

## *Answers to Problems*

### **Chapter 1**

1. (a)  $4.00 \times 10^4$  km; (b)  $5.10 \times 10^8$  km<sup>2</sup>; (c)  $1.08 \times 10^{12}$  km<sup>3</sup>
2. 0.18 points<sup>2</sup>
3. (a)  $10^9$   $\mu$ m; (b)  $10^{-4}$ ; (c)  $9.1 \times 10^5$   $\mu$ m
4. (a) 1.9 picas; (b) 23 points
5. (a) 160 rods; (b) 40 chains
6. (a)  $8.33 \times 10^{-2}$ ,  $2.08 \times 10^{-2}$ ,  $6.94 \times 10^{-3}$ ,  $3.47 \times 10^{-3}$ ;  
(b) 0.250,  $8.33 \times 10^{-2}$ ,  $4.17 \times 10^{-2}$ ; (c) 0.333, 0.167; (d) 0.500; (e) 14.0 medios; (f)  $4.86 \times 10^{-2}$  cahiz; (g)  $3.24 \times 10^4$  cm<sup>3</sup>
7.  $1.1 \times 10^3$  acre-feet
8. (a) 60.8 W; (b) 43.3 Z
9.  $1.9 \times 10^{22}$  cm<sup>3</sup>
10. 15°
11. (a) 1.43; (b) 0.864
12. 3.1  $\mu$ m/s
13. (a) 495 s; (b) 141 s; (c) 198 s; (d) -245 s
14. (a) 52.6 min; (b) 4.9%
15.  $1.21 \times 10^{12}$   $\mu$ s
16. (a)  $3.88 \times 10^8$  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.  $5.2 \times 10^6$  m
20. (a)  $2.69 \times 10^5$  cm<sup>3</sup>; (b) 0.77 y
21.  $9.0 \times 10^{49}$  atoms
22. (a) 1.430 m<sup>2</sup>; (b) 72.84 km
23. (a)  $1 \times 10^3$  kg; (b) 158 kg/s
24. 0.260 kg
25.  $1.9 \times 10^5$  kg
26. (a)  $2 \times 10^3$  m<sup>3</sup>,  $2 \times 10^4$  m<sup>3</sup>; (b)  $2 \times 10^6$  bottles,  $2 \times 10^7$  bottles; (c)  $2 \times 10^6$  kg,  $2 \times 10^7$  kg
27. (a)  $1.18 \times 10^{-29}$  m<sup>3</sup>; (b) 0.282 nm
28. 1 kilomole
29.  $1.75 \times 10^3$  kg
30. (a) 4.21 s; (b) 23.2 g; (c)  $2.89 \times 10^{-2}$  kg/min; (d)  $-6.05 \times 10^{-3}$  kg/min
31. 1.43 kg/min
32. (a) 1.0 m<sup>3</sup>; (b)  $6.0 \times 10^{-4}$  m<sup>3</sup>
33. (a) 293 U.S. bushels; (b)  $3.81 \times 10^3$  U.S. bushels
34. 403 L
35. (a) 22 pecks; (b) 5.5 Imperial bushels; (c) 200 L

36. (a)  $0.900$ ,  $7.50 \times 10^{-2}$ ,  $1.56 \times 10^{-3}$ ,  $8.32 \times 10^{-6}$ ; (b)  $1.00$ ,  $8.33 \times 10^{-2}$ ,  $1.74 \times 10^{-3}$ ,  $9.24 \times 10^{-6}$ ; (c)  $12.0$ ,  $1.00$ ,  $2.08 \times 10^{-2}$ ,  $1.11 \times 10^{-4}$ ; (d)  $576$ ,  $48$ ,  $1.00$ ,  $5.32 \times 10^{-3}$ ; (e)  $1.08 \times 10^5$ ,  $9.02 \times 10^3$ ,  $188$ ,  $1.00$ ; (f)  $1.96 \text{ m}^3$
37.  $8 \times 10^2 \text{ km}$
38. (a)  $14.5 \text{ roods}$ ; (b)  $1.47 \times 10^4 \text{ m}^2$
39. (a)  $18.8 \text{ gallons}$ ; (b)  $22.5 \text{ gallons}$
40.  $6.0 \times 10^{26} \text{ atoms}$
41.  $0.3 \text{ cord}$
42. (a)  $3.0 \times 10^{-26} \text{ kg}$ ; (b)  $5 \times 10^{46} \text{ molecules}$
43.  $3.8 \text{ mg/s}$
44.  $1.3 \times 10^9 \text{ kg}$
45. (a) yes; (b)  $8.6 \text{ universe seconds}$
46.  $0.020 \text{ km}^3$
47.  $0.12 \text{ AU/min}$
48.  $10 \text{ u}$
49. (a)  $3.88$ ; (b)  $7.65$ ; (c)  $156 \text{ ken}^3$ ; (d)  $1.19 \times 10^3 \text{ m}^3$
50.  $5.95 \text{ km}$
51. (a)  $3.9 \text{ m}$ ,  $4.8 \text{ m}$ ; (b)  $3.9 \times 10^3 \text{ mm}$ ,  $4.8 \times 10^3 \text{ mm}$ ; (c)  $2.2 \text{ m}^3$ ,  $4.2 \text{ m}^3$
52.  $\approx 1 \times 10^{36}$
53. (a)  $4.9 \times 10^{-6} \text{ pc}$ ; (b)  $1.6 \times 10^{-5} \text{ ly}$
54. (a)  $11.3 \text{ m}^2/\text{L}$ ; (b)  $1.13 \times 10^4 \text{ m}^{-1}$ ; (c)  $2.17 \times 10^{-3} \text{ gal/ft}^2$ ; (d) number of gallons to cover a square foot

## **Chapter 2**

1.  $13 \text{ m}$
2. (a)  $1.74 \text{ m/s}$ ; (b)  $2.14 \text{ m/s}$
3. (a)  $+40 \text{ km/h}$ ; (b)  $40 \text{ km/h}$
4.  $48 \text{ km/h}$
5. (a)  $0$ ; (b)  $-2 \text{ m}$ ; (c)  $0$ ; (d)  $12 \text{ m}$ ; (e)  $+12 \text{ m}$ ; (f)  $+7 \text{ m/s}$
6.  $5.554 \text{ s}$
7.  $60 \text{ km}$
8. (a)  $0.50 \text{ m/s}$ ; (b)  $10 \text{ s}$
9.  $1.4 \text{ m}$
10. (a) method 1; (b)  $5.76 \times 10^{-4}$
11.  $128 \text{ km/h}$
12. (a)  $48.0 \text{ m}$ ; (b)  $2.5 \text{ m/s}$ ; (c) downstream
13. (a)  $73 \text{ km/h}$ ; (b)  $68 \text{ km/h}$ ; (c)  $70 \text{ km/h}$ ; (d)  $0$
14.  $5.9 \text{ m}$
15. (a)  $-6 \text{ m/s}$ ; (b)  $-x \text{ direction}$ ; (c)  $6 \text{ m/s}$ ; (d) decreasing; (e)  $2 \text{ s}$ ; (f) no
16. (a)  $0$ ; (b)  $4.0 \text{ m}$ ; (c)  $-0.82 \text{ s}$ ; (d)  $0.82 \text{ s}$ ; (f)  $+20t$ ; (g) increase
17. (a)  $28.5 \text{ cm/s}$ ; (b)  $18.0 \text{ cm/s}$ ; (c)  $40.5 \text{ cm/s}$ ; (d)  $28.1 \text{ cm/s}$ ; (e)  $30.3 \text{ cm/s}$
18. (a)  $54 \text{ m}$ ; (b)  $18 \text{ m/s}$ ; (c)  $-12 \text{ m/s}^2$ ; (d)  $64 \text{ m}$ ; (e)  $4.0 \text{ s}$ ; (f)  $24 \text{ m/s}$ ; (g)  $2.0 \text{ s}$ ; (h)  $-24 \text{ m/s}^2$ ; (i)  $18 \text{ m/s}$
19.  $-20 \text{ m/s}^2$
20. (a)  $1.2 \text{ s}$ ; (b)  $0$ ; (c) positive; (d) negative

21. (a) 1.10 m/s; (b) 6.11 mm/s<sup>2</sup>; (c) 1.47 m/s; (d) 6.11 mm/s<sup>2</sup>  
22. (a) m/s<sup>2</sup>; (b) m/s<sup>3</sup>; (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<sup>2</sup>; (k) -18 m/s<sup>2</sup>; (l) -30 m/s<sup>2</sup>; (m) -42 m/s<sup>2</sup>  
23.  $1.62 \times 10^{15}$  m/s<sup>2</sup>  
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)  $3.1 \times 10^6$  s; (b)  $4.6 \times 10^{13}$  m  
32. 21g  
33. (a) 3.56 m/s<sup>2</sup>; (b) 8.43 m/s  
34. (a) -50 km/h; (b) -2.0 m/s<sup>2</sup>  
35. 0.90 m/s<sup>2</sup>  
36. (a) 56.6 s; (b) 31.8 m/s  
37. (a) 4.0 m/s<sup>2</sup>; (b) +x  
38. (a) 32.9 m/s; (b) 49.1 s; (c) 11.7 m/s  
39. (a) -2.5 m/s<sup>2</sup>; (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 m/s<sup>2</sup>  
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 m/s<sup>2</sup>; (b) up  
56. 3.0 m/s  
57. (a)  $1.26 \times 10^3$  m/s<sup>2</sup>; (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<sup>2</sup>; (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)  $-9.00 \text{ cm/s}^2$ ; (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)  $6.2 \text{ m/s}^2$   
 76. (a)  $D_{23}/v_p$ ; (b)  $t_r + v_p/2a + (D_{12} - d)/v_p$   
 77. (a)  $3.1 \text{ m/s}^2$ ; (b) 45 m; (c) 13 s  
 78. yes, 0, 10 m/s  
 79. 17 m/s  
 80. (a)  $5.0 \text{ m/s}^2$ ; (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)  $1.67 \text{ m/s}^2$ ; (c) 7.50 m  
 89.  $4H$   
 90. (a) 15 m; (b) 2.0 m/s; (c)  $-2.0 \text{ m/s}^2$ ; (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)  $2.0 \text{ m/s}^2$ ; (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

### **Chapter 3**

1. (a)  $-2.5 \text{ m}$ ; (b)  $-6.9 \text{ m}$   
 2. (a) 13 m; (b) 7.5 m  
 3. (a) 47.2 m; (b)  $122^\circ$   
 4. (a) 0.349 rad; (b) 0.873 rad; (c) 1.75 rad; (d)  $18.9^\circ$ ; (e)  $120^\circ$ ; (f)  $441^\circ$   
 5. (a) 156 km; (b)  $39.8^\circ$  west of due north

6. (a) 4.28 m; (b) 11.7 m
7. (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
8. (b) 3.2 km; (c)  $41^\circ$  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)  $-5.8 \text{ m}$ ; (c)  $-2.8 \text{ m}$
11. (a)  $(-9.0 \text{ m})\hat{i} + (10 \text{ m})\hat{j}$ ; (b) 13 m; (c)  $132^\circ$
12. (a) 81 km; (b)  $40^\circ$  north of due east
13. 4.74 km
14. (a)  $-80 \text{ m}$ ; (b) 110 m; (c) 143 m; (d)  $168^\circ$
15. (a) 1.59 m; (b) 12.1 m; (c) 12.2 m; (d)  $82.5^\circ$
16. (a)  $(8.0 \text{ m})\hat{i} + (2.0 \text{ m})\hat{j}$ ; (b) 8.2 m; (c)  $14^\circ$ ; (d)  $(2.0 \text{ m})\hat{i} - (6.0 \text{ m})\hat{j}$ ; (e) 6.3 m; (f)  $-72^\circ$
17. (a) 38 m; (b)  $-37.5^\circ$ ; (c) 130 m; (d)  $1.2^\circ$ ; (e) 62 m; (f)  $130^\circ$
18. (a) 26.6 m; (b)  $-151^\circ$
19. 5.39 m at  $21.8^\circ$  left of forward
20. (a) 5.0 km; (b)  $4.3^\circ$  south of due west
21. (a)  $-70.0 \text{ cm}$ ; (b) 80.0 cm; (c) 141 cm; (d)  $-172^\circ$
22. (a)  $(1.28 \text{ m})\hat{i} + (6.60 \text{ m})\hat{j}$ ; (b) 6.72 m; (c)  $79.0^\circ$ ; (d) 1.38 rad
23. 3.2
24. 2.2 m
25. 2.6 km
26. (a)  $(-3.18 \text{ m})\hat{i} + (4.72 \text{ m})\hat{j}$ ; (b) 5.69 m; (c)  $+124^\circ$
27. (a)  $8\hat{i} + 16\hat{j}$ ; (b)  $2\hat{i} + 4\hat{j}$
28. (a) 0.84 m; (b)  $79^\circ$  south of due east
29. (a) 7.5 cm; (b)  $90^\circ$ ; (c) 8.6 cm; (d)  $48^\circ$
30. (a) 5.0 m; (b)  $-37^\circ$ ; (c) 10 m; (d)  $53^\circ$ ; (e) 11 m; (f)  $27^\circ$ ; (g) 11 m; (h)  $80^\circ$ ; (i) 11 m; (j)  $260^\circ$ ; (k)  $180^\circ$
31. (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)  $54.7^\circ$ ; (f)  $3^{0.5}a$
32. (a) 9.51 m; (b) 14.1 m; (c) 13.4 m; (d) 10.5 m
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.  $70.5^\circ$
40. (a)  $2.81 \text{ m}^2$ ; (b)  $(1.43 \text{ m}^2)\hat{i} + (4.86 \text{ m}^2)\hat{j} - (2.48 \text{ m}^2)\hat{k}$ ; (c)  $63.5^\circ$
41.  $22^\circ$
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)  $-5.00 \text{ m}$ ; (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)  $1.14 \times 10^3$ ,  $\theta$  not defined,  $\phi = 0^\circ$ ; (d)  $90.0^\circ$ ; (e)  $-5.14\hat{i} + 6.13\hat{j} + 3.00\hat{k}$ ; (f) 8.54,  $\theta = 130^\circ$ ,  $\phi = 69.4^\circ$
46. (a) 4.2 m; (b)  $50^\circ$  north of due east; (c) 8.0 m; (d)  $24^\circ$  north of due west

47. (a)  $140^\circ$ ; (b)  $90.0^\circ$ ; (c)  $99.1^\circ$   
 48. (a)  $57^\circ$ ; (b) 2.2 m; (c)  $-4.5$  m; (d)  $-2.2$  m; (e) 4.5 m  
 49. (a) 103 km; (b)  $60.9^\circ$  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)  $123^\circ$ ; (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)  $25^\circ$  north of due east; (k) 5.69 m; (l)  $25^\circ$  south of due west  
 56. (a)  $(10.0 \text{ m})\hat{i} + (1.63 \text{ m})\hat{j}$ ; (b) 10.2 m; (c)  $9.24^\circ$   
 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)  $120^\circ$ ; (c)  $-4.9$ ; (d) 7.3  
 62. (a) 1.8 m; (b)  $69^\circ$  north of due east  
 63. (a)  $3.0 \text{ m}^2$ ; (b)  $52 \text{ m}^3$ ; (c)  $(11 \text{ m}^2)\hat{i} + (9.0 \text{ m}^2)\hat{j} + (3.0 \text{ m}^2)\hat{k}$   
 64. (a) parallel; (b) antiparallel; (c) perpendicular  
 65. (a)  $(-40\hat{i} - 20\hat{j} + 25\hat{k}) \text{ m}$ ; (b) 45 m

#### **Chapter 4**

1. (a) 6.2 m  
 2. (a)  $(-5.0 \text{ m})\hat{i} + (8.0 \text{ m})\hat{j}$ ; (b) 9.4 m; (c)  $122^\circ$ ; (e)  $(8.0 \text{ m})\hat{i} - (8.0 \text{ m})\hat{j}$ ; (f) 11 m;  
 (g)  $-45^\circ$   
 3.  $(-2.0 \text{ m})\hat{i} + (6.0 \text{ m})\hat{j} - (10 \text{ m})\hat{k}$   
 4. (a) 14 cm; (b)  $-135^\circ$ ; (c) 20 cm; (d)  $90^\circ$ ; (e) 0; (f) 0  
 5. (a) 7.59 km/h; (b)  $22.5^\circ$  east of due north  
 6. (a)  $(3.00 \text{ m/s})\hat{i} - (8.00 \text{ m/s}^2)\hat{j}$ ; (b)  $(3.00 \text{ m/s})\hat{i} - (16.0 \text{ m/s})\hat{j}$ ; (c) 16.3 m/s; (d)  $-79.4^\circ$   
 7.  $(-0.70 \text{ m/s})\hat{i} + (1.4 \text{ m/s})\hat{j} - (0.40 \text{ m/s})\hat{k}$   
 8. (a)  $1.08 \times 10^3$  km; (b)  $26.6^\circ$  east of due south; (c) 480 km/h; (d)  $26.6^\circ$  east of due south; (e) 644 km/h  
 9. (a) 0.83 cm/s; (b)  $0^\circ$ ; (c) 0.11 m/s; (d)  $-63^\circ$   
 10. (a) 3.50 m/s; (b)  $-0.125$  m/s  
 11. (a)  $(6.00 \text{ m})\hat{i} - (106 \text{ m})\hat{j}$ ; (b)  $(19.0 \text{ m/s})\hat{i} - (224 \text{ m/s})\hat{j}$ ; (c)  $(24.0 \text{ m/s}^2)\hat{i} - (336 \text{ m/s}^2)\hat{j}$ ;  
 (d)  $-85.2^\circ$   
 12. (a) 56.6 m; (b)  $45^\circ$  north of due west (NW); (c) 1.89 m/s; (d)  $45^\circ$  north of due west (NW); (e)  $0.471 \text{ m/s}^2$ ; (f)  $45^\circ$  north of due east (NE)  
 13. (a)  $(8 \text{ m/s}^2)\hat{i} + (1 \text{ m/s})\hat{k}$ ; (b)  $(8 \text{ m/s}^2)\hat{j}$   
 14. (a)  $(-1.5 \text{ m/s}^2)\hat{i} + (0.50 \text{ m/s}^2)\hat{k}$ ; (b)  $1.6 \text{ m/s}^2$ ; (c)  $162^\circ$   
 15. (a)  $(-1.50 \text{ m/s})\hat{j}$ ; (b)  $(4.50 \text{ m})\hat{i} - (2.25 \text{ m})\hat{j}$   
 16. (a)  $(-18 \text{ m/s}^2)\hat{i}$ ; (b) 0.75 s; (c) never; (d) 2.2 s  
 17.  $(32 \text{ m/s})\hat{i}$   
 18. (a) 15.8 m/s; (b)  $42.6^\circ$

19. (a)  $(72.0 \text{ m})\hat{i} + (90.7 \text{ m})\hat{j}$ ; (b)  $49.5^\circ$
20.  $60^\circ$
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.  $78.5^\circ$
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)  $-171 \text{ m/s}$
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)  $40.4^\circ$ ; (d) below
40. (a) 24.95 m; (b) 25.02 m
41.  $56.4^\circ$
42. (a) 5.3 m; (b) 7.9 m; (c) 69 m
43. (a) 11 m; (b) 23 m; (c) 17 m/s; (d)  $63^\circ$
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)  $31.0^\circ$
46. 70.7%
47. (a) yes; (b) 2.56 m
48. (a) 33.7 m; (b) 26.0 m/s; (c)  $71.1^\circ$
49. (a)  $31^\circ$ ; (b)  $63^\circ$
50. (a) 20 m/s; (b) 36 m/s; (c) 74 m
51. (a)  $2.3^\circ$ ; (b) 1.4 m; (c)  $18^\circ$
52.  $14^\circ$
53. (a) 75.0 m; (b) 31.9 m/s; (c)  $66.9^\circ$ ; (d) 25.5 m
54. 42 m/s
55. the third
56. (a) 7.49 km/s; (b)  $8.00 \text{ m/s}^2$
57. (a) 7.32 m; (b) west; (c) north
58. (a) 0.94 m; (b) 19 m/s; (c)  $2.4 \text{ km/s}^2$ ; (d) 50 ms
59. (a) 12 s; (b)  $4.1 \text{ m/s}^2$ ; (c) down; (d)  $4.1 \text{ m/s}^2$ ; (e) up
60. (a) 0; (b) 0
61. (a)  $1.3 \times 10^5 \text{ m/s}$ ; (b)  $7.9 \times 10^5 \text{ m/s}^2$ ; (c) increase
62.  $4.0 \text{ m/s}^2$
63. 2.92 m
64. (a) 4.00 m; (b) 6.00 m

65.  $(3.00 \text{ m/s}^2)\hat{i} + (6.00 \text{ m/s}^2)\hat{j}$
66. (a) 8.82 m; (b) 6.00 m
67.  $160 \text{ m/s}^2$
68. (a)  $5.24 \text{ m/s}^2$ ; (b)  $3.33 \text{ m/s}^2$
69. (a)  $13 \text{ m/s}^2$ ; (b) eastward; (c)  $13 \text{ m/s}^2$ ; (d) eastward
70. (a) 5 km/h; (b) +x; (c) 1 km/h; (d) -x
71. 1.67
72.  $130^\circ$
73. (a)  $(80 \text{ km/h})\hat{i} - (60 \text{ km/h})\hat{j}$ ; (b)  $0^\circ$ ; (c) answers do not change
74. 240 km/h
75. 32 m/s
76. (a) 185 km/h; (b)  $22^\circ$  south of due west
77.  $60^\circ$
78. (a) 24.8 m/s; (b)  $83.8^\circ$  north of due east; (c)  $0.40 \text{ m/s}^2$ ; (d)  $60.0^\circ$  north of due east
79. (a) 38 knots; (b)  $1.5^\circ$  east of due north; (c) 4.2 h; (d)  $1.5^\circ$  west of due south
80. (a) 7.2 m/s; (b)  $16^\circ$  west of due north; (c) 29 s (not 28 s)
81. (a)  $(-32 \text{ km/h})\hat{i} - (46 \text{ km/h})\hat{j}$ ; (b)  $[(2.5 \text{ km}) - (32 \text{ km/h})t]\hat{i} + [(4.0 \text{ km}) - (46 \text{ km/h})t]\hat{j}$ ; (c) 0.084 h; (d)  $2 \times 10^2 \text{ m}$
82. (a)  $37^\circ$  west of due north; (b) 62.6 s
83. (a)  $-30^\circ$ ; (b) 69 min; (c) 80 min; (d) 80 min; (e)  $0^\circ$ ; (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)  $76^\circ$  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)  $2.6 \times 10^2 \text{ m/s}$ ; (b) 45 s; (c) increase
92. (a) 19 m/s; (b) 35 rev/min; (c) 1.7 s
93. (a) 63 km; (b)  $18^\circ$  south of due east; (c) 0.70 km/h; (d)  $18^\circ$  south of due east; (e) 1.6 km/h; (f) 1.2 km/h; (g)  $33^\circ$  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)  $4.8 \times 10^2 \text{ m/s}$
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)  $9.8 \text{ m/s}^2$ ; (d)  $9.8 \text{ m/s}^2$
102. (a)  $6.7 \times 10^6 \text{ m/s}$ ; (b)  $1.4 \times 10^{-7} \text{ s}$

103. (a) 6.79 km/h; (b)  $6.96^\circ$   
 104. 7.0 m/s  
 105. (a) 16 m/s; (b)  $23^\circ$ ; (c) above; (d) 27 m/s; (e)  $57^\circ$ ; (f) below  
 106. (a)  $(-7.0 \text{ m})\hat{i} + (12 \text{ m})\hat{j}$ ; (b)  $xy$  plane  
 107. (a) 4.2 m,  $45^\circ$ ; (b) 5.5 m,  $68^\circ$ ; (c) 6.0 m,  $90^\circ$ ; (d) 4.2 m,  $135^\circ$ ; (e) 0.85 m/s,  $135^\circ$ ;  
 (f) 0.94 m/s,  $90^\circ$ ; (g) 0.94 m/s,  $180^\circ$ ; (h)  $0.30 \text{ m/s}^2$ ,  $180^\circ$ ; (i)  $0.30 \text{ m/s}^2$ ,  $270^\circ$   
 108. (a) 7.3 km; (b) 80 km/h  
 109. (a)  $5.4 \times 10^{-13} \text{ m}$ ; (b) decrease  
 110. 36 s, no  
 111. (a)  $0.034 \text{ m/s}^2$ ; (b) 84 min  
 112. longer by about 1 cm  
 113. (a) 8.43 m; (b)  $-129^\circ$   
 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,  $-0.87 \text{ m/s}^2$ ; 0,  $-1.2 \text{ m/s}^2$ ; 0,  $-0.87 \text{ m/s}^2$   
 115. (a) 2.00 ns; (b) 2.00 mm; (c)  $1.00 \times 10^7 \text{ m/s}$ ; (d)  $2.00 \times 10^6 \text{ m/s}$   
 116. (a) 76 m; (b) 4.2 s  
 117. (a) 24 m/s; (b) 65  
 118. 48 s  
 119.  $93^\circ$  from the car's direction of motion

## **Chapter 5**

1.  $2.9 \text{ m/s}^2$
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)  $0.88 \text{ m/s}^2$ ; (c)  $-11^\circ$
6. 241 N
7. (a)  $(-32.0 \text{ N})\hat{i} - (20.8 \text{ N})\hat{j}$ ; (b) 38.2 N; (c)  $-147^\circ$
8.  $(-34\hat{i} - 12\hat{j}) \text{ N}$
9. (a) 8.37 N; (b)  $-133^\circ$ ; (c)  $-125^\circ$
10.  $(-7.98 \text{ N})\hat{i}$
11.  $9.0 \text{ m/s}^2$
12.  $56^\circ$
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)  $4.9 \text{ m/s}^2$
18. 0.22 m/s
19.  $1.2 \times 10^5 \text{ N}$
20.  $6.8 \times 10^3 \text{ N}$
21. (a)  $-9.80\hat{j} \text{ m/s}^2$ ; (b)  $2.35\hat{j} \text{ m/s}^2$ ; (c) 1.37 s; (d)  $(-5.56 \times 10^{-3} \text{ N})\hat{j}$ ; (e)  $(1.333 \times 10^{-3} \text{ N})\hat{j}$
22. (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)  $-22.0^\circ$ ; (e)  $3.67 \text{ m/s}^2$ ; (f)  $-22.0^\circ$

23. (a) 11.7 N; (b)  $-59.0^\circ$
24. (a) 0; (b)  $(20\text{ N})\hat{i}$ ; (c)  $(-20\text{ N})\hat{i}$ ; (d)  $(-40\text{ N})\hat{i}$ ; (e)  $(-60\text{ N})\hat{i}$
25. (a)  $0.022\text{ m/s}^2$ ; (b)  $8.3 \times 10^4\text{ km}$ ; (c)  $1.9 \times 10^3\text{ m/s}$
26.  $3.1 \times 10^2\text{ N}$
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.  $2.1 \times 10^2\text{ N}$
31. (a) 1.18 m; (b) 0.674 s; (c) 3.50 m/s
32. (a)  $(1.70\text{ N})\hat{i} + (3.06\text{ N})\hat{j}$ ; (b)  $(1.70\text{ N})\hat{i} + (3.06\text{ N})\hat{j}$ ; (c)  $(2.02\text{ N})\hat{i} + (2.71\text{ N})\hat{j}$
33.  $1.8 \times 10^4\text{ N}$
34. (a) 566 N; (b) 1.13 kN
35. (a)  $46.7^\circ$ ; (b)  $28.0^\circ$
36. (a) 68 N; (b) 73 N
37. (a)  $0.62\text{ m/s}^2$ ; (b)  $0.13\text{ m/s}^2$ ; (c) 2.6 m
38. (a) +68 N; (b) +28 N; (c) -12 N
39. (a)  $2.2 \times 10^{-3}\text{ N}$ ; (b)  $3.7 \times 10^{-3}\text{ N}$
40. 47.4 N
41. (a)  $1.4\text{ m/s}^2$ ; (b) 4.1 m/s
42. (a) 6.8 kN; (b)  $201^\circ$
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.  $6.4 \times 10^3\text{ N}$
48. 176 N
49. (a)  $2.18\text{ m/s}^2$ ; (b) 116 N; (c)  $21.0\text{ m/s}^2$
50. (a) 36.8 N; (b) 19.1 cm
51. (a)  $3.6\text{ m/s}^2$ ; (b) 17 N
52. 5.1 m/s
53. (a)  $0.970\text{ m/s}^2$ ; (b) 11.6 N; (c) 34.9 N
54. 23 kg
55. (a) 1.1 N
56. (a)  $2.50\text{ m/s}^2$ ; (b) 30.0 N
57. (a)  $0.735\text{ m/s}^2$ ; (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)  $4.9\text{ m/s}^2$ ; (b)  $2.0\text{ m/s}^2$ ; (c) up; (d) 120 N
60. (a)  $-5.90 \times 10^{-4}\text{ m/s}^3$ ; (b)  $5.90 \times 10^{-4}\text{ m/s}^3$
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)  $0.653\text{ m/s}^3$ ; (b)  $0.896\text{ m/s}^3$ ; (c) 6.50 s
66. 18 kN
67. 81.7 N

