) (15 m)$\hat{i}$ + (6.4 m)$\hat{j}$
95	(a) 4 kg; (b) 6.5 m/s^2; (c) 13 N
96	16 N
97	(a) (1.0$\hat{i}$ - 2.0$\hat{j}$) N; (b) 2.2 N; (c) -63°; (d) 2.2 m/s^2; (e) -63°

Chapter 6 Answers

1	36 m
2	0.58
3	(a) 2.0×10^2 N; (b) 1.2×10^2 N
4	0.53

5	(a) 6.0 N; (b) 3.6 N; (c) 3.1 N
6	0.61
7	(a) 1.9×10^2 N; (b) 0.56 m/s^2
8	1.6×10^2 N
9	(a) 11 N; (b) 0.14 m/s^2
10	(a) 0; (b) 2.17 m/s^2
11	(a) 3.0×10^2 N; (b) 1.3 m/s^2
12	2.8×10^2 N
13	(a) 1.3×10^2 N; (b) no; (c) 1.1×10^2 N; (d) 46 N; (e) 17 N
14	(b) 3.0×10^7 N
15	2°
16	(a) 8.6 N; (b) 46 N; (c) 39 N
17	(a) (17 N)$\hat{i}$; (b) (20 N)$\hat{i}$; (c) (15 N)$\hat{i}$
18	(a) 12.1 m/s; (b) 19.4 m/s
19	(a) no; (b) (-12 N)$\hat{i}$ + (5.0 N)$\hat{j}$
20	8.5 N
21	(a) 19°; (b) 3.3 kN
22	18º
23	0.37
24	0.54
25	1.0×10^2 N
26	(a) 147 N; (b) same
27	(a) 0; (b) (-3.9 m/s^2)$\hat{i}$; (c) (-1.0 m/s^2) $\hat{i}$
28	3.3 kg
29	(a) 66 N; (b) 2.3 m/s^2

30	(a) 74 N; (b) (76 N)/(cos θ + 0.42 sin θ); (c) 23°; (d) 70 N
31	(a) 3.5 m/s^2; (b) 0.21 N
32	60º
33	9.9 s
34	(a) (-6.1 m/s^2)$\hat{i}$; (b) (-0.98 m/s^2)$\hat{i}$
35	4.9×10^2 N
36	3.75
37	(a) 3.2×10^2 km/h; (b) 6.5×10^2 km/h; (c) no
38	(a) 2×10^4 N; (b) 18*g*
39	2.3
40	(a) 66.0 m/s; (b) -2.20×10^2 *dC*
41	0.60
42	48 km/h
43	21 m
44	9.7*g*
45	(a) light; (b) 778 N; (c) 223 N; (d) 1.11 kN
46	(a) 547 N; (b) 9.53°
47	(a) 10 s; (b) 4.9×10^2 N; (c) 1.1×10^3 N
48	(a) 3.7 kN; (b) up; (c) 1.3 kN; (d) down
49	1.37×10^3 N
50	(a) 4.03×10^2 N·s/m; (b) -1.50×10^3 N/s
51	2.2 km
52	(a) 3.7 kN; (b) up; (c) 2.3 kN; (d) down

53	12°
54	(a) $-(mv^2/r^2)\,dr$; (b) $(2mv/r)\,dv$; (c) $-(mv^3/\pi r^2)\,dT$
55	2.6×10^3 N
56	0.078
57	1.81 m/s
58	(a) 8.0×10^3 N; (b) 6.9×10^3 N; (c) 20 m/s; (d) 1.6×10^4 N; (e) no
59	(a) 8.74 N; (b) 37.9 N; (c) 6.45 m/s; (d) radially inward
60	(a) 1.05 N; (b) 3.62 m/s^2; (c) answers are the same except that the rod is under compression
61	(a) 27 N; (b) 3.0 m/s^2
62	118 N
63	(b) 240 N; (c) 0.60
64	(a) 210 N; (b) 44.0 m/s
65	(a) 69 km/h; (b) 139 km/h; (c) yes
66	8.8 N
67	$g(\sin\theta - 2^{0.5}\mu_k \cos\theta)$
68	(a) $v_{max} = [Rg(\tan\theta + \mu_s)/(1 - \mu_s \tan\theta)]^{0.5}$; (c) 149 km/h; (d) 76.2 km/h
69	3.4 m/s^2
70	(a) 0.40 N; (b) 1.9 s
71	(a) 35.3 N; (b) 39.7 N; (c) 320 N
72	0.74
73	(a) 7.5 m/s^2; (b) down; (c) 9.5 m/s^2; (d) down

74	(a) 0.13 N; (b) 0.12
75	(a) 3.0×10^5 N; (b) 1.2°
76	20°
77	147 m/s
78	(a) 0.58; (b) 0.54
79	(a) 13 N; (b) 1.6 m/s^2
80	6.2 kN
81	(a) 275 N; (b) 877 N
82	178 km/h
83	(a) 84.2 N; (b) 52.8 N; (c) 1.87 m/s^2
84	(b) 55°; (c) increase; (d) 59°
85	3.4%
86	(a) lowest point; (b) 8.73 m/s
87	(a) 3.21×10^3 N; (b) yes old answer: 3.75×10^3 N
88	9.4 N
89	(a) 222 N; (b) 334 N; (c) 311 N; (d) 311 N; (e) c, d
90	(a) 12 N; (b) 10 N; (c) 26 N; (d) 23 N; (e) 32 N; (f) 23 N; (g) d; (h) f; (i) a, c, d
91	(a) $v_0^2/(4g \sin \theta)$; (b) no

92	(a) 11°; (b) 0.19
93	(a) 0.34; (b) 0.24
94	(a) 0.37; (b) $0.37 < \mu_s < 0.47$
95	(a) $\mu_k mg/(\sin\theta - \mu_k \cos\theta)$; (b) $\theta_0 = \tan^{-1}\mu_s$
96	(a) 0.96 m/s; (b) 0.021
97	0.18
98	(a) 2.1 m/s^2; (b) down the plane; (c) 3.9 m; (d) at rest
99	(a) 56 N; (b) 59 N; (c) 1.1×10^3 N
100	(a) 0.11 m/s^2; (b) 0.23 m/s^2; (c) 0.041; (d) 0.029
101	0.76
102	(a) 100 N; (b) 245 N; (c) 86.6 N; (d) 195 N; (e) 50.0 N; (f) 158 N; (g) at rest; (h) slides; (i) at rest
103	(a) bottom of circle; (b) 9.5 m/s
104	(a) 6.80 s; (b) 6.76 s
105	0.56

Chapter 7 Answers

1	(a) 2.9×10^7 m/s; (b) 2.1×10^{-13} J
2	1.8×10^{13} J

3	(a) 5×10^{14} J; (b) 0.1 megaton TNT; (c) 8 bombs
4	(a) 1×10^{5} megatons TNT; (b) 1×10^{7} bombs
5	(a) 2.4 m/s; (b) 4.8 m/s
6	7.1 J
7	0.96 J
8	5.0 kJ
9	20 J
10	6.8 J
11	(a) 62.3°; (b) 118°
12	(a) 3.00 N; (b) 9.00 J
13	(a) 1.7×10^{2} N; (b) 3.4×10^{2} m; (c) -5.8×10^{4} J; (d) 3.4×10^{2} N; (e) 1.7×10^{2} m; (f) -5.8×10^{4} J
14	15.3 J
15	(a) 1.50 J; (b) increases
16	3.5 m/s
17	(a) 12 kJ; (b) -11 kJ; (c) 1.1 kJ; (d) 5.4 m/s
18	(a) 36 kJ; (b) 2.0×10^{2} J
19	25 J
20	45 N
21	(a) $-3Mgd/4$; (b) Mgd; (c) $Mgd/4$; (d) $(gd/2)^{0.5}$
22	(a) 8.84 kJ; (b) 7.84 kJ; (c) 6.84 kJ
23	4.41 J
24	(a) 1.31 J; (b) 0.935 m/s

25	(a) 25.9 kJ; (b) 2.45 N
26	x = -4.9 cm and x = +4.9 cm
27	(a) 7.2 J; (b) 7.2 J; (c) 0; (d) –25 J
28	1.25 kJ
29	(a) 0.90 J; (b) 2.1 J; (c) 0
30	(a) 8.0 N; (b) 8.0 N/m
31	(a) 6.6 m/s; (b) 4.7 m
32	(a) 16 J; (b) 16 J; (c) 0; (d) –14 J
33	(a) 0.12 m; (b) 0.36 J; (c) –0.36 J; (d) 0.060 m; (e) 0.090 J
34	8.0×10^2 J
35	(a) 0; (b) 0
36	25 J
37	(a) 42 J; (b) 30 J; (c) 12 J; (d) 6.5 m/s, +x axis; (e) 5.5 m/s, +x axis; (f) 3.5 m/s, +x axis
38	(a) 2.3 J; (b) 2.6 J
39	4.00 N/m
40	0.21 J
41	5.3×10^2 J
42	+41.7 J
43	(a) 0.83 J; (b) 2.5 J; (c) 4.2 J; (d) 5.0 W

44	(a) 9.0×10^2 J; (b) 1.1×10^2 W; (c) 2.3×10^2 W
45	4.9×10^2 W
46	2.7×10^5 W
47	(a) 1.0×10^2 J; (b) 8.4 W
48	(a) 0; (b) -3.5×10^2 W
49	7.4×10^2 W
50	(a) 28 W; (b) (6 m/s)$\hat{j}$
51	(a) 32.0 J; (b) 8.00 W; (c) 78.2°
52	(-*T*/3P) *dP*
53	(a) 1.20 J; (b) 1.10 m/s
54	(a) 12 J; (b) 4.0 m; (c) 18 J
55	(a) 1.8×10^5 ft·lb; (b) 0.55 hp
56	(a) 1.0×10^2 J; (b) 67 W; (c) 33 W
57	(a) 797 N; (b) 0; (c) –1.55 kJ; (d) 0; (e) 1.55 kJ; (f) *F* varies during displacement
58	(a) 590 J; (b) 0; (c) 0; (d) 590 J
59	(a) 11 J; (b) –21 J
60	(a) 2.1×10^2 J; (b) 2.1×10^2 J
61	-6 J
62	(a) 0.29 J; (b) -1.8 J; (c) 3.5 m/s; (d) 23 cm

63	(a) 314 J; (b) –155 J; (c) 0; (d) 158 J
64	(a) 1.7 W; (b) 0; (c) -1.7 W
65	(a) 98 N; (b) 4.0 cm; (c) 3.9 J; (d) -3.9 J
66	6.67×10^5 J
67	(a) 23 mm; (b) 45 N
68	1.5 kJ
69	165 kW
70	(a) 6.0 N; (b) -2.5 N; (c) 15 N
71	-37 J
72	(a) $v_f = (\cos \theta)^{0.5}$, with v_f in meters per second; (b) $v_f = (1 + \cos \theta)^{0.5}$; (c) $v_f = (1 - \cos \theta)^{0.5}$
73	(a) 13 J; (b) 13 J
74	(a) $c = 4$ m; (b) $c < 4$ m; (c) $c > 4$ m
75	235 kW
76	(a) 2.7×10^2 N; (b) -4.0×10^2 J; (c) 4.0×10^2 J; (d) 0; (e) 0
77	(a) 6 J; (b) 6.0 J
78	(b) $x = 3.00$ m; (c) 13.5 J; (d) $x = 4.50$ m; (e) $x = 4.50$ m
79	(a) 0.6 J; (b) 0; (c) –0.6 J
80	0.47 J
81	(a) 3.35 m/s; (b) 22.5 J; (c) 0; (d) 0; (e) 0.200 m

82	4.44 m/s
83	(a) -5.20 $\times$ 10^{-2} J; (b) -0.160 J
84	(a) 41.7 J; (b) 19.8 W; (c) 79.8°
85	6.63 m/s

Chapter 8 Answers

1	89 N/cm
2	(a) 0; (b) 170 kJ; (c) 340 kJ; (d) 170 kJ; (e) 340 kJ; (f) increase
3	(a) 167 J; (b) -167 J; (c) 196 J; (d) 29 J; (e) 167 J; (f) -167 J; (g) 296 J; (h) 129 J
4	(a) 1.51 J; (b) –1.51 J; (c) 0; (d) –1.51 J; (e) 1.51 J; (f) 0; (g) same
5	(a) 4.31 mJ; (b) -4.31 mJ; (c) 4.31 mJ; (d) -4.31 mJ; (e) all increase