68. 334.8 N  
 69. 2.4 N  
 70. (a)  $245 \text{ m/s}^2$ ; (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)  $17^\circ$   
 74. 2.2 kg  
 75. (a) 0; (b)  $0.83 \text{ m/s}^2$ ; (c) 0  
 76. (b)  $F/(m + M)$ ; (c)  $FM/(m + M)$ ; (d)  $F(m + 2M)/2(m + M)$   
 77. (a)  $0.74 \text{ m/s}^2$ ; (b)  $7.3 \text{ m/s}^2$   
 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)  $(1.0\hat{i} - 1.3\hat{j}) \text{ m/s}^2$ ; (b)  $1.6 \text{ m/s}^2$ ; (c)  $-50^\circ$   
 83. (a)  $4.6 \text{ m/s}^2$ ; (b)  $2.6 \text{ m/s}^2$   
 84. (a)  $\cos \theta$ ; (b)  $(\cos \theta)^{0.5}$   
 85. (a) rope breaks; (b)  $1.6 \text{ m/s}^2$   
 86. (a)  $7.4 \times 10^2 \text{ N}$ ; (b)  $2.8 \times 10^2 \text{ N}$ ; (c) 0; (d) 75 kg  
 87. (a) 65 N; (b) 49 N  
 88. (a) 3260 N; (b)  $2.7 \times 10^3 \text{ kg}$ ; (c)  $1.2 \text{ m/s}^2$   
 89. (a)  $4.6 \times 10^3 \text{ N}$ ; (b)  $5.8 \times 10^3 \text{ N}$   
 90. (a)  $1.2 \times 10^2 \text{ m/s}^2$ ; (b) 12g; (c)  $1.4 \times 10^8 \text{ N}$ ; (d) 4.2 y  
 91. (a)  $1.8 \times 10^2 \text{ N}$ ; (b)  $6.4 \times 10^2 \text{ N}$   
 92.  $10 \text{ m/s}^2$   
 93. (a) 44 N; (b) 78 N; (c) 54 N; (d) 152 N  
 94. (a)  $(5.0 \text{ m/s})\hat{i} + (4.3 \text{ m/s})\hat{j}$ ; (b)  $(15 \text{ m})\hat{i} + (6.4 \text{ m})\hat{j}$   
 95. (a) 4 kg; (b)  $6.5 \text{ m/s}^2$ ; (c) 13 N  
 96. 16 N

## **Chapter 6**

1. 36 m  
 2. 0.58  
 3. (a)  $2.0 \times 10^2 \text{ N}$ ; (b)  $1.2 \times 10^2 \text{ N}$   
 4. 0.53  
 5. (a) 6.0 N; (b) 3.6 N; (c) 3.1 N  
 6. 0.61  
 7. (a)  $1.9 \times 10^2 \text{ N}$ ; (b)  $0.56 \text{ m/s}^2$   
 8.  $1.6 \times 10^2 \text{ N}$   
 9. (a) 11 N; (b)  $0.14 \text{ m/s}^2$   
 10. (a) 0; (b)  $2.17 \text{ m/s}^2$   
 11. (a)  $3.0 \times 10^2 \text{ N}$ ; (b)  $1.3 \text{ m/s}^2$   
 12.  $2.8 \times 10^2 \text{ N}$   
 13. (a)  $1.3 \times 10^2 \text{ N}$ ; (b) no; (c)  $1.1 \times 10^2 \text{ N}$ ; (d) 46 N; (e) 17 N  
 14. (b)  $3.0 \times 10^7 \text{ N}$

15.  $2^\circ$
16. (a) 8.6 N;(b) 46 N;(c) 39 N
17. (a)  $(17 \text{ N})\hat{i}$ ;(b)  $(20 \text{ N})\hat{i}$ ;(c)  $(15 \text{ N})\hat{i}$
18. (a) 12.1 m/s;(b) 19.4 m/s
19. (a) no;(b)  $(-12 \text{ N})\hat{i} + (5.0 \text{ N})\hat{j}$
20. 8.5 N
21. (a)  $19^\circ$ ;(b) 3.3 kN
22.  $18^\circ$
23. 0.37
24. 0.54
25.  $1.0 \times 10^2 \text{ N}$
26. (a) 147 N;(b) same
27. (a) 0;(b)  $(-3.9 \text{ m/s}^2)\hat{i}$ ;(c)  $(-1.0 \text{ m/s}^2)\hat{i}$
28. 3.3 kg
29. (a) 66 N;(b)  $2.3 \text{ m/s}^2$
30. (a) 74 N;(b)  $(76 \text{ N})/(\cos \theta + 0.42 \sin \theta)$ ;(c)  $23^\circ$ ;(d) 70 N
31. (a)  $3.5 \text{ m/s}^2$ ;(b) 0.21 N
32.  $60^\circ$
33. 9.9 s
34. (a)  $(-6.1 \text{ m/s}^2)\hat{i}$ ;(b)  $(-0.98 \text{ m/s}^2)\hat{i}$
35.  $4.9 \times 10^2 \text{ N}$
36. 3.75
37. (a)  $3.2 \times 10^2 \text{ km/h}$ ;(b)  $6.5 \times 10^2 \text{ km/h}$ ;(c) no
38. (a)  $2 \times 10^4 \text{ N}$ ;(b) 18g
39. 2.3
40. (a) 66.0 m/s; (b)  $-2.20 \times 10^2 \text{ dC}$
41. 0.60
42. 48 km/h
43. 21 m
44. 9.7g
45. (a) light;(b) 778 N;(c) 223 N;(d) 1.11 kN
46. (a) 547 N;(b)  $9.53^\circ$
47. (a) 10 s;(b)  $4.9 \times 10^2 \text{ N}$ ;(c)  $1.1 \times 10^3 \text{ N}$
48. (a) 3.7 kN;(b) up;(c) 1.3 kN;(d) down
49.  $1.37 \times 10^3 \text{ N}$
50. (a)  $4.03 \times 10^2 \text{ N}\cdot\text{s/m}$ ;(b)  $-1.50 \times 10^3 \text{ N/s}$
51. 2.2 km
52. (a) 3.7 kN;(b) up;(c) 2.3 kN;(d) down
53.  $12^\circ$
54. (a)  $-(mv^2/r^2) dr$ ;(b)  $(2mv/r) dv$ ;(c)  $-(mv^3/\pi r^2) dT$
55.  $2.6 \times 10^3 \text{ N}$
56. 0.078
57. 1.81 m/s
58. (a)  $8.0 \times 10^3 \text{ N}$ ;(b)  $6.9 \times 10^3 \text{ N}$ ; (c) 20 m/s; (d)  $1.6 \times 10^4 \text{ N}$ ; (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<sup>2</sup>;(c) answers are the same except that the rod is under compression
61. (a) 27 N;(b) 3.0 m/s<sup>2</sup>
62. 118 N
63. (b) 240 N;(c) 0.60
64. (a) 69 km/h;(b) 139 km/h;(c) yes
65. (a) 210 N;(b) 44.0 m/s
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<sup>2</sup>
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<sup>2</sup>;(b) down;(c) 9.5 m/s<sup>2</sup>; (d) down
74. (a) 0.13 N;(b) 0.12
75. (a)  $3.0 \times 10^5$  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<sup>2</sup>
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<sup>2</sup>
84. (b) 55°;(c) increase;(d) 59°
85. 3.4%
86. (a) lowest point;(b) 8.73 m/s
87. (a)  $3.21 \times 10^3$  N;(b)  $3.75 \times 10^3$  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<sup>2</sup>;(b) down the plane;(c) 3.9 m;(d) at rest

## **Chapter 7**

- (a)  $2.9 \times 10^7$  m/s;(b)  $2.1 \times 10^{-13}$  J
- $1.8 \times 10^{13}$  J
- (a)  $5 \times 10^{14}$  J;(b) 0.1 megaton TNT;(c) 8 bombs
- 7.1 J

5. (a) 2.4 m/s;(b) 4.8 m/s
6. (a) 11 J;(b) -21 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)  $1.7 \times 10^2$  N;(b)  $3.4 \times 10^2$  m;(c)  $-5.8 \times 10^4$  J;(d)  $3.4 \times 10^2$  N;(e)  $1.7 \times 10^2$  m;(f)  $-5.8 \times 10^4$  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)  $2.0 \times 10^2$  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.  $8.0 \times 10^2$  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.  $5.3 \times 10^2$  J
42. +41.7 J
43. (a) 0.83 J;(b) 2.5 J;(c) 4.2 J;(d) 5.0 W
44. (a)  $9.0 \times 10^2$  J;(b)  $1.1 \times 10^2$  W;(c)  $2.3 \times 10^2$  W
45.  $4.9 \times 10^2$  W
46.  $2.7 \times 10^5$  W
47. (a)  $1.0 \times 10^2$  J;(b) 8.4 W
48. (a) 0;(b)  $-3.5 \times 10^2$  W

49.  $7.4 \times 10^2$  W  
 50. (a) 28 W; (b)  $(6 \text{ m/s})^{\hat{}}$   
 51. (a) 32.0 J; (b) 8.00 W; (c)  $78.2^\circ$   
 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)  $1.8 \times 10^5$  ft-lb; (b) 0.55 hp  
 56. (a)  $1.0 \times 10^2$  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)  $1 \times 10^5$  megatons TNT; (b)  $1 \times 10^7$  bombs  
 60. (a)  $2.1 \times 10^2$  J; (b)  $2.1 \times 10^2$  J  
 61. -6 J  
 62. (a) 0.29 J; (b) -1.8 J; (c) 3.5 m/s; (d) 23 cm  
 63. (a) 98 N; (b) 4.0 cm; (c) 3.9 J; (d) -3.9 J  
 64. (a) 1.7 W; (b) 0; (c) -1.7 W  
 65. (a) 314 J; (b)  $-155$  J; (c) 0; (d) 158 J  
 66.  $6.67 \times 10^5$  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)  $2.7 \times 10^2$  N; (b)  $-4.0 \times 10^2$  J; (c)  $4.0 \times 10^2$  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

## **Chapter 8**

- 89 N/cm
- (a) 0; (b) 170 kJ; (c) 340 kJ; (d) 170 kJ; (e) 340 kJ; (f) increase
- (a) 167 J; (b) -167 J; (c) 196 J; (d) 29 J; (e) 167 J; (f) -167 J; (g) 296 J; (h) 129 J
- (a) 1.51 J; (b)  $-1.51$  J; (c) 0; (d)  $-1.51$  J; (e) 1.51 J; (f) 0; (g) same
- (a) 4.31 mJ; (b)  $-4.31$  mJ; (c) 4.31 mJ; (d)  $-4.31$  mJ; (e) all increase
- (a) 0.15 J; (b) 0.11 J; (c) 0.19 J; (d) 38 mJ; (e) 75 mJ; (f) all the same (a) 0.15 J; (b) 0.11 J; (c) 0.19 J; (d) 38 mJ; (e) 75 mJ; (f) all the same
- (a) 13.1 J; (b)  $-13.1$  J; (c) 13.1 J; (d) all increase
- (a) 184 J; (b)  $-184$  J; (c) -184 J
- (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)  $2.6 \times 10^2$  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)  $79^\circ$ ;(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.  $-3.2 \times 10^2$  J
26. (a)  $U = 27 + 12x - 3x^2$ ;(b) 39 J;(c) -1.6 m;(d) 5.6 m
27. (a) no;(b)  $9.3 \times 10^2$  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)  $6.3 \text{ m/s}^2$ ;(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)  $5.6 \times 10^2$  J;(b)  $5.6 \times 10^2$  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)  $3.9 \times 10^2$  J;(c)  $2.1 \times 10^2$  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)  $1.5 \times 10^2$  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)  $1.5 \times 10^{-2}$  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)  $71^\circ$ ;(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)  $4.7 \times 10^2$  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)  $6.0 \times 10^2$  W;(c)  $3.0 \times 10^2$  W;(d)  $9.0 \times 10^2$  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)  $7.7 \times 10^2$  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)  $1.2 \times 10^2$  N  
94.  $5.5 \times 10^6$  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)  $7.4 \times 10^2$  J;(b)  $2.4 \times 10^2$  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)  $2.35 \times 10^3$  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)  $3.0 \times 10^5$  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)  $2.1 \times 10^6$  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

## **Chapter 9**

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)  $3.13 \times 10^{-11}$  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)  $(2.35\hat{i} - 1.57\hat{j}) \text{ m/s}^2$ ;(b)  $(2.35\hat{i} - 1.57\hat{j})t \text{ m/s}$ , with  $t$  in seconds;(d) straight, at downward angle  $34^\circ$   
 16. 58 kg  
 17. 4.2 m  
 18. 4.9 kg·m/s

19. (a)  $7.5 \times 10^4$  J;(b)  $3.8 \times 10^4$  kg·m/s;(c)  $39^\circ$  south of due east  
 20.  $48^\circ$   
 21. (a) 5.0 kg·m/s;(b) 10 kg·m/s  
 22. (a)  $30.0^\circ$ ;(b)  $(-0.572 \text{ kg·m/s})\hat{j}$   
 23.  $1.0 \times 10^3$  to  $1.2 \times 10^3$  kg·m/s  
 24. (a) 1.1 m;(b)  $4.8 \times 10^3$  kg·m/s  
 25. (a) 42 N·s;(b) 2.1 kN  
 26. (a)  $2.2 \times 10^2$  N·s; (b)  $2.7 \times 10^3$  N  
 27. (a) 67 m/s;(b) -x;(c) 1.2 kN;(d) -x  
 28. (a) 9.1 N·s;(b)  $1.8 \times 10^3$  N  
 29. 5 N  
 30. (a) 1.00 N·s;(b) 100 N;(c) 20 N  
 31. (a)  $2.39 \times 10^3$  N·s; (b)  $4.78 \times 10^5$  N; (c)  $1.76 \times 10^3$  N·s; (d)  $3.52 \times 10^5$  N  
 32. (a)  $(30 \text{ kg·m/s})\hat{i}$ ;(b)  $(38 \text{ kg·m/s})\hat{i}$ ;(c)  $(6.0 \text{ m/s})\hat{i}$   
 33. (a) 5.86 kg·m/s;(b)  $59.8^\circ$ ;(c) 2.93 kN;(d)  $59.8^\circ$   
 34. (a)  $4.50 \times 10^{-3}$  N·s;(b) 0.529 N·s;(c) push  
 35.  $9.9 \times 10^2$  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)  $(1.8 \text{ N·s})\hat{j}$ ;(b)  $(-180 \text{ N})\hat{j}$   
 39. 3.0 mm/s  
 40.  $4.4 \times 10^3$  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)  $45^\circ$   
 48. (a) 20 J;(b) 40 J  
 49.  $3.1 \times 10^2$  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)  $(2.67 \text{ m/s})\hat{i} + (-3.00 \text{ m/s})\hat{j}$ ;(b) 4.01 m/s;(c)  $48.4^\circ$   
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)  $4.15 \times 10^5 \text{ m/s}$ ;(b)  $4.84 \times 10^5 \text{ m/s}$   
72. (a)  $27^\circ$   
73.  $120^\circ$   
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)  $1.57 \times 10^6 \text{ N}$ ;(b)  $1.35 \times 10^5 \text{ kg}$ ;(c) 2.08 km/s  
80. (a)  $(-4.0 \times 10^4 \text{ kg}\cdot\text{m/s})\hat{i}$ ;(b) due west;(c) 0  
81. (a) 7290 m/s;(b) 8200 m/s;(c)  $1.271 \times 10^{10} \text{ J}$ ;(d)  $1.275 \times 10^{10} \text{ J}$   
82.  $6.0 \times 10^2$   
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)  $1.8 \times 10^2 \text{ N}$   
88. 41.7 cm/s  
89. (a)  $(7.4 \times 10^3 \text{ N}\cdot\text{s})\hat{i} - (7.4 \times 10^3 \text{ N}\cdot\text{s})\hat{j}$ ;(b)  $(-7.4 \times 10^3 \text{ N}\cdot\text{s})\hat{i}$ ;(c)  $2.3 \times 10^3 \text{ N}$ ;(d)  $2.1 \times 10^4 \text{ N}$ ;(e)  $-45^\circ$   
90. (a)  $1.4 \times 10^{-22} \text{ kg}\cdot\text{m/s}$ ;(b)  $28^\circ$ ;(c)  $1.6 \times 10^{-19} \text{ J}$   
91. +4.4 m/s  
92. 0.57 m/s  
93.  $1.18 \times 10^4 \text{ kg}$   
94. 72 km/h  
95. (a) 1.9 m/s;(b)  $-30^\circ$ ;(c) elastic  
96. (a)  $8.0 \times 10^4 \text{ N}$ ;(b) 27 kg/s  
97. (a) 6.9 m/s;(b)  $30^\circ$ ;(c) 6.9 m/s;(d)  $-30^\circ$ ;(e) 2.0 m/s;(f)  $-180^\circ$   
98. (a)  $(-0.450\hat{i} - 0.450\hat{j} - 1.08\hat{k}) \text{ kg}\cdot\text{m/s}$ ; (b)  $(-0.450\hat{i} - 0.450\hat{j} - 1.08\hat{k}) \text{ N}\cdot\text{s}$ ; (c)  $(0.450\hat{i} + 0.450\hat{j} + 1.08\hat{k}) \text{ N}\cdot\text{s}$   
99. (a) 25 mm;(b) 26 mm;(c) down;(d)  $1.6 \times 10^{-2} \text{ m/s}^2$   
100. (a)  $41.0^\circ$ ;(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)  $1.6 \times 10^2$  kg/s
108.  $2.5 \times 10^{-3}$
109. (a)  $4.6 \times 10^3$  km;(b) 73%
110. (a) 2.18 kg-m/s;(b) 575 N
111. (a) 1.0 kg-m/s;(b)  $2.5 \times 10^2$  J;(c) 10 N;(d) 1.7 kN;(e) answer for (c) includes time between pellet collisions
112. 28.8 N(a) -0.25 m;(b) 0
113. (a) 0.745 mm;(b)  $153^\circ$ ;(c) 1.67 mJ
114. (a) 0;(b) 0.75 m
115. (a) 30 cm;(b) 3.3 m
116. (a) 0.60 cm;(b) 4.9 cm;(c) 9.0 cm;(d) 0
117. (a) -0.50 m;(b) -1.8 cm; (c) 0.50 m
118. (a) 0;(b) 4.0 m/s
119. 0.22%
120. 1.10 m/s

## **Chapter 10**

1. 14 rev
2. (a) 0.105 rad/s;(b)  $1.75 \times 10^{-3}$  rad/s;(c)  $1.45 \times 10^{-4}$  rad/s
3. (a) 4.0 rad/s; (b) 11.9 rad/s
4. (a) 2.0 rad;(b) 0;(c)  $1.3 \times 10^2$  rad/s;(d) 32 rad/s<sup>2</sup>;(e) no
5. 11 rad/s
6. (a) 4.0 rad/s;(b) 28 rad/s;(c) 12 rad/s<sup>2</sup>;(d) 6.0 rad/s<sup>2</sup>;(e) 18 rad/s<sup>2</sup>
7. (a)  $1.2t^5 - 1.3t^3 + 2.0$ ;(b)  $0.20t^6 - 0.33t^4 + 2.0t + 1.0$
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<sup>2</sup>;(b) 5.0 rad/s;(c) 10 rad/s;(d) 75 rad
11. (a) 30 s;(b)  $1.8 \times 10^3$  rad
12. (a)  $9.0 \times 10^3$  rev/min<sup>2</sup>;(b)  $4.2 \times 10^2$  rev
13. (a)  $3.4 \times 10^2$  s;(b)  $-4.5 \times 10^{-3}$  rad/s<sup>2</sup>;(c) 98 s
14. (a) 1.0 rev/s<sup>2</sup>;(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)  $3.1 \times 10^2$  m/s;(b)  $3.4 \times 10^2$  m/s
19. (a)  $2.50 \times 10^{-3}$  rad/s;(b) 20.2 m/s<sup>2</sup>;(c) 0
20. (a) 6.4 cm/s<sup>2</sup>;(b) 2.6 cm/s<sup>2</sup>
21.  $6.9 \times 10^{-13}$  rad/s
22. (a) 3.0 rad/s;(b) 30 m/s;(c) 6.0 m/s<sup>2</sup>;(d) 90 m/s<sup>2</sup>

23. (a) 20.9 rad/s;(b) 12.5 m/s;(c) 800 rev/min<sup>2</sup>;(d) 600 rev  
24. 199 hits/s  
25. (a)  $7.3 \times 10^{-5}$  rad/s;(b)  $3.5 \times 10^2$  m/s;(c)  $7.3 \times 10^{-5}$  rad/s;(d)  $4.6 \times 10^2$  m/s  
26. (a) -1.1 rev/min<sup>2</sup>;(b)  $9.9 \times 10^3$  rev;(c) -0.99 mm/s<sup>2</sup>;(d) 31 m/s<sup>2</sup>  
27. (a) 73 cm/s<sup>2</sup>;(b) 0.075;(c) 0.11  
28. 16 s  
29. (a)  $3.8 \times 10^3$  rad/s;(b)  $1.9 \times 10^2$  m/s  
30. (a) 40.2 cm/s<sup>2</sup>;(b)  $2.36 \times 10^3$  m/s<sup>2</sup>;(c) 83.2 m  
31. (a) 40 s;(b) 2.0 rad/s<sup>2</sup>  
32. (a)  $-2.3 \times 10^{-9}$  rad/s<sup>2</sup>;(b)  $2.6 \times 10^3$  y;(c) 24 ms  
33. 12.3 kg·m<sup>2</sup>  
34. (a) 1.5 rad/s<sup>2</sup>;(b) 0.40 J  
35. (a) 1.1 kJ;(b) 9.7 kJ  
36. 2.5 kg  
37. 0.097 kg·m<sup>2</sup>  
38. (a) 7.1%;(b) 64%  
39. (a) 49 MJ;(b)  $1.0 \times 10^2$  min  
40. (a)  $8.352 \times 10^{-3}$  kg·m<sup>2</sup>;(b) -0.22%  
41. (a) 0.023 kg·m<sup>2</sup>;(b) 11 mJ  
42. (a)  $1.3 \times 10^3$  g·cm<sup>2</sup>;(b)  $5.5 \times 10^2$  g·cm<sup>2</sup>;(c)  $1.9 \times 10^3$  g·cm<sup>2</sup>;(d)  $A + B$   
43.  $4.7 \times 10^{-4}$  kg·m<sup>2</sup>  
44. (a) 2.0 kg·m<sup>2</sup>;(b) 6.0 kg·m<sup>2</sup>;(c) 2.0 kg·m<sup>2</sup>  
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<sup>2</sup>;(b) 338 N·m  
50. 1.28 kg·m<sup>2</sup>  
51. (a) 6.00 cm/s<sup>2</sup>;(b) 4.87 N;(c) 4.54 N;(d) 1.20 rad/s<sup>2</sup>;(e) 0.0138 kg·m<sup>2</sup>  
52. (a) 9.7 rad/s<sup>2</sup>;(b) counterclockwise  
53. 0.140 N  
54. (a) 3.0 rad/s<sup>2</sup>;(b) 9.4 rad/s<sup>2</sup>  
55.  $2.51 \times 10^{-4}$  kg·m<sup>2</sup>  
56. (a) 1.7 m/s<sup>2</sup>;(b) 6.9 m/s<sup>2</sup>  
57. (a)  $4.2 \times 10^2$  rad/s<sup>2</sup>;(b)  $5.0 \times 10^2$  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)  $2.80 \times 10^{-5}$  J·s<sup>2</sup>/rad<sup>2</sup>  
63. 5.42 m/s  
64. (a) 0.15 kg·m<sup>2</sup>;(b) 11 rad/s

65. (a)  $5.32 \text{ m/s}^2$ ; (b)  $8.43 \text{ m/s}^2$ ; (c)  $41.8^\circ$   
 66.  $1.4 \text{ m/s}$   
 67.  $9.82 \text{ rad/s}$   
 68. (a)  $0.689 \text{ N}\cdot\text{m}$ ; (b)  $3.05 \text{ N}$ ; (c)  $9.84 \text{ N}\cdot\text{m}$ ; (d)  $11.5 \text{ N}$   
 69.  $6.16 \times 10^{-5} \text{ kg}\cdot\text{m}^2$   
 70. (a)  $27.0 \text{ rad/s}$ ; (b)  $13.5 \text{ s}$   
 71. (a)  $31.4 \text{ rad/s}^2$ ; (b)  $0.754 \text{ m/s}^2$ ; (c)  $56.1 \text{ N}$ ; (d)  $55.1 \text{ N}$   
 72. (a)  $-7.66 \text{ rad/s}^2$ ; (b)  $-11.7 \text{ N}\cdot\text{m}$ ; (c)  $4.59 \times 10^4 \text{ J}$ ; (d)  $624 \text{ rev}$ ; (e)  $4.59 \times 10^4 \text{ J}$   
 73. (a)  $4.81 \times 10^5 \text{ N}$ ; (b)  $1.12 \times 10^4 \text{ N}\cdot\text{m}$ ; (c)  $1.25 \times 10^6 \text{ J}$   
 74. (a)  $8.6 \text{ s}$ ; (b) no  
 75. (a)  $2.3 \text{ rad/s}^2$ ; (b)  $1.4 \text{ rad/s}^2$   
 76.  $1.5 \times 10^3 \text{ rad}$   
 77. (a)  $-67 \text{ rev/min}^2$ ; (b)  $8.3 \text{ rev}$   
 78.  $6.06 \text{ rad/s}$   
 79. ---  
 80. (a)  $5.00 \text{ rad/s}$ ; (b)  $1.67 \text{ rad/s}^2$ ; (c)  $2.50 \text{ rad}$   
 81.  $3.1 \text{ rad/s}$   
 82.  $3 \times 10^5 \text{ J}$   
 83. (a)  $1.57 \text{ m/s}^2$ ; (b)  $4.55 \text{ N}$ ; (c)  $4.94 \text{ N}$   
 84. (a)  $5.1 \text{ h}$ ; (b)  $8.1 \text{ h}$   
 85.  $30 \text{ rev}$   
 86.  $146 \text{ rad/s}$   
 87.  $0.054 \text{ kg}\cdot\text{m}^2$   
 88. (a)  $155 \text{ kg}\cdot\text{m}^2$ ; (b)  $64.4 \text{ kg}$   
 89.  $1.4 \times 10^2 \text{ N}\cdot\text{m}$   
 90. (a)  $-1.25 \text{ rad/s}^2$ ; (b)  $250 \text{ rad}$ ; (c)  $39.8 \text{ rev}$   
 91. (a)  $10 \text{ J}$ ; (b)  $0.27 \text{ m}$   
 92. (a)  $5.5 \times 10^{15} \text{ s}$ ; (b)  $26$   
 93.  $4.6 \text{ rad/s}^2$   
 94. (a)  $1.94 \text{ m/s}^2$ ; (b)  $75.1^\circ$   
 95.  $2.6 \text{ J}$   
 96.  $25 \text{ N}$   
 97. (a)  $5.92 \times 10^4 \text{ m/s}^2$ ; (b)  $4.39 \times 10^4 \text{ s}^{-2}$   
 98.  $1.6 \text{ kg}\cdot\text{m}^2$   
 99. (a)  $0.791 \text{ kg}\cdot\text{m}^2$ ; (b)  $1.79 \times 10^{-2} \text{ N}\cdot\text{m}$   
 100. (a)  $0.019 \text{ kg}\cdot\text{m}^2$ ; (b)  $0.019 \text{ kg}\cdot\text{m}^2$   
 101. (a)  $1.5 \times 10^2 \text{ cm/s}$ ; (b)  $15 \text{ rad/s}$ ; (c)  $15 \text{ rad/s}$ ; (d)  $75 \text{ cm/s}$ ; (e)  $3.0 \text{ rad/s}$   
 102. (a)  $3.3 \text{ J}$ ; (b)  $2.9 \text{ J}$   
 103. (a)  $7.0 \text{ kg}\cdot\text{m}^2$ ; (b)  $7.2 \text{ m/s}$ ; (c)  $71^\circ$   
 104. (a)  $0.20 \text{ kg}\cdot\text{m}^2$ ; (b)  $6.3 \text{ rad/s}$

## **Chapter 11**

1. (a) 0;(b)  $(22 \text{ m/s})\hat{i}$ ;(c)  $(-22 \text{ m/s})\hat{i}$ ;(d) 0;(e)  $1.5 \times 10^3 \text{ m/s}^2$ ;(f)  $1.5 \times 10^3 \text{ m/s}^2$ ;(g)  $(22 \text{ m/s})\hat{i}$ ;(h)  $(44 \text{ m/s})\hat{i}$ ;(i) 0;(j) 0;(k)  $1.5 \times 10^3 \text{ m/s}^2$ ;(l)  $1.5 \times 10^3 \text{ m/s}^2$
2. (a) 59.3 rad/s;(b) 9.31 rad/s<sup>2</sup>;(c) 70.7 m
3. -3.15 J
4. (a) 8.0°;(b) more
5. 0.020
6.  $7.2 \times 10^{-4} \text{ kg}\cdot\text{m}^2$
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)  $(-4.0 \text{ N})\hat{i}$ ;(b)  $0.60 \text{ kg}\cdot\text{m}^2$
12. (a) 37.8 cm;(b)  $1.96 \times 10^{-2} \text{ N}$ ;(c) toward loop's center
13. 0.50
14. 1.34 m/s
15. (a)  $-(0.11 \text{ m})\omega$ ;(b)  $-2.1 \text{ m/s}^2$ ;(c)  $-47 \text{ rad/s}^2$ ;(d) 1.2 s;(e) 8.6 m;(f) 6.1 m/s
16. 0.25
17. (a) 13 cm/s<sup>2</sup>;(b) 4.4 s;(c) 55 cm/s;(d) 18 mJ;(e) 1.4 J;(f) 27 rev/s
18. (a)  $0.19 \text{ m/s}^2$ ;(b)  $0.19 \text{ m/s}^2$ ;(c) 1.1 kN;(d) no;(e) same;(f) greater
19.  $(-2.0 \text{ N}\cdot\text{m})\hat{i}$
20. (a)  $(24 \text{ N}\cdot\text{m})\hat{j}$ ;(b)  $(-24 \text{ N}\cdot\text{m})\hat{j}$ ;(c)  $(12 \text{ N}\cdot\text{m})\hat{j}$ ;(d)  $(-12 \text{ N}\cdot\text{m})\hat{j}$
21. (a)  $(6.0 \text{ N}\cdot\text{m})\hat{j} + (8.0 \text{ N}\cdot\text{m})\hat{k}$ ;(b)  $(-22 \text{ N}\cdot\text{m})\hat{i}$
22. -5.00 N
23. (a)  $(-1.5 \text{ N}\cdot\text{m})\hat{i} - (4.0 \text{ N}\cdot\text{m})\hat{j} - (1.0 \text{ N}\cdot\text{m})\hat{k}$ ;(b)  $(-1.5 \text{ N}\cdot\text{m})\hat{i} - (4.0 \text{ N}\cdot\text{m})\hat{j} - (1.0 \text{ N}\cdot\text{m})\hat{k}$
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)  $-7.84 \text{ N}\cdot\text{m}$ ;(d)  $-7.84 \text{ N}\cdot\text{m}$
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)  $48t\hat{k} \text{ N}\cdot\text{m}$ ;(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)  $0.53 \text{ kg}\cdot\text{m}^2/\text{s}$ ;(b)  $4.2 \times 10^3 \text{ rev/min}$

39. (a) 1.47 N·m;(b) 20.4 rad;(c) -29.9 J;(d) 19.9 W  
 40. 23 kg·m<sup>2</sup>/s  
 41. (a) 1.6 kg·m<sup>2</sup>; (b) 4.0 kg·m<sup>2</sup>/s  
 42. (a) 24 kg·m<sup>2</sup>/s; (b) 1.5 kg·m<sup>2</sup>/s  
 43. (a) 1.5 m; (b) 0.93 rad/s; (c) 98 J; (d) 8.4 rad/s; (e)  $8.8 \times 10^2$  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.  $5.0 \times 10^2$  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.  $1.3 \times 10^3$  m/s  
 54. 39.1 J  
 55. 3.4 rad/s  
 56. 6.46 kg·m<sup>2</sup>/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<sup>2</sup>; (b)  $1.8 \times 10^3$  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<sup>2</sup>; (b) 16 rad/s<sup>2</sup>; (c) (4.0 N) $\hat{i}$   
 72. 1.00  
 73. (a) 0; (b) 0; (c)  $-30t^3\hat{k}$  kg·m<sup>2</sup>/s; (d)  $-90t^2\hat{k}$  N·m; (e)  $30t^3\hat{k}$  kg·m<sup>2</sup>/s; (f)  $90t^2\hat{k}$  N·m  
 74. 12 s  
 75. (a) 149 kg·m<sup>2</sup>; (b) 158 kg·m<sup>2</sup>/s; (c) 0.744 rad/s  
 76. 0.62 J  
 77. (a)  $6.65 \times 10^{-5}$  kg·m<sup>2</sup>/s; (b) no; (c) 0; (d) yes  
 78. (a) 4.11 m/s<sup>2</sup>; (b) 16.4 rad/s<sup>2</sup>; (c) 2.55 N·m  
 79. (a) 0.333; (b) 0.111

80.  $(5.55 \text{ kg}\cdot\text{m}^2/\text{s})\hat{k}$   
 81. (a) 58.8 J;(b) 39.2 J  
 82. (a)  $12.2 \text{ kg}\cdot\text{m}^2$ ;(b)  $308 \text{ kg}\cdot\text{m}^2/\text{s}$   
 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)  $4.4 \times 10^2 \text{ rad/s}$ ;(f) 9.2 J  
 85. (a)  $mvR/(I + MR^2)$ ;(b)  $mvR^2/(I + MR^2)$   
 86. (a)  $(-24t^2 \text{ kg}\cdot\text{m}^2/\text{s})\hat{k}$ ;(b)  $(-48t \text{ N}\cdot\text{m})\hat{k}$ ;(c)  $(12t^2 \text{ kg}\cdot\text{m}^2/\text{s})\hat{k}$ ;(d)  $(24t \text{ N}\cdot\text{m})\hat{k}$   
 87. rotational speed would decrease; day would be about 0.8 s longer  
 88.  $1.2 \times 10^8 \text{ kg}\cdot\text{m}^2/\text{s}$   
 89. (a) 12.7 rad/s;(b) clockwise  
 90.  $2.5 \times 10^{11} \text{ kg}\cdot\text{m}^2/\text{s}$   
 91. (a) 0.81 mJ;(b) 0.29;(c)  $1.3 \times 10^{-2} \text{ N}$   
 92. (a)  $9.9 \times 10^2 \text{ J}$ ;(b)  $3.0 \times 10^3 \text{ J}$ ;(c)  $1.2 \times 10^5 \text{ J}$   
 93. (a)  $mR^2/2$ ;(b) a solid circular cylinder

## **Chapter 12**

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.  $120^\circ$   
 5. 7.92 kN  
 6. (a)  $8.4 \times 10^2 \text{ N}$ ;(b)  $5.3 \times 10^2 \text{ N}$   
 7. (a)  $2.8 \times 10^2 \text{ N}$ ;(b)  $8.8 \times 10^2 \text{ N}$ ;(c)  $71^\circ$   
 8. (a) 2;(b) 7  
 9. 74.4 g  
 10. (a) 49 N;(b) 28 N;(c) 57 N;(d)  $29^\circ$   
 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)  $6.5 \times 10^2 \text{ N}$ ;(b)  $5.6 \times 10^2 \text{ N}$   
 21. (a) 6.63 kN;(b) 5.74 kN;(c) 5.96 kN  
 22. (a)  $3.4 \times 10^2 \text{ N}$ ;(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)  $3.9 \text{ m/s}^2$ ;(b) 2.0 kN;(c) 3.5 kN;(d) 0.79 kN;(e) 1.4 kN  
33. (a)  $60.0^\circ$ ;(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)  $1.7 \times 10^2 \text{ N}$   
37. 0.34  
38. (a)  $(-797\hat{i} + 265\hat{j}) \text{ N}$ ;(b)  $(797\hat{i} + 265\hat{j}) \text{ N}$ ;(c)  $(797\hat{i} + 931\hat{j}) \text{ N}$ ;(d)  $(-797\hat{i} - 265\hat{j}) \text{ N}$   
39. (a) 211 N;(b) 534 N;(c) 320 N  
40. (a)  $30.0^\circ$ ;(b) 51.0 kg;(c) 10.2 kg  
41. (a) slides;(b)  $31^\circ$ ;(c) tips;(d)  $34^\circ$   
42. 85%  
43. (a)  $6.5 \times 10^6 \text{ N/m}^2$ ;(b)  $1.1 \times 10^{-5} \text{ m}$   
44. (a)  $7.5 \times 10^{10} \text{ N/m}^2$ ;(b)  $2.9 \times 10^8 \text{ N/m}^2$   
45. (a) 0.80;(b) 0.20;(c) 0.25  
46. (a)  $30 \mu\text{J}$ ; (b)  $8.67 \mu\text{J}$ ; (c)  $34.2 \mu\text{J}$ ; (d) no; (e) yes  
47. (a)  $1.4 \times 10^9 \text{ N}$ ;(b) 75  
48. 56.0 mJ  
49. (a) 866 N;(b) 143 N;(c) 0.165  
50. 0.421 g  
51. (a)  $1.2 \times 10^2 \text{ N}$ ;(b) 68 N  
52. (a)  $1.9 \times 10^{-3}$ ;(b)  $1.3 \times 10^7 \text{ N/m}^2$ ;(c)  $6.9 \times 10^9 \text{ N/m}^2$   
53. (a)  $1.8 \times 10^7 \text{ N}$ ;(b)  $1.4 \times 10^7 \text{ N}$ ;(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)  $50^\circ$ ;(b)  $0.77 \text{ mg}$   
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)  $2 \text{ mg}$ ;(b)  $\text{mg}$ ;(c)  $\text{mg}$ ;(d)  $2^{0.5} \text{ mg}$   
65. (a) 88 N;(b)  $(30\hat{i} + 97\hat{j}) \text{ N}$   
66.  $(-1.5 \times 10^2 \text{ N})\hat{i} + (2.6 \times 10^2 \text{ N})\hat{j}$   
67.  $2.4 \times 10^9 \text{ N/m}^2$   
68. (a) 200 N;(b) 360 N;(c) 0.35  
69.  $60^\circ$   
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)  $(35\hat{i} + 200\hat{j}) \text{ N}$ ;(b)  $(-45\hat{i} + 200\hat{j}) \text{ N}$ ;(c)  $1.9 \times 10^2 \text{ N}$   
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)  $64.0^\circ$

### **Chapter 13**

1.  $\frac{1}{2}$
2. (a) 6.9%; (b)  $(2.3 \times 10^{-5})\%$
3. 19 m
4. 2.16
5. 0.8 m
6.  $(1.18 \times 10^{-14} \text{ N})\hat{i} + (1.18 \times 10^{-14} \text{ N})\hat{j}$
7.  $-5.00d$
8. (a)  $2.13 \times 10^{-8}$  N; (b)  $60.6^\circ$
9.  $2.60 \times 10^5$  km
10. (a)  $0.716d$ ; (b)  $-1.07d$
11. (a)  $M = m$ ; (b) 0
12. (a) 0.25 kg; (b) 1.0 kg
13.  $8.31 \times 10^{-9}$  N
14. (a)  $-0.20$  m; (b)  $-0.35$  m
15. (a)  $-1.88d$ ; (b)  $-3.90d$ ; (c)  $0.489d$
16.  $3.0 \times 10^{-10}$  N
17. (a) 17 N; (b) 2.4
18.  $8.2 \mu\text{m}$
19.  $2.6 \times 10^6$  m
20.  $-0.30$  N
21.  $5 \times 10^{24}$  kg
22. (a)  $(3.02 \times 10^{43} \text{ kg}\cdot\text{m}/\text{s}^2)/M_h$ ; (b) decrease; (c)  $9.82 \text{ m}/\text{s}^2$ ; (d)  $7.30 \times 10^{-15} \text{ m}/\text{s}^2$ ; (e) no
23. (a)  $7.6 \text{ m}/\text{s}^2$ ; (b)  $4.2 \text{ m}/\text{s}^2$
24. (a)  $G(M_1 + M_2)m/a^2$ ; (b)  $GM_1m/b^2$ ; (c) 0
25. (a)  $(3.0 \times 10^{-7} \text{ N}/\text{kg})m$ ; (b)  $(3.3 \times 10^{-7} \text{ N}/\text{kg})m$ ; (c)  $(6.7 \times 10^{-7} \text{ N}/\text{kg}\cdot\text{m})mr$
26. 0.031%
27. (a)  $9.83 \text{ m}/\text{s}^2$ ; (b)  $9.84 \text{ m}/\text{s}^2$ ; (c)  $9.79 \text{ m}/\text{s}^2$
28. (a)  $0.414R$ ; (b)  $0.500R$
29.  $5.0 \times 10^9$  J
30.  $\frac{1}{2}$
31. (a) 0.74; (b)  $3.8 \text{ m}/\text{s}^2$ ; (c) 5.0 km/s
32. (a)  $-4.4 \times 10^{-11}$  J; (b)  $-2.9 \times 10^{-11}$  J; (c)  $2.9 \times 10^{-11}$  J
33. (a) 0.0451; (b) 28.5
34. (a)  $2.0 \times 10^9$  J; (b)  $2.5R_s$

35.  $-4.82 \times 10^{-13}$  J
36. (a) 22 MJ;(b) 69 MJ
37. (a) 0.50 pJ;(b)  $-0.50$  p
38. (a)  $-1.7 \times 10^{-8}$  J;(b)  $0.56 \times 10^{-8}$  J
39. (a) 1.7 km/s;(b)  $2.5 \times 10^5$  m;(c) 1.4 km/s
40. (a) 1.33;(b) 2.00;(c) 0
41. (a) 82 km/s;(b)  $1.8 \times 10^4$  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.  $6.5 \times 10^{23}$  kg
46. (a)  $5.4 \times 10^4$  km/h;(b)  $3.8 \times 10^4$  km/h
47.  $5 \times 10^{10}$  stars
48. 1.87 y
49. (a)  $1.9 \times 10^{13}$  m;(b)  $3.6R_p$
50.  $3.58 \times 10^4$  km
51. (a)  $6.64 \times 10^3$  km;(b) 0.0136
52. (a)  $5.01 \times 10^9$  m;(b) 7.20 solar radii
53.  $5.8 \times 10^6$  m
54. 9
55. ---
56. (a)  $6 \times 10^{16}$  kg;(b)  $4 \times 10^3$  kg/m<sup>3</sup>
57. 0.71 y
58. (a)  $3.7m_J$ ;(b)  $2.5r_E$
59.  $(GM/L)^{0.5}$
60. (a)  $-6.33 \times 10^9$  J;(b)  $-6.33 \times 10^9$  J;(c) falling
61. (a)  $3.19 \times 10^3$  km;(b) lifting
62. (a) 1/2;(b) 1/2;(c)  $B$ ;(d)  $1.1 \times 10^8$  J
63. (a) 2.8 y;(b)  $1.0 \times 10^{-4}$
64. (a)  $8.0 \times 10^8$  J;(b) 36 N
65. (a)  $r^{1.5}$ ;(b)  $r^{-1}$ ;(c)  $r^{0.5}$ ;(d)  $r^{-0.5}$
66. (a)  $4.6 \times 10^5$  J;(b)  $2.6 \times 10^2$
67. (a) 7.5 km/s;(b) 97 min;(c)  $4.1 \times 10^2$  km;(d) 7.7 km/s;(e) 93 min;(f)  $3.2 \times 10^{-3}$  N;(g) no;(h) yes
68. (a) 92.3 min; (b)  $7.68 \times 10^3$  m/s; (c)  $5.78 \times 10^{10}$  J; (d)  $-1.18 \times 10^{11}$  J; (e)  $-6.02 \times 10^{10}$  J; (f)  $6.63 \times 10^6$  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)  $1.3 \times 10^{12}$  m/s<sup>2</sup>;(b)  $1.6 \times 10^6$  m/s
73. (a)  $1.0 \times 10^3$  kg;(b) 1.5 km/s
74. (a)  $2 \times 10^{-5}$  m/s<sup>2</sup>;(b) 2 cm/s
75.  $3.2 \times 10^{-7}$  N
76. 29 pN
77.  $0.37\hat{j}$   $\mu$ N

78. (a)  $-1.3 \times 10^{-4}$  J;(b) less;(c) positive;(d) negative  
 79.  $2\pi^{1.5}G^{-0.5}(M + m/4)^{-0.5}$   
 80. (b) 1.9 h  
 81. (a)  $2.2 \times 10^{-7}$  rad/s;(b) 89 km/s  
 82.  $9.2 \times 10^{-5}$  rad/s  
 83. (a)  $2.15 \times 10^4$  s;(b) 12.3 km/s;(c) 12.0 km/s;(d)  $2.17 \times 10^{11}$  J;(e)  $-4.53 \times 10^{11}$  J;(f)  $-2.35 \times 10^{11}$  J;(g)  $4.04 \times 10^7$  m;(h)  $1.22 \times 10^3$  s;(i) elliptical  
 84. (a)  $R/3$ ;(b)  $3^{0.5}R$   
 85.  $2.5 \times 10^4$  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)  $1.4 \times 10^6$  m/s;(b)  $3 \times 10^6$  m/s<sup>2</sup>  
 88. 7.9 km/s  
 89. (a) 0;(b)  $1.8 \times 10^{32}$  J;(c)  $1.8 \times 10^{32}$  J;(d) 0.99 km/s  
 90. (a)  $1.9 \times 10^7$  m;(b)  $7.6 \times 10^8$  J;(c)  $8.6 \times 10^{24}$  kg  
 91.  $7.2 \times 10^{-9}$  N  
 92. (a) 38.3 MJ;(b)  $1.03 \times 10^3$  km  
 93.  $2.4 \times 10^4$  m/s  
 94. (a)  $5.3 \times 10^{-8}$  J;(b)  $(-6.4 \times 10^{-8})\hat{i}$  N  
 95.  $-0.044\hat{j}$   $\mu$ N  
 96. (a)  $(2.8 \times 10^4)g$ ;(b) deadly;(c) 714g;(d) 1.5 km/s  
 97.  $GM_E m/12R_E$

### **Chapter 14**

1. 0.074
2. 38 kPa
3.  $1.1 \times 10^5$  Pa
4. 18 N
5.  $2.9 \times 10^4$  N
6. (a)  $1.9 \times 10^2$  kPa;(b) 15.9/10.6
7. (b) 26 kN
8.  $1.4 \times 10^5$  Pa
9. (a)  $1.0 \times 10^3$  torr; (b)  $1.7 \times 10^3$  torr
10. 2.80 m
11. (a) 94 torr; (b)  $4.1 \times 10^2$  torr; (c)  $3.1 \times 10^2$  torr
12. 17 cm
13.  $1.08 \times 10^3$  atm
14.  $1.90 \times 10^4$  Pa
15.  $-2.6 \times 10^4$  Pa
16. (a) 0.019 atm; (b) 0.39 atm
17.  $7.2 \times 10^5$  N
18. 2.0
19.  $4.69 \times 10^5$  N
20. (a)  $5.0 \times 10^6$  N;(b)  $5.6 \times 10^6$  N
21. 0.635 J
22. 26 torr

23. 44 km
24. (a)  $1.88 \times 10^9$  N;(b)  $2.20 \times 10^{10}$  N·m;(c) 11.7 m
25. 739.26 torr
26.  $-3.9 \times 10^{-3}$  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)  $6.7 \times 10^2$  kg/m<sup>3</sup>;(b)  $7.4 \times 10^2$  kg/m<sup>3</sup>
32. (a) 37.5 kN;(b) 39.6 kN;(c) 2.23 kN;(d) 2.18 kN
33. (a)  $2.04 \times 10^{-2}$  m<sup>3</sup>;(b) 1.57 kN
34. (a) 35.6 kN;(b) 0.330 m<sup>3</sup>
35. Five
36. 1.8 g/cm<sup>3</sup>
37. 57.3 cm
38. (a) 1.5 g/cm<sup>3</sup>;(b)  $2.7 \times 10^{-3}$  m<sup>3</sup>
39. (a) 1.2 kg;(b)  $1.3 \times 10^3$  kg/m<sup>3</sup>
40. 6.5 mm
41. (a) 0.10; (b) 0.083
42. 4.11 kJ
43. (a) 637.8 cm<sup>3</sup>;(b) 5.102 m<sup>3</sup>;(c)  $5.102 \times 10^3$  kg
44. (a) 1.84 kg;(b) 2.01 kg
45. 0.126 m<sup>3</sup>
46. 1.40 m
47. (a) 1.80 m<sup>3</sup>;(b) 4.75 m<sup>3</sup>
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.  $1.4 \times 10^5$  J
56. (a) 2;(b) 1/2;(c) 3.0 cm
57. (a)  $1.6 \times 10^{-3}$  m<sup>3</sup>/s;(b) 0.90 m
58. 1.7 MPa
59. (a) 2.5 m/s;(b)  $2.6 \times 10^5$  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.  $1.1 \times 10^2$  m/s
64. (a) 6.4 m<sup>3</sup>;(b) 5.4 m/s;(c)  $9.8 \times 10^4$  Pa
65. (b)  $2.0 \times 10^{-2}$  m<sup>3</sup>/s
66. (a) 4.1 m/s;(b) 21 m/s;(c)  $8.0 \times 10^{-3}$  m<sup>3</sup>/s
67. (a) 74 N;(b)  $1.5 \times 10^2$  m<sup>3</sup>

68. (a)  $0.25 \text{ m}^2$ ; (b)  $6.1 \text{ m}^3/\text{s}$   
 69.  
 70.  $-2.50 \text{ J}$   
 71. (a)  $35 \text{ cm}$ ; (b)  $30 \text{ cm}$ ; (c)  $20 \text{ cm}$   
 71. (a)  $0.0776 \text{ m}^3/\text{s}$ ; (b)  $69.8 \text{ kg/s}$   
 72.  $7.8 \text{ cm/h}$   
 73.  $1.5 \text{ g/cm}^3$   
 74.  $0.412 \text{ cm}$   
 75.  $5.11 \times 10^{-7} \text{ kg}$   
 76. (a)  $0.050$ ; (b)  $0.41$ ; (c) no  
 77.  $44.2 \text{ g}$   
 78.  $9.4\%$   
 79.  $6.0 \times 10^2 \text{ kg/m}^3$   
 80. (a)  $2$ ; (b)  $3$ ; (c)  $4/3$   
 81.  $45.3 \text{ cm}^3$   
 82.  $3.82 \text{ m/s}^2$   
 83. (a)  $3.2 \text{ m/s}$ ; (b)  $9.2 \times 10^4 \text{ Pa}$ ; (c)  $10.3 \text{ m}$   
 84. (a)  $0.13$ ; (b)  $0.96$   
 85.  $1.07 \times 10^3 \text{ g}$

### **Chapter 15**

1. (a)  $0.50 \text{ s}$ ; (b)  $2.0 \text{ Hz}$ ; (c)  $18 \text{ cm}$   
 2. (a)  $10 \text{ N}$ ; (b)  $1.2 \times 10^2 \text{ N/m}$   
 3.  $37.8 \text{ m/s}^2$   
 4. (a)  $1.29 \times 10^5 \text{ N/m}$ ; (b)  $2.68 \text{ Hz}$   
 5. (a)  $1.0 \text{ mm}$ ; (b)  $0.75 \text{ m/s}$ ; (c)  $5.7 \times 10^2 \text{ m/s}^2$   
 6. (a)  $6.28 \times 10^5 \text{ rad/s}$ ; (b)  $1.59 \text{ mm}$   
 7. (a)  $498 \text{ Hz}$ ; (b) greater  
 8.  $+1.91 \text{ rad}$  (or  $-4.37 \text{ rad}$ )  
 9. (a)  $3.0 \text{ m}$ ; (b)  $-49 \text{ m/s}$ ; (c)  $-2.7 \times 10^2 \text{ m/s}^2$ ; (d)  $20 \text{ rad}$ ; (e)  $1.5 \text{ Hz}$ ; (f)  $0.67 \text{ s}$   
 10. (a)  $0.75 \text{ s}$ ; (b)  $1.3 \text{ Hz}$ ; (c)  $8.4 \text{ rad/s}$   
 11.  $39.6 \text{ Hz}$   
 12.  $-0.927 \text{ rad}$  (or  $+5.36 \text{ rad}$ )  
 13. (a)  $0.500 \text{ s}$ ; (b)  $2.00 \text{ Hz}$ ; (c)  $12.6 \text{ rad/s}$ ; (d)  $79.0 \text{ N/m}$ ; (e)  $4.40 \text{ m/s}$ ; (f)  $27.6 \text{ N}$   
 14. (a)  $0.500 \text{ m}$ ; (b)  $-0.251 \text{ m}$ ; (c)  $3.06 \text{ m/s}$   
 15. (a)  $0.184$ ; (b) same direction  
 16.  $2\pi/3 \text{ rad}$   
 17. (a)  $5.58 \text{ Hz}$ ; (b)  $0.325 \text{ kg}$ ; (c)  $0.400 \text{ m}$   
 18.  $2.08 \text{ h}$   
 19. (a)  $25 \text{ cm}$ ; (b)  $2.2 \text{ Hz}$   
 20.  $1.03 \text{ rad}$  (or  $-5.25 \text{ rad}$ )  
 21.  $54 \text{ Hz}$   
 22.  $4.00 \text{ m}$   
 23.  $3.1 \text{ cm}$   
 24.  $18.2 \text{ Hz}$   
 25. (a)  $0.525 \text{ m}$ ; (b)  $0.686 \text{ s}$

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.  $8.3 \times 10^2$  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<sup>2</sup>
40. 5.6 cm
41. (a) 0.205 kg·m<sup>2</sup>;(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.  $1.3 \times 10^{-5}$  kg·m<sup>2</sup>
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)  $4.9 \times 10^2$  N/cm;(b)  $1.1 \times 10^3$  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)  $2.8 \times 10^3$  rad/s;(b) 2.1 m/s;(c) 5.7 km/s<sup>2</sup>
66. (a)  $2.1 \times 10^4$  N/m;(b)  $1.5 \times 10^4$  N/m;(c)  $3.1 \times 10^2$  Hz;(d)  $2.6 \times 10^2$  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)  $1.3 \times 10^2$  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)  $1.7 \times 10^3$  m/s<sup>2</sup>  
 79. 1.53 m  
 80. 65.5%  
 81. (a) 0.30 m;(b) 0.28 s;(c)  $1.5 \times 10^2$  m/s<sup>2</sup>;(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<sup>2</sup>;(e)  $\pm 10$  cm;(f) (-10 N/m) $x$   
 85. 1.6 kg  
 86. (a)  $1.6 \times 10^4$  m/s<sup>2</sup>;(b) 2.5 m/s;(c)  $7.9 \times 10^3$  m/s<sup>2</sup>;(d) 2.2 m/s  
 87. (a) 0.735 kg·m<sup>2</sup>;(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)  $\pi/2$  rad/s;(c) 0.37 cm;(d) (0.37 cm)  $\cos(\pi/2)$ ;(e) (-0.58 cm/s)  $\sin(\pi/2)$ ;(f) 0.58 cm/s;(g) 0.91 cm/s<sup>2</sup>;(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<sup>2</sup>  
 96. 1.58  
 97. (a)  $8.11 \times 10^{-5}$  kg·m<sup>2</sup>;(b) 3.14 rad/s  
 98. (a)  $1.0 \times 10^2$  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)  $-2.0 \times 10^2$  m/s<sup>2</sup>;(e) 4.0 J  
 107.  $7 \times 10^2$  N/m

## **Chapter 16**

1. 1.1 ms
2. (a) 22 seats/s; (b) 39 seats
3. (a)  $3.49 \text{ m}^{-1}$ ;(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)  $5.0 \text{ m}^{-1}$ ;(e)  $4.0 \times 10^2 \text{ s}^{-1}$ ;(f)  $\pi/2$  rad;(g) minus
8. -0.64 rad or 5.64 rad
9. (a) 3.0 mm;(b)  $16 \text{ m}^{-1}$ ;(c)  $2.4 \times 10^2 \text{ s}^{-1}$ ;(d) minus
10. (a) 6.0 cm;(b)  $1.0 \times 10^2 \text{ cm}$ ;(c) 2.0 Hz;(d)  $2.0 \times 10^2 \text{ cm/s}$ ;(e) -x direction;(f) 75 cm/s;(g) -2.0 cm
11. (a) negative;(b) 4.0 cm;(c)  $0.31 \text{ cm}^{-1}$ ;(d)  $0.63 \text{ s}^{-1}$ ;(e)  $\pi$  rad;(f) minus;(g) 2.0 cm/s;(h) -2.5 cm/s
12. 4.24 m/s
13. (a) 11.7 cm;(b)  $\pi$  rad
14. (a) 30 m/s;(b) 17 g/m
15. (a) 0.12 mm;(b)  $141 \text{ m}^{-1}$ ;(c)  $628 \text{ s}^{-1}$ ;(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)  $0.10 \text{ cm}^{-1}$ ;(e)  $4.0 \text{ s}^{-1}$ ;(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)  $16 \text{ m}^{-1}$ ;(g)  $1.9 \times 10^2 \text{ s}^{-1}$ ;(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.  $1.41 y_m$
32. (a)  $82.8^\circ$ ;(b) 1.45 rad;(c) 0.230 wavelength
33. (a) 9.0 mm;(b)  $16 \text{ m}^{-1}$ ;(c)  $1.1 \times 10^3 \text{ s}^{-1}$ ;(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)  $\pi$  rad;(b) 3.0 mm;(c) 0 rad;(d) 13 mm;(e) 9.4 mm
39.  $84^\circ$
40. 10 cm
41. (a) 82.0 m/s;(b) 16.8 m;(c) 4.88 Hz
42. (a)  $2f_3$ ;(b)  $\lambda_3$
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)  $3.1 \text{ m}^{-1}$ ;(c)  $3.1 \times 10^2 \text{ s}^{-1}$ ;(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)  $1.2 \times 10^2 \text{ cm/s}$ ;(c) 3.0 cm;(d) 0  
54. (a) 4.5 mm;(b)  $16 \text{ m}^{-1}$ ;(c)  $5.2 \times 10^2 \text{ s}^{-1}$ ;(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)  $0.63 \text{ cm}^{-1}$ ;(c)  $2.5 \times 10^3 \text{ s}^{-1}$ ;(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)  $0.79 \text{ m}^{-1}$ ;(d)  $13 \text{ s}^{-1}$ ;(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)  $37^\circ$   
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)  $\pm 0.50 \text{ cm}$   
72. (a) 3.0 mm;(b)  $31 \text{ m}^{-1}$ ;(c)  $7.5 \times 10^2 \text{ s}^{-1}$ ;(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)  $4.3 \times 10^{14} \text{ Hz}$  to  $7.5 \times 10^{14} \text{ Hz}$ ;(b) 1.0 m to  $2.0 \times 10^2 \text{ m}$ ;(c)  $6.0 \times 10^{16} \text{ Hz}$  to  $3.0 \times 10^{19} \text{ Hz}$   
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)  $3.46 \times 10^3 \text{ s}^{-1}$ ;(c)  $10.5 \text{ m}^{-1}$ ;(d) plus  
82. (a) 6.7 mm;(b)  $45^\circ$   
83. (a)  $2\pi y_m/\lambda$ ;(b) no  
84. (a) 1.3 m;(b) (2.0 mm)  $\sin[(9.4 \text{ m}^{-1})x] \cos[(3.8 \times 10^3 \text{ s}^{-1})t]$   
85. (a) 240 cm;(b) 120 cm;(c) 80 cm  
86. (a)  $z(y, t) = (3.0 \text{ mm}) \sin[(60 \text{ cm}^{-1})y - (31 \text{ s}^{-1})t]$ ;(b) 9.4 cm/s  
87. (a) 1.33 m/s;(b) 1.88 m/s;(c)  $16.7 \text{ m/s}^2$ ;(d)  $23.7 \text{ m/s}^2$   
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)  $2.4 \times 10^2$  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)  $x = \lambda/4 = 6.26 \text{ cm}$ ;(e)  $x = 0$  and  $x = \lambda/2 = 12.5 \text{ cm}$ ;(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)  $-x$