6	(a) 0.15 J; (b) 0.11 J; (c) 0.19 J; (d) 38 mJ; (e) 75 mJ; (f) all the same
7	(a) 13.1 J; (b) –13.1 J; (c) 13.1 J; (d) all increase
8	(a) 184 J; (b) –184 J; (c) -184 J
9	(a) 17.0 m/s; (b) 26.5 m/s; (c) 33.4 m/s; (d) 56.7 m; (e) all the same
10	(a) 12.9 m/s; (b) 12.9 m/s; (c) increase
11	(a) 2.08 m/s; (b) 2.08 m/s; (c) increase
12	(a) 21.0 m/s; (b) 21.0 m/s; (c) 21.0 m/s
13	(a) 0.98 J; (b) -0.98 J; (c) 3.1 N/cm
14	(a) 2.98 m/s; (b) 4.21 m/s; (c) 2.98 m/s; (d) all the same
15	(a) 2.6×10^2 m; (b) same; (c) decrease
16	(a) 7.2 J; (b) -7.2 J; (c) 86 cm; (d) 26 cm
17	(a) 2.5 N; (b) 0.31 N; (c) 30 cm

18	(a) 2.29 m/s; (b) same
19	(a) 784 N/m; (b) 62.7 J; (c) 62.7 J; (d) 80.0 cm
20	(a) 5.0 m/s; (b) 79°; (c) 64 J
21	(a) 8.35 m/s; (b) 4.33 m/s; (c) 7.45 m/s; (d) both decrease
22	(a) 4.4 m; (b) same
23	(a) 4.85 m/s; (b) 2.42 m/s
24	10 cm
25	-3.2×10^2 J
26	(a) $U = 27 + 12x - 3x^2$; (b) 39 J; (c) –1.6 m; (d) 5.6 m
27	(a) no; (b) 9.3×10^2 N
28	(a) 2.8 m/s; (b) 2.7 m/s
29	(a) 35 cm; (b) 1.7 m/s
30	(a) 0.81 m/s; (b) 0.21 m; (c) 6.3 m/s^2; (d) up
31	(a) 39.2 J; (b) 39.2 J; (c) 4.00 m
32	1.0 Mj
33	(a) 2.40 m/s; (b) 4.19 m/s
34	9.20 m
35	(a) 39.6 cm; (b) 3.64 cm
36	1.25 cm
37	-18 mJ
38	(a) 8.37 m/s; (b) 12.6 m/s; (c) 7.67 m; (d) 1.73 m

39	(a) 2.1 m/s; (b) 10 N; (c) +x direction; (d) 5.7 m; (e) 30 N; (f) -x direction
40	(a) $1.12(A/B)^{1/6}$; (b) repulsive; (c) attractive
41	(a) -3.7 J; (c) 1.3 m; (d) 9.1 m; (e) 2.2 J; (f) 4.0 m; (g) $(4 - x)e^{-x/4}$; (h) 4.0 m
42	(a) 5.6×10^2 J; (b) 5.6×10^2 J
43	(a) 5.6 J; (b) 3.5 J
44	(a) 105 J; (b) 30.6 J; (c) 34.4 J
45	(a) 30.1 J; (b) 30.1 J; (c) 0.225
46	20 ft·lb
47	0.53 J
48	75 J
49	(a) –2.9 kJ; (b) 3.9×10^2 J; (c) 2.1×10^2 N
50	11 kJ
51	(a) 1.5 MJ; (b) 0.51 MJ; (c) 1.0 MJ; (d) 63 m/s
52	(a) 0.292 m; (b) 14.2 J
53	(a) 67 J; (b) 67 J; (c) 46 cm
54	(a) 1.5×10^2 J; (b) 5.5 m/s

55	(a) -0.90 J; (b) 0.46 J; (c) 1.0 m/s
56	0.15
57	1.2 m
58	(a) 13 cm; (b) 2.7 m/s; (c) both increase
59	(a) 19.4 m; (b) 19.0 m/s
60	4.3 m
61	(a) 1.5×10^{-2} N; (b) $(3.8 \times 10^{2})g$
62	3.5 m/s
63	(a) 7.4 m/s; (b) 90 cm; (c) 2.8 m; (d) 15 m
64	H = 30 cm
65	20 cm
66	(a) 94 J; (b) 94 J; (c) 7.7 m/s
67	(a) 7.0 J; (b) 22 J
68	(a) 54 m/s; (b) 52 m/s; (c) -76 m
69	3.7 J
70	0.72 m
71	4.33 m/s
72	(a) 44 m/s; (b) 0.036
73	25 J
74	(a) 6.4 m/s; (b) 4.9 m/s; (c) same
75	(a) 4.9 m/s; (b) 4.5 N; (c) 71°; (d) same

76	(a) 18 J; (b) 0; (c) 30 J; (d) 0; (e) b and d
77	(a) 4.8 N; (b) +*x* direction; (c) 1.5 m; (d) 13.5 m; (e) 3.5 m/s
78	(a) 216 J; (b) 1.18 kN; (c) 432 J; (d) motor also supplies thermal energy to crate and belt
79	(a) 24 kJ; (b) 4.7×10^2 N
80	17 kW
81	(a) 5.00 J; (b) 9.00 J; (c) 11.0 J; (d) 3.00 J; (e) 12.0 J; (f) 2.00 J; (g) 13.0 J; (h) 1.00 J; (i) 13.0 J; (j) 1.00 J; (l) 11.0 J; (m) 10.8 m; (n) It returns to $x = 0$ and stops.
82	(a) 0.950 m/s; (b) 11.0 m
83	(a) 6.0 kJ; (b) 6.0×10^2 W; (c) 3.0×10^2 W; (d) 9.0×10^2 W
84	(a) 31.0 J; (b) 5.35 m/s; (c) conservative
85	880 MW
86	(a) 13 m/s; (b) 11 m/s; (c) no, 9.3 m

87	(a) $v_0 = (2gL)^{0.5}$; (b) $5mg$; (c) $-mgL$; (d) $-2mgL$
88	(a) 6.75 J; (b) –6.75 J; (c) 6.75 J; (d) 6.75 J; (e) –6.75 J; (f) 0.459 m
89	(a) 109 J; (b) 60.3 J; (c) 68.2 J; (d) 41.0 J
90	(a) 2.2 kJ; (b) 7.7×10^2 J
91	(a) 2.7 J; (b) 1.8 J; (c) 0.39 m
92	56 m/s
93	(a) 10 m; (b) 49 N; (c) 4.1 m; (d) 1.2×10^2 N
94	5.5×10^6 N
95	(a) 5.5 m/s; (b) 5.4 m; (c) same
96	(a) 3.5 kJ; (b) 3.5 kJ
97	80 mJ
98	181 W
99	24 W
100	100 m
101	-12 J
102	(a) 7.8 MJ; (b) 6.2 bars
103	(a) 8.8 m/s; (b) 2.6 kJ; (c) 1.6 kW
104	(a) 19 J; (b) 6.4 m/s; (c) 11 J, 6.4 m/s
105	(a) 7.4×10^2 J; (b) 2.4×10^2 J

106	(a) 12 m/s; (b) 11 cm
107	15 J
108	(a) 0.2 to 0.3 MJ; (b) same amount
109	(a) 2.35×10^3 J; (b) 352 J
110	(a) 2.6 m; (b) 1.5 m; (c) 26 J; (d) 2.1 m/s
111	738 m
112	8580 J
113	(a) –3.8 kJ; (b) 31 kN
114	(a) 3.0×10^5 J; (b) 10 kW; (c) 20 kW
115	(a) 300 J; (b) 93.8 J; (c) 6.38 m
116	(a) 39 kW; (b) 39 kW
117	(a) 5.6 J; (b) 12 J; (c) 13 J
118	69 hp
119	(a) 1.2 J; (b) 11 m/s; (c) no; (d) no
120	(a) –0.80 J; (b) –0.80 J; (c) +1.1 J
121	(a) 2.1×10^6 kg; (b) $(100 + 1.5t)^{0.5}$ m/s; (c) $(1.5 \times 10^6)/(100 + 1.5t)^{0.5}$ N; (d) 6.7 km
122	(a) 3.7 J; (b) 4.3 J; (c) 4.3 J
123	54%
124	(a) $U(x) = -Gm_1m_2/x$; (b) $Gm_1m_2d/x_1(x_1 + d)$

125	(a) 2.7×10^9 J; (b) 2.7×10^9 W; (c) $\$2.4 \times 10^8$
126	(a) 1.4 m/s; (b) 1.9 m/s; (c) 28°
127	5.4 kJ
128	(a) 9.2 m/s; (b) 4.8 m/s
129	3.1×10^{11} W
130	(a) 0.75 J; (b) -1.0 J; (c) 0.25 J; (d) 1.0 J; (e) -2.0 J; (f) 1.0 J; (g) 0.75 J; (h) -3.0 J; (i) 2.3 J; (j) 0 J; (k) -4.0 J; (l) 4.0 J
131	because your force on the cabbage (as you lower it) does work
132	(a) 3.0 mm; (b) 1.1 J; (d) yes; (e) ≈ 40 J; (f) no
133	---
134	(a) turning point on left, none on right, molecule breaks apart; (b) turning points on both left and right, molecule does not break apart; (c) -1.1×10^{-19} J; (d) 2.1×10^{-19} J; (e) ≈ 1×10^{-9} N on each, directed toward the other; (f) $r < 0.2$ nm; (g) $r > 0.2$ nm; (h) $r = 0.2$ nm
135	(a) 8.6 kJ; (b) 8.6×10^2 W; (c) 4.3×10^2 W; (d) 1.3 kW

136	(a) 0; (b) 4.48 J; (c) 7.40 J; (d) 8.78 J; (e) 8.60 J; (f) 0.388 m

Chapter 9 Answers

1	(a) -1.50 m; (b) -1.43 m
2	(a) 1.1 m; (b) 1.3 m; (c) toward
3	(a) -6.5 cm; (b) 8.3 cm; (c) 1.4 cm
4	(a) 11 cm; (b) -4.4 cm
5	(a) –0.45 cm; (b) –2.0 cm
6	(a) 20 cm; (b) 20 cm; (c) 16 cm
7	(a) 0; (b) 3.13×10^{-11} m
8	(a) 6.0 cm; (b) 6.0 cm; (c) descends to lowest point and then ascends to 6.0 cm; (d) 4.2 cm
9	(a) 28 cm; (b) 2.3 m/s
10	(a) 22 m; (b) 9.3 m/s
11	$(-4.0\text{ m})\hat{i} + (4.0\text{ m})\hat{j}$
12	6.2 m
13	53 m
14	(a) 5.74 m; (b) $(10.0\text{ m/s})\hat{i}$; (c) $(-3.68\text{ m/s}^2)\hat{j}$
15	(a) $(2.35\hat{i} - 1.57\hat{j})$ m/s^2; (b) $(2.35\hat{i} - 1.57\hat{j})t$ m/s, with t in seconds; (d) straight, at downward angle 34°
16	58 kg
17	4.2 m
18	4.9 kg·m/s

19	(a) 7.5×10^4 J; (b) 3.8×10^4 kg·m/s; (c) 39° south of due east
20	48°
21	(a) 5.0 kg·m/s; (b) 10 kg·m/s
22	(a) 30.0°; (b) (-0.572 kg·m/s)$\hat{j}$
23	1.0×10^3 to 1.2×10^3 kg·m/s
24	(a) 1.1 m; (b) 4.8×10^3 kg·m/s
25	(a) 42 N·s; (b) 2.1 kN
26	(a) 2.2×10^2 N·s; (b) 2.7×10^3 N
27	(a) 67 m/s; (b) -*x*; (c) 1.2 kN; (d) -*x*
28	(a) 9.1 N·s; (b) 1.8×10^3 N
29	5 N
30	(a) 1.00 N·s; (b) 100 N; (c) 20 N
31	(a) 2.39×10^3 N·s; (b) 4.78×10^5 N; (c) 1.76×10^3 N·s; (d) 3.52×10^5 N
32	(a) (30 kg·m/s)$\hat{i}$; (b) (38 kg·m/s)$\hat{i}$; (c) (6.0 m/s)$\hat{i}$
33	(a) 5.86 kg·m/s; (b) 59.8°; (c) 2.93 kN; (d) 59.8°
34	(a) 4.50×10^{-3} N·s; (b) 0.529 N·s; (c) push
35	9.9×10^2 N
36	(a) 7.17 N·s; (b) 16.0 kg·m/s

37	(a) 9.0 kg·m/s; (b) 3.0 kN; (c) 4.5 kN; (d) 20 m/s
38	(a) $(1.8\ \text{N}\cdot\text{s})\hat{j}$; (b) $(-180\ \text{N})\hat{j}$
39	3.0 mm/s
40	4.4×10^3 km/h
41	(a) $-(0.15\ \text{m/s})\hat{i}$; (b) 0.18 m
42	$mv^2/6$
43	55 cm
44	3.4 kg
45	(a) $(1.00\hat{i} - 0.167\hat{j})$ km/s; (b) 3.23 MJ
46	3.5 m/s
47	(a) 14 m/s; (b) 45°
48	(a) 20 J; (b) 40 J
49	3.1×10^2 m/s
50	(a) 1.81 m/s; (b) 4.96 m/s
51	(a) 721 m/s; (b) 937 m/s
52	7.3 cm
53	(a) 33%; (b) 23%; (c) decreases
54	2.6 m
55	(a) +2.0 m/s; (b) -1.3 J; (c) +40 J; (d) system got energy from some source, such as a small explosion
56	(a) 4.6 m/s; (b) 3.9 m/s; (c) 7.5 m/s
57	(a) 4.4 m/s; (b) 0.80
58	33 cm
59	25 cm
60	(a) 1.9 m/s; (b) right; (c) yes