### **Chapter 17**

1. (a) 79 m;(b) 41 m;(c) 89 m
2. 0.144 MPa
3. (a) 2.6 km;(b)  $2.0 \times 10^2$
4.  $1.7 \times 10^2$  m
5.  $1.9 \times 10^3$  km
6. 44 m
7. 40.7 m
8. 9.00
9. 0.23 ms
10. (a)  $(D \sin \theta)/v$ ;(b)  $D/v_w$ ;(c)  $13^\circ$
11. (a)  $76.2 \mu\text{m}$ ;(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)  $9.2 \text{ m}^{-1}$ ;(c)  $3.1 \times 10^3 \text{ s}^{-1}$ ;(d) 5.9 nm;(e)  $9.8 \text{ m}^{-1}$ ;(f)  $3.1 \times 10^3 \text{ s}^{-1}$
15. (a)  $2.3 \times 10^2$  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)  $10 \mu\text{W}/\text{m}^2$ ;(b)  $0.10 \mu\text{W}/\text{m}^2$ ;(c) 70 nm;(d) 7.0 nm
25. 36.8 nm
26. (a)  $0.080 \text{ W}/\text{m}^2$ ;(b)  $0.013 \text{ W}/\text{m}^2$
27. (a)  $1.0 \times 10^3$ ;(b) 32
28. 1.26
29. 15.0 mW
30. (a)  $8.84 \text{ nW}/\text{m}^2$ ;(b) 39.5 dB
31.  $2 \mu\text{W}$
32. (a) 0.26 nm;(b)  $1.5 \text{ nW}/\text{m}^2$
33.  $0.76 \mu\text{m}$
34. (a) 3.2;(b) 5.0 dB
35. (a)  $5.97 \times 10^{-5} \text{ W}/\text{m}^2$ ;(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.  $3.3 \times 10^2$  m/s  
69. (a)  $42^\circ$ ;(b) 11 s  
70. 33.0 km  
71. 1 cm  
72.  $30^\circ$   
73. 2.1 m  
74.  $7.9 \times 10^{10}$  Pa  
75. (a)  $39.7 \mu\text{W}/\text{m}^2$ ;(b) 171 nm;(c) 0.893 Pa  
76. (a)  $5.0 \times 10^3$ ;(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)  $2.81 \times 10^{-4}$   
82. (a) 0.30 cm;(b)  $0.26 \text{ cm}^{-1}$ ;(c)  $1.6 \times 10^2 \text{ s}^{-1}$ ;(d) 6.0 m/s;(e) plus  
83. (a) rightward;(b) 0.90 m/s;(c) less  
84. (a)  $L(v_m - v)/v_mv$ ;(b) 364 m  
85. (a) 11 ms;(b) 3.8 m

86. 0.33
87. (a)  $9.7 \times 10^2$  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)  $3.9 \times 10^2$  to  $9.2 \times 10^2$  GJ;(b) 0.63 to 1.5 W/m<sup>2</sup>;(c) 25 to 58 kW/m<sup>2</sup>;(d) surface wave
95. (a) 10 W;(b) 0.032 W/m<sup>2</sup>;(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)  $3.6 \times 10^2$  m/s;(b) 150 Hz
102. (b) length<sup>2</sup>
103. 400 Hz
104. (a) 88 mW/m<sup>2</sup>;(b) 0.75
105. (a) 14;(b) 12

## **Chapter 18**

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<sup>2</sup>
9. 2.731 cm
10. 1.1 cm
11. 49.87 cm<sup>3</sup>
12. (a) 9.996 cm;(b) 68°C
13. 29 cm<sup>3</sup>
14. (a) 0.36%;(b) 0.18%;(c) 0.54%;(d) 0.00%;(e)  $1.8 \times 10^{-5}/C^\circ$
15. 360°C
16. (a) -0.69%;(b) aluminum
17. 0.26 cm<sup>3</sup>
18.  $23 \times 10^{-6}/C^\circ$
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<sup>2</sup>  
30. (a) 68 kJ/kg;(b) 2.3 kJ/kg·K  
31. 33 g  
32. 82 cal  
33. 3.0 min  
34.  $4.0 \times 10^2$  J/kg·K  
35. 13.5 C°  
36. (a)  $2.03 \times 10^4$  cal;(b)  $1.11 \times 10^3$  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)  $1.2 \times 10^2$  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)  $8 \times 10^2$  W;(b)  $2 \times 10^4$  J  
55. (a) 16 J/s;(b) 0.048 g/s  
56. 0.81 J  
57. (a)  $1.7 \times 10^4$  W/m<sup>2</sup>;(b) 18 W/m<sup>2</sup>  
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.  $3.1 \times 10^2$  J  
68.  $6.7 \times 10^{12}$  J

69. (a) 80 J;(b) 80 J  
 70.  $35.7 \text{ m}^3$   
 71.  $4.5 \times 10^2 \text{ J/kg}\cdot\text{K}$   
 72.  $766^\circ\text{C}$   
 73.  $0.432 \text{ cm}^3$   
 74. (a)  $2.5 \times 10^2 \text{ K}$ ;(b) 1.5  
 75. 10%  
 76.  $66^\circ\text{C}$   
 77.  $79.5^\circ\text{C}$   
 78. (a)  $16.7A \text{ W}$ ;(b)  $(5.0 \times 10^{-5})A \text{ kg/s}$ ;(c) 50 nm/s  
 79. 23 J  
 80. 33.3 kJ  
 81. (a)  $11p_1V_1$ ;(b)  $6p_1V_1$   
 82. (a)  $84.3^\circ\text{C}$ ;(b)  $57.6^\circ\text{C}$   
 83.  $4.83 \times 10^{-2} \text{ cm}^3$   
 84. (a)  $2.3 \times 10^2 \text{ J/s}$ ;(b) 15  
 85.  $10.5^\circ\text{C}$   
 86.  $0.32 \text{ cm}^2$   
 87. (a) 90 W;(b)  $2.3 \times 10^2 \text{ W}$ ;(c)  $3.3 \times 10^2 \text{ W}$   
 88.  $-157^\circ\text{C}$   
 89. (a)  $1.87 \times 10^4$ ;(b) 10.4 h  
 90.  $1.7 \times 10^2 \text{ km}$   
 91. 333 J  
 92.  $2.16 \times 10^{-5} \text{ m}^2$   
 93. 8.6 J  
 94.  $45.5^\circ\text{C}$   
 95. (a)  $-45 \text{ J}$ ;(b)  $+45 \text{ J}$

## **Chapter 19**

1. 0.933 kg
2. (a) 0.0127 mol;(b)  $7.64 \times 10^{21}$  atoms
3. (a) 0.0388 mol;(b)  $220^\circ\text{C}$
4. (a) 106 mol;(b)  $0.892 \text{ m}^3$
5. 25 molecules/ $\text{cm}^3$
6. 1.25 atm
7. (a)  $3.14 \times 10^3 \text{ J}$ ;(b) from
8. (a)  $5.47 \times 10^{-8} \text{ mol}$ ;(b)  $3.29 \times 10^{16}$  molecules
9. 186 kPa
10. 0.2
11. 5.60 kJ
12. (a)  $12.6 \text{ m}^3$ ; (b)  $1.16 \text{ m}^3$ ; (c)  $5.10 \times 10^3 \text{ mol}$
13. (a) 1.5 mol;(b)  $1.8 \times 10^3 \text{ K}$ ;(c)  $6.0 \times 10^2 \text{ K}$ ;(d) 5.0 kJ
14. 207 J
15. 360 K
16.  $1.0 \times 10^2 \text{ cm}^3$

17.  $2.0 \times 10^5$  Pa
18.  $9.53 \times 10^6$  m/s
19. (a) 511 m/s;(b)  $-200^\circ\text{C}$ ;(c)  $899^\circ\text{C}$
20. 2.50 km/s
21.  $1.8 \times 10^2$  m/s
22. 442 m/s
23. 1.9 kPa
24. (a) 494 m/s;(b) 27.9 g/mol;(c)  $\text{N}_2$
25. (a)  $5.65 \times 10^{-21}$  J;(b)  $7.72 \times 10^{-21}$  J;(c) 3.40 kJ;(d) 4.65 kJ
26.  $3.3 \times 10^{-20}$  J
27. (a)  $6.76 \times 10^{-20}$  J;(b) 10.7
28. 3.7 GHz
29. (a)  $6 \times 10^9$  km
30. 0.32 nm
31. (a)  $3.27 \times 10^{10}$  molecules/ $\text{cm}^3$ ;(b) 172 m
32. (a) 1.7;(b)  $5.0 \times 10^{-5}$  cm;(c)  $7.9 \times 10^{-6}$  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)  $2.7 \times 10^2$  K;(b)  $4.9 \times 10^2$  m/s
39. (a)  $1.0 \times 10^4$  K;(b)  $1.6 \times 10^5$  K;(c)  $4.4 \times 10^2$  K;(d)  $7.0 \times 10^3$  K;(e) no;(f) yes
40. 4.7
41. (a) 7.0 km/s;(b)  $2.0 \times 10^{-8}$  cm;(c)  $3.5 \times 10^{10}$  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)  $6.6 \times 10^{-26}$  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.  $1.5 \times 10^3$  N·m<sup>2</sup>
55. (a) 14 atm;(b)  $6.2 \times 10^2$  K
56. (a) 2.46 atm;(b) 336 K;(c) 0.406 L
57. (a) diatomic;(b) 446 K;(c) 8.10 mol
58.  $-87^\circ\text{C}$
59. -15 J
60.  $17^\circ\text{C}$
61. -20 J

62.  $-1.33 \times 10^4 \text{ J}$
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)  $0.0246 \text{ m}^3$ ;(n) 2.00 atm;(o)  $0.0373 \text{ m}^3$ ;(p) 1.00 atm
64. 653 J
65. (a) monatomic;(b)  $2.7 \times 10^4 \text{ K}$ ;(c)  $4.5 \times 10^4 \text{ mol}$ ;(d) 3.4 kJ;(e)  $3.4 \times 10^2 \text{ kJ}$ ;(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.  $5.0 \text{ m}^3$
71. (a) -374 J;(b) 0;(c) +374 J;(d)  $+3.11 \times 10^{-22} \text{ J}$
72.  $307^\circ\text{C}$
73.  $7.03 \times 10^9 \text{ s}^{-1}$
74. (a)  $2.5 \times 10^{25} \text{ molecules/m}^3$ ;(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.  $9.2 \times 10^{-6}$
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)  $7.72 \times 10^4 \text{ J}$ ;(b)  $5.46 \times 10^4 \text{ J}$ ;(c)  $5.17 \text{ J/mol}\cdot\text{K}$ ;(d)  $4.32 \times 10^4 \text{ J}$ ;(e)  $8.86 \times 10^4 \text{ J}$ ;(f)  $8.38 \text{ J/mol}\cdot\text{K}$
87. -3.0 J
88. (a) -45 J;(b)  $1.8 \times 10^2 \text{ K}$

## **Chapter 20**

- (a) 9.22 kJ;(b) 23.1 J/K;(c) 0
- 2.75 mol
- 14.4 J/K
- $1.86 \times 10^4 \text{ J}$
- (a)  $5.79 \times 10^4 \text{ J}$ ;(b) 173 J/K
- (a) 14.6 J/K;(b) 30.2 J/K
- (a) 320 K;(b) 0;(c) +1.72 J/K
- 0.0368 J/K
- +0.76 J/K
- $4.5 \times 10^2 \text{ J/kg}\cdot\text{K}$

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)  $1.49 \times 10^4$  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)  $1.26 \times 10^{14}$ ;(b)  $1.13 \times 10^{15}$ ;(c) 11.1%;(d)  $1.01 \times 10^{29}$ ;(e)  $1.27 \times 10^{30}$ ;(f) 8.0%;(g)  $9.25 \times 10^{58}$ ;(h)  $1.61 \times 10^{60}$ ;(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)  $4.2 \times 10^{16}$
48. (a) 1;(b) 6;(c) 0;(d)  $2.47 \times 10^{-23}$  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)  $1.2 \times 10^2$  m/s;(c) 22 J/K
52. (a) 7.2 kJ;(b)  $9.6 \times 10^2$  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) 30.5 J/K;(d) 3.4 J/K  
 56. 2.65 mJ/K·m  
 57. +3.59 J/K  
 58. +5.98 J/K  
 59.  $1.18 \times 10^3$  J/K  
 60. 13.1%  
 61. ---  
 62. (a) 700 J;(b) 0;(c) 50 J;(d) 700 J;(e) 0.226 m<sup>3</sup>;(f) 0.284 m<sup>3</sup>;(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)  $1.26 \times 10^{14}$ ;(b)  $4.71 \times 10^{13}$ ;(c) 0.37;(d)  $1.01 \times 10^{29}$ ;(e)  $1.37 \times 10^{28}$ ;(f) 0.14;(g)  $9.05 \times 10^{58}$ ;(h)  $1.64 \times 10^{57}$ ;(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)  $1.5 \times 10^{-23}$  J/K;(f)  $3.2 \times 10^{-23}$  J/K

## **Chapter 21**

1. 0.500  
 2. 0.375  
 3. 1.39 m  
 4. 0.50 C  
 5. 2.81 N  
 6. (a)  $4.9 \times 10^{-7}$  kg;  
 (b)  $7.1 \times 10^{-11}$  C  
 7. -4.00  
 8. 0.375  
 9. (a) -1.00  $\mu$ C;  
 (b) 3.00  $\mu$ C  
 10. (a) -2.83; (b) no  
 11. (a) 0.17 N;  
 (b) -0.046 N  
 12. (a) -83  $\mu$ C;  
 (b) 55  $\mu$ C  
 13. (a) -14 cm;  
 (b) 0  
 14. (a) 9.0; (b) -25

15. (a) -14 cm;  
(b) 0
16. (a) positive;  
(b) +9.0
17. (a) 1.60 N;  
(b) 2.77 N
18. 1.333
19. (a) 3.00 cm;  
(b) 0;  
(c) -0.444
20. (a) -4;  
(b) +16
21.  $3.8 \times 10^{-8}$  C
22. (a) 1.92 cm;  
(b) less than
23. (a) 0;  
(b) 12 cm;  
(c) 0;  
(d)  $4.9 \times 10^{-26}$  N
24. (a)  $8.99 \times 10^{-19}$  N;  
(b) 625
25.  $6.3 \times 10^{11}$
26.  $2.89 \times 10^{-9}$  N
27. (a)  $3.2 \times 10^{-19}$  C;  
(b) 2
28.  $2.25 \times 10^{20}$
29. (a) -6.05 cm;  
(b) 6.05 cm
30. (a) 2.00 cm;  
(b)  $9.21 \times 10^{-24}$  N
31. 122 mA
32. +13e
33.  $1.3 \times 10^7$  C
34. (a) 0.654 rad;  
(b) 0.889 rad;  
(c) 0.988 rad
35. (a) 0;  
(b)  $1.9 \times 10^{-9}$  N
36. (a) positron;  
(b) electron
37. (a)  ${}^9\text{B}$ ;  
(b)  ${}^{13}\text{N}$ ;  
(c)  ${}^{12}\text{C}$
38. +16e
39.  $1.31 \times 10^{-22}$  N
40. -2.25

41. (a)  $5.7 \times 10^{13}$  C;  
 (b) cancels out;  
 (c)  $6.0 \times 10^5$  kg
42. (b)  $2.4 \times 10^{-8}$  C
43. (b) 3.1 cm
44. 11.9 cm
45. 0.19 MC
46. (a)  $(3.52 \times 10^{-25} \text{ N})\hat{i}$ ;  
 (b) 0
47.  $-45 \mu\text{C}$
48. (a)  $3.60 \mu\text{N}$ ;  
 (b)  $2.70 \mu\text{N}$ ;  
 (c)  $3.60 \mu\text{N}$
49. 3.8 N
50. (a)  $(L/2)(1 + kqQ/Wh^2)$ ;  
 (b)  $(3kqQ/W)^{0.5}$
51. (a)  $2.00 \times 10^{10}$  electrons;  
 (b)  $1.33 \times 10^{10}$  electrons
52.  $-11.1 \mu\text{C}$
53. (a)  $8.99 \times 10^9$  N;  
 (b) 8.99 kN
54. 9.0 kN
55. (a) 0.5;  
 (b) 0.15;  
 (c) 0.85
56. (a)  $1.25 \times 10^{13}$  electrons;  
 (b) from you to faucet;  
 (c) positive;  
 (d) from faucet to the cat;  
 (e) stroking the cat transfers electrons from you to the fur, which then induces charge in the cat's body, with negative charge on the surface away from the stroked region; if you bring your positive hand near the negative nose, electrons can spark across the gap
57.  $1.7 \times 10^8$  N
58. (a)  $(89.9 \text{ N})\hat{i}$ ;  
 (b)  $(-2.50 \text{ N})\hat{i}$ ;  
 (c) 68.3 cm;  
 (d) 0
59.  $-1.32 \times 10^{13}$  C
60. 0
61. (a)  $(0.829 \text{ N})\hat{i}$ ;  
 (b)  $(-0.621 \text{ N})\hat{j}$
62. (a)  $6.16 \times 10^{-24}$  N;  
 (b)  $208^\circ$
63.  $2.2 \times 10^{-6}$  kg

64.  $1.2 \times 10^{-5} \text{ C}$
65.  $4.68 \times 10^{-19} \text{ N}$
66.  $-5.1 \text{ m}$
67. (a)  $1.72L$ ;  
(b) 0
68.  $10^{18} \text{ N}$
69. (a)  $5.1 \times 10^2 \text{ N}$ ;  
(b)  $7.7 \times 10^{28} \text{ m/s}^2$
70. 0.707

## **Chapter 22**

1. ---
2. (a)  $6.4 \times 10^{-18} \text{ N}$ ; (b)  $20 \text{ N/C}$
3. (a)  $3.07 \times 10^{21} \text{ N/C}$ ; (b) outward
4.  $(-6.39 \times 10^5 \text{ N/C})\hat{i}$
5.  $56 \text{ pC}$
6.  $0.111 \text{ nC}$
7.  $(1.02 \times 10^5 \text{ N/C})\hat{j}$
8. 0
9. (a)  $1.38 \times 10^{-10} \text{ N/C}$ ; (b)  $180^\circ$
10. (a)  $34 \text{ cm}$ ; (b)  $2.2 \times 10^{-8} \text{ N/C}$
11.  $-30 \text{ cm}$
12. (a)  $3.93 \times 10^{-6} \text{ N/C}$ ; (b)  $-76.4^\circ$
13. (a)  $3.60 \times 10^{-6} \text{ N/C}$ ; (b)  $2.55 \times 10^{-6} \text{ N/C}$ ; (c)  $3.60 \times 10^{-4} \text{ N/C}$ ; (d)  $7.09 \times 10^{-7} \text{ N/C}$ ;  
(e) As the proton nears the disk, the forces on it from electrons  $e_s$  more nearly cancel.
14. (a)  $2.72L$
15. (a)  $160 \text{ N/C}$ ; (b)  $45^\circ$
16. (a)  $67.8^\circ$ ; (b)  $-67.8^\circ$
17. (a)  $-90^\circ$ ; (b)  $+2.0 \mu\text{C}$ ; (c)  $-1.6 \mu\text{C}$
18.  $qd^3/4\pi\epsilon_0z^5$
19. (a)  $qd/4\pi\epsilon_0r^3$ ; (b)  $-90^\circ$
20. 0.98
21. ---
22. (a)  $-1.72 \times 10^{-15} \text{ C/m}$ ; (b)  $-3.82 \times 10^{-14} \text{ C/m}^2$ ; (c)  $-9.56 \times 10^{-15} \text{ C/m}^2$ ; (d)  $-1.43 \times 10^{-12} \text{ C/m}^3$
23. 0.506
24. (a) 0; (b) 0; (c)  $0.707R$ ; (d)  $3.46 \times 10^7 \text{ N/C}$
25. (a)  $1.62 \times 10^6 \text{ N/C}$ ; (b)  $-45^\circ$
26. (a)  $20.6 \text{ N/C}$ ; (b)  $-90^\circ$
27. (a)  $23.8 \text{ N/C}$ ; (b)  $-90^\circ$
28.  $1.70 \text{ cm}$
29. 1.57
30.  $-4.19Q$

31. (a)  $-5.19 \times 10^{-14} \text{ C/m}$ ; (b)  $1.57 \times 10^{-3} \text{ N/C}$ ; (c)  $-180^\circ$ ; (d)  $1.52 \times 10^{-8} \text{ N/C}$ ; (e)  $1.52 \times 10^{-8} \text{ N/C}$
32. (a)  $12.4 \text{ N/C}$ ; (b)  $90^\circ$
33. ---
34.  $6.3 \times 10^3 \text{ N/C}$
35.  $0.346 \text{ m}$
36.  $2.4 \times 10^{-16} \text{ C}$
37.  $28\%$
38.  $6.9 \text{ cm}$
39.  $-5e$
40. (a)  $7.12 \text{ cm}$ ; (b)  $28.5 \text{ ns}$ ; (c)  $0.112$
41. (a)  $1.5 \times 10^3 \text{ N/C}$ ; (b)  $2.4 \times 10^{-16} \text{ N}$ ; (c) up; (d)  $1.6 \times 10^{-26} \text{ N}$ ; (e)  $1.5 \times 10^{10}$
42. (a)  $4.8 \times 10^{-13} \text{ N}$ ; (b)  $4.8 \times 10^{-13} \text{ N}$
43.  $3.51 \times 10^{15} \text{ m/s}^2$
44. (a)  $2.03 \times 10^{-7} \text{ N/C}$ ; (b) up
45.  $6.6 \times 10^{-15} \text{ N}$
46. (a)  $1.02 \times 10^{-2} \text{ N/C}$ ; (b) west
47. (a)  $1.92 \times 10^{12} \text{ m/s}^2$ ; (b)  $1.96 \times 10^5 \text{ m/s}$
48. (a)  $1.16 \times 10^{16} \text{ m/s}^2$ ; (b)  $3.94 \times 10^{16} \text{ m/s}^2$ ; (c)  $3.97 \times 10^{16} \text{ m/s}^2$ ; (d) because the net force due to the charged particles near the edge of the disk decreases
49. (a)  $0.245 \text{ N}$ ; (b)  $-11.3^\circ$ ; (c)  $108 \text{ m}$ ; (d)  $-21.6 \text{ m}$
50. (a)  $(-2.1 \times 10^{13} \text{ m/s}^2)\hat{j}$ ; (b)  $(1.5 \times 10^5 \text{ m/s})\hat{i} - (2.8 \times 10^6 \text{ m/s})\hat{j}$
51. (a)  $3.2 \times 10^{-11} \text{ N}$ ; (b)  $3.1 \times 10^{-8} \text{ N}$ ; (c) moves to stigma
52. (a)  $27 \text{ km/s}$ ; (b)  $50 \mu\text{m}$
53.  $27 \mu\text{m}$
54.  $(1.53 \times 10^6 \text{ m/s})\hat{i} - (4.34 \times 10^5 \text{ m/s})\hat{j}$
55. (a)  $2.7 \times 10^6 \text{ m/s}$ ; (b)  $1.0 \text{ kN/C}$
56. (a)  $0$ ; (b)  $8.5 \times 10^{-22} \text{ N}\cdot\text{m}$ ; (c)  $0$
57. (a)  $9.30 \times 10^{-15} \text{ C}\cdot\text{m}$ ; (b)  $2.05 \times 10^{-11} \text{ J}$
58.  $5.0 \times 10^{-28} \text{ C}\cdot\text{m}$
59.  $1.22 \times 10^{-23} \text{ J}$
60.  $2.5 \times 10^{-28} \text{ C}\cdot\text{m}$
61.  $(1/2\pi)(pE/l)^{0.5}$
62. (a)  $2.46 \times 10^{17} \text{ m/s}^2$ ; (b)  $0.122 \text{ ns}$ ; (c)  $1.83 \text{ mm}$
63. (a)  $8.87 \times 10^{-15} \text{ N}$ ; (b)  $120$
64.  $Q/3\pi\epsilon_0 d^2$
65.  $217^\circ$
66.  $3.6 \times 10^2 \text{ N/C}$
67.  $61 \text{ N/C}$
68.  $(1.08 \times 10^{-5} \text{ N/C})\hat{i}$
69. (a)  $47 \text{ N/C}$ ; (b)  $27 \text{ N/C}$
70.  $1.64 \times 10^{-19} \text{ C}$  (approx 2% high)
71.  $38 \text{ N/C}$
72. ---

73. (a) -1.0 cm; (b) 0; (c) 10 pC  
 74. (a) 0.10  $\mu\text{C}$ ; (b)  $1.3 \times 10^{17}$ ; (c)  $5.0 \times 10^{-6}$   
 75. +1.00  $\mu\text{C}$   
 76.  $-3.28 \times 10^{-21}$  J  
 77. (a) 6.0 mm; (b) 180°  
 78. (a)  $(2q/4\pi\epsilon_0 d^2)\alpha/(1 + \alpha^2)^{1.5}$ ; (c) 0.71; (d) 0.20 and 2.0  
 79. 9:30  
 80.  $6.88 \times 10^{-28}$  C·m  
 81. (a) -0.029 C; (b) repulsive forces would explode the sphere  
 82. 5.39 N/C  
 83. (a)  $-1.49 \times 10^{-26}$  J; (b)  $(-1.98 \times 10^{-26} \text{ N}\cdot\text{m})\hat{k}$ ; (c)  $3.47 \times 10^{-26}$  J  
 84. (a) yes; (b) upper plate, 2.72 cm  
 85. (a) top row: 4, 8, 12; middle row: 5, 10, 14; bottom row: 7, 11, 16; (b)  $1.63 \times 10^{-19}$  C  
 86. (a) 0°; (b) 9.96 pN  
 87. (a)  $(-1.80 \text{ N/C})\hat{i}$ ; (b)  $(43.2 \text{ N/C})\hat{i}$ ; (c)  $(-6.29 \text{ N/C})\hat{i}$   
 88. ---

### **Chapter 23**

1.  $-0.015 \text{ N}\cdot\text{m}^2/\text{C}$
2. (a)  $-72 \text{ N}\cdot\text{m}^2/\text{C}$ ; (b)  $+24 \text{ N}\cdot\text{m}^2/\text{C}$ ; (c)  $-16 \text{ N}\cdot\text{m}^2/\text{C}$ ; (d) 0; (e)  $-48 \text{ N}\cdot\text{m}^2/\text{C}$
3. (a) 0; (b)  $-3.92 \text{ N}\cdot\text{m}^2/\text{C}$ ; (c) 0; (d) 0
4.  $-1.1 \times 10^{-4} \text{ N}\cdot\text{m}^2/\text{C}$
5.  $3.01 \text{ nN}\cdot\text{m}^2/\text{C}$
6.  $-4.3 \text{ nC}$
7.  $2.0 \times 10^5 \text{ N}\cdot\text{m}^2/\text{C}$
8. (a)  $-1.3 \times 10^{-8} \text{ C}/\text{m}^3$ ; (b)  $8.2 \times 10^{10} \text{ charges}/\text{m}^3$
9. (a)  $8.23 \text{ N}\cdot\text{m}^2/\text{C}$ ; (b) 72.9 pC; (c)  $8.23 \text{ N}\cdot\text{m}^2/\text{C}$ ; (d) 72.9 pC
10. +0.213 nC
11.  $-1.70 \text{ nC}$
12.  $(-2.8 \times 10^4 \text{ N/C})\hat{i}$
13. 3.54  $\mu\text{C}$
14. (a) +1.8  $\mu\text{C}$ ; (b)  $-5.3 \mu\text{C}$ ; (c) +8.9  $\mu\text{C}$
15. (a) 0; (b) 0.0417
16. 2.00 N/C·m
17. (a) 37  $\mu\text{C}$ ; (b)  $4.1 \times 10^6 \text{ N}\cdot\text{m}^2/\text{C}$
18. 2.0  $\mu\text{C}/\text{m}^2$
19. (a)  $4.5 \times 10^{-7} \text{ C}/\text{m}^2$ ; (b)  $5.1 \times 10^4 \text{ N/C}$
20. (a)  $-8.0 \mu\text{C}$ ; (b) +12  $\mu\text{C}$ ; (c)  $-5.3 \mu\text{C}$
21. (a)  $-3.0 \times 10^{-6} \text{ C}$ ; (b)  $+1.3 \times 10^{-5} \text{ C}$
22.  $2.1 \times 10^{17} \text{ m}/\text{s}^2$
23. (a) 0.32  $\mu\text{C}$ ; (b) 0.14  $\mu\text{C}$
24. (a) 0; (b)  $5.99 \times 10^3 \text{ N/C}$