61	(a) 99 g; (b) 1.9 m/s; (c) 0.93 m/s
62	(a) 100 g; (b) 1.0 m/s
63	(a) 3.00 m/s; (b) 6.00 m/s
64	(a) 2.47 m/s; (b) 1.23 m/s
65	(a) 1.2 kg; (b) 2.5 m/s
66	(a) 30 cm; (b) 3.3 m
67	–28 cm
68	(a) 2.22 m; (b) 0.556 m
69	(a) 0.21 kg; (b) 7.2 m
70	1.0 kg
71	(a) 4.15×10^5 m/s; (b) 4.84×10^5 m/s
72	(a) 27°
73	120°
74	(a) $(10 \text{ m/s})\hat{i} + (15 \text{ m/s})\hat{j}$; (b) -500 J
75	(a) 433 m/s; (b) 250 m/s
76	108 m/s
77	(a) 46 N; (b) none
78	(a) 2.7; (b) 7.4
79	(a) 1.57×10^6 N; (b) 1.35×10^5 kg; (c) 2.08 km/s
80	(a) $(-4.0 \times 10^4 \text{ kg·m/s})\hat{i}$; (b) due west; (c) 0
81	(a) 7290 m/s; (b) 8200 m/s; (c) 1.271×10^{10} J; (d) 1.275×10^{10} J
82	6.0×10^2

83	(a) 1.92 m; (b) 0.640 m
84	(a) stuck-together particles travel along *x* axis; (b) one particle along line 2, other along line 3; (c) one particle through region *B*, other through region *C*, with paths symmetric about *x* axis; (d) 3.06 m/s; (e) 4.00 m/s, each particle
85	(a) 1.78 m/s; (b) less; (c) less; (d) greater
86	(a) 7.11 m/s; (b) greater; (c) less; (d) less
87	(a) 3.7 m/s; (b) 1.3 N·s; (c) 1.8×10^2 N
88	41.7 cm/s
89	(a) $(7.4 \times 10^3\ \text{N·s})\hat{i} - (7.4 \times 10^3\ \text{N·s})\hat{j}$; (b) $(-7.4 \times 10^3\ \text{N·s})\hat{i}$; (c) 2.3×10^3 N; (d) 2.1×10^4 N; (e) –45°
90	(a) 1.4×10^{-22} kg·m/s; (b) 28°; (c) 1.6×10^{-19} J
91	+4.4 m/s
92	0.57 m/s
93	1.18×10^4 kg
94	72 km/h
95	(a) 1.9 m/s; (b) -30°; (c) elastic
96	(a) 8.0×10^4 N; (b) 27 kg/s

97	(a) 6.9 m/s; (b) 30°; (c) 6.9 m/s; (d) -30°; (e) 2.0 m/s; (f) –180°
98	(a) $(-0.450\hat{i} - 0.450\hat{j} - 1.08\hat{k})$ kg·m/s; (b) $(-0.450\hat{i} - 0.450\hat{j} - 1.08\hat{k})$ N·s; (c) $(0.450\hat{i} + 0.450\hat{j} + 1.08\hat{k})$ N·s
99	(a) 25 mm; (b) 26 mm; (c) down; (d) 1.6×10^{-2} m/s^2
100	(a) 41.0°; (b) 4.75 m/s; (c) no
101	29 J
102	(a) down; (b) 0.50 m/s; (c) 0
103	2.2 kg
104	3.0 m
105	5.0 kg
106	(a) 0.54 m/s; (b) 0; (c) 1.1 m/s
107	(a) 50 kg/s; (b) 1.6×10^2 kg/s
108	2.5×10^{-3}
109	(a) 4.6×10^3 km; (b) 73%
110	(a) 2.18 kg·m/s; (b) 575 N
111	190 m/s
112	(a) 1.0 kg·m/s; (b) 2.5×10^2 J; (c) 10 N; (d) 1.7 kN; (e) answer for (c) includes time between pellet collisions
113	28.8 N
114	(a) -0.25 m; (b) 0

115	(a) 0.745 mm; (b) 153°; (c) 1.67 mJ
116	(a) 0; (b) 0.75 m
117	(a) $(2.67\ \text{m/s})\hat{\imath} + (-3.00\ \text{m/s})\hat{\jmath}$; (b) 4.01 m/s; (c) 48.4°
118	(a) 0.60 cm; (b) 4.9 cm; (c) 9.0 cm; (d) 0
119	(a) –0.50 m; (b) –1.8 cm; (c) 0.50 m
120	(a) 0; (b) 4.0 m/s
121	0.22%
122	1.10 m/s
123	36.5 km/s
124	(a) $(8.25\ \text{kg·m/s})\hat{\jmath}$; (b) $(8.25\ \text{N·s})\hat{\jmath}$; (c) $(-8.25\ \text{N·s})\hat{\jmath}$
125	(a) $(-1.00 \times 10^{-19}\hat{\imath} + 0.67 \times 10^{-19}\hat{\jmath})$ kg·m/s; (b) 1.19×10^{-12} J
126	(a) 0.800 kg·m/s; (b) 0.400 kg·m/s
127	2.2×10^{-3}
128	2.2 m/s

Chapter 10 Answers

1	14 rev
2	(a) 0.105 rad/s; (b) 1.75×10^{-3} rad/s; (c) 1.45×10^{-4} rad/s
3	(a) 4.0 rad/s; (b) 11.9 rad/s

4	(a) 2.0 rad; (b) 0; (c) 1.3×10^2 rad/s; (d) 32 rad/s^2; (e) no
5	11 rad/s
6	(a) 4.0 rad/s; (b) 28 rad/s; (c) 12 rad/s^2; (d) 6.0 rad/s^2; (e) 18 rad/s^2
7	(a) 4.0 m/s; (b) no
8	(a) $1.2t^5 - 1.3t^3 + 2.0$; (b) $0.20t^6 - 0.33t^4 + 2.0t + 1.0$
9	(a) 3.00 s; (b) 18.9 rad
10	(a) 2.0 rad/s^2; (b) 5.0 rad/s; (c) 10 rad/s; (d) 75 rad
11	(a) 30 s; (b) 1.8×10^3 rad
12	(a) 9.0×10^3 rev/min^2; (b) 4.2×10^2 rev
13	(a) 3.4×10^2 s; (b) -4.5×10^{-3} rad/s^2; (c) 98 s
14	(a) 1.0 rev/s^2; (b) 4.8 s; (c) 9.6 s; (d) 48 rev
15	8.0 s
16	(a) 4.09 s; (b) 1.70 s
17	(a) 44 rad; (b) 5.5 s; (c) 32 s; (d) -2.1 s; (e) 40 s
18	(a) -2.3×10^{-9} rad/s^2; (b) 2.6×10^3 y; (c) 24 ms

19	(a) 2.50×10^{-3} rad/s; (b) 20.2 m/s^2; (c) 0
20	(a) 6.4 cm/s^2; (b) 2.6 cm/s^2
21	6.9×10^{-13} rad/s
22	(a) 3.0 rad/s; (b) 30 m/s; (c) 6.0 m/s^2; (d) 90 m/s^2
23	(a) 20.9 rad/s; (b) 12.5 m/s; (c) 800 rev/min^2; (d) 600 rev
24	199 hits/s
25	(a) 7.3×10^{-5} rad/s; (b) 3.5×10^{2} m/s; (c) 7.3×10^{-5} rad/s; (d) 4.6×10^{2} m/s
26	(a) -1.1 rev/min^2; (b) 9.9×10^{3} rev; (c) -0.99 mm/s^2; (d) 31 m/s^2
27	(a) 73 cm/s^2; (b) 0.075; (c) 0.11
28	16 s
29	(a) 3.8×10^{3} rad/s; (b) 1.9×10^{2} m/s
30	(a) 40.2 cm/s^2; (b) 2.36×10^{3} m/s^2; (c) 83.2 m
31	(a) 40 s; (b) 2.0 rad/s^2
32	(a) 1.94 m/s^2; (b) 75.1°
33	12.3 kg·m^2
34	(a) 1.5 rad/s^2; (b) 0.40 J
35	(a) 1.1 kJ; (b) 9.7 kJ
36	2.5 kg
37	0.097 kg·m^2
38	(a) 7.1%; (b) 64%

39	(a) 49 MJ; (b) 1.0×10^2 min
40	(a) 8.352×10^{-3} kg·m^2; (b) -0.22%
41	(a) 0.023 kg·m^2; (b) 1.1 mJ
42	(a) 1.3×10^3 g·cm^2; (b) 5.5×10^2 g·cm^2; (c) 1.9×10^3 g·cm^2; (d) $A + B$
43	4.7×10^{-4} kg·m^2
44	(a) 2.0 kg·m^2; (b) 6.0 kg·m^2; (c) 2.0 kg·m^2
45	-3.85 N·m
46	12 N·m
47	4.6 N·m
48	(a) 8.4 N·m; (b) 17 N·m; (c) 0
49	(a) 28.2 rad/s^2; (b) 338 N·m
50	1.28 kg·m^2
51	(a) 6.00 cm/s^2; (b) 4.87 N; (c) 4.54 N; (d) 1.20 rad/s^2; (e) 0.0138 kg·m^2
52	(a) 9.7 rad/s^2; (b) counterclockwise
53	0.140 N
54	(a) 3.0 rad/s^2; (b) 9.4 rad/s^2
55	2.51×10^{-4} kg·m^2
56	(a) 1.7 m/s^2; (b) 6.9 m/s^2
57	(a) 4.2×10^2 rad/s^2; (b) 5.0×10^2 rad/s
58	(a) 1.4 m/s; (b) 1.4 m/s
59	396 N·m

60	(a) 0.63 J; (b) 0.15 m
61	(a) -19.8 kJ; (b) 1.32 kW
62	(a) 11.2 mJ; (b) 33.6 mJ; (c) 56.0 mJ; (d) 2.80×10^{-5} J·s^2/rad^2
63	5.42 m/s
64	(a) 0.15 kg·m^2; (b) 11 rad/s
65	(a) 5.32 m/s^2; (b) 8.43 m/s^2; (c) 41.8°
66	1.4 m/s
67	9.82 rad/s
68	(a) 0.689 N·m; (b) 3.05 N; (c) 9.84 N·m; (d) 11.5 N
69	6.16×10^{-5} kg·m^2
70	(a) 27.0 rad/s; (b) 13.5 s
71	(a) 31.4 rad/s^2; (b) 0.754 m/s^2; (c) 56.1 N; (d) 55.1 N
72	(a) –7.66 rad/s^2; (b) –11.7 N·m; (c) 4.59×10^4 J; (d) 624 rev; (e) 4.59×10^4 J
73	(a) 4.81×10^5 N; (b) 1.12×10^4 N·m; (c) 1.25×10^6 J
74	(a) 8.6 s; (b) no
75	(a) 2.3 rad/s^2; (b) 1.4 rad/s^2
76	1.5×10^3 rad
77	(a) -67 rev/min^2; (b) 8.3 rev
78	6.06 rad/s

79	---
80	(a) 5.00 rad/s; (b) 1.67 rad/s^2; (c) 2.50 rad
81	3.1 rad/s
82	3×10^5 J
83	(a) 1.57 m/s^2; (b) 4.55 N; (c) 4.94 N
84	(a) 5.1 h; (b) 8.1 h
85	30 rev
86	146 rad/s
87	0.054 $kg \cdot m^2$
88	(a) 155 $kg \cdot m^2$; (b) 64.4 kg
89	1.4×10^2 N·m
90	(a) –1.25 rad/s^2; (b) 250 rad; (c) 39.8 rev
91	(a) 10 J; (b) 0.27 m
92	(a) 5.5×10^{15} s; (b) 26
93	4.6 rad/s^2
94	(a) 3.1×10^2 m/s; (b) 3.4×10^2 m/s
95	2.6 J
96	25 N
97	(a) 5.92×10^4 m/s^2; (b) 4.39×10^4 s^{-2}
98	1.6 $kg \cdot m^2$
99	(a) 0.791 $kg \cdot m^2$; (b) 1.79×10^{-2} N·m
100	(a) 0.019 $kg \cdot m^2$; (b) 0.019 $kg \cdot m^2$
101	(a) 1.5×10^2 cm/s; (b) 15 rad/s; (c) 15 rad/s; (d) 75 cm/s; (e) 3.0 rad/s
102	(a) 3.3 J; (b) 2.9 J

103	(a) 7.0 kg·m^2; (b) 7.2 m/s; (c) 71°
104	(a) 0.20 kg·m^2; (b) 6.3 rad/s
105	(a) 0.32 rad/s; (b) 1.0×10^2 km/h
106	5.6 rad/s^2
107	(a) 1.4×10^2 rad; (b) 14 s
108	(a) 3.5 rad/s; (b) 52 cm/s; (c) 26 cm/s

Chapter 11 Answers

1	(a) 0; (b) (22 m/s)$\hat{i}$; (c) (-22 m/s)$\hat{i}$; (d) 0; (e) 1.5×10^3 m/s^2; (f) 1.5×10^3 m/s^2; (g) (22 m/s)$\hat{i}$; (h) (44 m/s)$\hat{i}$; (i) 0; (j) 0; (k) 1.5×10^3 m/s^2; (l) 1.5×10^3 m/s^2
2	(a) 59.3 rad/s; (b) 9.31 rad/s^2; (c) 70.7 m
3	-3.15 J
4	(a) 8.0°; (b) more
5	0.020
6	7.2×10^{-4} kg·m^2
7	(a) 63 rad/s; (b) 4.0 m
8	(a) 2.0 m; (b) 7.3 m/s
9	4.8 m

10	(a) 8.0 J; (b) 3.0 m/s; (c) 6.9 J; (d) 1.8 m/s
11	(a) $(-4.0\ \text{N})\hat{\mathbf{i}}$; (b) 0.60 $\text{kg}\cdot\text{m}^2$
12	(a) 37.8 cm; (b) 1.96×10^{-2} N; (c) toward loop's center
13	0.50
14	1.34 m/s
15	(a) $-(0.11\ \text{m})\omega$; (b) -2.1 m/s^2; (c) -47 rad/s^2; (d) 1.2 s; (e) 8.6 m; (f) 6.1 m/s
16	0.25
17	(a) 13 cm/s^2; (b) 4.4 s; (c) 55 cm/s; (d) 18 mJ; (e) 1.4 J; (f) 27 rev/s
18	(a) 0.19 m/s^2; (b) 0.19 m/s^2; (c) 1.1 kN; (d) no; (e) same; (f) greater
19	$(-2.0\ \text{N}\cdot\text{m})\hat{\mathbf{i}}$
20	(a) $(24\ \text{N}\cdot\text{m})\hat{\mathbf{j}}$; (b) $(-24\ \text{N}\cdot\text{m})\hat{\mathbf{j}}$; (c) $(12\ \text{N}\cdot\text{m})\hat{\mathbf{j}}$; (d) $(-12\ \text{N}\cdot\text{m})\hat{\mathbf{j}}$
21	(a) $(6.0\ \text{N}\cdot\text{m})\hat{\mathbf{j}} + (8.0\ \text{N}\cdot\text{m})\hat{\mathbf{k}}$; (b) $(-22\ \text{N}\cdot\text{m})\hat{\mathbf{i}}$
22	–5.00 N
23	(a) $(-1.5\ \text{N}\cdot\text{m})\hat{\mathbf{i}} - (4.0\ \text{N}\cdot\text{m})\hat{\mathbf{j}} - (1.0\ \text{N}\cdot\text{m})\hat{\mathbf{k}}$; (b) $(-1.5\ \text{N}\cdot\text{m})\hat{\mathbf{i}} - (4.0\ \text{N}\cdot\text{m})\hat{\mathbf{j}} - (1.0\ \text{N}\cdot\text{m})\hat{\mathbf{k}}$

24	(a) $(6.0\ \text{N}\cdot\text{m})\hat{i} - (3.0\ \text{N}\cdot\text{m})\hat{j} - (6.0\ \text{N}\cdot\text{m})\hat{k}$; (b) $(26\ \text{N}\cdot\text{m})\hat{i} + (3.0\ \text{N}\cdot\text{m})\hat{j} - (18\ \text{N}\cdot\text{m})\hat{k}$; (c) $(32\ \text{N}\cdot\text{m})\hat{i} - (24\ \text{N}\cdot\text{m})\hat{k}$; (d) 0
25	(a) $(50\ \text{N}\cdot\text{m})\hat{k}$; (b) 90°
26	(a) 12 $\text{kg}\cdot\text{m}^2/\text{s}$; (b) +z direction; (c) 3.0 N·m; (d) +z direction
27	(a) 0; (b) $(8.0\ \text{N}\cdot\text{m})\hat{i} + (8.0\ \text{N}\cdot\text{m})\hat{k}$
28	(a) $(6.0 \times 10^2\ \text{kg}\cdot\text{m}^2/\text{s})\hat{k}$; (b) $(7.2 \times 10^2\ \text{kg}\cdot\text{m}^2/\text{s})\hat{k}$
29	(a) 9.8 $\text{kg}\cdot\text{m}^2/\text{s}$; (b) +z direction
30	(a) $(3.00\ \text{m/s}^2)\hat{i} - (4.00\ \text{m/s}^2)\hat{j} + (2.00\ \text{m/s}^2)\hat{k}$; (b) $(42.0\ \text{kg}\cdot\text{m}^2/\text{s})\hat{i} + (24.0\ \text{kg}\cdot\text{m}^2/\text{s})\hat{j} + (60.0\ \text{kg}\cdot\text{m}^2/\text{s})\hat{k}$; (c) $(-8.00\ \text{N}\cdot\text{m})\hat{i} - (26.0\ \text{N}\cdot\text{m})\hat{j} - (40.0\ \text{N}\cdot\text{m})\hat{k}$; (d) 127°
31	(a) 0; (b) $-22.6\ \text{kg}\cdot\text{m}^2/\text{s}$; (c) –7.84 N·m; (d) –7.84 N·m
32	$(2.0\ \text{N}\cdot\text{m})\ )\hat{i} + (-4.0\ \text{N}\cdot\text{m})\hat{j}$
33	(a) $(-1.7 \times 10^2\ \text{kg}\cdot\text{m}^2/\text{s})\hat{k}$; (b) $(+56\ \text{N}\cdot\text{m})\hat{k}$; (c) $(+56\ \text{kg}\cdot\text{m}^2/\text{s}^2)\hat{k}$
34	(a) 0; (b) $(-8.0t\hat{k})\ \text{N}\cdot\text{m}$; (c) $(-2.0t^{-0.5}\hat{k})\ \text{N}\cdot\text{m}$; (d) $(8.0t^{-3}\hat{k})\ \text{N}\cdot\text{m}$
35	(a) $48t\hat{k}$ N·m; (b) increasing
36	1024
37	(a) $4.6 \times 10^{-3}\ \text{kg}\cdot\text{m}^2$; (b) $1.1 \times 10^{-3}\ \text{kg}\cdot\text{m}^2/\text{s}$; (c) $3.9 \times 10^{-3}\ \text{kg}\cdot\text{m}^2/\text{s}$

38	(a) 0.53 $kg \cdot m^2/s$; (b) 4.2×10^3 rev/min
39	(a) 1.47 N·m; (b) 20.4 rad; (c) -29.9 J; (d) 19.9 W
40	23 $kg \cdot m^2/s$
41	(a) 1.6 $kg \cdot m^2$; (b) 4.0 $kg \cdot m^2/s$
42	(a) 24 $kg \cdot m^2/s$; (b) 1.5 $kg \cdot m^2/s$
43	(a) 1.5 m; (b) 0.93 rad/s; (c) 98 J; (d) 8.4 rad/s; (e) 8.8×10^2 J; (f) internal energy of the skaters
44	(a) 4.2 rad/s; (b) no, because energy transferred to internal energy of cockroach
45	(a) 3.6 rev/s; (b) 3.0; (c) forces on the bricks from the man transferred energy from the man's internal energy to kinetic energy
46	3
47	0.17 rad/s
48	0.20
49	(a) 750 rev/min; (b) 450 rev/min; (c) clockwise
50	5.0×10^2 rev
51	(a) 267 rev/min; (b) 0.667
52	(a) 0.347 rad/s; (b) 1.33; (c) energy transferred from internal energy of cockroach to kinetic energy
53	1.3×10^3 m/s
54	39.1 J
55	3.4 rad/s
56	6.46 $kg \cdot m^2/s$
57	(a) 18 rad/s; (b) 0.92

58	2.6 rad/s
59	11.0 m/s
60	(a) 0.24 kg·m^2; (b) 1.8×10^3 m/s
61	1.5 rad/s
62	3.23 rev/s
63	0.070 rad/s
64	1.5
65	(a) 0.148 rad/s; (b) 0.0123; (c) 181°
66	32°
67	(a) 0.180 m; (b) clockwise
68	(a) 0.33 rev/s; (b) clockwise
69	0.041 rad/s
70	2.33 m/s
71	(a) 1.6 m/s^2; (b) 16 rad/s^2; (c) (4.0 N)$\hat{\mathbf{i}}$
72	1.00
73	(a) 0; (b) 0; (c) $-30t^3\hat{\mathbf{k}}$ kg·m^2/s; (d) $-90t^2\hat{\mathbf{k}}$ N·m; (e) $30t^3\hat{\mathbf{k}}$ kg·m^2/s; (f) $90t^2\hat{\mathbf{k}}$ N·m
74	12 s
75	(a) 149 kg·m^2; (b) 158 kg·m^2/s; (c) 0.744 rad/s
76	0.62 J
77	(a) 6.65×10^{-5} kg·m^2/s; (b) no; (c) 0; (d) yes
78	(a) 4.11 m/s^2; (b) 16.4 rad/s^2; (c) 2.55 N·m
79	(a) 0.333; (b) 0.111
80	(5.55 kg·m^2/s)$\hat{\mathbf{k}}$

81	(a) 58.8 J; (b) 39.2 J
82	(a) 12.2 kg·m^2; (b) 308 kg·m^2/s
83	(a) 61.7 J; (b) 3.43 m; (c) no
84	(a) 0.89 s; (b) 9.4 J; (c) 1.4 m/s; (d) 0.12 J; (e) 4.4×10^2 rad/s; (f) 9.2 J
85	(a) $mvR/(I + MR^2)$; (b) $mvR^2/(I + MR^2)$
86	(a) $mR^2/2$; (b) a solid circular cylinder

Chapter 12 Answers

1	(a) 1.00 m; (b) 2.00 m; (c) 0.987 m; (d) 1.97 m
2	(a) 2.77 kN; (b) 3.89 kN
3	(a) 9.4 N; (b) 4.4 N
4	120°
5	7.92 kN
6	(a) 8.4×10^2 N; (b) 5.3×10^2 N
7	(a) 2.8×10^2 N; (b) 8.8×10^2 N; (c) 71°
8	(a) 2; (b) 7
9	74.4 g
10	(a) 49 N; (b) 28 N; (c) 57 N; (d) 29°

11	(a) 1.2 kN; (b) down; (c) 1.7 kN; (d) up; (e) left; (f) right
12	8.3 kN
13	(a) 2.7 kN; (b) up; (c) 3.6 kN; (d) down
14	0.702 m
15	(a) 5.0 N; (b) 30 N; (c) 1.3 m
16	0.536 m
17	(a) 0.64 m; (b) increased
18	457 N
19	8.7 N
20	(a) 6.5×10^2 N; (b) 5.6×10^2 N
21	(a) 6.63 kN; (b) 5.74 kN; (c) 5.96 kN
22	(a) 3.4×10^2 N; (b) 0.88 m; (c) increases; (d) decreases
23	(a) 192 N; (b) 96.1 N; (c) 55.5 N
24	1.19
25	13.6 N
26	0.216
27	(a) 1.9 kN; (b) up; (c) 2.1 kN; (d) down
28	(a) 1.50 m; (b) 433 N; (c) 250 N
29	(a) $(-80\text{ N})\hat{i} + (1.3 \times 10^2\text{ N})\hat{j}$; (b) $(80\text{ N})\hat{i} + (1.3 \times 10^2\text{ N})\hat{j}$

30	(a) 408 N; (b) 245 N; (c) right; (d) 163 N; (e) up
31	2.20 m
32	(a) 3.9 m/s^2; (b) 2.0 kN; (c) 3.5 kN; (d) 0.79 kN; (e) 1.4 kN
33	(a) 60.0°; (b) 300 N
34	(a) $Wx/(L \sin \theta)$; (b) $Wx/(L \tan \theta)$; (c) $W(1 - x/L)$
35	(a) 445 N; (b) 0.50; (c) 315 N
36	(a) 17 N; (b) 1.7×10^2 N
37	0.34
38	(a) $(-797\hat{i} + 265\hat{j})$ N; (b) $(797\hat{i} + 265\hat{j})$ N; (c) $(797\hat{i} + 931\hat{j})$ N; (d) $(-797\hat{i} - 265\hat{j})$ N
39	(a) 211 N; (b) 534 N; (c) 320 N
40	(a) 30.0°; (b) 51.0 kg; (c) 10.2 kg
41	(a) slides; (b) 31°; (c) tips; (d) 34°
42	85%
43	(a) 6.5×10^6 N/m^2; (b) 1.1×10^{-5} m
44	(a) 7.5×10^{10} N/m^2; (b) 2.9×10^8 N/m^2
45	(a) 0.80; (b) 0.20; (c) 0.25
46	(a) 30 μJ; (b) 8.67 μJ; (c) 34.2 μJ; (d) no; (e) yes