25.  $5.0 \mu\text{C}/\text{m}$
26.  $-5.8 \text{ nC}/\text{m}$
27.  $3.8 \times 10^{-8} \text{ C}/\text{m}^2$
28. (a)  $0.24 \text{ kN}/\text{C}$ ; (b)  $-6.4 \text{ nC}/\text{m}^2$ ; (c)  $+3.2 \text{ nC}/\text{m}^2$
29. (a)  $0.214 \text{ N}/\text{C}$ ; (b) inward; (c)  $0.855 \text{ N}/\text{C}$ ; (d) outward; (e)  $-3.40 \times 10^{-12} \text{ C}$ ; (f)  $-3.40 \times 10^{-12} \text{ C}$
30.  $8.0 \text{ cm}$
31. (a)  $2.3 \times 10^6 \text{ N}/\text{C}$ ; (b) outward; (c)  $4.5 \times 10^5 \text{ N}/\text{C}$ ; (d) inward
32. (a)  $1.9 \text{ N}/\text{C}$ ; (b)  $3.6 \text{ N}/\text{C}$
33. (a) 0; (b) 0; (c)  $(-7.91 \times 10^{-11} \text{ N}/\text{C})\hat{i}$
34.  $(0.208 \text{ N}/\text{C})\hat{k}$
35.  $-1.5$
36. (a)  $(2.00 \times 10^{-11} \text{ N}/\text{C})\hat{j}$ ; (b) 0; (c)  $(-2.00 \times 10^{-11} \text{ N}/\text{C})\hat{j}$
37. (a)  $5.3 \times 10^7 \text{ N}/\text{C}$ ; (b)  $60 \text{ N}/\text{C}$
38.  $2.9 \mu\text{C}/\text{m}^2$
39.  $5.0 \text{ nC}/\text{m}^2$
40. (a)  $+69.1 \text{ cm}$ ; (b)  $-69.1 \text{ cm}$ ; (c)  $+69.1 \text{ cm}$
41.  $0.44 \text{ mm}$
42.  $4.9 \times 10^{-10} \text{ C}$
43. (a) 0; (b)  $1.31 \mu\text{N}/\text{C}$ ; (c)  $3.08 \mu\text{N}/\text{C}$ ; (d)  $3.08 \mu\text{N}/\text{C}$
44.  $2.2 \mu\text{C}$
45. (a)  $2.50 \times 10^4 \text{ N}/\text{C}$ ; (b)  $1.35 \times 10^4 \text{ N}/\text{C}$
46. (a)  $-750 \text{ N}\cdot\text{m}^2/\text{C}$ ; (b)  $-6.64 \text{ nC}$
47.  $-7.5 \text{ nC}$
48.  $+6.6 \mu\text{C}$
49. (a) 0; (b)  $56.2 \text{ mN}/\text{C}$ ; (c)  $112 \text{ mN}/\text{C}$ ; (d)  $49.9 \text{ mN}/\text{C}$ ; (e) 0; (f) 0; (g)  $-5.00 \text{ fC}$ ; (h) 0
50.  $-3.3 \text{ cm}$
51.  $1.79 \times 10^{-11} \text{ C}/\text{m}^2$
52. (a) 0; (b) 0; (c) 0; (d)  $7.32 \text{ N}/\text{C}$ ; (e)  $12.1 \text{ N}/\text{C}$ ; (f)  $1.35 \text{ N}/\text{C}$
53. (a)  $7.78 \text{ fC}$ ; (b) 0; (c)  $5.58 \text{ mN}/\text{C}$ ; (d)  $22.3 \text{ mN}/\text{C}$
54.  $1.125$
55.  $6K\epsilon_0 r^3$
56. (a)  $0.50 \text{ N}\cdot\text{m}^2/\text{C}$ ; (b)  $2.2 \text{ pC}$
57. (a) 0; (b)  $2.88 \times 10^4 \text{ N}/\text{C}$ ; (c)  $200 \text{ N}/\text{C}$
58.  $7.1 \text{ N}\cdot\text{m}^2/\text{C}$
59. (a)  $5.4 \text{ N}/\text{C}$ ; (b)  $6.8 \text{ N}/\text{C}$
60. (a)  $E = |\rho| r/2\epsilon_0$ ; (b) increases; (c) inward; (d)  $3 \times 10^6 \text{ N}/\text{C}$ , at inside pipe surface; (e) yes, along inside pipe surface
61. (a) 0; (b)  $q_a/4\pi\epsilon_0 r^2$ ; (c)  $(q_a + q_b)/4\pi\epsilon_0 r^2$
62. (a)  $4.0 \times 10^6 \text{ N}/\text{C}$ ; (b) 0
63.  $-1.04 \text{ nC}$
64. ---
65. (a)  $0.125$ ; (b)  $0.500$
66. (a)  $0.41R$ ; (b)  $0.50R$
67. (a)  $+2.0 \text{ nC}$ ; (b)  $-1.2 \text{ nC}$ ; (c)  $+1.2 \text{ nC}$ ; (d)  $+0.80 \text{ nC}$

68. 26.6 nC
69.  $(5.65 \times 10^4 \text{ N/C})\hat{j}$
70. (a) 4.2 kN/C; (b) 2.4 kN/C
71. (a)  $-2.53 \times 10^{-2} \text{ N}\cdot\text{m}^2/\text{C}$ ; (b)  $+2.53 \times 10^{-2} \text{ N}\cdot\text{m}^2/\text{C}$
72.  $-4.2 \times 10^{-10} \text{ C}$
73. ---
74. (a)  $3.62 \text{ N}\cdot\text{m}^2/\text{C}$ ; (b)  $51.1 \text{ N}\cdot\text{m}^2/\text{C}$
75. 3.6 nC
76. (b)  $\rho R^2/2\epsilon_0 r$
77. (a)  $+4.0 \mu\text{C}$ ; (b)  $-4.0 \mu\text{C}$
78. (a) 15.0 N/C; (b) 25.3 N/C
79. (a) 693 kg/s; (b) 693 kg/s; (c) 347 kg/s; (d) 347 kg/s; (e) 575 kg/s
80. (a) 0.282 kN/C; (b) 0.621 kN/C
81. (a)  $0.25R$ ; (b)  $2.0R$
82. (a)  $4.9 \times 10^{-22} \text{ C}/\text{m}^2$ ; (b) down

### **Chapter 24**

1. (a)  $3.0 \times 10^5 \text{ C}$ ; (b)  $3.6 \times 10^6 \text{ J}$
2.  $1.2 \times 10^9 \text{ eV}$
3.  $2.8 \times 10^5$
4. (a)  $2.4 \times 10^4 \text{ V}/\text{m}$ ; (b) 2.9 kV
5. 8.8 mm
6. (a) 2.46 V; (b) 2.46 V; (c) 0
7. -32.0 V
8. (a) 30 V; (b) 40 V; (c) 5.5 m
9. (a)  $1.87 \times 10^{-21} \text{ J}$ ; (b) -11.7 mV
10. 2.5 kV
11. (a) -0.268 mV; (b) -0.681 mV
12. -1.1 nC
13. (a) 3.3 nC; (b)  $12 \text{ nC}/\text{m}^2$
14. (a) -4.5 kV; (b) -4.5 kV
15. (a) 0.54 mm; (b) 790 V
16. 2.21 V
17. 0.562 mV
18.  $-32e$
19. (a) 6.0 cm; (b) -12.0 cm
20. None
21.  $16.3 \mu\text{V}$
22.  $5.6 \times 10^{-37} \text{ C}\cdot\text{m}$
23. (a) 24.3 mV; (b) 0
24. -6.20 V
25. (a) -2.30 V; (b) -1.78 V
26.  $2.18 \times 10^4 \text{ V}$
27. 13 kV
28. 7.39 mV

29. 32.4 mV  
 30. 0  
 31. 47.1  $\mu\text{V}$   
 32. (a) 36 V;(b) 18 V  
 33. 18.6 mV  
 34.  $6.7 \times 10^2$  V/m  
 35.  $(-12 \text{ V/m})\hat{i} + (12 \text{ V/m})\hat{j}$   
 36. (a) 39 V/m(b) toward  
 37. 150 N/C  
 38. (a)  $(2.90 \text{ mV}) \ln(1 + (0.135 \text{ m})/d)$ ;(b)  $(0.392 \text{ mN}\cdot\text{m}^2/\text{C})/[x(x + 0.135 \text{ m})]$ ;(c)  $180^\circ$ ;(d) 32.1 mN/C;(e) 0  
 39.  $(-4.0 \times 10^{-16} \text{ N})\hat{i} + (1.6 \times 10^{-16} \text{ N})\hat{j}$   
 40. (a) 31.6 mV;(b) 0.298 N/C  
 41. (a) 0.90 J;(b) 4.5 J  
 42. (a)  $1.15 \times 10^{-19}$  J;(b) decrease  
 43. -0.192 pJ  
 44.  $2.1 \times 10^{-25}$  J  
 45. 2.5 km/s  
 46.  $1.8 \times 10^{-10}$  J  
 47. 22 km/s  
 48.  $6.63 \times 10^6$  m/s  
 49. 0.32 km/s  
 50. 0  
 51. (a)  $+6.0 \times 10^4$  V;(b)  $-7.8 \times 10^5$  V;(c) 2.5 J;(d) increase;(e) same;(f) same  
 52.  $4.5 \times 10^{-12}$  C·m  
 53. (a) 0.225 J;(b) *A* 45.0 m/s<sup>2</sup>, *B* 22.5 m/s<sup>2</sup>;(c) *A* 7.75 m/s, *B* 3.87 m/s  
 54. (a) 0;(b)  $1.0 \times 10^7$  m/s  
 55.  $1.6 \times 10^{-9}$  m  
 56.  $-5.7 \mu\text{C}$   
 57. (a) 3.0 J;(b) -8.5 m  
 58. (a) 1.7 cm;(b) 20 km/s;(c)  $4.8 \times 10^{-17}$  N;(d) positive;(e)  $3.2 \times 10^{-17}$  N;(f) negative  
 59. (a) proton;(b) 65.3 km/s  
 60. (a)  $-12.0 \mu\text{C}$ ;(b) +0.216 pJ  
 61. (a) 12;(b) 2  
 62. (a) equal;(b) 0.333;(c) 0.667;(d) 2.00  
 63. (a)  $-1.8 \times 10^2$  V;(b) 2.9 kV;(c) -8.9 kV  
 64. 400 V  
 65.  $2.5 \times 10^{-8}$  C  
 66. (a) 1.69 kV/m;(b) 36.7 kV/m;(c) 0;(d) 6.74 kV;(e) 27.0 kV;(f) 34.7 kV;(g) 45.0 kV;(h) 45.0 kV;(i) 45.0 kV  
 67. (a) 12 kN/C;(b) 1.8 kV;(c) 5.8 cm  
 68. -1.93 J  
 69. (a) 64 N/C;(b) 2.9 V;(c) 0  
 70. (a)  $V = \rho(R^2 - r^2)/4\epsilon_0$ ;(b) 78 kV  
 71.  $p/2\pi\epsilon_0 r^3$

72.  $(2.9 \times 10^{-2} \text{ m}^{-3})A$
73. (a)  $3.6 \times 10^5 \text{ V}$ ; (b) no
74. (a)  $-24 \text{ J}$ ; (b) 0
75.  $6.4 \times 10^8 \text{ V}$
76.  $3.71 \times 10^4 \text{ V}$
77. 2.90 kV
78. 0.956 V
79.  $7.0 \times 10^5 \text{ m/s}$
80. 10.3 mV
81. (a) 1.8 cm; (b)  $8.4 \times 10^5 \text{ m/s}$ ; (c)  $2.1 \times 10^{-17} \text{ N}$ ; (d) positive; (e)  $1.6 \times 10^{-17} \text{ N}$ ; (f) negative
82. (a)  $-0.12 \text{ V}$ ; (b)  $1.8 \times 10^{-8} \text{ N/C}$ ; (c) inward
83. (a)  $+7.19 \times 10^{-10} \text{ V}$ ; (b)  $+2.30 \times 10^{-28} \text{ J}$ ; (c)  $+2.43 \times 10^{-29} \text{ J}$
84. (a) 3.6 kV; (b) 3.6 kV
85.  $2.30 \times 10^{-28} \text{ J}$
86. 240 kV
87. 2.1 days
88. (a) 2.5 MV; (b) 5.1 J; (c) 6.9 J
89.  $2.30 \times 10^{-22} \text{ J}$
90.  $(qQ/8\pi\epsilon_0)(1/r_1 - 1/r_2)$
91.  $1.48 \times 10^7 \text{ m/s}$
92. 0.334 mV
93. -1.92 MV
94. (a) spherical, centered on  $q$ , radius 4.5 m; (b) no
95. (a)  $Q/4\pi\epsilon_0 r$ ; (b)  $(\rho/3\epsilon_0)(1.5r_2^2 - 0.50r^2 - r_1^3 r^{-1})$ ,  $\rho = Q/[4\pi/3(r_2^3 - r_1^3)]$ ; (c)  $(\rho/2\epsilon_0)(r_2^2 - r_1^2)$ , with  $\rho$  as in (b); (d) yes
96. (a)  $q(3R^2 - r^2)/8\pi\epsilon_0 R^3$ ; (b)  $q/8\pi\epsilon_0 R$
97. ---
98.  $-1.2 \mu\text{J}$
99. ---
100.  $8.8 \times 10^{-14} \text{ m}$
101. (a) 0.484 MeV; (b) 0
102. (a) 25 fm; (b) 2.0
103. -1.7
104. 843 V
105. (a) 38 s; (b) 280 days

### **Chapter 25**

1. (a) 3.5 pF; (b) 3.5 pF; (c) 57 V
2. 3.0 mC
3. (a) 144 pF; (b) 17.3 nC
4. (a) 84.5 pF; (b) 191 cm<sup>2</sup>
5. 0.280 pF
6. (a)  $8.85 \times 10^{-12} \text{ m}$
7.  $6.79 \times 10^{-4} \text{ F/m}^2$

8.  $9.09 \times 10^3$
9. 315 mC
10.  $7.33 \mu\text{F}$
11.  $3.16 \mu\text{F}$
12. (a)  $60 \mu\text{C}$ ; (b)  $60 \mu\text{C}$
13. 43 pF
14. (a)  $100 \mu\text{C}$ ; (b)  $20.0 \mu\text{C}$
15. (a)  $3.00 \mu\text{F}$ ; (b)  $60.0 \mu\text{C}$ ; (c) 10.0 V; (d)  $30.0 \mu\text{C}$ ; (e) 10.0 V; (f)  $20.0 \mu\text{C}$ ; (g) 5.00 V; (h)  $20.0 \mu\text{C}$
16.  $12 \mu\text{C}$
17. (a)  $789 \mu\text{C}$ ; (b) 78.9 V
18. (a)  $2.0 \mu\text{F}$ ; (b)  $0.80 \mu\text{F}$
19. (a)  $4.0 \mu\text{F}$ ; (b)  $2.0 \mu\text{F}$
20. 2.28 pF
21. (a) 50 V; (b)  $5.0 \times 10^{-5} \text{ C}$ ; (c)  $1.5 \times 10^{-4} \text{ C}$
22.  $20 \mu\text{C}$
23. (a)  $4.5 \times 10^{14}$ ; (b)  $1.5 \times 10^{14}$ ; (c)  $3.0 \times 10^{14}$ ; (d)  $4.5 \times 10^{14}$ ; (e) up; (f) up
24. (a)  $2.0 \times 10^7$ ; (b) away
25. 3.6 pC
26. (a) 10 V; (b)  $8.0 \mu\text{F}$ ; (c)  $2.0 \mu\text{F}$
27. (a)  $9.00 \mu\text{C}$ ; (b)  $16.0 \mu\text{C}$ ; (c)  $9.00 \mu\text{C}$ ; (d)  $16.0 \mu\text{C}$ ; (e)  $8.40 \mu\text{C}$ ; (f)  $16.8 \mu\text{C}$ ; (g) 10.8  $\mu\text{C}$ ; (h)  $14.4 \mu\text{C}$
28. (a)  $32.0 \mu\text{C}$ ; (b)  $16.0 \mu\text{C}$ ; (c)  $16.0 \mu\text{C}$
29. 72 F
30. 99.6 nJ
31. 0.27 J
32. (a) 35 pF; (b) 21 nC; (c)  $6.3 \mu\text{J}$ ; (d) 0.60 MV/m; (e)  $1.6 \text{ J/m}^3$
33.  $0.11 \text{ J/m}^3$
34. (a)  $400 \mu\text{C}$ ; (b) 100 V; (c) 20.0 mJ; (d)  $333 \mu\text{C}$ ; (e) 33.3 V; (f) 5.55 mJ; (g) 333  $\mu\text{C}$ ; (h) 66.7 V; (i) 11.1 mJ
35. (a)  $9.16 \times 10^{-18} \text{ J/m}^3$ ; (b)  $9.16 \times 10^{-6} \text{ J/m}^3$ ; (c)  $9.16 \times 10^6 \text{ J/m}^3$ ; (d)  $9.16 \times 10^{18} \text{ J/m}^3$ ; (e)  $\infty$
36. (a)  $-0.50 \mu\text{C}$ ; (b) 3.6 mJ; (c) no
37. (a) 16.0 V; (b) 45.1 pJ; (c) 120 pJ; (d) 75.2 pJ
38. (a)  $750 \mu\text{C}$ ; (b) 50.0 V; (c) 18.8 mJ (d)  $500 \mu\text{C}$ ; (e) 50.0 V; (f) 12.5 mJ; (g) 250  $\mu\text{C}$ ; (h) 50.0 V; (i) 6.25 mJ;
39. (a) 190 V; (b) 95 mJ
40. 4.0
41. 81 pF/m
42. (a) 6.2 cm; (b) 0.28 nF
43. Pyrex
44. (a) 0.73 nF; (b) 28 kV
45.  $66 \mu\text{J}$
46. 1.06 nC
47.  $0.63 \text{ m}^2$

48. 8.41 pF  
 49. 17.3 pF  
 50. 45.5 pF  
 51. (a) 10 kV/m;(b) 5.0 nC;(c) 4.1 nC  
 52. (a) 13.4 pF;(b) 1.15 nC;(c)  $1.13 \times 10^4$  N/C;(d)  $4.33 \times 10^3$  N/C  
 53. (a) 89 pF;(b) 0.12 nF;(c) 11 nC;(d) 11 nC;(e) 10 kV/m;(f) 2.1 kV/m;(g) 88 V;(h) –  
 0.17  $\mu$ J  
 54. (a) 7.2;(b) 0.77  $\mu$ C  
 55. (a) 0.107 nF;(b) 7.79 nC;(c) 7.45 nC  
 56. (a) 100  $\mu$ C;(b) 20.0  $\mu$ C  
 57. 45  $\mu$ C  
 58. (a) 41  $\mu$ F;(b) 42  $\mu$ F  
 59. 16  $\mu$ C  
 60. (a) 4.9 mJ;(b) no  
 61. (a) 7.20  $\mu$ C;(b) 18.0  $\mu$ C;(c) Battery supplies charges only to plates to which it is connected; charges on other plates are due to electron transfers between plates, in accord with new distribution of voltages across the capacitors. So battery does not directly supply charge on capacitor 4.  
 62. (a) 2.0  $\mu$ F;(b) 6.0  $\mu$ F  
 63. (a) 10  $\mu$ C;(b) 20  $\mu$ C  
 64. (a) 36  $\mu$ C;(b) 12  $\mu$ C  
 65. 1.06 nC  
 66. ---  
 67. (a) 2.40  $\mu$ F;(b) 0.480 mC;(c) 80 V;(d) 0.480 mC;(e) 120 V  
 68. (a) 10.0  $\mu$ F;(b) 1.20 mC;(c) 200 V;(d) 0.800 mC;(e) 200 V  
 69. 4.9%  
 70. (a) 0.708 pF;(b) 1.67;(c) -5.44 J;(d) sucked in  
 71. (a) 0.708 pF;(b) 0.600;(c)  $1.02 \times 10^{-9}$  J;(d) sucked in  
 72. (a) 0.480 mC;(b) 240 V;(c) 0.480 mC;(d) 60.0 V;(e) 0.192 mC;(f) 96.0 V;(g)  
 0.768 mC;(h) 96.0 V;(i) 0;(j) 0;(k) 0;(l) 0  
 73. 5.3 V  
 74. Mica  
 75. 40  $\mu$ F  
 76. 4  
 77. (a) 200 kV/m;(b) 200 kV/m;(c)  $1.77 \mu$ C/m<sup>2</sup>;(d)  $4.60 \mu$ C/m<sup>2</sup>;(e)  $-2.83 \mu$ C/m<sup>2</sup>  
 78. (a) five capacitors in series;(b) one possible answer: three rows in parallel, each row containing five capacitors in series

## **Chapter 26**

1. (a) 1.2 kC;(b)  $7.5 \times 10^{21}$   
 2. 5.6 ms  
 3.  $6.7 \mu$ C/m<sup>2</sup>  
 4. 14  
 5. (a) 6.4 A/m<sup>2</sup>;(b) north;(c) cross-sectional area  
 6. (a) yes;(b)  $4.0 \times 10^2$  A/m<sup>2</sup>

7. 0.38 mm
8. (a)  $2.4 \times 10^{-5} \text{ A/m}^2$ ; (b)  $1.8 \times 10^{-15} \text{ m/s}$
9. 18.1  $\mu\text{A}$
10. 2.59 mA
11. (a) 1.33 A; (b) 0.666 A; (c)  $J_a$
12. (a)  $0.654 \mu\text{A/m}^2$ ; (b) 83.4 MA
13. 13 min
14. 100 V
15. 2.4  $\Omega$
16. (a)  $5.32 \times 10^5 \text{ A/m}^2$ ; (b) 1.01 kg/m; (c)  $3.27 \times 10^5 \text{ A/m}^2$ ; (d) 0.495 kg/m
17.  $2.0 \times 10^6 (\Omega \cdot \text{m})^{-1}$
18. (a) 1.53 kA; (b)  $54.1 \text{ MA/m}^2$ ; (c)  $10.6 \times 10^{-8} \Omega \cdot \text{m}$ ; (d) platinum
19.  $2.0 \times 10^{-8} \Omega \cdot \text{m}$
20.  $2R$
21.  $(1.8 \times 10^3)^\circ\text{C}$
22. 9.42 mA
23.  $8.2 \times 10^{-4} \Omega \cdot \text{m}$
24. (a) 1.55 mm; (b) 1.22 mm
25. 54  $\Omega$
26. (a)  $6.00 \times 10^7 (\Omega \cdot \text{m})^{-1}$ ; (b)  $7.50 \times 10^6 (\Omega \cdot \text{m})^{-1}$
27. 3.0
28. 3.0 mA
29.  $3.35 \times 10^{-7} \text{ C}$
30. 0.40  $\Omega$
31. (a) 6.00 mA; (b)  $1.59 \times 10^{-8} \text{ V}$ ; (c) 21.2 n $\Omega$
32. (a) 3.24 pA/m<sup>2</sup>; (b) 1.73 cm/s
33. (a) 38.3 mA; (b) 109 A/m<sup>2</sup>; (c) 1.28 cm/s; (d) 227 V/m
34.  $5.44 \times 10^{-9} \text{ m/s}$
35. 981 k $\Omega$
36. 52 mA
37. ---
38. 0.10 V
39. 150 s
40. 11.1  $\Omega$
41. (a) 1.0 kW; (b) US\$0.25
42. (a) upward; (b) 12 eV; (c) 12 eV
43. 0.135 W
44. 14 kC
45. (a) 10.9 A; (b) 10.6  $\Omega$ ; (c) 4.50 MJ
46. (a) 16.9 mV/m; (b) 243 J
47. (a) 5.85 m; (b) 10.4 m
48. 5.00 A
49. (a) US\$4.46; (b) 144  $\Omega$ ; (c) 0.833 A
50. 12 mW
51. (a) 5.1 V; (b) 10 V; (c) 10 W; (d) 20 W

52. 756 kJ
53. (a) 28.8  $\Omega$ ; (b)  $2.60 \times 10^{19} \text{ s}^{-1}$
54. 0.224 m
55. 660 W
56. (a) 1.74 A; (b) 2.15 MA/m<sup>2</sup>; (c) 36.3 mV/m; (d) 2.09 W
57. 28.8 kC
58. (a) 1.3 m $\Omega$ ; (b) 4.6 mm
59. (a) silver; (b) 51.6 n $\Omega$
60. (a)  $\rho\pi R^2 v$ ; (b) 17  $\mu\text{A}$ ; (c) no, because current is perpendicular to the radial potential difference; (d) 1.3 W; (e) 0.27 J; (f) exit of pipe into silo
61. (a)  $2.3 \times 10^{12}$ ; (b)  $5.0 \times 10^3$ ; (c) 10 MV
62. 13.3  $\Omega$
63. 2.4 kW
64. (a)  $1.3 \times 10^5 \text{ A/m}^2$ ; (b) 94 mV
65. (a) 1.37; (b) 0.730
66. 0.20 hp
67. (a) -8.6%; (b) smaller
68. 57°C
69. 146 kJ
70. (a) 0.38 mV; (b) negative; (c) 3 min 58 s
71. (a) 250°C; (b) yes
72. 0.536  $\Omega$
73.  $3.0 \times 10^6 \text{ J/kg}$
74.  $3.4 \times 10^4 \text{ s}$
75. 560 W
76. (a) 0.67 A; (b) toward

### **Chapter 27**

1. (a) 0.50 A; (b) 1.0 W; (c) 2.0 W; (d) 6.0 W; (e) 3.0 W; (f) supplied; (g) absorbed
2. -10 V
3. (a) 14 V; (b)  $1.0 \times 10^2 \text{ W}$ ; (c)  $6.0 \times 10^2 \text{ W}$ ; (d) 10 V; (e)  $1.0 \times 10^2 \text{ W}$
4. (a) 80  $\Omega$ ; (b) 200  $\Omega$
5. 11 kJ
6. (a) US\$ $3.2 \times 10^2$ ; (b) US\$0.048
7. (a) 80 J; (b) 67 J; (c) 13 J
8. 14.4 h
9. (a) 12.0 eV; (b) 6.53 W
10. (a)  $9.9 \times 10^2 \Omega$ ; (b)  $9.9 \times 10^{-4} \text{ W}$
11. (a) 50 V; (b) 48 V; (c) negative
12. (a) 12.0 V; (b) 2.15 mV; (c) 24.0 W; (d) 4.30 mW
13. (a) 6.9 km; (b) 20  $\Omega$
14. (a) 0.20  $\Omega$ ; (b) 0.30  $\Omega$
15. 8.0  $\Omega$
16. (a) 1.0 k $\Omega$ ; (b) 0.30 V; (c) 0.23%
17. (a) 0.004  $\Omega$ ; (b) 1

18. 0.25 V
19. (a) 4.00  $\Omega$ ; (b) parallel
20. (a) 4.0  $\Omega$ ; (b) 12  $\Omega$
21. 5.56 A
22. (a) 2.50  $\Omega$ ; (b) 3.13  $\Omega$
23. (a) 50 mA; (b) 60 mA; (c) 9.0 V
24. 4.50  $\Omega$
25. 3d
26.  $100R\mathcal{E}^2x^2R_0^{-2}(100RR_0^{-1} + 10x - x^2)^{-2}$ ,  $x$  in cm
27.  $3.5 \times 10^3$  A
28. 0.82 mA
29. (a) 0.333 A; (b) right; (c) 720 J
30. (a) 0; (b) 1.25 A
31. (a) -11 V; (b) -9.0 V
32. (a) 6.0 V; (b) 20  $\Omega$ ; (c) 40  $\Omega$
33. 48.3 V
34. (a) same; (b) -2.0 V
35. (a) 5.25 V; (b) 1.50 V; (c) 5.25 V; (d) 6.75 V
36. (a) 38.2 mA; (b) down; (c) 10.9 mA; (d) right; (e) 27.3 mA; (f) left; (g) +3.82 V
37. 1.43  $\Omega$
38. (a) providing; (b)  $3.6 \times 10^2$  W
39. (a) 0.150  $\Omega$ ; (b) 240 W
40. (a) 24.0 A; (b) 30.0 A; (c) series; (d) 60.0 A; (e) 48.0 A; (f) parallel
41. (a) 0.709 W; (b) 0.050 W; (c) 0.346 W; (d) 1.26 W; (e) -0.158 W
42. 8
43. 9
44. (a) 119  $\Omega$ ; (b) 50.5 mA; (c) 19.0 mA; (d) 19.0 mA; (e) 12.5 mA
45. (a) 0.67 A; (b) down; (c) 0.33 A; (d) up; (e) 0.33 A; (f) up; (g) 3.3 V
46. (a) 2.0 k $\Omega$ ; (b) 4.0 k $\Omega$
47. (a) 1.11 A; (b) 0.893 A; (c) 126 m
48. (a) 19.5  $\Omega$ ; (b) 0; (c)  $\infty$ ; (d) 82.3 W; (e) 57.6 W
49. (a) 0.45 A
50. 0.143
51. (a) 55.2 mA; (b) 4.86 V; (c) 88.0  $\Omega$ ; (d) decrease
52. (a) 13.5 k $\Omega$ ; (b) 1.50 k $\Omega$ ; (c) 167  $\Omega$ ; (d) 1.48 k $\Omega$
53. -3.0%
54. (a) 12.5 V; (b) 50.0 A
55. ---
56. (a) 70.9 mA; (b) 4.70 V; (c) 66.3  $\Omega$ ; (d) decrease
57. 0.208 ms
58. (a) 2.52 s; (b) 21.6  $\mu\text{C}$ ; (c) 3.40 s
59. 4.61
60. (a) 0.41; (b) 1.1
61. (a) 2.41  $\mu\text{s}$ ; (b) 161 pF
62. 2.35 M $\Omega$