47	(a) 1.4×10^9 N; (b) 75
48	56.0 mJ
49	(a) 866 N; (b) 143 N; (c) 0.165
50	0.421 g
51	(a) 1.2×10^2 N; (b) 68 N
52	(a) 1.9×10^{-3}; (b) 1.3×10^7 N/m^2; (c) 6.9×10^9 N/m^2
53	(a) 1.8×10^7 N; (b) 1.4×10^7 N; (c) 16
54	3.4 m
55	0.29
56	(a) 500 kg; (b) 62.5 kg
57	76 N
58	(a) 196 N; (b) 294 N; (c) 441 N; (d) 49.0 N; (e) 0.16 m
59	(a) 8.01 kN; (b) 3.65 kN; (c) 5.66 kN
60	(a) 50°; (b) 0.77*mg*
61	71.7 N
62	(a) 0.80 mm; (b) 2.3 cm
63	(a) $L/2$; (b) $L/4$; (c) $L/6$; (d) $L/8$; (e) $25L/24$
64	(a) 2*mg*; (b) *mg*; (c) *mg*; (d) $2^{0.5}$*mg*
65	(a) 88 N; (b) $(30\hat{i} + 97\hat{j})$ N
66	$(-1.5 \times 10^2 \text{ N})\hat{i} + (2.6 \times 10^2 \text{ N})\hat{j}$

67	2.4×10^9 N/m^2
68	(a) 200 N; (b) 360 N; (c) 0.35
69	60°
70	(a) 1.5 kN; (b) 1.9 kN
71	(a) $\mu < 0.57$; (b) $\mu > 0.57$
72	(a) 15 N; (b) 29 N
73	(a) $(35\hat{i} + 200\hat{j})$ N; (b) $(-45\hat{i} + 200\hat{j})$ N; (c) 1.9×10^2 N
74	---
75	(a) *BC*, *CD*, *DA*; (b) 535 N; (c) 757 N
76	(a) $1.16\hat{j}$ kN; (b) $1.74\hat{j}$ kN
77	(a) 1.38 kN; (b) 180 N
78	(a) $(-671\hat{j})$ N; (b) $(400\hat{i} + 670\hat{j})$ N
79	(a) $a_1 = L/2$, $a_2 = 5L/8$, $h = 9L/8$; (b) $b_1 = 2L/3$, $b_2 = L/2$, $h = 7L/6$
80	44 N
81	$L/4$
82	3.1 cm
83	(a) 106 N; (b) 64.0°
84	(a) 270 N; (b) 72 N; (c) 19°
85	1.8×10^2 N
86	(a) 42 N; (b) 66 N
87	(a) -24.4 N; (b) 1.60 N; (c) -3.75°
88	(a) 3.37 m; (b) 7.18°

Chapter 13 Answers

1	1/2
2	(a) 6.9%; (b) $(2.3 \times 10^{-5})\%$
3	19 m
4	2.16
5	0.8 m
6	$(1.18 \times 10^{-14}\ \text{N})\hat{\mathbf{i}} + (1.18 \times 10^{-14}\ \text{N})\hat{\mathbf{j}}$
7	$-5.00d$
8	(a) 2.13×10^{-8} N; (b) 60.6°
9	2.60×10^{5} km
10	(a) $0.716d$; (b) $-1.07d$
11	(a) $M = m$; (b) 0
12	(a) 0.25 kg; (b) 1.0 kg
13	8.31×10^{-9} N
14	(a) -0.20 m; (b) -0.35 m
15	(a) $-1.88d$; (b) $-3.90d$; (c) $0.489d$
16	3.0×10^{-10} N
17	(a) 17 N; (b) 2.4
18	8.2 μm
19	2.6×10^{6} m
20	-0.30 N
21	5×10^{24} kg
22	(a) $(3.02 \times 10^{43}\ \text{kg}\cdot\text{m/s}^2)/M_h$; (b) decrease; (c) 9.82 m/s^2; (d) 7.30×10^{-15} m/s^2; (e) no
23	(a) 7.6 m/s^2; (b) 4.2 m/s^2
24	(a) $G(M_1 + M_2)m/a^2$; (b) GM_1m/b^2; (c) 0

25	(a) $(3.0 \times 10^{-7}$ N/kg)m; (b) $(3.3 \times 10^{-7}$ N/kg)m; (c) $(6.7 \times 10^{-7}$ N/kg·m)mr
26	(a) $R/3$; (b) $3^{0.5}R$
27	(a) 9.83 m/s^2; (b) 9.84 m/s^2; (c) 9.79 m/s^2
28	(a) 0.414R; (b) 0.500R
29	5.0×10^9 J
30	½
31	(a) 0.74; (b) 3.8 m/s^2; (c) 5.0 km/s
32	(a) -4.4×10^{-11} J; (b) -2.9×10^{-11} J; (c) 2.9×10^{-11} J
33	(a) 0.0451; (b) 28.5
34	(a) 2.0×10^9 J; (b) $2.5R_s$
35	-4.82×10^{-13} J
36	(a) 22 MJ; (b) 69 MJ
37	(a) 0.50 pJ; (b) –0.50 pJ
38	(a) -1.7×10^{-8} J; (b) 0.56×10^{-8} J
39	(a) 1.7 km/s; (b) 2.5×10^5 m; (c) 1.4 km/s
40	(a) 1.33; (b) 2.00; (c) 0
41	(a) 82 km/s; (b) 1.8×10^4 km/s
42	(a) 0.50 kg; (b) 1.5 kg
43	(a) 7.82 km/s; (b) 87.5 min
44	0.35 lunar month
45	6.5×10^{23} kg

46	(a) 5.4×10^4 km/h; (b) 3.8×10^4 km/h
47	5×10^{10} stars
48	1.87 y
49	(a) 1.9×10^{13} m; (b) $6.4R_P$
50	3.58×10^4 km
51	(a) 6.64×10^3 km; (b) 0.0136
52	(a) 5.01×10^9 m; (b) 7.20 solar radii
53	5.8×10^6 m
54	9
55	---
56	(a) 6×10^{16} kg; (b) 4×10^3 kg/m^3
57	0.71 y
58	(a) $3.7m_J$; (b) $2.5r_E$
59	$(GM/L)^{0.5}$
60	(a) -6.33×10^9 J; (b) -6.33×10^9 J; (c) falling
61	(a) 3.19×10^3 km; (b) lifting
62	(a) 1/2; (b) 1/2; (c) B; (d) 1.1×10^8 J
63	(a) 2.8 y; (b) 1.0×10^{-4}
64	(a) 8.0×10^8 J; (b) 36 N
65	(a) $r^{1.5}$; (b) r^{-1}; (c) $r^{0.5}$; (d) $r^{-0.5}$
66	(a) 4.6×10^5 J; (b) 2.6×10^2

67	(a) 7.5 km/s; (b) 97 min; (c) 4.1×10^2 km; (d) 7.7 km/s; (e) 93 min; (f) 3.2×10^{-3} N; (g) no; (h) yes
68	(a) 92.3 min; (b) 7.68×10^3 m/s; (c) 5.78×10^{10} J; (d) -1.18×10^{11} J; (e) -6.02×10^{10} J; (f) 6.63×10^6 m; (g) 89.5 min; (h) 80 s
69	1.1 s
70	(a) $(1 \times 10^2)M_S$; (b) lower
71	(a) $GMmx(x^2 + R^2)^{-3/2}$; (b) $[2GM(R^{-1} - (R^2 + x^2)^{-1/2})]^{1/2}$
72	(a) 1.3×10^{12} m/s^2; (b) 1.6×10^6 m/s
73	(a) 1.0×10^3 kg; (b) 1.5 km/s
74	(a) 2×10^{-5} m/s^2; (b) 2 cm/s
75	3.2×10^{-7} N
76	29 pN
77	$0.37\hat{\mathrm{j}}$ μN
78	(a) -1.3×10^{-4} J; (b) less; (c) positive; (d) negative
79	$2\pi r^{1.5}G^{-0.5}(M + m/4)^{-0.5}$
80	(b) 1.9 h
81	(a) 2.2×10^{-7} rad/s; (b) 89 km/s
82	9.2×10^{-5} rad/s
83	(a) 2.15×10^4 s; (b) 12.3 km/s; (c) 12.0 km/s; (d) 2.17×10^{11} J; (e) -4.53×10^{11} J; (f) -2.35×10^{11} J; (g) 4.04×10^7 m; (h) 1.22×10^3 s; (i) elliptical
84	0.031%

85	2.5×10^4 km
86	(a) $(3.4 \times 10^{-3})g$; (b) $(6.1 \times 10^{-4})g$; (c) $(1.4 \times 10^{-11})g$
87	(a) 1.4×10^6 m/s; (b) 3×10^6 m/s^2
88	7.9 km/s
89	(a) 0; (b) 1.8×10^{32} J; (c) 1.8×10^{32} J; (d) 0.99 km/s
90	(a) 1.9×10^7 m; (b) 7.6×10^8 J; (c) 8.6×10^{24} kg
91	(a) Gm^2/R_i; (b) $Gm^2/2R_i$; (c) $(Gm/R_i)^{0.5}$; (d) $2(Gm/R_i)^{0.5}$; (e) Gm^2/R_i; (f) $(2Gm/R_i)^{0.5}$; (g) The center-of-mass frame is an inertial frame, and in it the principle of conservation of energy may be written as in Chapter 8; the reference frame attached to body *A* is noninertial, and the principle cannot be written as in Chapter 8. Answer (d) is correct.
92	(a) 38.3 MJ; (b) 1.03×10^3 km
93	2.4×10^4 m/s
94	(a) 5.3×10^{-8} J; (b) $(-6.4 \times 10^{-8})\hat{\mathrm{i}}$ N
95	$-0.044\hat{\mathrm{j}}\ \mu$N
96	(a) $(2.8 \times 10^4)g$; (b) deadly; (c) $714g$; (d) 1.5 km/s
97	$GM_Em/12R_E$
98	42.1 min
99	1.51×10^{-12} N
100	3.07×10^{-7} N
101	3.4×10^5 km

Chapter 14 Answers

1	0.074
2	38 kPa
3	1.1×10^5 Pa
4	18 N
5	2.9×10^4 N
6	(a) 1.9×10^2 kPa; (b) 15.9/10.6
7	(b) 26 kN
8	1.4×10^5 Pa
9	(a) 1.0×10^3 torr; (b) 1.7×10^3 torr
10	2.80 m
11	(a) 94 torr; (b) 4.1×10^2 torr; (c) 3.1×10^2 torr
12	17 cm
13	1.08×10^3 atm
14	1.90×10^4 Pa
15	-2.6×10^4 Pa
16	(a) 0.019 atm; (b) 0.39 atm
17	7.2×10^5 N
18	2.0
19	4.69×10^5 N
20	(a) 5.0×10^6 N; (b) 5.6×10^6 N
21	0.635 J
22	26 torr
23	44 km
24	(a) 1.88×10^9 N; (b) 2.20×10^{10} N·m; (c) 11.7 m
25	739.26 torr
26	-3.9×10^{-3} atm
27	(a) 7.9 km; (b) 16 km
28	(a) fA/a; (b) 103 N
29	8.50 kg
30	7.84 cm, down
31	(a) 6.7×10^2 kg/m^3; (b) 7.4×10^2 kg/m^3
32	(a) 37.5 kN; (b) 39.6 kN; (c) 2.23 kN; (d) 2.18 kN

33	(a) 2.04×10^{-2} m^3; (b) 1.57 kN
34	(a) 35.6 kN; (b) 0.330 m^3
35	five
36	1.8 g/cm^3
37	57.3 cm
38	(a) 1.5 g/cm^3; (b) 2.7×10^{-3} m^3
39	(a) 1.2 kg; (b) 1.3×10^3 kg/m^3
40	6.5 mm
41	(a) 0.10; (b) 0.083
42	4.11 kJ
43	(a) 637.8 cm^3; (b) 5.102 m^3; (c) 5.102×10^3 kg
44	(a) 1.84 kg; (b) 2.01 kg
45	0.126 m^3
46	1.40 m
47	(a) 1.80 m^3; (b) 4.75 m^3
48	9.7 mm
49	(a) 3.0 m/s; (b) 2.8 m/s
50	3.60 cm
51	8.1 m/s
52	4.0 m
53	66 W
54	(a) 56 L/min; (b) 1.0
55	1.4×10^5 J
56	(a) 2; (b) 1/2; (c) 3.0 cm
57	(a) 1.6×10^{-3} m^3/s; (b) 0.90 m
58	1.7 MPa
59	(a) 2.5 m/s; (b) 2.6×10^5 Pa
60	(a) 2.40 m/s; (b) 245 Pa
61	(a) 3.9 m/s; (b) 88 kPa

62	(b) 63.3 m/s
63	1.1×10^2 m/s
64	(a) 6.4 m^3; (b) 5.4 m/s; (c) 9.8×10^4 Pa
65	(b) 2.0×10^{-2} m^3/s
66	(a) 4.1 m/s; (b) 21 m/s; (c) 8.0×10^{-3} m^3/s
67	(a) 74 N; (b) 1.5×10^2 m^3
68	(a) 0.25 m^2; (b) 6.1 m^3/s
69	(a) 0.0776 m^3/s; (b) 69.8 kg/s
70	–2.50 J
71	(a) 35 cm; (b) 30 cm; (c) 20 cm
72	7.8 cm/h
73	1.5 g/cm^3
74	0.412 cm
75	5.11×10^{-7} kg
76	(a) 0.050; (b) 0.41; (c) no
77	44.2 g
78	9.4%
79	6.0×10^2 kg/m^3
80	(a) 2; (b) 3; (c) 4/3
81	45.3 cm^3
82	3.82 m/s^2
83	(a) 3.2 m/s; (b) 9.2×10^4 Pa; (c) 10.3 m
84	(a) 0.13; (b) 0.96
85	1.07×10^3 g
86	1.25
87	26.3 m^2
88	(a) 2.23×10^7 Pa; (b) 2.24×10^7 Pa; (c) 1.09×10^6 N; (d) 10.1 N; (e) 8.62 m/s^2

89	(a) 5.66×10^9 N; (b) 25.4 atm
90	4.34×10^4 Pa

Chapter 15 Answers

1	(a) 0.50 s; (b) 2.0 Hz; (c) 18 cm
2	(a) 10 N; (b) 1.2×10^2 N/m
3	37.8 m/s^2
4	(a) 1.29×10^5 N/m; (b) 2.68 Hz
5	(a) 1.0 mm; (b) 0.75 m/s; (c) 5.7×10^2 m/s^2
6	(a) 6.28×10^5 rad/s; (b) 1.59 mm
7	(a) 498 Hz; (b) greater
8	+1.91 rad (or –4.37 rad)
9	(a) 3.0 m; (b) -49 m/s; (c) -2.7×10^2 m/s^2; (d) 20 rad; (e) 1.5 Hz; (f) 0.67 s
10	(a) 0.75 s; (b) 1.3 Hz; (c) 8.4 rad/s
11	39.6 Hz
12	–0.927 rad (or +5.36 rad)

13	(a) 0.500 s; (b) 2.00 Hz; (c) 12.6 rad/s; (d) 79.0 N/m; (e) 4.40 m/s; (f) 27.6 N
14	(a) 0.500 m; (b) -0.251 m; (c) 3.06 m/s
15	(a) 0.18*A*; (b) same direction
16	$2\pi/3$ rad
17	(a) 5.58 Hz; (b) 0.325 kg; (c) 0.400 m
18	2.08 h
19	(a) 25 cm; (b) 2.2 Hz
20	1.03 rad (or –5.25 rad)
21	54 Hz
22	4.00 m
23	3.1 cm
24	18.2 Hz
25	(a) 0.525 m; (b) 0.686 s
26	23 cm
27	(a) 0.75; (b) 0.25; (c) $2^{-0.5}x_m$
28	(a) yes; (b) 12 cm
29	37 mJ
30	(a) 200 N/m; (b) 1.39 kg; (c) 1.91 Hz
31	(a) 2.25 Hz; (b) 125 J; (c) 250 J; (d) 86.6 cm
32	8.3×10^2 N/m
33	(a) 1.1 m/s; (b) 3.3 cm
34	2.4 cm

35	(a) 3.1 ms; (b) 4.0 m/s; (c) 0.080 J; (d) 80 N; (e) 40 N
36	0.333
37	(a) 2.2 Hz; (b) 56 cm/s; (c) 0.10 kg; (d) 20.0 cm
38	12 s
39	(a) 39.5 rad/s; (b) 34.2 rad/s; (c) 124 rad/s^2
40	5.6 cm
41	(a) 0.205 kg·m^2; (b) 47.7 cm; (c) 1.50 s
42	(a) 0.499 m; (b) 0.940 mJ
43	(a) 1.64 s; (b) equal
44	1.83 s
45	8.77 s
46	---
47	0.366 s
48	(b) 16 cm; (c) circle
49	(a) 0.845 rad; (b) 0.0602 rad
50	(a) 0.84 m; (b) 0.031 J
51	(a) 0.53 m; (b) 2.1 s
52	0.18 s
53	0.0653 s
54	1.3×10^{-5} kg·m^2
55	(a) 2.26 s; (b) increases; (c) same
56	(a) 2.00 s; (b) 18.5 N·m/rad
57	6.0%
58	0.39

59	(a) 14.3 s; (b) 5.27
60	(a) 4.9×10^2 N/cm; (b) 1.1×10^3 kg/s
61	(a) $F_m/b\omega$; (b) F_m/b
62	d and e
63	5.0 cm
64	0.19g
65	(a) 2.8×10^3 rad/s; (b) 2.1 m/s; (c) 5.7 km/s^2
66	(a) 2.1×10^4 N/m; (b) 1.5×10^4 N/m; (c) 3.1×10^2 Hz; (d) 2.6×10^2 Hz
67	(a) 1.1 Hz; (b) 5.0 cm
68	(a) 147 N/m; (b) 0.733 s
69	7.2 m/s
70	(a) $(r/R)(k/m)^{0.5}$; (b) $(k/m)^{0.5}$; (c) 0 (no oscillation)
71	(a) 7.90 N/m; (b) 1.19 cm; (c) 2.00 Hz
72	(a) 0.873 s; (b) 6.3 cm
73	(a) 1.3×10^2 N/m; (b) 0.62 s; (c) 1.6 Hz; (d) 5.0 cm; (e) 0.51 m/s
74	(a) 0.21 m; (b) 1.6 Hz; (c) 0.10 m
75	(a) 16.6 cm; (b) 1.23%
76	(a) 1.72 ms; (b) 11.2 ms
77	(a) 1.2 J; (b) 50
78	(a) 11 m/s; (b) 1.7×10^3 m/s^2

79	1.53 m
80	65.5%
81	(a) 0.30 m; (b) 0.28 s; (c) 1.5×10^2 m/s^2; (d) 11 J
82	3.5 Hz
83	(a) 1.23 kN/m; (b) 76.0 N
84	(a) 1.6 Hz; (b) 1.0 m/s; (c) 0; (d) 10 m/s^2; (e) ±10 cm; (f) (-10 N/m)x
85	1.6 kg
86	(a) 1.6×10^4 m/s^2; (b) 2.5 m/s; (c) 7.9×10^3 m/s^2; (d) 2.2 m/s
87	(a) 0.735 kg·m^2; (b) 0.0240 N·m; (c) 0.181 rad/s
88	(a) 10 N, up; (b) 0.10 m; (c) 0.90 s; (d) 0.50 J
89	(a) 3.5 m; (b) 0.75 s
90	(a) 4.0 s; (b) π/2 rad/s; (c) 0.37 cm; (d) (0.37 cm) cos(πt/2); (e) (-0.58 cm/s) sin(πt/2); (f) 0.58 cm/s; (g) 0.91 cm/s^2; (h) 0; (i) 0.58 cm/s
91	(a) 0.35 Hz; (b) 0.39 Hz; (c) 0 (no oscillation)
92	831.5 mm
93	(a) 245 N/m; (b) 0.284 s
94	+1.82 rad (or –4.46 rad)

95	0.079 kg·m^2
96	1.58
97	(a) 8.11×10^{-5} kg·m^2; (b) 3.14 rad/s
98	(a) 1.0×10^2 N/m; (b) 0.45 s
99	14.0°
100	(a) 62.5 mJ; (b) 31.3 mJ
101	(a) 3.2 Hz; (b) 0.26 m; (c) $x = (0.26\text{ m})\cos(20t - \pi/2)$, with t in seconds
102	(a) 0.20 m; (b) 25; (c) 4.0 J; (d) 2.1 m/s
103	(a) 0.44 s; (b) 0.18 m
104	(a) 0.102 kg/s; (b) 0.137 J
105	(a) 0.45 s; (b) 0.10 m above and 0.20 m below; (c) 0.15 m; (d) 2.3 J
106	(a) 0.20 s; (b) 0.20 kg; (c) –0.20 m; (d) -2.0×10^2 m/s^2; (e) 4.0 J
107	7×10^2 N/m
108	2.00 cm
109	0.804 m
110	50 cm
111	(a) 0.30 m; (b) 30 m/s^2; (c) 0; (d) 4.4 s
112	(a) 8.3 s; (b) no
113	(a) F/m; (b) $2F/mL$; (c) 0
114	(a) 4.03×10^6 N; (b) 1.89×10^4
115	2.54 m

116	(a) y_m = 0.008 m, T = 0.18 s, ω = 35 rad/s; (b) y_m = 0.07 m, T = 0.48 s, ω = 13 rad/s; (c) y_m = 0.03 m, T = 0.31 s, ω = 20 rad/s

Chapter 16 Answers

1	1.1 ms
2	(a) 22 seats/s; (b) 39 seats
3	(a) 3.49 m^{-1}; (b) 31.5 m/s
4	30 cm
5	(a) 0.680 s; (b) 1.47 Hz; (c) 2.06 m/s
6	1.3 cm
7	(a) 64 Hz; (b) 1.3 m; (c) 4.0 cm; (d) 5.0 m^{-1}; (e) 4.0×10^2 s^{-1}; (f) $\pi/2$ rad; (g) minus
8	-0.64 rad or 5.64 rad
9	(a) 3.0 mm; (b) 16 m^{-1}; (c) 2.4×10^2 s^{-1}; (d) minus
10	(a) 6.0 cm; (b) 1.0×10^2 cm; (c) 2.0 Hz; (d) 2.0×10^2 cm/s; (e) -x direction; (f) 75 cm/s; (g) -2.0 cm
11	(a) negative; (b) 4.0 cm; (c) 0.31 cm^{-1}; (d) 0.63 s^{-1}; (e) π rad; (f) minus; (g) 2.0 cm/s; (h) –2.5 cm/s
12	4.24 m/s

13	(a) 11.7 cm; (b) π rad
14	(a) 30 m/s; (b) 17 g/m
15	(a) 0.12 mm; (b) 141 m^{-1}; (c) 628 s^{-1}; (d) plus
16	135 N
17	(a) 15 m/s; (b) 0.036 N
18	3.2
19	129 m/s
20	$2^{0.5}$
21	2.63 m
22	(a) 0.64 Hz; (b) 63 cm; (c) 5.0 cm; (d) 0.10 cm^{-1}; (e) 4.0 s^{-1}; (f) minus; (g) 0.064 N
23	(a) 5.0 cm; (b) 40 cm; (c) 12 m/s; (d) 0.033 s; (e) 9.4 m/s; (f) 16 m^{-1}; (g) 1.9×10^2 s^{-1}; (h) 0.93 rad; (i) plus
24	(a) 28.6 m/s; (b) 22.1 m/s; (c) 188 g; (d) 313 g
25	---
26	198 Hz
27	3.2 mm
28	1.75 m/s
29	0.20 m/s
30	0.20 m/s
31	$1.41y_m$
32	(a) 82.8°; (b) 1.45 rad; (c) 0.230 wavelength

33	(a) 9.0 mm; (b) 16 m^{-1}; (c) 1.1×10^3 s^{-1}; (d) 2.7 rad; (e) plus
34	(a) 10 W; (b) 20 W; (c) 40 W; (d) 26 W; (e) 0
35	5.0 cm
36	0
37	(a) 3.29 mm; (b) 1.55 rad; (c) 1.55 rad
38	(a) π rad; (b) 3.0 mm; (c) 0 rad; (d) 13 mm; (e) 9.4 mm
39	84°
40	10 cm
41	(a) 82.0 m/s; (b) 16.8 m; (c) 4.88 Hz
42	(a) $2f_3$; (b) λ_3
43	(a) 7.91 Hz; (b) 15.8 Hz; (c) 23.7 Hz
44	(a) 66.1 m/s; (b) 26.4 Hz
45	(a) 105 Hz; (b) 158 m/s
46	(a) 4; (b) 8; (c) none
47	260 Hz
48	(a) 6.36 Hz; (b) 6.36 Hz
49	(a) 144 m/s; (b) 60.0 cm; (c) 241 Hz
50	(a) +4.0 cm; (b) 0; (c) 0; (d) -0.13 m/s

51	(a) 0.50 cm; (b) 3.1 m^{-1}; (c) 3.1×10^2 s^{-1}; (d) minus
52	(a) 4.0 m; (b) 24 m/s; (c) 1.4 kg; (d) 0.11 s
53	(a) 0.25 cm; (b) 1.2×10^2 cm/s; (c) 3.0 cm; (d) 0
54	(a) 4.5 mm; (b) 16 m^{-1}; (c) 5.2×10^2 s^{-1}; (d) minus
55	0.25 m
56	(a) 0; (b) 0.20 m; (c) 0.40 m; (d) 50 ms; (e) 8.0 m/s; (f) 2.0 cm; (g) 0; (h) 25 ms; (i) 50 ms
57	(a) 2.00 Hz; (b) 2.00 m; (c) 4.00 m/s; (d) 50.0 cm; (e) 150 cm; (f) 250 cm; (g) 0; (h) 100 cm; (i) 200 cm
58	(a) 0.846 kg; (b) none
59	(a) 324 Hz; (b) eight
60	0.845 g/m
61	36 N