63. (a) 1.1 mA;(b) 0.55 mA;(c) 0.55 mA;(d) 0.82 mA;(e) 0.82 mA;(f) 0;(g)  $4.0 \times 10^2$  V;(h)  $6.0 \times 10^2$  V
64. (a) 2.17 s;(b) 39.6 mV
65. 411  $\mu$ A
66. (a)  $1.0 \times 10^{-3}$  C;(b)  $1.0 \times 10^{-3}$  A;(c)  $(1.0 \times 10^3 \text{ V})e^{-t}$ ;(d)  $(1.0 \times 10^3 \text{ V})e^{-t}$ ;(e)  $e^{-2t}$  W
67. 0.72 M $\Omega$
68. 162  $\mu$ s
69. (a) 0.955  $\mu$ C/s;(b) 1.08  $\mu$ W;(c) 2.74  $\mu$ W;(d) 3.82  $\mu$ W
70. (a) 6.0 A;(b) 8.0 V;(c) 60 W;(d) 36 W
71. (a) 3.00 A;(b) 3.75 A;(c) 3.94 A
72. (a) 3.0 A;(b) 10 A;(c) 13 A;(d) 1.5 A;(e) 7.5 A
73. (a)  $1.32 \times 10^7$  A/m<sup>2</sup>;(b) 8.90 V;(c) copper;(d)  $1.32 \times 10^7$  A/m<sup>2</sup>;(e) 51.1 V;(f) iron
74. (a) 4.0 A;(b) up
75. (a) 3.0 kV;(b) 10 s;(c) 11 G $\Omega$
76. (a) 5.00 A;(b) left;(c) supply;(d) 100 W;(e) supply;(f) 50.0 W;(g) supply;(h) 56.3 W
77. (a) 85.0  $\Omega$ ;(b) 915  $\Omega$
78. 0.90%
79. ---
80. 250  $\mu$ J
81. 4.0 V
82. 2.5 V
83. (a) 24.8  $\Omega$ ;(b) 14.9 k $\Omega$
84. (a) 80 mA;(b) 0.13 A;(c) 0.40 A
85. the cable
86. (a) 38  $\Omega$ ;(b) 260  $\Omega$
87. -13  $\mu$ C
88. 13.3  $\Omega$
89. 20  $\Omega$
90. ---
91. (a) 3.00 A;(b) down;(c) 1.60 A;(d) down;(e) supply; (f) 55.2 W;(g) supply;(h) 6.40 W
92. 2.00 A
93. (a) 1.0 V;(b) 50 m $\Omega$
94. (a) 6.67  $\Omega$ ;(b) 6.67  $\Omega$ ;(c) 0
95. 3
96. 2.5 A
97. ---
98. (a) 0;(b) 14.4 W
99. (a) 1.5 mA;(b) 0;(c) 1.0 mA

## **Chapter 28**

1. (a) 400 km/s;(b) 835 eV
2. -61  $\hat{k}$  mT
3. (a)  $(6.2 \times 10^{-14} \text{ N})\hat{k}$ ;(b)  $(-6.2 \times 10^{-14} \text{ N})\hat{k}$

4. (a)  $6.2 \times 10^{-18}$  N;(b)  $9.5 \times 10^8$  m/s<sup>2</sup>;(c) same
5. -2.0 T
6. (a) -3.5 km/s;(b) 7.0 km/s
7.  $(-11.4 \text{ V/m})\hat{i} - (6.00 \text{ V/m})\hat{j} + (4.80 \text{ V/m})\hat{k}$
8. 3.75 km/s
9.  $-(0.267 \text{ mT})\hat{k}$
10. (a)  $(1.44 \times 10^{-18} \text{ N})\hat{k}$ ;(b)  $(1.60 \times 10^{-19} \text{ N})\hat{k}$ ;(c)  $(6.41 \times 10^{-19} \text{ N})\hat{i} + (8.01 \times 10^{-19} \text{ N})\hat{k}$
11. 0.68 MV/m
12. (a) 1.25 V/m;(b)  $(25.0 \text{ mT})\hat{k}$
13. 7.4  $\mu\text{V}$
14. 38.2 cm/s
15. (a)  $(-600 \text{ mV/m})\hat{k}$ ;(b) 1.20 V
16. (a) 25 cm;(b) 30 cm;(c) 20 cm
17. (a)  $2.60 \times 10^6$  m/s;(b) 0.109  $\mu\text{s}$ ;(c) 0.140 MeV;(d) 70.0 kV
18. (a)  $4.99 \times 10^6$  m/s;(b) 7.10 mm;(c) 8.93 ns
19.  $1.2 \times 10^{-9}$  kg/C
20.  $6.7 \times 10^{-2}$  T
21. (a)  $2.05 \times 10^7$  m/s;(b) 467  $\mu\text{T}$ ;(c) 13.1 MHz;(d) 76.3 ns
22. (a) 1.0 MeV;(b) 0.50 MeV
23. 21.1  $\mu\text{T}$
24. (a)  $1.11 \times 10^7$  m/s;(b) 0.316 mm
25. (a) 0.978 MHz;(b) 96.4 cm
26. (a) 0.252 T;(b) 130 ns
27. (a) 495 mT;(b) 22.7 mA;(c) 8.17 MJ
28.  $2.09 \times 10^{-22}$  J
29. 65.3 km/s
30. 8.7 ns
31. 5.07 ns
32. 0.53 m
33. (a) 0.358 ns;(b) 0.166 mm;(c) 1.51 mm
34. (a) 84°;(b) no;(c) no;(d) 5.7 nm
35. (a) 200 eV;(b) 20.0 keV;(c) 0.499%
36. (a) 0.787 T;(b) 8.34 MeV;(c) 23.9 MHz;(d) 33.2 MeV
37.  $2.4 \times 10^2$  m
38. (a) 18.3 MHz;(b) 17.2 MeV
39. (a) 28.2 N;(b) horizontally west
40. 20.1 N
41. (a) 467 mA;(b) right
42. (a)  $-16\hat{j}$  N;(b) 0
43. (a) 0;(b) 0.138 N;(c) 0.138 N;(d) 0
44. 0.60  $\mu\text{N}$
45.  $(-2.50 \text{ mN})\hat{j} + (0.750 \text{ mN})\hat{k}$
46. (a) 3.34 cm/s;(b) left
47. (a) 0.10 T;(b) 31°
48.  $(-0.35\hat{k})$  N

49.  $(-4.3 \times 10^{-3} \text{ N}\cdot\text{m})\hat{j}$   
 50.  $6.58 \times 10^{-26} \text{ N}\cdot\text{m}$   
 51. 2.45 A  
 52. 3.0 mA  
 53. ---  
 54. (a)  $77^\circ$ ; (b)  $77^\circ$   
 55. (a)  $2.86 \text{ A}\cdot\text{m}^2$ ; (b)  $1.10 \text{ A}\cdot\text{m}^2$   
 56. (a)  $0.184 \text{ A}\cdot\text{m}^2$ ; (b)  $1.45 \text{ N}\cdot\text{m}$   
 57. (a) 12.7 A; (b)  $0.0805 \text{ N}\cdot\text{m}$   
 58. 2.08 GA  
 59. (a)  $0.30 \text{ A}\cdot\text{m}^2$ ; (b)  $0.024 \text{ N}\cdot\text{m}$   
 60.  $(0.150\hat{j} - 0.300\hat{k}) \text{ A}\cdot\text{m}^2$   
 61. (a)  $-72.0 \mu\text{J}$ ; (b)  $(96.0\hat{i} + 48.0\hat{k}) \mu\text{N}\cdot\text{m}$   
 62.  $4.8 \times 10^{-5} \text{ A}\cdot\text{m}^2$   
 63. (a)  $(-9.7 \times 10^{-4} \text{ N}\cdot\text{m})\hat{i} - (7.2 \times 10^{-4} \text{ N}\cdot\text{m})\hat{j} + (8.0 \times 10^{-4} \text{ N}\cdot\text{m})\hat{k}$ ; (b)  $-6.0 \times 10^{-4} \text{ J}$   
 64.  $110^\circ$   
 65. (a)  $90^\circ$ ; (b) 1; (c)  $1.28 \times 10^{-7} \text{ N}\cdot\text{m}$   
 66.  $\vec{v} = v_{0x}\hat{i} + v_{0y} \cos(\omega t)\hat{j} - v_{0y} \sin(\omega t)\hat{k}$ , where  $\omega = eB/m$   
 67. (a) 20 min; (b)  $5.9 \times 10^{-2} \text{ N}\cdot\text{m}$   
 68.  $(18.8 \mu\text{N})\hat{k}$   
 69. 8.2 mm  
 70.  $(-0.34 \text{ mT})\hat{k}$   
 71. 127 u  
 72. (b) out of plane of page  
 73. (a)  $6.3 \times 10^{14} \text{ m/s}^2$ ; (b) 3.0 mm  
 74.  $(-3.0\hat{i} - 3.0\hat{j} - 4.0\hat{k}) \text{ T}$   
 75. (a) 1.4; (b) 1.0  
 76. ---  
 77.  $(-500 \text{ V/m})\hat{j}$   
 78. (b)  $2.84 \times 10^{-3}$   
 79. (a) 0.50; (b) 0.50; (c) 14 cm; (d) 14 cm  
 80. (a)  $9.56 \times 10^{-14} \text{ N}$ ; (b) 0; (c)  $0.267^\circ$   
 81.  $(0.80\hat{j} - 1.1\hat{k}) \text{ mN}$   
 82. (a) 0.67 mm/s; (b)  $2.8 \times 10^{29} \text{ m}^{-3}$   
 83. -40 mC  
 84.  $(-0.600 \text{ N})\hat{k}$   
 85. (a)  $(12.8\hat{i} + 6.41\hat{j}) \times 10^{-22} \text{ N}$ ; (b)  $90^\circ$ ; (c)  $173^\circ$   
 86. (a) 3.8 mm; (b) 19 mm; (c) clockwise

## **Chapter 29**

- (a)  $3.3 \mu\text{T}$ ; (b) yes
- $3.0 \mu\text{T}$
- (a) 16 A; (b) east

4. 0
5. (a) 1.0 mT;(b) out;(c) 0.80 mT;(d) out
6. (a) 0;(b) 3.82 cm
7. (a)  $0.102 \mu\text{T}$ ;(b) out
8. (a)  $1.67 \mu\text{T}$ ;(b) into
9. (a) opposite;(b) 30 A
10. (a)  $0.118 \mu\text{T}$ ;(b) into
11. (a) 4.3 A;(b) out
12. (a) 4.0 cm;(b) unchanged
13. 50.3 nT
14. 14.1
15. (a)  $1.7 \mu\text{T}$ ;(b) into;(c)  $6.7 \mu\text{T}$ ;(d) into
16.  $144^\circ$
17. 132 nT
18. 2.00 cm
19.  $5.0 \mu\text{T}$
20. (a)  $(253 \text{ nT})\hat{k}$ ;(b)  $(192 \text{ nT})\hat{i} + (61.2 \text{ nT})\hat{k}$
21. 256 nT
22. (a) 30 cm;(b) 2.0 nT;(c) out;(d) into
23.  $(-7.75 \times 10^{-23} \text{ N})\hat{i}$
24. (a) -7.0 cm;(b) 7.0 cm
25. 2.00 rad
26. 1.8 rad
27. 61.3 mA
28. 1.0 rad
29.  $(80 \mu\text{T})\hat{j}$
30. (a)  $-90^\circ$ ;(b) 4.0 A;(c) out;(d) 2.0 A;(e) into
31. (a)  $20 \mu\text{T}$ ;(b) into
32. 2.3 cm
33.  $(22.3 \text{ pT})\hat{j}$
34.  $104^\circ$
35. 88.4 pN/m
36. (a)  $(469 \mu\text{N})\hat{j}$ ;(b)  $(188 \mu\text{N})\hat{j}$ ;(c) 0;(d)  $(-188 \mu\text{N})\hat{j}$ ;(e)  $(-469 \mu\text{N})\hat{j}$
37.  $(-125 \mu\text{N/m})\hat{i} + (41.7 \mu\text{N/m})\hat{j}$
38. (a) 0.50 A;(b) out
39. 800 nN/m
40.  $(0.794 \text{ mN/m})\hat{i} + (-0.794 \text{ mN/m})\hat{j}$
41.  $(3.20 \text{ mN})\hat{j}$
42.  $4.5 \times 10^{-6} \text{ T}\cdot\text{m}$
43. (a) 0;(b) 0.850 mT;(c) 1.70 mT;(d) 0.850 mT
44. (a)  $-2.5 \mu\text{T}\cdot\text{m}$ ;(b)  $-16 \mu\text{T}\cdot\text{m}$
45. (a)  $-2.5 \mu\text{T}\cdot\text{m}$ ;(b) 0
46. +28.3 nT·m
47. (a) 0;(b)  $0.10 \mu\text{T}$ ;(c)  $0.40 \mu\text{T}$
48. (a) 3.00 mA;(b) into

49. (a)  $533 \mu\text{T}$ ; (b)  $400 \mu\text{T}$   
50.  $5.71 \text{ mT}$   
51.  $0.30 \text{ mT}$   
52.  $108 \text{ m}$   
53.  $0.272 \text{ A}$   
54.  $1.6 \times 10^6 \text{ rev}$   
55. (a)  $4.77 \text{ cm}$ ; (b)  $35.5 \mu\text{T}$   
56.  $8.78 \mu\text{T}$   
57. (a)  $2.4 \text{ A}\cdot\text{m}^2$ ; (b)  $46 \text{ cm}$   
58. (a)  $4.0$ ; (b)  $0.50$   
59.  $0.47 \text{ A}\cdot\text{m}^2$   
60. (a)  $0.90 \text{ A}$ ; (b)  $2.7 \text{ A}$   
61. (a)  $79 \mu\text{T}$ ; (b)  $1.1 \times 10^{-6} \text{ N}\cdot\text{m}$   
62. (a)  $0.497 \mu\text{T}$ ; (b) into; (c)  $1.06 \text{ mA}\cdot\text{m}^2$ ; (d) into  
63. (a)  $(0.060 \text{ A}\cdot\text{m}^2)\hat{j}$ ; (b)  $(96 \text{ pT})\hat{j}$   
64. (a)  $27.5 \text{ nT}$ ; (b) into  
65.  $1.28 \text{ mm}$   
66. (a)  $(-52.0 \mu\text{T})\hat{k}$ ; (b)  $8.13 \text{ cm}$ ; (c)  $17.5 \text{ cm}$   
67. ---  
68. (a)  $3.2 \times 10^{-16} \text{ N}$ ; (b)  $3.2 \times 10^{-16} \text{ N}$ ; (c)  $0$   
69. (a)  $15 \text{ A}$ ; (b)  $-z$   
70.  $157 \text{ nT}$   
71.  $7.7 \text{ mT}$   
72. (a)  $5.0 \text{ mA}$ ; (b) downward  
73. (a)  $15.3 \mu\text{T}$   
74.  $32.1 \text{ A}$   
75. (a)  $(0.24\hat{i}) \text{ nT}$ ; (b)  $0$ ; (c)  $(-43\hat{k}) \text{ pT}$ ; (d)  $(0.14\hat{k}) \text{ nT}$   
76. (a)  $(-400 \mu\text{T})\hat{i}$ ; (b)  $(400 \mu\text{T})\hat{j}$   
77. ---  
78.  $4.0 \text{ mm}$   
79. (a)  $4.8 \text{ mT}$ ; (b)  $0.93 \text{ mT}$ ; (c)  $0$   
80.  $5.3 \text{ mm}$   
81. ---  
82.  $(1.25 \mu\text{T})\hat{i}$   
83.  $(-0.20 \text{ mT})\hat{k}$   
84. (a)  $0.17 \text{ mN}$ ; (b)  $0.021 \text{ mN}$   
85. ---  
86. ---  
87. (a)  $\mu_0 i r / 2\pi c^2$ ; (b)  $\mu_0 i / 2\pi r$ ; (c)  $\mu_0 i (a^2 - r^2) / 2\pi (a^2 - b^2) r$ ; (d)  $0$   
88. (b)  $2.3 \text{ km/s}$   
89. ---  
90. ---  
91. ---  
92. ---  
93. ---

## **Chapter 30**

1. 0
2. 0.452 V
3. 30 mA
4. (a) -11 mV;(b) 0;(c) 11 mV
5. 0
6.  $8.0 \times 10^{-3}$  T/s
7. (a) 31 mV;(b) left
8. 1.4 T/s
9. 0.198 mV
10. (a) 51 mV;(b) clockwise
11. (b)  $0.796 \text{ m}^2$
12. (a) 0;(b) none;(c) 6.00 mV;(d) clockwise;(e) 1.00 mV;(f) clockwise;(g) 0;(h) none;(i) 0;(j) none
13. 29.5 mC
14. 1.2 m $\Omega$
15. (a) 21.7 V; (b) counterclockwise
16. (a) 8.0  $\mu\text{A}$ ;(b) counterclockwise
17. (a)  $1.26 \times 10^{-4}$  T;(b) 0;(c)  $1.26 \times 10^{-4}$  T;(d) yes;(e)  $5.04 \times 10^{-8}$  V
18. (a) 85.2 Wb;(b) 56.8 V;(c) 1
19. 5.50 kV
20. 15.5  $\mu\text{C}$
21. (a) 40 Hz;(b) 3.2 mV
22. 18 mV
23. (a)  $\mu_0 i R^2 \pi r^2 / 2x^3$ ;(b)  $3\mu_0 i \pi R^2 r^2 v / 2x^4$ ;(c) counterclockwise
24. (a) 24  $\mu\text{V}$ ; (b) from *c* to *b*
25. (a) 13  $\mu\text{Wb/m}$ ;(b) 17%;(c) 0
26. (a) 0.598  $\mu\text{V}$ ;(b) counterclockwise
27. (a) 80  $\mu\text{V}$ ;(b) clockwise
28. (a) 14 nWb;(b) 10  $\mu\text{A}$
29. (a) 48.1 mV;(b) 2.67 mA;(c) 0.129 mW
30. 1.0 m $\Omega$
31. 3.68  $\mu\text{W}$
32. 750 pJ
33. (a) 240  $\mu\text{V}$ ;(b) 0.600 mA;(c) 0.144  $\mu\text{W}$ ;(d)  $2.87 \times 10^{-8}$  N;(e) 0.144  $\mu\text{W}$
34.  $v_i = mgR/B^2 L^2$
35. (a) 0.60 V;(b) up; (c) 1.5 A;(d) clockwise;(e) 0.90 W;(f) 0.18 N;(g) 0.90 W
36. (a) -1.07 mV;(b) -2.40 mV;(c) 1.33 mV
37. (a) 71.5  $\mu\text{V/m}$ ;(b) 143  $\mu\text{V/m}$
38. 0.030 T/s
39. 0.15 V/m
40. 0.10  $\mu\text{Wb}$
41. (a) 2.45 mWb;(b) 0.645 mH
42. (a) 0.27  $\mu\text{T}$ ;(b) 8.0 nH
43. 1.81  $\mu\text{H/m}$

44. 5.0 A/s
45. (a) decreasing;(b) 0.68 mH
46. (a) 16 kV;(b) 3.1 kV;(c) 23 kV
47. (b)  $L_{\text{eq}} = \Sigma L_j$ , sum from  $j = 1$  to  $j = N$
48. (b)  $1/L_{\text{eq}} = \Sigma 1/L_j$ , sum from  $j = 1$  to  $j = N$
49. 59.3 mH
50. 12.3 s
51. 46  $\Omega$
52. (a) 1.00;(b) 0.135;(c) 0.693
53. (a) 8.45 ns;(b) 7.37 mA
54. (a) 3.33 A;(b) 3.33 A;(c) 4.55 A;(d) 2.73 A;(e) 0;(f) -1.82 A (reversed);(g) 0;(h) 0
55. 6.91
56.  $7.1 \times 10^2$  A/s
57. (a) 1.5 s
58.  $(42 + 20t)$  V
59. (a)  $i[1 - \exp(-Rt/L)]$ ;(b)  $(L/R) \ln 2$
60. (a) 0.29 mH;(b) 0.29 ms
61. (a) 97.9 H;(b) 0.196 mJ
62. (a)  $2.4 \times 10^2$  W;(b)  $1.5 \times 10^2$  W;(c)  $3.9 \times 10^2$  W
63. 25.6 ms
64. 1.23
65. (a) 18.7 J;(b) 5.10 J;(c) 13.6 J
66. (a) 1.3 mT;(b)  $0.63 \text{ J/m}^3$
67. (a)  $34.2 \text{ J/m}^3$ ;(b) 49.4 mJ
68. 5.58 A
69.  $1.5 \times 10^8$  V/m
70. (a) 23 mA;(b) 70 mA
71. (a)  $1.0 \text{ J/m}^3$ ;(b)  $4.8 \times 10^{-15} \text{ J/m}^3$
72. (a)  $1.5 \mu\text{Wb}$ ;(b)  $1.0 \times 10^2$  mV;(c) 90 nWb;(d) 12 mV
73. (a) 1.67 mH;(b) 6.00 mWb
74. 13 H
75. 13  $\mu\text{H}$
76. (b) magnetic field exists only within the solenoid cross section
77. (b) have the turns of the two solenoids wrapped in opposite directions
78. 95.4  $\Omega$
79. (a) 2.0 A;(b) 0;(c) 2.0 A;(d) 0;(e) 10 V;(f) 2.0 A/s;(g) 2.0 A;(h) 1.0 A;(i) 3.0 A;(j) 10 V;(k) 0;(l) 0
80. 1.0 ns
81. (a) 10  $\mu\text{T}$ ;(b) out;(c) 3.3  $\mu\text{T}$ ;(d) out
82.  $(\pi B_0 r^2 / \tau) \exp(-t/\tau)$
83. 0.520 ms
84. (a) 25  $\mu\text{T/s}$ ;(b) 13  $\mu\text{T/s}$ (c) increasing
85. (a)  $(4.4 \times 10^7 \text{ m/s}^2)\hat{i}$ ;(b) 0;(c)  $(-4.4 \times 10^7 \text{ m/s}^2)\hat{i}$
86. 81.1  $\mu\text{s}$
87. (a) 0.40 V;(b) 20 A

88. (a) 3.75 mH;(b) 3.75 mH;(c) 100 nWb;(d) 4.24 mV  
 89. (a) 10 A;(b)  $1.0 \times 10^2$  J  
 90. 1.54 s  
 91. (a) 0;(b)  $8.0 \times 10^2$  A/s;(c) 1.8 mA;(d)  $4.4 \times 10^2$  A/s;(e) 4.0 mA;(f) 0  
 92. (a) 4.7 mH;(b) 2.4 ms  
 93. 1.15 W  
 94. (a) 0.10 H/m;(b) 1.3 V/m  
 95. (a) 20 A/s;(b) 0.75 A  
 96. 2.9 mV  
 97. 12 A/s  
 98. (a) 0.600 mH;(b) 120

### **Chapter 31**

1. (a)  $1.17 \mu\text{J}$ ;(b) 5.58 mA  
 2. (a)  $5.00 \mu\text{s}$ ;(b)  $2.50 \mu\text{s}$ ;(c)  $1.25 \mu\text{s}$   
 3. (a)  $6.00 \mu\text{s}$ ;(b) 167 kHz;(c)  $3.00 \mu\text{s}$   
 4. 9.14 nF  
 5. 45.2 mA  
 6. (a) 89 rad/s;(b) 70 ms;(c)  $25 \mu\text{F}$   
 7. (a) 1.25 kg;(b) 372 N/m;(c)  $1.75 \times 10^{-4}$  m;(d) 3.02 mm/s  
 8. ---  
 9.  $7.0 \times 10^{-4}$  s  
 10.  $38 \mu\text{H}$   
 11. (a) 6.0;(b) 36 pF;(c) 0.22 mH  
 12. (a) 0.500;(b) 0.866  
 13. (a) 0.180 mC;(b)  $70.7 \mu\text{s}$ ;(c) 66.7 W  
 14. (a)  $6.0 \times 10^2$  Hz;(b)  $7.1 \times 10^2$  Hz;(c) 1.1 kHz(d) 1.3 kHz  
 15. (a) 3.0 nC;(b) 1.7 mA;(c) 4.5 nJ  
 16. ---  
 17. (a) 275 Hz;(b) 365 mA  
 18. (a)  $46.1 \mu\text{s}$ ;(b) 6.88 nJ;(c) 6.88 nJ;(d)  $1.02 \times 10^3$  A/s;(e) 0.938 mW  
 19. ---  
 20. (a) 3.60 mH;(b) 1.33 kHz; c) 0.188 ms  
 21. (a)  $356 \mu\text{s}$ ;(b) 2.50 mH;(c) 3.20 mJ  
 22.  $\omega$   
 23. (a)  $1.98 \mu\text{J}$ ;(b)  $5.56 \mu\text{C}$ ;(c) 12.6 mA;(d)  $-46.9^\circ$ ;(e)  $+46.9^\circ$   
 24. (a)  $5.85 \mu\text{C}$ ;(b)  $5.52 \mu\text{C}$ ;(c)  $1.93 \mu\text{C}$   
 25.  $8.66 \text{ m}\Omega$   
 26.  $(L/R) \ln 2$   
 27. ---  
 28. (a) 0.283 A;(b) 2.26 A  
 29. (a) 95.5 mA;(b) 11.9 mA  
 30. (a) 0.600 A;(b) 0.600 A  
 31. (a) 0.65 kHz;(b)  $24 \Omega$   
 32. (a) 5.22 mA;(b) 0;(c) 4.51 mA

33. (a) 6.73 ms;(b) 11.2 ms;(c) inductor;(d) 138 mH  
34. (a) 39.1 mA;(b) 0;(c) 33.8 mA  
35. 89  $\Omega$   
36. (a) 500  $\Omega$ ;(b) 40  $\mu\text{F}$   
37. 7.61 A  
38. (a) 8.0  $\mu\text{F}$ ;(b) 2.0  $\Omega$   
39. (a) 267  $\Omega$ ;(b)  $-41.5^\circ$ ;(c) 135 mA  
40. -8.00 V  
41. (a) 206  $\Omega$ ;(b)  $13.7^\circ$ ;(c) 175 mA  
42. (a) 40  $\Omega$ ;(b) 60 mH  
43. (a) 218  $\Omega$ ;(b)  $23.4^\circ$ ;(c) 165 mA  
44. (a) 16.6  $\Omega$ ;(b) 422  $\Omega$ ;(c) 0.521 A;(d) increase;(e) decrease;(f) increase  
45.  
46. (b) 159 Hz;(c)  $-45^\circ$ ;(d)  $1.00 \times 10^3$  rad/s;(e) 170 mA  
47. (a) 224 rad/s;(b) 6.00 A;(c) 219 rad/s;(d) 228 rad/s;(e) 0.040  
48. (a) 100  $\Omega$ ;(b) 30.6  $\mu\text{F}$ ;(c) 301 mH  
49. (a) 796 Hz;(b) no change;(c) decreased;(d) increased  
50. (b) 318 Hz;(c)  $+45^\circ$ ;(d)  $2.00 \times 10^3$  rad/s;(e) 53.0 mA  
51. ---  
52. 100 V  
53. (a) 12.1  $\Omega$ ;(b) 1.19 kW  
54. 141 V  
55. 1.84 A  
56. (a) 76.4 mH;(b) yes;(c) 17.8  $\Omega$   
57. (a) 117  $\mu\text{F}$ ;(b) 0;(c) 90.0 W;(d)  $0^\circ$ ;(e) 1;(f) 0;(g)  $-90^\circ$ ;(h) 0  
58. ---  
59. (a) 2.59 A;(b) 38.8 V;(c) 159 V;(d) 224 V;(e) 64.2 V;(f) 75.0 V;(g) 100 W;(h) 0;(i) 0  
60. (a) 41.4 W;(b) -17.0 W;(c) 44.1 W;(d) 14.4 W;(e) equal  
61. (a) 0.743;(b) lead;(c) capacitive;(d) no;(e) yes;(f) no;(g) yes;(h) 33.4 W  
62. 1.0 kV  
63. (a) 2.4 V;(b) 3.2 mA;(c) 0.16 A  
64. (a) 1.25;(b) 4.00;(c) 5.00;(d) 0.200;(e) 0.250;(f) 0.800  
65. (a) 1.9 V;(b) 5.9 W;(c) 19 V;(d)  $5.9 \times 10^2$  W;(e) 0.19 kV;(f) 59 kW  
66. (b) 10  
67. (a) 6.73 ms;(b) 2.24 ms;(c) capacitor;(d) 59.0  $\mu\text{F}$   
68. (a) +1.22 rad;(b) 0.288 A  
69. (a)  $-0.405$  rad;(b) 2.76 A;(c) capacitive  
70. (a) 4.60 kHz;(b) 26.6 nF;(c) 2.60 k $\Omega$ ;(d) 0.650 k $\Omega$   
71. (a) 64.0  $\Omega$ ;(b) 50.9  $\Omega$ ;(c) capacitive  
72. (a) 0.588 rad;(b) inductive;(c) 12.0 V  
73. (a) 2.41  $\mu\text{H}$ ;(b) 21.4 pJ;(c) 82.2 nC  
74. (a)  $5.77 \times 10^3$  rad/s;(b) 1.09 ms  
75. (a) 39.1  $\Omega$ ;(b) 21.7  $\Omega$ ;(c) capacitive  
76. (a) 8.84 kHz;(b) 6.00  $\Omega$