62	(a) 2.0 cm; (b) 0.63 cm^{-1}; (c) 2.5×10^3 s^{-1}; (d) minus; (e) 50 m/s; (f) 40 m/s
63	(a) 75 Hz; (b) 13 ms
64	(a) –3.9 cm; (b) 0.15 m; (c) 0.79 m^{-1}; (d) 13 s^{-1}; (e) plus (f) –0.14 m
65	(a) 2.0 mm; (b) 95 Hz; (c) +30 m/s; (d) 31 cm; (e) 1.2 m/s
66	2.8 rad or -3.5 rad
67	(a) 0.31 m; (b) 1.64 rad; (c) 2.2 mm
68	(a) 5.0 cm/s; (b) $+x$
69	(a) $0.83y_1$; (b) 37°
70	2.9 rad or -3.4 rad
71	(a) 3.77 m/s; (b) 12.3 N; (c) 0; (d) 46.4 W; (e) 0; (f) 0; (g) ±0.50 cm
72	(a) 3.0 mm; (b) 31 m^{-1}; (c) 7.5×10^2 s^{-1}; (d) minus
73	1.2 rad
74	(a) $2P_1$; (b) $P_1/4$
75	(a) 300 m/s; (b) no

76	(a) 0.50 m; (b) 0; (c) 0.25 s; (d) 0.50 s
77	(a) $[k\,\Delta\ell\,(\ell + \Delta\ell)/m]^{0.5}$
78	(a) 4.3×10^{14} Hz to 7.5×10^{14} Hz; (b) 1.0 m to 2.0×10^{2} m; (c) 6.0×10^{16} Hz to 3.0×10^{19} Hz
79	(a) 144 m/s; (b) 3.00 m; (c) 1.50 m; (d) 48.0 Hz; (e) 96.0 Hz
80	(a) 880 Hz; (b) 1320 Hz
81	(a) 1.00 cm; (b) 3.46×10^{3} s^{-1}; (c) 10.5 m^{-1}; (d) plus
82	(a) 6.7 mm; (b) 45°
83	(a) $2\pi y_m/\lambda$; (b) no
84	(a) 1.3 m; (b) (2.0 mm) sin[(9.4 m^{-1})x] cos[(3.8 × 10^{3} s^{-1})t]
85	(a) 240 cm; (b) 120 cm; (c) 80 cm
86	(a) $z(y, t)$ = (3.0 mm) sin[(60 cm^{-1})y – (31 s^{-1})t); (b) 9.4 cm/s
87	(a) 1.33 m/s; (b) 1.88 m/s; (c) 16.7 m/s^2; (d) 23.7 m/s^2
88	(a) 8.0 cm; (b) 1.0 cm
89	(a) 0.52 m; (b) 40 m/s; (c) 0.40 m
90	(a) 5.0 cm/s; (b) 3.2 cm; (c) 0.25 Hz

91	(a) 0.16 m; (b) 2.4×10^2 N; (c) $y(x, t) = (0.16\text{ m}) \sin[(1.57\text{ m}^{-1})x] \sin[(31.4\text{ s}^{-1})t]$
92	(b) $+x$; (c) interchange their amplitudes; (d) $x = \lambda/4 = 6.26$ cm; (e) $x = 0$ and $x = \lambda/2 = 12.5$ cm; (f) amplitude (4.00 mm) is sum of amplitudes of original waves; (g) amplitude (1.00 mm) is difference of amplitudes of original waves
93	(c) 2.0 m/s; (d) $-x$
94	4.0 cm/s
95	(a) ∞; (b)1.0; (c) 4.0%
96	(a) 10.6 W; (b) 21.2 W; (c) 8.83×10^{-2} J

Chapter 17 Answers

1	(a) 79 m; (b) 41 m; (c) 89 m
2	0.144 MPa
3	(a) 2.6 km; (b) 2.0×10^2
4	1.7×10^2 m
5	1.9×10^3 km
6	44 m
7	40.7 m
8	9.00
9	0.23 ms
9	(a) 2.3×10^2 Hz; (b) higher
10	(a) $(D \sin\theta)/v$; (b) D/v_w; (c) 13º
11	(a) 76.2 μm; (b) 0.333 mm
12	(a) 1.50 Pa; (b) 158 Hz; (c) 2.22 m; (d) 350 m/s
13	960 Hz

14	(a) 6.1 nm; (b) 9.2 m^{-1}; (c) 3.1×10^3 s^{-1}; (d) 5.9 nm; (e) 9.8 m^{-1}; (f) 3.1×10^3 s^{-1}
15	(a) 2.3×10^2 Hz; (b) higher
16	4.12 rad
17	(a) 143 Hz; (b) 3; (c) 5; (d) 286 Hz; (e) 2; (f) 3
18	(a) 0.5; (b) 1.5
19	(a) 14; (b) 14
20	(a) 0; (b) 0; (c) 4
21	(a) 343 Hz; (b) 3; (c) 5; (d) 686 Hz; (e) 2; (f) 3
22	17.5 cm
23	(a) 0; (b) fully constructive; (c) increase; (d) 128 m; (e) 63.0 m; (f) 41.2 m
24	(a) 10 μW/m^2; (b) 0.10 μW/m^2; (c) 70 nm; (d) 7.0 nm
25	36.8 nm
26	(a) 0.080 W/m^2; (b) 0.013 W/m^2
27	(a) 1.0×10^3; (b) 32
28	1.26

29	15.0 mW
30	(a) 8.84 nW/m^2; (b) 39.5 dB
31	2 μW
32	(a) 0.26 nm; (b) 1.5 nW/m^2
33	0.76 μm
34	(a) 3.2; (b) 5.0 dB;
35	(a) 5.97×10^{-5} W/m^2; (b) 4.48 nW
36	0.67 m
37	(a) 0.34 nW; (b) 0.68 nW; (c) 1.4 nW; (d) 0.88 nW; (e) 0
38	(a) 4; (b) 0.125 m; (c) 0.375 m
39	(a) 405 m/s; (b) 596 N; (c) 44.0 cm; (d) 37.3 cm
40	(a) 57.2 cm; (b) 42.9 cm
41	(a) 833 Hz; (b) 0.418 m
42	20 kHz
43	(a) 3; (b) 1129 Hz; (c) 1506 Hz
44	(a) 86 Hz; (b) yes, low frequency; (c) higher
45	(a) 2; (b) 1
46	(a) 2; (b) 0; (c) 0.40 m; (d) 143 Hz
47	12.4 m

48	(a) 260 Hz; (b) 4; (c) 840 Hz; (d) 7
49	45.3 N
50	(a) 71.5 Hz; (b) 64.8 N
51	2.25 ms
52	387 Hz
53	0.020
54	(a) 10; (b) 4
55	(a) 526 Hz; (b) 555 Hz
56	4.61 m/s
57	0
58	(a) 1.58 kHz; (b) 0.208 m; (c) 2.16 kHz; (d) 0.152 m
59	(a) 1.022 kHz; (b) 1.045 kHz
60	0.195 MHz
61	41 kHz
62	(a) $2v/3$; (b) $2v/3$; (c) $2v/3$; (d) $2v/3$
63	155 Hz
64	0.236
65	(a) 2.0 kHz; (b) 2.0 kHz
66	(a) 598 Hz; (b) 608 Hz; (c) 589 Hz
67	(a) 485.8 Hz; (b) 500.0 Hz; (c) 486.2 Hz; (d) 500.0 Hz
68	3.3×10^2 m/s
69	(a) 42°; (b) 11 s
70	33.0 km
71	1 cm
72	30°

73	2.1 m
74	7.9×10^{10} Pa
75	(a) 39.7 μW/m^2; (b) 171 nm; (c) 0.893 Pa
76	(a) 5.0×10^3; (b) 71; (c) 71
77	0.25
78	3.1 m/s
79	(a) 2.10 m; (b) 1.47 m
80	0.250
81	(a) 59.7; (b) 2.81×10^{-4}
82	(a) 0.30 cm; (b) 0.26 cm^{-1}; (c) 1.6×10^2 s^{-1}; (d) 6.0 m/s; (e) plus
83	(a) rightward; (b) 0.90 m/s; (c) less
84	(a) $L(v_m - v)/v_m v$; (b) 364 m
85	(a) 11 ms; (b) 3.8 m
86	0.33
87	(a) 9.7×10^2 Hz; (b) 1.0 kHz; (c) 60 Hz, no
88	(a) 2.00; (b) 1.41; (c) 1.73; (d) 1.85
89	(a) 21 nm; (b) 35 cm; (c) 24 nm; (d) 35 cm
90	(a) 572 Hz; (b) 1.14 kHz
91	(a) 7.70 Hz; (b) 7.70 Hz
92	3

93	(a) 5.2 kHz; (b) 2
94	(a) 3.9×10^2 to 9.2×10^2 GJ; (b) 0.63 to 1.5 W/m^2; (c) 25 to 58 kW/m^2; (d) surface wave
95	(a) 10 W; (b) 0.032 W/m^2; (c) 99 dB
96	0
97	(a) 0; (b) 0.572 m; (c) 1.14 m
98	(a) 0.50 m; (b) 0.34 m; (c) 0.66 m
99	171 m
100	(a) 2; (b) 6; (c) 10
101	(a) 3.6×10^2 m/s; (b) 150 Hz
102	(b) length^2
103	400 Hz
104	(a) 88 mW/m^2; (b) 0.75
105	(a) 14; (b) 12
106	35.8 m/s
107	821 m/s
108	$2[d^2 + 4(H + h)^2]^{0.5} - 2[d^2 + 4H^2]^{0.5}$
109	(a) 39.3 Hz; (b) 118 Hz
110	(a) 467 Hz; (b) 494 Hz
111	4.8×10^2 Hz

Chapter 18 Answers

1	1.366
2	(a) 0.06 kPa; (b) nitrogen
3	348 K
4	(a) –96°F; (b) 56.7°C

5	(a) 320°F; (b) -12.3°F
6	1375°X
7	-92.1°X
8	11 cm^2
9	2.731 cm
10	1.1 cm
11	49.87 cm^3
12	(a) 9.996 cm; (b) 68°C
13	29 cm^3
14	(a) 0.36%; (b) 0.18%; (c) 0.54%; (d) 0.00%; (e) 1.8×10^{-5}/C°
15	360°C
16	(a) -0.69%; (b) aluminum
17	0.26 cm^3
18	23×10^{-6}/C°
19	0.13 mm
20	0.217 K/s
21	7.5 cm
22	(a) 52 MJ; (b) 0°C
23	160 s
24	(a) 523 J/kg·K; (b) 26.2 J/mol·K; (c) 0.600 mol
25	94.6 L
26	0.25 kg
27	42.7 kJ
28	109 g
29	33 m^2
30	(a) 68 kJ/kg; (b) 2.3 kJ/kg·K
31	33 g
32	82 cal
33	3.0 min
34	4.0×10^2 J/kg·K
35	13.5 C°

36	(a) 2.03×10^4 cal; (b) 1.11×10^3 cal; (c) 873°C
37	(a) 5.3°C; (b) 0; (c) 0°C; (d) 60 g
38	(a) 37 W; (b) 2.0 kg; (c) 0.13 kg
39	742 kJ
40	0.41 kJ/kg·K
41	(a) 0°C; (b) 2.5°C
42	8.71 g
43	(a) 1.2×10^2 J; (b) 75 J; (c) 30 J
44	(a) +; (b) +; (c) 0; (d) +; (e) -; (f) -; (g) -; (h) -20 J
45	-30 J
46	(a) -200 J; (b) -293 J; (c) -93 J
47	(a) 6.0 cal; (b) -43 cal; (c) 40 cal; (d) 18 cal; (e) 18 cal
48	-5.0 J
49	60 J
50	(a) +8.0 J; (b) –9.3 J
51	(a) 1.23 kW; (b) 2.28 kW; (c) 1.05 kW
52	(a) 0.13 m; (b) 2.3 km
53	1.66 kJ/s

54	(a) 8×10^2 W; (b) 2×10^4 J
55	(a) 16 J/s; (b) 0.048 g/s
56	0.81 J
57	(a) 1.7×10^4 W/m^2; (b) 18 W/m^2
58	(a) 1.4 W; (b) 3.3
59	0.50 min
60	(a) 15.8 C°; (b) greater than; (c) 13.8 C°
61	0.40 cm/h
62	(a) 0.21 W; (b) 65 s
63	-4.2°C
64	(a) 0.16; (b) 84%
65	1.1 m
66	0.68 mg/s
67	10%
68	6.7×10^{12} J
69	(a) 80 J; (b) 80 J
70	35.7 m^3
71	4.5×10^2 J/kg·K
72	766°C
73	0.432 cm^3
74	(a) 2.5×10^2 K; (b) 1.5
75	3.1×10^2 J
76	66°C
77	79.5°C
78	(a) 16.7A W; (b) $(5.0 \times 10^{-5})A$ kg/s; (c) 50 nm/s
79	23 J
80	33.3 kJ
81	(a) $11p_1V_1$; (b) $6\ p_1V_1$
82	(a) 84.3°C; (b) 57.6°C
83	4.83×10^{-2} cm^3