77. ---  
 78. (a)  $177\ \Omega$ ; (b) no  
 79. (a)  $0.577Q$ ; (b) 0.152  
 80. (a) 37.0 V; (b) 60.9 V; (c) 113 V; (d) 68.6 W  
 81. (a)  $45.0^\circ$ ; (b)  $70.7\ \Omega$   
 82. 0.115 A  
 83. 1.84 kHz  
 84. (a)  $707\ \Omega$ ; (b) 32.2 mH; (c) 21.9 nF  
 85. (a)  $0.689\ \mu\text{H}$ ; (b) 17.9 pJ; (c)  $0.110\ \mu\text{C}$   
 86.  $69.3\ \Omega$   
 87. (a)  $165\ \Omega$ ; (b) 313 mH; (c)  $14.9\ \mu\text{F}$   
 88. (a)  $1.27\ \mu\text{C}$ ; (b)  $83.1\ \mu\text{s}$ ; (c) 5.44 mW  
 89. ---  
 90.  $1.59\ \mu\text{F}$   
 91. ---  
 92. ---

### **Chapter 32**

1. +3 Wb  
 2. (a) 1.1 mWb; (b) inward  
 3. (a)  $47.4\ \mu\text{Wb}$ ; (b) inward  
 4.  $(\mu_0 i L / \pi) \ln 3$   
 5.  $2.4 \times 10^{13}\ \text{V/m}\cdot\text{s}$   
 6. 52 nT·m  
 7. (a)  $1.18 \times 10^{-19}\ \text{T}$ ; (b)  $1.06 \times 10^{-19}\ \text{T}$   
 8. (a)  $3.54 \times 10^{-17}\ \text{T}$ ; (b)  $2.13 \times 10^{-17}\ \text{T}$   
 9. (a)  $5.01 \times 10^{-22}\ \text{T}$ ; (b)  $4.51 \times 10^{-22}\ \text{T}$   
 10. (a)  $3.09 \times 10^{-20}\ \text{T}$ ; (b)  $1.67 \times 10^{-20}\ \text{T}$   
 11. (a) 1.9 pT  
 12. (a) 30 mm; (b) 53 mm; (c)  $3.0 \times 10^{-5}\ \text{T}$   
 13.  $7.5 \times 10^5\ \text{V/s}$   
 14. ---  
 15. ---  
 16.  $7.2 \times 10^{12}\ \text{V/m}\cdot\text{s}$   
 17. (a) 0.324 V/m; (b)  $2.87 \times 10^{-16}\ \text{A}$ ; (c)  $2.87 \times 10^{-18}$   
 18.  $8.40 \times 10^{-13}\ \text{T}$   
 19. (a) 75.4 nT; (b) 67.9 nT  
 20. (a)  $2.22\ \mu\text{T}$ ; (b)  $2.00\ \mu\text{T}$   
 21. (a) 27.9 nT; (b) 15.1 nT  
 22. (a)  $20.0\ \mu\text{T}$ ; (b)  $12.0\ \mu\text{T}$   
 23. (a) 2.0 A; (b)  $2.3 \times 10^{11}\ \text{V/m}\cdot\text{s}$ ; (c) 0.50 A; (d)  $0.63\ \mu\text{T}\cdot\text{m}$   
 24. (a)  $2.1 \times 10^{-8}\ \text{A}$ ; (b) downward; (c) clockwise  
 25. (a)  $0.63\ \mu\text{T}$ ; (b)  $2.3 \times 10^{12}\ \text{V/m}\cdot\text{s}$   
 26. (a) 1.33 A; (b) 0.300 cm; (c) 4.80 cm

27. (a) 0.71 A;(b) 0;(c) 2.8 A\
28. (a) 0.089 mT;(b) 0.18 mT;(c) 0.22 mT;(d)  $6.4 \times 10^{-22}$  T;(e)  $6.4 \times 10^{-22}$  T;(f) 0;(g) out;(h) out
29. (a) 7.60  $\mu$ A;(b) 859 kV·m/s;(c) 3.39 mm;(d) 5.16 pT
30. (a) 13 MWb;(b) outward
31. 55  $\mu$ T
32. (a) 0;(b) -1, 0, 1;(c)  $4.64 \times 10^{-24}$  J
33. (a) 0;(b) 0;(c) 0;(d)  $\pm 3.2 \times 10^{-25}$  J;(e)  $-3.2 \times 10^{-34}$  J·s;(f)  $2.8 \times 10^{-23}$  J/T;(g)  $-9.7 \times 10^{-25}$  J;(h)  $\pm 3.2 \times 10^{-25}$  J
34.  $4.6 \times 10^{-24}$  J
35. (a)  $-9.3 \times 10^{-24}$  J/T;(b)  $1.9 \times 10^{-23}$  J/T
36. 32.3 mT
37. (b) +x;(c) clockwise;(d) +x
38.  $e^2 r^2 B / 4m$
39. yes
40. (a)  $1.5 \times 10^2$  T;(b)  $6.0 \times 10^2$  T;(c) no
41. 20.8 mJ/T
42. 0.48 K
43. (b)  $K/B$ ;(c) -z;(d) 0.31 kA/m
44. 0.30
45. ---
46.  $3.19 \times 10^{-9}$  kg·m<sup>2</sup>
47. (a)  $1.8 \times 10^2$  km;(b)  $2.3 \times 10^{-5}$
48. (a) 8.9 A·m<sup>2</sup>;(b) 13 N·m
49. (a) 3.0  $\mu$ T;(b)  $5.6 \times 10^{-10}$  eV
50. (a)  $1.49 \times 10^{-4}$  N·m;(b)  $-72.9 \mu$ J
51.  $5.15 \times 10^{-24}$  A·m<sup>2</sup>
52. 25 km
53. (a) 0.14 A;(b) 79  $\mu$ C
54. (a)  $1.66 \times 10^3$  km;(b) 383  $\mu$ T;(c) 61.1  $\mu$ T;(d) 84.2°
55. (a)  $6.3 \times 10^8$  A;(b) yes;(c) no
56. (b) in the direction of the angular momentum vector
57. 0.84 kJ/T
58. (a) 222  $\mu$ T;(b) 167  $\mu$ T;(c) 22.7  $\mu$ T;(d) 1.25  $\mu$ T;(e) 3.75  $\mu$ T;(f) 22.7  $\mu$ T
59. (a)  $(1.2 \times 10^{-13} \text{ T}) \exp[-t/(0.012 \text{ s})]$ ;(b)  $5.9 \times 10^{-15}$  T
60. (a) 9.2 mWb;(b) inward
61. ---
62. (a) 31.0  $\mu$ T;(b) 0°;(c) 55.9  $\mu$ T;(d) 73.9°;(e) 62.0  $\mu$ T;(f) 90.0°
63. (a) 27.5 mm;(b) 110 mm
64. (a) 4 K;(b) 1 K
65. 8.0 A
66.  $3.5 \times 10^{-5}$  A
67. (a)  $-8.8 \times 10^{15}$  V/m·s;(b)  $5.9 \times 10^{-7}$  T·m
68. (a)  $-2.78 \times 10^{-23}$  J/T;(b)  $3.71 \times 10^{-23}$  J/T

69. (b) sign is minus;(c) no, because there is compensating positive flux through open end nearer to magnet
70. (a)  $5.3 \times 10^{11}$  V/m;(b) 20 mT;(c)  $6.6 \times 10^2$
71. (b)  $-x$ ;(c) counterclockwise;(d)  $-x$
72. (a) 16.7 nT;(b) 5.00 mA
73. (a) 7;(b) 7;(c)  $3h/2\pi$ ;(d)  $3eh/4\pi m$ ;(e)  $3.5h/2\pi$ ;(f) 8
74. 0.300 A
75. (a) 9;(b)  $3.71 \times 10^{-23}$  J/T;(c)  $+9.27 \times 10^{-24}$  J;(d)  $-9.27 \times 10^{-24}$  J

### **Chapter 33**

1. 7.49 GHz
2. (a)  $4.7 \times 10^{-3}$  Hz;(b) 3 min 32 s
3. (a) 515 nm;(b) 610 nm;(c) 555 nm;(d)  $5.41 \times 10^{14}$  Hz;(e)  $1.85 \times 10^{-15}$  s
4. 30 cm
5.  $5.0 \times 10^{-21}$  H
6. 4.74 m
7.  $1.2$  MW/m<sup>2</sup>
8.  $4.8 \times 10^{-29}$  W/m<sup>2</sup>
9. 0.10 MJ
10. 1.07 pT
11. (a) 6.7 nT;(b)  $y$ ;(c) negative direction of  $y$
12. (a) 16.7 nT;(b)  $33.1$  mW/m<sup>2</sup>
13. (a) 1.03 kV/m;(b)  $3.43$   $\mu$ T
14.  $3.44 \times 10^6$  T/s
15. (a) 87 mV/m;(b) 0.29 nT;(c) 6.3 kW
16. (a)  $1.4 \times 10^{-22}$  W;(b)  $1.1 \times 10^{15}$  W
17. (a) 6.7 nT;(b)  $5.3$  mW/m<sup>2</sup>;(c) 6.7 W
18. 0.25 kW
19.  $1.0 \times 10^7$  Pa
20. (a)  $6.0 \times 10^8$  N;(b)  $3.6 \times 10^{22}$  N
21.  $5.9 \times 10^{-8}$  Pa
22.  $3.3 \times 10^{-8}$  Pa
23. (a)  $4.68 \times 10^{11}$  W;(b) any chance disturbance could move sphere from directly above source---the two force vectors no longer along the same axis
24.  $0.95$  km<sup>2</sup>
25. ---
26. 491 nm
27. (a)  $1.0 \times 10^8$  Hz;(b)  $6.3 \times 10^8$  rad/s;(c)  $2.1$  m<sup>-1</sup>; (d)  $1.0$   $\mu$ T;(e)  $z$ ;(f)  $1.2 \times 10^2$  W/m<sup>2</sup>;(g)  $8.0 \times 10^{-7}$  N;(h)  $4.0 \times 10^{-7}$  Pa
28. (a)  $4.7 \times 10^{-6}$  Pa;(b)  $4.7 \times 10^{-11}$
29. 1.9 mm/s
30. (a)  $3.97$  GW/m<sup>2</sup>;(b) 13.2 Pa;(c)  $1.67 \times 10^{-11}$  N;(d)  $3.14 \times 10^3$  m/s<sup>2</sup>
31. (a)  $0.17$   $\mu$ m; (b) toward the Sun
32. 0.045%
33. 3.1%

34.  $19 \text{ W/m}^2$   
35.  $4.4 \text{ W/m}^2$   
36. (a) 0.16;(b) 0.84  
37. (a) 2 sheets;(b) 5 sheets  
38. 9.4%  
39. (a)  $1.9 \text{ V/m}$ ;(b)  $1.7 \times 10^{-11} \text{ Pa}$   
40. 7.3%  
41.  $20^\circ$  or  $70^\circ$   
42. 44%  
43. 0.67  
44. (a)  $19.6^\circ$ ;(b)  $70.4^\circ$   
45. 1.26  
46. (a) greater;(b) greater;(c) 1.9;(d) 1.4  
47. 1.48  
48. (a) greater;(b) greater;(c) 1.4;(d) 1.9  
49.  $180^\circ$   
50. (a) 1.6;(b) need more information;(c)  $39^\circ$   
51. (a)  $56.9^\circ$ ;(b)  $35.3^\circ$   
52. (a) 1.7;(b)  $38^\circ$   
53. ---  
54. (a)  $0.33^\circ$ ;(b)  $0^\circ$   
55. 1.07 m  
56. (a)  $3.1^\circ$ ;(b)  $0^\circ$  (no rainbow)  
57. 182 cm  
58.  $34^\circ$   
59. (a)  $48.9^\circ$ ;(b)  $29.0^\circ$   
60. (a)  $54.3^\circ$ ;(b) yes;(c)  $51.1^\circ$ ; (d) no  
61. (a)  $26.8^\circ$ ;(b) yes  
62. (a) 4.56 m;(b) increase  
63. (a)  $(1 + \sin^2 \theta)^{0.5}$ ;(b)  $2^{0.5}$ ;(c) yes;(d) no  
64. (a)  $35.6^\circ$ ;(b)  $53.1^\circ$   
65.  $23.2^\circ$   
66. (a) 3;(b) 2;(c)  $40^\circ$ ;(d) none;(e) 2;(f) 3;(g) none;(h)  $70^\circ$   
67. (a) 1.39;(b)  $28.1^\circ$ ;(c) no  
68. (a)  $53^\circ$ ;(b) yes  
69.  $49.0^\circ$   
70. 1.0  
71. (a) 0.50 ms;(b) 8.4 min;(c) 2.4 h;(d) 5446 B.C.  
72. (a) 30.1 nm;(b) 345 nm  
73. (a)  $(16.7 \text{ nT}) \sin[(1.00 \times 10^6 \text{ m}^{-1})z + (3.00 \times 10^{14} \text{ s}^{-1})t]$ ;(b)  $6.28 \text{ } \mu\text{m}$ ;(c) 20.9 fs;(d)  $33.2 \text{ mW/m}^2$ ;(e) x;(f) infrared  
74. (b)  $5.8 \times 10^{-7} \text{ m}$   
75. 1.22  
76.  $0.50 \text{ W/m}^2$   
77. (c)  $137.6^\circ$ ;(d)  $139.4^\circ$ ;(e)  $1.7^\circ$

78. (b)  $230.4^\circ$ ; (c)  $233.5^\circ$ ; (d)  $3.1^\circ$ ; (e)  $317.5^\circ$ ; (f)  $321.9^\circ$ ; (g)  $4.4^\circ$   
 79. ---  
 80. (a)  $0.33 \mu\text{T}$ ; (b)  $-x$   
 81. (a)  $z$  axis; (b)  $7.5 \times 10^{14} \text{ Hz}$ ; (c)  $1.9 \text{ kW/m}^2$   
 82. 0.031  
 83. (a) white; (b) white dominated by red end; (c) no refracted light  
 84. 0.125  
 85.  $1.5 \times 10^{-9} \text{ m/s}^2$   
 86. 0.21  
 87. (a)  $3.5 \mu\text{W/m}^2$ ; (b)  $0.78 \mu\text{W}$ ; (c)  $1.5 \times 10^{-17} \text{ W/m}^2$ ; (d)  $1.1 \times 10^{-7} \text{ V/m}$ ; (e) 0.25 fT  
 88. (a)  $1.91 \times 10^8 \text{ Hz}$ ; (b)  $18.2 \text{ V/m}$ ; (c)  $0.878 \text{ W/m}^2$   
 89. (a)  $55.8^\circ$ ; (b)  $55.5^\circ$   
 90. (a) 0; (b)  $20^\circ$ ; (c) 0; (d)  $20^\circ$   
 91. 1.3  
 92.  $35^\circ$

### **Chapter 34**

1. 9.10 m
2. 40 cm
3. 1.11
4. 1.5 m
5. 351 cm
6. -2.5
7. 10.5 cm
8. +28 cm
9. (a) +24 cm; (b) +36 cm; (c) -2.0; (d) R; (e) I; (f) same
10. (a) +20 cm; (b) +30 cm; (c) -2.0; (d) R; (e) I; (f) same
11. (a) -20 cm; (b) -4.4 cm; (c) +0.56; (d) V; (e) NI; (f) opposite
12. (a) +72 cm; (b) -72 cm; (c) +3.0; (d) V; (e) NI; (f) opposite
13. (a) +36 cm; (b) -36 cm; (c) +3.0; (d) V; (e) NI; (f) opposite
14. (a) -70 cm; (b) -14 cm; (c) +0.61; (d) V; (e) NI; (f) opposite
15. (a) -16 cm; (b) -4.4 cm; (c) +0.44; (d) V; (e) NI; (f) opposite
16. (a) -28 cm; (b) -7.7 cm; (c) +0.45; (d) V; (e) NI; (f) opposite
17. (b) plus; (c) +40 cm; (e) -20 cm; (f) +2.0; (g) V; (h) NI; (i) opposite
18. (a) concave; (b) +8.0 cm; (c) +16 cm; (e) +12 cm; (f) minus; (g) R; (i) same
19. (a) convex; (b) -20 cm; (d) +20 cm; (f) +0.50; (g) V; (h) NI; (i) opposite
20. (a) concave; (b) +16 cm; (c) +32 cm; (e) +28 cm; (g) R; (h) I; (i) same
21. (a) concave; (c) +40 cm; (e) +60 cm; (f) -2.0; (g) R; (h) I; (i) same
22. (a) convex; (b) minus; (c) -40 cm; (d) +1.8 m; (e) -18 cm; (g) V; (h) NI; (i) opposite
23. (a) convex; (b) minus; (c) -60 cm; (d) +1.2 m; (e) -24 cm; (g) V; (h) NI; (i) opposite
24. (a) concave; (b) +20 cm; (c) +40 cm; (e) +30 cm; (g) R; (h) I; (i) same
25. (a) concave; (b) +8.6 cm; (c) +17 cm; (e) +12 cm; (f) minus; (g) R; (i) same
26. (a) concave; (b) plus; (c) +40 cm; (e) +30 cm; (f) -0.50; (g) R; (h) I
27. (a) convex; (c) -60 cm; (d) +30 cm; (f) +0.50; (g) V; (h) NI; (i) opposite

28. (a) plane;(b)  $\infty$ ;(c)  $\infty$ ;(e) -10 cm;(g) V;(h) NI;(i) opposite  
29. (b) -20 cm;(c) minus;(d) +5.0 cm;(e) minus;(f) +0.80;(g) V;(h) NI;(i) opposite  
30. +0.32  
31. (b) 0.56 cm/s;(c) 11 m/s;(d) 6.7 cm/s  
32. (d) -18 cm;(e) V;(f) same  
33. (c) -33 cm;(e) V;(f) same  
34. (a) 1.0;(e) R;(f) opposite  
35. (d) -26 cm;(e) V;(f) same  
36. (b) +10 cm;(e) V;(f) same  
37. (c) +30 cm;(e) V;(f) same  
38. (b) +71 cm;(e) R;(f) opposite  
39. (a) 2.00;(b) none  
40. 7.4 cm  
41. (a) +40 cm;(b)  $\infty$   
42. +0.30  
43. 5.0 mm  
44. +43 cm  
45. 1.86 mm  
46. -16 cm  
47. (a) 45 mm;(b) 90 mm  
48. -2.5  
49. 22 cm  
50. (a) +5.3 cm;(b) -0.33;(c) R;(d) I;(e) opposite  
51. (a) -48 cm;(b) +4.0;(c) V;(d) NI;(e) same  
52. (a) -88 cm;(b) +3.5;(c) V;(d) NI;(e) same  
53. (a) -4.8 cm;(b) +0.60;(c) V;(d) NI;(e) same  
54. (a) -3.8 cm;(b) +0.38;(c) V;(d) NI;(e) same  
55. (a) -8.6 cm;(b) +0.39;(c) V;(d) NI;(e) same  
56. (a) -8.7 cm;(b) +0.72;(c) V;(d) NI;(e) same  
57. (a) +36 cm;(b) -0.80;(c) R;(d) I;(e) opposite  
58. (a) -63 cm;(b) +2.2;(c) V;(d) NI;(e) same  
59. (a) +55 cm;(b) -0.74;(c) R;(d) I;(e) opposite  
60. (a) -26 cm;(b) +4.3;(c) V;(d) NI;(e) same  
61. (a) -18 cm;(b) +0.76;(c) V;(d) NI;(e) same  
62. (a) -15 cm;(b) +1.5;(c) V;(d) NI;(e) same  
63. (a) -30 cm;(b) +0.86;(c) V;(d) NI;(e) same  
64. (a) -9.2 cm;(b) +0.92;(c) V;(d) NI;(e) same  
65. (a) -7.5 cm;(b) +0.75;(c) V;(d) NI;(e) same  
66. (a) -9.7 cm;(b) +0.54;(c) V;(d) NI;(e) same  
67. (a) +84 cm;(b) -1.4;(c) R;(d) I;(e) opposite  
68. (a) converging;(b) 26.7 cm;(c) 8.89 cm  
69. (a) C;(d) -10 cm;(e) +2.0;(f) V;(g) NI;(h) same  
70. (a) D;(b) minus;(d) -5.7 cm;(e) +0.71;(f) V;(h) same  
71. (a) D;(b) -5.3 cm;(d) -4.0 cm;(f) V;(g) NI;(h) same  
72. (a) C;(b) +3.2 cm;(d) +4.0 cm;(f) R;(g) I;(h) opposite  
73. (a) C;(b) +3.3 cm;(d) +5.0 cm;(f) R;(g) I;(h) opposite

74. (b) plus;(d) +20 cm;(e) -1.0;(f) R;(g) I;(h) opposite  
75. (a) D;(b) minus;(d) -3.3 cm;(e) +0.67;(f) V;(g) NI  
76. (a) C;(b) plus;(d) -10 cm;(e) +2.0;(f) V;(g) NI;(h) same  
77. (a) C;(b) +80 cm;(d) -20 cm;(f) V;(g) NI;(h) same  
78. (a) D;(b) -10 cm;(d) -5.0 cm;(e) plus;(f) V;(h) same  
79. (a) C;(b) plus;(d) -13 cm;(e) +1.7;(f) V;(g) NI;(h) same  
80. (a) +10 cm;(b) -0.75;(c) R;(d) I;(e) opposite  
81. (a) +24 cm;(b) +6.0;(c) R;(d) NI;(e) opposite  
82. (a) +9.8 cm;(b) -0.27;(c) R;(d) I;(e) opposite  
83. (a) +3.1 cm;(b) -0.31;(c) R;(d) I;(e) opposite  
84. (a) -23 cm;(b) -13;(c) V;(d) I;(e) same  
85. (a) -4.6 cm;(b) +0.69;(c) V;(d) NI;(e) same  
86. (a) -3.4 cm;(b) -1.1;(c) V;(d) I;(e) same  
87. (a) -5.5 cm;(b) +0.12;(c) V;(d) NI;(e) same  
88. 2.1 mm  
89. (a) 13.0 cm;(b) 5.23 cm;(c) -3.25;(d) 3.13;(e) -10.2  
90. (a) 5.3 cm;(b) 3.0 mm  
91. (a) 2.35 cm;(b) decrease  
92. -125  
93. (a) 3.5;(b) 2.5  
94. -21 cm  
95. (a) +8.6 cm;(b) +2.6;(c) R;(d) NI;(e) opposite  
96. (a) -4.0 cm;(b) -1.2;(c) V;(d) I;(e) same  
97. (a) +7.5 cm;(b) -0.75;(c) R;(d) I;(e) opposite  
98. (a) +10 cm;(b) +0.75;(c) R;(d) NI;(e) opposite  
99. (a) +24 cm;(b) -0.58;(c) R;(d) I;(e) opposite  
100. (a) -5.2 cm;(b) +0.29;(c) V;(d) NI;(e) same  
101. ---  
102. (a) 3;(b) 7;(c) 5;(d) 1;(e) 3  
103. ---  
104. (a) 20 cm; b) 60 cm;(c) 80 cm;(d) 1.0 m  
105. (a) 3.00 cm;(b) 2.33 cm  
106. (a)  $2f_1$ ;(b) -1.0;(c) real;(d) left;(e) inverted  
107. (a) 40 cm;(b) 20 cm;(c) -40 cm;(d) 40 cm  
108. (a) 40 cm;(b) real;(c) 80 cm;(d) real;(e) 2.4 m;(f) real;(g) -40 cm;(h) virtual;(i) -80 cm;(j) virtual;(k) -2.4 m;(l) virtual  
109. (a) 20 cm;(b) 15 cm  
110. 1.14  
111. (a) 6.0 mm;(b) 1.6 kW/m<sup>2</sup>;(c) 4.0 cm  
112. ---

### **Chapter 35**

1. (a) 155 nm;(b) 310 nm
2. (a) 0.25;(b) 0.75;(c) 1.25
3. (a) 3.60  $\mu\text{m}$ ;(b) intermediate closer to fully constructive
4.  $2.0 \times 10^8$  m/s

5.  $4.55 \times 10^7$  m/s
6. (a)  $5.09 \times 10^{14}$  Hz;(b) 388 nm;(c)  $1.97 \times 10^8$  m/s
7. 1.56
8. (a) 2;(b) 0.03
9. (a)  $1.55 \mu\text{m}$ ;(b)  $4.65 \mu\text{m}$
10. (a)  $50^\circ$ ;(b) 0.14 ps
11. (a) 1.70;(b) 1.70;(c) 1.30;(d) all tie
12. (a) 52.50 nm;(b) 157.5 nm
13. (a) 0.833;(b) intermediate closer to fully constructive
14. (a) 0.010 rad;(b) 5.0 mm
15. 648 nm
16.  $0.15^\circ$
17. 16
18. (a) 2.90;(b) 18.2 rad;(c) between  $m = 2$  minimum (third minimum from the center) and  $m = 3$  maximum (third maximum to one side of center maximum)
19. 2.25 mm
20. (a) 0.216 rad;(b)  $12.4^\circ$
21.  $72 \mu\text{m}$
22. 7.5
23. 0
24. (a) 0;(b) 0;(c)  $\infty$ ;(d) 6.00;(e) 1.71;(f) intermediate closer to minimum
25.  $7.88 \mu\text{m}$
26. (a) 600 nm to 700 nm;(b) decreased;(c)  $0.20 \mu\text{m}$
27.  $6.64 \mu\text{m}$
28.  $3.5 \mu\text{m}$
29. 2.65
30.  $17 \sin(\omega t + 13^\circ)$
31.  $27 \sin(\omega t + 8.5^\circ)$
32. (a)  $2.33 \mu\text{V/m}$ ;(b) 0.338;(c) between  $m = 6$  maximum (sixth side maximum) and  $m = 6$  minimum (seventh minimum);(d)  $1.26 \times 10^{15}$  rad/s;(e) 39.6 rad
33.  $(17.1 \mu\text{V/m}) \sin[(2.0 \times 10^{14} \text{ rad/s})t]$
34. (a) between central maximum and first minimum ( $m = 0$ );(b) 0.101
35. 120 nm
36. (a) 4;(b) 3
37. 70.0 nm
38. (a) 567 nm;(b) 425 nm;(c) longer
39. (a)  $0.117 \mu\text{m}$ ;(b)  $0.352 \mu\text{m}$
40. 840 nm
41. 161 nm
42. 608 nm
43. 560 nm
44. 329 nm
45. 478 nm
46. 528 nm
47. 509 nm

48. 339 nm
49. 273 nm
50. 248 nm
51. 409 nm
52. 455 nm
53. 338 nm
54. 673 nm
55. (a) 552 nm;(b) 442 nm
56. 450 nm
57. 608 nm
58. 273 nm
59. 528 nm
60. 509 nm
61. 455 nm
62. 161 nm
63. 248 nm
64. 409 nm
65. 339 nm
66. 560 nm
67. 329 nm
68. 478 nm
69.  $1.89 \mu\text{m}$
70. (a)  $10.3 \text{ nm/s}$ ;(b)  $1.09 \mu\text{m}$
71.  $0.012^\circ$
72. 1.00025
73. 140
74. 11
75.  $[(m + \frac{1}{2})\lambda R]^{0.5}$ , for  $m = 0, 1, 2, \dots$
76. (a) 34;(b) 46
77. 1.00 m
78.  $1.67 \times 10^{-11} \text{ m}^3/\text{s}$
79. 588 nm
80.  $5.2 \mu\text{m}$
81. 1.00030
82. 0.291 mm
83. (a) 50.0 nm;(b) 36.2 nm
84. (a)  $\infty$ ;(b) 0;(c) 0;(d) 6.00;(e) 5.80;(f) intermediate closer to maximum
85.  $0.23^\circ$
86. (a) 1.8;(b) 2.2;(c) 1.25
87. (a) 1500 nm;(b) 2250 nm;(c) 0.80
88. (a)  $411.4^\circ$ ;(b)  $51.4^\circ$
89.  $x = (D/2a)(m + 0.5)\lambda$ , for  $m = 0, 1, 2, \dots$
90. (a) 2.90(b) intermediate closer to fully constructive
91. (a)  $22^\circ$ ;(b) refraction reduces  $\theta$
92. (a) 1.6;(b) 1.4
93. 600 nm