84	(a) 2.3×10^2 J/s; (b) 15
85	10.5°C
86	0.32 cm^2
87	(a) 90 W; (b) 2.3×10^2 W; (c) 3.3×10^2 W
88	-157°C
89	(a) 1.87×10^4; (b) 10.4 h
90	1.7×10^2 km
91	333 J
92	2.16×10^{-5} m^2
93	8.6 J
94	45.5°C
95	(a) –45 J; (b) +45 J
96	(a) $(\alpha_1 L_1 + \alpha_2 L_2)/L$; (b) 39.3 cm; (c) 13.1 cm
97	4.0×10^3 min
98	1.5
99	-6.1 nW
100	2.5 kJ/kg·K
101	1.17 C°
102	660 μm
103	8.0×10^{-3} m^2
104	7.9×10^{-3}
105	(a) too fast; (b) 0.79 s/h
106	7.3×10^6 J
107	1.9
108	5.6×10^4 W

Chapter 19

1	0.933 kg
2	(a) 0.0127 mol; (b) 7.64×10^{21} atoms
3	(a) 0.0388 mol; (b) 220°C
4	(a) 106 mol; (b) 0.892 m^3
5	25 molecules/cm^3
6	1.25 atm

7	(a) 3.14×10^3 J; (b) from
8	(a) 5.47×10^{-8} mol; (b) 3.29×10^{16} molecules
9	186 kPa
10	0.2
11	5.60 kJ
12	(a) 12.6 m^3; (b) 1.16 m^3; (c) 5.10×10^3 mol
13	(a) 1.5 mol; (b) 1.8×10^3 K; (c) 6.0×10^2 K; (d) 5.0 kJ
14	207 J
15	360 K
16	1.0×10^2 cm^3
17	2.0×10^5 Pa
18	9.53×10^6 m/s
19	(a) 511 m/s; (b) –200°C; (c) 899°C
20	2.50 km/s
21	1.8×10^2 m/s
22	442 m/s
23	1.9 kPa
24	(a) 494 m/s; (b) 27.9 g/mol; (c) N_2
25	(a) 5.65×10^{-21} J; (b) 7.72×10^{-21} J; (c) 3.40 kJ; (d) 4.65 kJ
26	3.3×10^{-20} J
27	(a) 6.76×10^{-20} J; (b) 10.7
28	3.7 GHz
29	(a) 6×10^9 km
30	0.32 nm
31	(a) 3.27×10^{10} molecules/cm^3; (b) 172 m
32	(a) 1.7; (b) 5.0×10^{-5} cm; (c) 7.9×10^{-6} cm
33	(a) 6.5 km/s; (b) 7.1 km/s

34	(a) 3.2 cm/s; (b) 3.4 cm/s; (c) 4.0 cm/s
35	(a) 420 m/s; (b) 458 m/s; (c) yes
36	1.50
37	(a) 0.67; (b) 1.2; (c) 1.3; (d) 0.33
38	(a) 2.7×10^2 K; (b) 4.9×10^2 m/s
39	(a) 1.0×10^4 K; (b) 1.6×10^5 K; (c) 4.4×10^2 K; (d) 7.0×10^3 K; (e) no; (f) yes
40	4.7
41	(a) 7.0 km/s; (b) 2.0×10^{-8} cm; (c) 3.5×10^{10} collisions/s
42	3.4 kJ
43	(a) 3.49 kJ; (b) 2.49 kJ; (c) 997 J; (d) 1.00 kJ
44	(a) -5.0 kJ; (b) 2.0 kJ; (c) 5.0 kJ
45	(a) 6.6×10^{-26} kg; (b) 40 g/mol
46	(a) +249 J; (b) +623 J; (c) +374 J; (d) $+3.11 \times 10^{-22}$ J
47	(a) 0; (b) +374 J; (c) +374 J; (d) $+3.11 \times 10^{-22}$ J
48	(a) 15.9 J; (b) 34.4 J/mol·K; (c) 26.1 J/mol·K

49	15.8 J/mol·K
50	50 J
51	8.0 kJ
52	(a) 0.375 mol; (b) 1.09 kJ; (c) 0.714
53	(a) 6.98 kJ; (b) 4.99 kJ; (c) 1.99 kJ; (d) 2.99 kJ
54	1.5×10^3 N·m$^{2.2}$
55	(a) 14 atm; (b) 6.2×10^2 K
56	(a) 2.46 atm; (b) 336 K; (c) 0.406 L
57	(a) diatomic; (b) 446 K; (c) 8.10 mol
58	-87ºC
59	-15 J
60	17ºC
61	–20 J
62	-1.33×10^4 J
63	(a) 3.74 kJ; (b) 3.74 kJ; (c) 0; (d) 0; (e) -1.81 kJ; (f) 1.81 kJ; (g) -3.22 kJ; (h) -1.93 kJ; (i) -1.29 kJ; (j) 520 J; (k) 0; (l) 520 J; (m) 0.0246 m^3; (n) 2.00 atm; (o) 0.0373 m^3; (p) 1.00 atm
64	653 J

65	(a) monatomic; (b) 2.7×10^4 K; (c) 4.5×10^4 mol; (d) 3.4 kJ; (e) 3.4×10^2 kJ; (f) 0.010
66	1.52 nm
67	(a) 2.00 atm; (b) 333 J; (c) 0.961 atm; (d) 236 J
68	38.8 m
69	349 K
70	5.0 m^3
71	(a) -374 J; (b) 0; (c) +374 J; (d) $+3.11 \times 10^{-22}$ J
72	307°C
73	7.03×10^9 s^{-1}
74	(a) 2.5×10^{25} molecules/m^3; (b) 1.2 kg
75	(a) 900 cal; (b) 0; (c) 900 cal; (d) 450 cal; (e) 1200 cal; (f) 300 cal; (g) 900 cal; (h) 450 cal; (i) 0; (j) –900 cal; (k) 900 cal; (l) 450 cal
76	(a) –60 J; (b) 90 K
77	(a) $3/v_0^3$; (b) $0.750v_0$; (c) $0.775v_0$
78	(a) 0.33; (b) polyatomic (ideal); (c) 1.44
79	(a) –2.37 kJ; (b) 2.37 kJ
80	9.2×10^{-6}

81	(b) 125 J; (c) to
82	(a) 22.4 L
83	(a) 8.0 atm; (b) 300 K; (c) 4.4 kJ; (d) 3.2 atm; (e) 120 K; (f) 2.9 kJ; (g) 4.6 atm; (h) 170 K; (i) 3.4 kJ
84	(a) 122 K; (b) 365 K; (c) 0
85	(a) 38 L; (b) 71 g
86	(a) 7.72×10^4 J; (b) 5.46×10^4 J; (c) 5.17 J/mol·K; (d) 4.32×10^4 J; (e) 8.86×10^4 J; (f) 8.38 J/mol·K
87	-3.0 J
88	(a) –45 J; (b) 1.8×10^2 K
89	22.8 m
90	(a) 1.2×10^4 W; (b) 16 hp
91	-
92	1.40
93	-
94	0.63
95	1.40
96	0.61 m/s
97	4.71

Chapter 20

1	(a) 9.22 kJ; (b) 23.1 J/K; (c) 0
2	2.75 mol
3	14.4 J/K
4	1.86×10^4 J

5	(a) 5.79×10^4 J; (b) 173 J/K
6	(a) 14.6 J/K; (b) 30.2 J/K
7	(a) 320 K; (b) 0; (c) +1.72 J/K
8	0.0368 J/K
9	+0.76 J/K
10	4.5×10^2 J/kg·K
11	(a) 57.0°C; (b) -22.1 J/K; (c) +24.9 J/K; (d) +2.8 J/K
12	3.5 mol
13	(a) -710 mJ/K; (b) +710 mJ/K; (c) +723 mJ/K; (d) -723 mJ/K; (e) +13 mJ/K; (f) 0
14	(a) 3.00; (b) 6.00; (c) 0; (d) 8.64 J/K; (e) 0
15	(a) -943 J/K; (b) +943 J/K; (c) yes
16	+0.64 J/K
17	(a) 0.333; (b) 0.215; (c) 0.644; (d) 1.10; (e) 1.10; (f) 0; (g) 1.10; (h) 0; (i) –0.889; (j) –0.889; (k) –1.10; (l) –0.889; (m) 0; (n) 0.889; (o) 0

18	(a) 4.5 kJ; (b) –5.0 kJ; (c) 9.5 kJ
19	(a) 0.693; (b) 4.50; (c) 0.693; (d) 0; (e) 4.50; (f) 23.0 J/K; (g) –0.693; (h) 7.50; (i) –0.693; (j) 3.00; (k) 4.50; (l) 23.0 J/K
20	(a) 1.84 kPa; (b) 441 K; (c) 3.16 kJ; (d) 1.94 J/K
21	-1.18 J/K
22	(a) 66.5°C; (b) 14.6 J/K; (c) 11.0 J/K; (d) –21.2 J/K; (e) 4.39 J/K
23	97 K
24	(a) 31%; (b) 16 kJ
25	(a) 266 K; (b) 341 K
26	99.999 95%
27	(a) 23.6%; (b) 1.49×10^4 J
28	---
29	(a) 2.27 kJ; (b) 14.8 kJ; (c) 15.4%; (d) 75.0%; (e) greater
30	(a) 4.67 kJ/s; (b) 4.17 kJ/s
31	(a) 33 kJ; (b) 25 kJ; (c) 26 kJ; (d) 18 kJ

32	1.7 kJ
33	(a) 1.47 kJ; (b) 554 J; (c) 918 J; (d) 62.4%
34	(a) monatomic; (b) 75%
35	(a) 3.00; (b) 1.98; (c) 0.660; (d) 0.495; (e) 0.165; (f) 34.0%
36	(a) 0.071 J; (b) 0.50 J; (c) 2.0 J; (d) 5.0 J
37	440 W
38	13 J
39	20 J
40	(a) 49 kJ; (b) 7.4 kJ
41	0.25 hp
42	1.08 MJ
43	2.03
44	(a) 167 J; (b) 343 J
45	---
46	(a) 1.26×10^{14}; (b) 1.13×10^{15}; (c) 11.1%; (d) 1.01×10^{29}; (e) 1.27×10^{30}; (f) 8.0%; (g) 9.25×10^{58}; (h) 1.61×10^{60}; (i) 5.7%; (j) decrease
47	(a) $W = N!/(n_1!\ n_2!\ n_3!)$; (b) $[(N/2)!\ (N/2)!]/[(N/3)!\ (N/3)!\ (N/3)!]$; (c) 4.2×10^{16}
48	(a) 1; (b) 6; (c) 0; (d) 2.47×10^{-23} J/K

49	0.141 J/K·s
50	(a) 6.34 J/K; (b) 6.34 J/K; (c) 6.34 J/K; (d) 6.34 J/K
51	(a) 87 m/s; (b) 1.2×10^2 m/s; (c) 22 J/K
52	(a) 7.2 kJ; (b) 9.6×10^2 J; (c) 13%
53	(a) 78%; (b) 82 kg/s
54	4.46 J/K
55	(a) 40.9°C; (b) –27.1 J/K; (c) 30.3 J/K; (d) 3.18 J/K
56	2.65 mJ/K·m
57	+3.59 J/K
58	+5.98 J/K
59	1.18×10^3 J/K
60	13.1%
61	---
62	(a) 700 J; (b) 0; (c) 50 J; (d) 700 J; (e) 0.226 m^3; (f) 0.284 m^3; (g) 0; (h) –1.25 kJ; (i) 0; (j) 1.25 kJ
63	(a) 0; (b) 0; (c) –23.0 J/K; (d) 23.0 J/K
64	(a) 93.8 J; (b) 231 J
65	(a) 25.5 kJ; (b) 4.73 kJ; (c) 18.5%
66	(a) 3.73; (b) 710 J

67	(a) 1.95 J/K; (b) 0.650 J/K; (c) 0.217 J/K; (d) 0.072 J/K; (e) decrease
68	75
69	(a) 4.45 J/K; (b) no
70	(a) –44.2°C; (b) –1.69 J/K; (c) 2.38 J/K; (d) 0.69 J/K
71	(a) 1.26×10^{14}; (b) 4.71×10^{13}; (c) 0.37; (d) 1.01×10^{29}; (e) 1.37×10^{28}; (f) 0.14; (g) 9.05×10^{58}; (h) 1.64×10^{57}; (i) 0.018; (j) decrease
72	25%
73	(a) 42.6 kJ; (b) 7.61 kJ
74	-40 K
75	(a) 1; (b) 1; (c) 3; (d) 10; (e) 1.5×10^{-23} J/K; (f) 3.2×10^{-23} J/K
76	(a) 75 J; (b) 75 J
77	$e = (1 + K)^{-1}$
78	(a) 4.66 kW; (b) 4.16 kW
79	6.7