94. 51.6 ns  
 95. (a)  $1.75 \mu\text{m}$ ; (b) 4.8 mm  
 96. 0.20  
 97.  $I_m \cos^2(2\pi x/\lambda)$   
 98. 310.0 nm  
 99. (a) 42.0 ps; (b) 42.3 ps; (c) 43.2 ps; (d) 41.8 ps; (e) 4  
 100. 492 nm  
 101.  $33 \mu\text{m}$   
 102. 450 nm

### **Chapter 36**

1. (a) 2.5 mm; (b)  $2.2 \times 10^{-4}$  rad  
 2. 1.41  
 3. (a) 70 cm; (b) 1.0 mm  
 4. (a) decrease; (b)  $11^\circ$ ; (c)  $0.23^\circ$   
 5. (a) 700 nm; (b) 4; (c) 6  
 6. (a)  $0.430^\circ$ ; (b) 0.118 mm  
 7.  $60.4 \mu\text{m}$   
 8. 41.2 m  
 9. 1.77 mm  
 10. 24.0 mm  
 11.  $160^\circ$   
 12. (a)  $2.33 \mu\text{m}$ ; (b) 6; (c)  $15.2^\circ$ ; (d)  $51.8^\circ$   
 13. (a)  $0.18^\circ$ ; (b) 0.46 rad; (c) 0.93  
 14. (a) 0.256; (b) between center and first minima  
 15. (d)  $52.5^\circ$ ; (e)  $10.1^\circ$ ; (f)  $5.06^\circ$   
 16. ---  
 17. (b) 0; (c) -0.500; (d) 4.493 rad; (e) 0.930; (f) 7.725 rad; (g) 1.96  
 18. 30 m  
 19. (a) 19 cm; (b) larger  
 20. 53 m  
 21. (a)  $1.1 \times 10^4$  km; (b) 11 km  
 22. (a) 50 m; (b) no; (c) light pollution on the night side of Earth would be a sure sign  
 23. (a)  $1.3 \times 10^{-4}$  rad; (b) 10 km  
 24.  $31 \mu\text{m}$   
 25. 50 m  
 26. (a) 32 cm; (b) 2.7 m; (c) 2.7 m aperture is too large; fine-scale resolution is due to computer enhancement, in which a computer removes much of the blurring due to turbulence.  
 27.  $1.6 \times 10^3$  km  
 28. 27 cm  
 29. (a)  $8.8 \times 10^{-7}$  rad; (b)  $8.4 \times 10^7$  km; (c) 0.025 mm  
 30.  $91 \mu\text{m}$   
 31. (a)  $0.346^\circ$ ; (b)  $0.97^\circ$   
 32. (a)  $6.8^\circ$ ; (b) no

33. (a) 17.1 m;(b)  $1.37 \times 10^{-10}$   
34. (a) red;(b) 0.13 mm  
35. 5  
36. 13  
37. 3  
38. (a) 11.1  $\mu\text{m}$ ;(b) 51;(c)  $0^\circ$ ;(d)  $79.0^\circ$   
39. (a) 5.0  $\mu\text{m}$ ;(b) 20  $\mu\text{m}$   
40. 22  
41. (a)  $7.43 \times 10^{-3}$ ;(b) between the  $m = 6$  minimum (the seventh one) and the  $m = 7$  maximum (the seventh side maximum);(c) between the  $m = 3$  minimum (the third one) and the  $m = 4$  minimum (the fourth one)  
42. (a) 4;(b) every fourth bright fringe missing  
43. (a) 9;(b) 0.255  
44. 2  $\mu\text{m}$   
45. (a)  $62.1^\circ$ ;(b)  $45.0^\circ$ ;(c)  $32.0^\circ$   
46. 635 nm  
47. 3  
48. (a) 3;(b)  $0.051^\circ$   
49. (a) 6.0  $\mu\text{m}$ ;(b) 1.5  $\mu\text{m}$ ;(c) 9;(d) 7;(e) 6  
50. 523 nm  
51. (a)  $2.1^\circ$ ;(b)  $21^\circ$ ;(c) 11  
52. (a) third (overlaps with fourth);(b) ninth;(c)  $41.5^\circ$ ;(d)  $67.2^\circ$ ;(e)  $73.1^\circ$   
53. (a) 470 nm;(b) 560 nm  
54. ---  
55.  $3.65 \times 10^3$   
56. (a) 23 100;(b)  $28.7^\circ$   
57. (a)  $0.032^\circ/\text{nm}$ ;(b)  $4.0 \times 10^4$ ;(c)  $0.076^\circ/\text{nm}$ ;(d)  $8.0 \times 10^4$ ;(e)  $0.24^\circ/\text{nm}$ ;(f)  $1.2 \times 10^5$   
58. (a) 56 pm;(b) none  
59. 0.15 nm  
60. 491  
61. (a) 10  $\mu\text{m}$ ;(b) 3.3 mm  
62. (a)  $\tan \theta$ ;(b) 0.89  
63.  $1.09 \times 10^3$  rulings/mm  
64.  $2.9^\circ$   
65. (a) 0.17 nm;(b) 0.13 nm  
66. 39.8 pm  
67. (a) 25 pm;(b) 38 pm  
68.  $6.8^\circ$   
69. 0.26 nm  
70. 0.570 nm  
71. (a)  $15.3^\circ$ ;(b)  $30.6^\circ$ ;(c)  $3.1^\circ$ ;(d)  $37.8^\circ$   
72. (a) 130 pm;(b) 3;(c) 97.2 pm;(d) 4  
73. (a)  $0.7071a_0$ ;(b)  $0.4472a_0$ ;(c)  $0.3162a_0$ ;(d)  $0.2774a_0$ ;(e)  $0.2425a_0$   
74. (a)  $1.3 \times 10^{-4}$  rad;(b) 21 m  
75. (a) 625 nm;(b) 500 nm;(c) 416 nm

76.  $4.84 \times 10^3$
77. 3.0 mm
78. 11
79. ---
80.  $30.5 \mu\text{m}$
81. ---
82. ---
83. (a) 13;(b) 6
84. 9.0
85. 59.5 pm
86. 6.1 mm
87. 4.9 km
88. 3.3
89.  $1.36 \times 10^4$
90. 53.4 cm
91. 2
92.  $4 \times 10^{-13}$
93. 4.7 cm
94. 500 nm
95. ---
96. 691 nm
97. 36 cm
98. 164 m
99. (a) fourth;(b) seventh

### **Chapter 37**

1. 0.990 50
2. (a) 0.140 370 76;(b) 0.994 987 44;(c) 0.999 950 00;(d) 0.999 999 50
3. (a) 0.999 999 50
4. 0.9959
5. 0.446 ps
6. 40 s
7.  $2.68 \times 10^3$  y
8. 1.53 cm
9. (a) 87.4 m;(b) 394 ns
10. 0.63 m
11. 1.32 m
12. (a) 0.866;(b) 2.00
13. (a) 26.26 y;(b) 52.26 y;(c) 3.705 y
14. 0.25 m
15. (a) 0.999 999 15;(b) 30 ly
16. (a) 0;(b) 2.29 s;(c)  $6.54 \times 10^8$  m;(d) 3.16 s
17. (a) 138 km;(b)  $-374 \mu\text{s}$
18. (a) 0;(b)  $-2.5 \mu\text{s}$ ;(c) reverse
19. (a)  $25.8 \mu\text{s}$ ;(b) small flash
20.  $0.63 \mu\text{s}$

21. (a)  $\gamma[1.00 \mu\text{s} - \beta(400 \text{ m})/(2.998 \times 10^8 \text{ m/s})]$ ; (d) 0.750; (e)  $0 < \beta < 0.750$ ; (f)  $0.750 < \beta < 1$ ; (g) no
22. (a)  $\gamma[400 \text{ m} - \beta c(1.00 \mu\text{s})]$ ; (d) 0.750; (e) 265 m
23. (a) 1.25; (b) 0.800  $\mu\text{s}$
24. (a) 0.500 m; (b) 1.00 m; (c) 1.00 m; (d) 19.2 m; (e) 35.5 ns; (f) event 2
25. (a) 0.480; (b) negative; (c) big flash; (d) 4.39  $\mu\text{s}$
26. 2.40  $\mu\text{s}$
27. 0.81c
28. (a)  $0.84c\hat{i}$ ; (b)  $1.1c\hat{i}$ ; (c)  $0.21c\hat{i}$ ; (d)  $0.15c\hat{i}$
29. (a) 0.35; (b) 0.62
30. 0.588
31. 1.2  $\mu\text{s}$
32. (a)  $-0.36c$ ; (b)  $-c$
33. (a) 1.25 y; (b) 1.60 y; (c) 4.00 y
34. 2.97 nm
35. 22.9 MHz
36. (a)  $1 \times 10^6 \text{ m/s}$ ; (b) receding
37. 0.13c
38. (a) 7000 km/s; (b) away
39. (a) 550 nm; (b) yellow
40. (a) 79.1 keV; (b) 3.11 MeV; (c) 10.9 MeV
41. (a) 196.695; (b) 0.999 987
42. 7.28 MeV
43. (a) 1.0 keV; (b) 1.1 MeV
44. 8.12 MeV
45. 110 km
46. (c) 207
47.  $1.01 \times 10^7 \text{ km}$
48. (a) 0.948; (b) 226 MeV; (c) 314 MeV/c
49. (a) 0.222 cm; (b) 701 ps; (c) 7.40 ps
50. (a) 20.57; (b) 0.9988; (c) 1.011; (d) 0.1448; (e) 1.003; (f)  $7.310 \times 10^{-2}$
51. 2.83mc
52. (a)  $mv^2/2 + 3mv^4/8c^2$ ; (b)  $1.0 \times 10^{-16} \text{ J}$ ; (c)  $1.9 \times 10^{-19} \text{ J}$ ; (d)  $2.6 \times 10^{-14} \text{ J}$ ; (e)  $1.3 \times 10^{-14} \text{ J}$ ; (f) 0.37
53. (a)  $\gamma(2\pi m/|q|B)$ ; (b) no; (c) 4.85 mm; (d) 15.9 mm; (e) 16.3 ps; (f) 0.334 ns
54. (a) 0.943; (b) 0.866
55. (a) 0.707; (b) 1.41; (c) 0.414
56. (a)  $1.2 \times 10^8 \text{ N}$ ; (b) truck or train; (c) 25 N; (d) backpack
57. 18 smu/y
58. (a) 1.001 957 0; (b)  $6.246 954 2 \times 10^{-2}$ ; (c) 2.956 951 4; (d) 0.941 079 24; (e) 1.957 951 4  $\times 10^3$ ; (f) 0.999 999 87
59. (a) 2.08 MeV; (b) -1.21 MeV
60. (a)  $\gamma[1.00 \mu\text{s} - \beta(240 \text{ m})/(2.998 \times 10^8 \text{ m/s})]$ ; (d) 0.801; (e) 0.599  $\mu\text{s}$ ; (f) yes
61. (d) 0.801
62. (a)  $-0.86c$ ; (b)  $-c$

63. (a)  $vt \sin \theta$ ; (b)  $t[1 - (v/c) \cos \theta]$ ; (c)  $3.24c$   
 64. 0.79 m  
 65. ---  
 66. (a)  $1/9$ ; (b)  $+0.80$ ; (c)  $+0.80c$   
 67. (b)  $+0.44c$   
 68. (a)  $2.59 \mu\text{s}$ ; (b)  $0.572 \mu\text{s}$ ; (c)  $2.59 \mu\text{s}$ ; (d)  $16.0 \mu\text{s}$   
 69. (a) 1.93 m; (b) 6.00 m; (c) 13.6 ns; (d) 13.6 ns; (e) 0.379 m; (f) 30.5 m; (g) -101 ns; (h) no; (i) 2; (k) no; (l) both  
 70. (a)  $2.21 \times 10^{-12}$ ; (b) 5.25 d  
 71. (a)  $5.4 \times 10^4 \text{ km/h}$ ; (b)  $6.3 \times 10^{-10}$   
 72. 0.75  
 73. 189 MeV  
 74. 55 m  
 75.  $8.7 \times 10^{-3} \text{ ly}$   
 76. 0.999 90  
 77. 7  
 78. (a)  $1.87 \times 10^4 \text{ km/s}$ ; (b) receding  
 79. 2.46 MeV/c  
 80. 6.4 cm  
 81.  $0.27c$   
 82. (a)  $2.24 \times 10^{-13} \text{ s}$ ; (b)  $64.4 \mu\text{m}$   
 83. (a) 5.71 GeV; (b) 6.65 GeV; (c) 6.58 GeV/c; (d) 3.11 MeV; (e) 3.62 MeV; (f) 3.59 MeV/c  
 84. (a)  $\tau_0(1 - v^2/c^2)^{-0.5}$   
 85.  $0.95c$   
 86. (a)  $2.7 \times 10^{14} \text{ J}$ ; (b)  $1.8 \times 10^7 \text{ kg}$ ; (c)  $6.0 \times 10^6$   
 87. (a) 256 kV; (b)  $0.745c$   
 88.  $0.678c$

### **Chapter 38**

1. (a)  $2.1 \mu\text{m}$ ; (b) infrared
2.  $8.6 \times 10^5 \text{ m/s}$
3.  $1.0 \times 10^{45} \text{ photons/s}$
4.  $1.7 \times 10^{21} \text{ photons/m}^2\cdot\text{s}$
5. 2.047 eV
6. 2.11 eV
7.  $1.1 \times 10^{-10} \text{ W}$
8.  $3.3 \times 10^{18} \text{ photons/s}$
9. (a)  $2.96 \times 10^{20} \text{ photons/s}$ ; (b)  $4.86 \times 10^7 \text{ m}$ ; (c)  $5.89 \times 10^{18} \text{ photons/m}^2\cdot\text{s}$
10. (a) 3.61 kW; (b)  $1.00 \times 10^{22} \text{ photons/s}$ ; (c) 60.2 s
11. (a) infrared; (b)  $1.4 \times 10^{21} \text{ photons/s}$
12.  $3.6 \times 10^{-17} \text{ W}$
13.  $4.7 \times 10^{26} \text{ photons}$
14.  $6 \text{ s}^{-1}$
15. 170 nm

16. 10 eV
17. 676 km/s
18. barium and lithium
19. (a) 1.3 V;(b)  $6.8 \times 10^2$  km/s
20.  $9.68 \times 10^{-20}$  A
21. (a) 3.1 keV;(b) 14 keV
22. 1.07 eV
23. (a) 2.00 eV;(b) 0;(c) 2.00 V;(d) 295 nm
24. (a)  $4.12 \times 10^{-15}$  eV·s;(b) 2.27 eV;(c) 545 nm
25. (a) 382 nm;(b) 1.82 eV
26. 233 nm
27. (a) 2.73 pm;(b) 6.05 pm
28. (a) 0.511 MeV/c;(b) 2.43 pm;(c)  $1.24 \times 10^{20}$  Hz
29. (a)  $8.57 \times 10^{18}$  Hz;(b)  $3.55 \times 10^4$  eV;(c) 35.4 keV/c
30. 2.64 fm
31. 300%
32. (a) +4.86 pm;(b) -40.6 keV;(c) 40.6 keV;(d)  $0^\circ$
33. (a)  $-8.1 \times 10^{-9}\%$ ;(b)  $-4.9 \times 10^{-4}\%$ ;(c) -8.9%;(d) -66%
34.  $3.0 \times 10^{-14}$  J
35. (a) 2.43 pm;(b) 1.32 fm;(c) 0.511 MeV;(d) 939 MeV
36. (a) 2.43 pm;(b) 4.86 pm;(c) 0.255 MeV
37. (a) 41.8 keV;(b) 8.2 keV
38. ---
39.  $44^\circ$
40. 1.1 keV
41. (a) 2.43 pm;(b)  $4.11 \times 10^{-6}$ ;(c)  $-8.67 \times 10^{-6}$  eV;(d) 2.43 pm;(e)  $9.78 \times 10^{-2}$ ;(f) -4.45 keV
42. (a) 38.8 pm;(b) 1.24 nm;(c) 906 fm
43. 7.75 pm
44. 9.76 kV
45. (a)  $1.9 \times 10^{-21}$  kg·m/s;(b) 346 fm
46. (a) 0.025 fm;(b)  $2.0 \times 10^2$
47.  $4.3 \mu\text{eV}$
48.  $(4.0 \times 10^{-6})^\circ$
49. (a)  $1.24 \mu\text{m}$ ;(b) 1.22 nm;(c) 1.24 fm;(d) 1.24 fm
50. (a)  $3.3 \times 10^{-24}$  kg·m/s;(b)  $3.3 \times 10^{-24}$  kg·m/s;(c) 38 eV;(d)  $6.2 \times 10^3$  eV
51. (a) 15 keV;(b) 120 keV
52. (a) 5.2 fm;(b) no, the de Broglie wavelength is much less than the distance of closest approach
53. Neutron
54. (a) 1.24 keV;(b) 1.50 eV;(c) 1.24 GeV;(d) 1.24 GeV
55. (a)  $3.96 \times 10^6$  m/s;(b) 81.7 kV
56. ---
57. ---
58. (d)  $x = n(\lambda/2)$ , with  $n = 0, 1, 2, 3, \dots$

59. ---  
 60. ---  
 61. ---  
 62. ---  
 63.  $2.1 \times 10^{-24}$  kg·m/s  
 64. (a) 124 keV;(b) 40.5 keV  
 65. ---  
 66. 5.1 eV  
 67. (a)  $9.02 \times 10^{-6}$ ;(b) 3.0 MeV;(c) 3.0 MeV;(d)  $7.33 \times 10^{-8}$ ;(e) 3.0 MeV;(f) 3.0 MeV  
 68. (a)  $10^{104}$  y;(b)  $2 \times 10^{-19}$  s  
 69. (a) -20%;(b) -10%;(c) +15%  
 70. (a) no;(b) plane wavefronts of infinite extent, perpendicular to  $x$  axis  
 71. 5.9  $\mu$ eV  
 72. ---  
 73. ---  
 74. (a) 38.8 meV;(b) 146 pm  
 75. (a) 73 pm;(b) 3.4 nm;(c) yes, their average de Broglie wavelength is smaller than their average separation  
 76. (a)  $4.14 \times 10^{-15}$  eV·s;(b) 2.31 eV  
 77. ---  
 78. ---  
 79.  $1.7 \times 10^{-35}$  m  
 80. (a) no;(b) 544 nm;(c) green  
 81. 0.19 m  
 82. ---  
 83. ---  
 84.  $T = 10^{-x}$ , where  $x = 7.2 \times 10^{39}$  ( $T$  is very small)

### **Chapter 39**

1. 1.41  
 2. (a) 9.42 eV;(b)  $5.13 \times 10^{-3}$  eV  
 3. 0.65 eV  
 4. 90.3 eV  
 5. 0.85 nm  
 6. 0.020 eV  
 7. 1.9 GeV  
 8. 350 pm  
 9. (a) 72.2 eV;(b) 13.7 nm;(c) 17.2 nm;(d) 68.7 nm;(e) 41.2 nm;(g) 68.7 nm;(h) 25.8 nm  
 10. (a) 11;(b) 10  
 11. (a) 13;(b) 12  
 12. (a) 68.7 nm;(b) 25.8 nm;(c) 13.7 nm  
 13. (a) 0.020; (b) 20  
 14.  $2.86 \times 10^{-17}$  J  
 15. (a) 0.050;(b) 0.10;(c) 0.0095  
 16. (a) 0.091;(b) 0.091;(c) 0.82

17. 56 eV
18. 233 eV
19. 109 eV
20. 7.0 eV
21. ---
22. 0.734 eV
23. 3.21 eV
24.  $2.2 \times 10^{-20}$  J
25.  $1.4 \times 10^{-3}$
26. (a) 1.25;(b) 2.00;(c) 5.00;(d) 1.00
27. (a) 8;(b) 0.75;(c) 1.00;(d) 1.25;(e) 3.75;(f) 3.00;(g) 2.25
28. (a) 3.00;(b) 9.00;(c) 2.00;(d) 3;(e) 6
29. (a) 7;(b) 1.00;(c) 2.00;(d) 3.00;(e) 9.00;(f) 8.00;(g) 6.00
30. 27.6 nm
31. 4.0
32. 1.17 eV
33. (a) 12.1 eV;(b)  $6.45 \times 10^{-27}$  kg·m/s;(c) 102 nm
34. (a) 0;(b)  $10.2 \text{ nm}^{-1}$ ;(c)  $5.54 \text{ nm}^{-1}$
35. (a)  $291 \text{ nm}^{-3}$ ;(b)  $10.2 \text{ nm}^{-1}$
36. (a) -3.4 eV;(b) 3.4 eV
37. ---
38. 2.6 eV
39. ---
40. (a) 31 nm;(b)  $8.2 \times 10^{14}$  Hz;(c) 0.29  $\mu\text{m}$ ;(d)  $3.7 \times 10^{14}$  Hz
41. (a) 0.0037;(b) 0.0054
42. 4.1 m/s
43. (a) 13.6 eV;(b) -27.2 eV
44. (a) 2.6 eV;(b) 4;(c) 2
45. (a)  $(r^4/8a^5)[\exp(-r/a)] \cos^2 \theta$ ;(b)  $(r^4/16a^5)[\exp(-r/a)] \sin^2 \theta$
46. 0.439
47.  $4.3 \times 10^3$
48. (a) 2;(b) 1;(c) Lyman
49. (a) 13.6 eV;(b) 3.40 eV
50. (a) 3;(b) 1;(c) Lyman
51. 0.68
52. (a) 12.8 eV;(b) 6;(c) 12.8 eV;(d) 12.1 eV;(e) 10.2 eV;(f) 0.661 eV;(g) 1.89 eV;(h) 2.55 eV
53. ---
54. (c)  $(r^2/8a^3)(2-r/a)^2 \exp(-r/a)$
55. ---
56. (b) no;(c) no;(d) yes
57. ---
58. (b)  $\pm(2\pi/h)(2mE)^{0.5}$
59. (b)  $(2\pi/h)[2m(U_0 - E)]^{0.5}$
60. (a)  $1.3 \times 10^{-19}$  eV;(b)  $1.2 \times 10^{19}$ ;(c)  $1.2 \times 10^{13}$ ;(d) yes
61. (b) meter<sup>-2.5</sup>

62. (a) 658 nm;(b) 366 nm  
 63. (a)  $n$ ;(b)  $2\ell + 1$ ;(c)  $n^2$   
 64. ---

### **Chapter 40**

1.  $24.1^\circ$
2. 50
3. (a)  $3.65 \times 10^{-34}$  J·s;(b)  $3.16 \times 10^{-34}$  J·s
4. (a) 32;(b) 2;(c) 18;(d) 8
5. (a) 3;(b) 3
6. (a) 14;(b) 6;(c) 6;(d) 2
7. (a) 4;(b) 5;(c) 2
8. (a) 3;(b) 2;(c) 14
9. (a) 3.46;(b) 3.46;(c) 3;(d) 3;(e) -3;(f)  $30.0^\circ$ ;(g)  $54.7^\circ$ ;(h)  $150^\circ$
10. (a) 3;(b) 5;(c) 2;(d) 18;(e) 3
11. ---
12.  $4.3 \times 10^{-5}$  rad/s
13.  $72 \text{ km/s}^2$
14. (a)  $1.5 \times 10^{-21}$  N;(b)  $20 \mu\text{m}$
15. (a)  $54.7^\circ$ ;(b)  $125^\circ$
16. (a)  $58 \mu\text{eV}$ ;(b) 14 GHz;(c) 2.1 cm;(d) short radio wave region
17. 19 mT
18. 51 mT
19. 5.35 cm
20. 17.25
21. 44
22. 66
23. 42
24. (a) 18.00;(b) 18.25;(c) 19.00
25. (a) 51;(b) 53;(c) 56
26. (a) 45;(b) 47;(c) 48
27. (a)  $(2, 0, 0, +\frac{1}{2})$ ,  $(2, 0, 0, -\frac{1}{2})$ ;(b)  $(2, 1, 1, +\frac{1}{2})$ ,  $(2, 1, 1, -\frac{1}{2})$ ,  $(2, 1, 0, +\frac{1}{2})$ ,  $(2, 1, 0, -\frac{1}{2})$ ,  $(2, 1, -1, +\frac{1}{2})$ ,  $(2, 1, -1, -\frac{1}{2})$
28. ---
29.  $G$
30. (a)  $(1, 0, 0, +\frac{1}{2})$ ;(b)  $(1, 0, 0, -\frac{1}{2})$
31. (a)  $4p$ ;(b) 4;(c)  $4p$ ;(d) 5;(e)  $4p$ ;(f) 6
32. (a) 15;(b) 21
33. 12.4 kV
34. 6.44 keV
35. (a) 35.4 pm;(b) 56.5 pm;(c) 49.6 pm
36. (a) 24.8 pm;(b) same
37. ---
38. ---
39. 0.563

40. (a)  $(Z - 1)^2 / (Z' - 1)^2$ ; (b) 57.5; (c)  $2.07 \times 10^3$   
 41. 80.3 pm  
 42. 2.2 keV  
 43. (a) 69.5 keV; (b) 17.8 pm; (c) 21.3 pm; (d) 18.5 pm  
 44. (a) 5.7 keV; (b) 87 pm; (c) 14 keV; (d)  $2.2 \times 10^2$  pm; (e) 5.7 keV  
 45. (a) 49.6 pm; (b) 99.2 pm  
 46. (a) -25%; (b) -15%; (c) -11%; (d) -7.9%; (e) -6.4%; (f) -4.7%; (g) -3.5%; (h) -2.6%; (i) -2.0%; (j) -1.5%  
 47.  $2.0 \times 10^{16} \text{ s}^{-1}$   
 48. 4.7 km  
 49.  $2 \times 10^7$   
 50.  $1.0 \times 10^4 \text{ K}$   
 51.  $9.0 \times 10^{-7}$   
 52.  $3.0 \times 10^{18}$   
 53.  $7.3 \times 10^{15} \text{ s}^{-1}$   
 54.  $1.3 \times 10^{15} \text{ mol}$   
 55. (a) 3.60 mm; (b)  $5.24 \times 10^{17}$   
 56.  $-2.75 \times 10^5 \text{ K}$   
 57. (a) 0; (b) 68 J  
 58. 1.8 pm  
 59. 3.0 eV  
 60. (a)  $7.33 \mu\text{m}$ ; (b)  $7.07 \times 10^5 \text{ W/m}^2$ ; (c)  $2.49 \times 10^{10} \text{ W/m}^2$   
 61. (a)  $3.03 \times 10^5$ ; (b) 1.43 GHz; (d)  $3.31 \times 10^{-6}$   
 62. 1.1 MW  
 63. 186  
 64. (a)  $4.3 \mu\text{m}$ ; (b)  $10 \mu\text{m}$ ; (c) infrared  
 65. (a) 2.13 meV; (b) 18 T  
 66. (a)  $6.9 \mu\text{eV}$ ; (b) radio waves  
 67. (a) 2.55 s; (b) 0.50 ns; (c)  $(4.5 \times 10^{-4})^\circ$  or  $1.6''$  of arc  
 68. (a) no; (b) 140 nm  
 69. (a) 20 keV; (b) 18 keV; (c) Zr; (d) Nb  
 70. (a) 20 keV; (b) 18 keV; (c) Zr; (d) Nb  
 71.  $n > 3$ ;  $\ell = 3$ ;  $m_\ell = +3, +2, +1, 0, -1, -2, -3$ ;  $m_s = \pm 1/2$   
 72. ---  
 73. (a) 6.0; (b)  $3.2 \times 10^6 \text{ y}$   
 74. ---  
 75. Argon  
 76. (a)  $3 \times 10^{74}$ ; (b)  $6 \times 10^{74}$ ; (c)  $6 \times 10^{-38} \text{ rad}$   
 77. ---

### **Chapter 41**

1. ---  
 2.  $1.9 \times 10^{28} \text{ m}^{-3} \text{ eV}^{-1}$   
 3.  $8.49 \times 10^{28} \text{ m}^{-3}$   
 4. 0.91

5. (b)  $6.81 \times 10^{27} \text{ m}^{-3} \text{ eV}^{-3/2}$ ; (c)  $1.52 \times 10^{28} \text{ m}^{-3} \text{ eV}^{-1}$
6. ---
7. (a) 0; (b) 0.0955
8.  $5.90 \times 10^{28} \text{ m}^{-3}$
9. (a)  $5.86 \times 10^{28} \text{ m}^{-3}$ ; (b) 5.49 eV; (c)  $1.39 \times 10^3 \text{ km/s}$ ; (d) 0.522 nm
10. ---
11. (a)  $1.36 \times 10^{28} \text{ m}^{-3} \text{ eV}^{-1}$ ; (b)  $1.68 \times 10^{28} \text{ m}^{-3} \text{ eV}^{-1}$ ; (c)  $9.01 \times 10^{27} \text{ m}^{-3} \text{ eV}^{-1}$ ; (d)  $9.56 \times 10^{26} \text{ m}^{-3} \text{ eV}^{-1}$ ; (e)  $1.71 \times 10^{18} \text{ m}^{-3} \text{ eV}^{-1}$
12. about  $10^{-42}$
13. (a) 6.81 eV; (b)  $1.77 \times 10^{28} \text{ m}^{-3} \text{ eV}^{-1}$ ; (c)  $1.59 \times 10^{28} \text{ m}^{-3} \text{ eV}^{-1}$
14. (a) 90.0%; (b) 12.4%; (c) sodium
15. (a)  $2.50 \times 10^3 \text{ K}$ ; (b)  $5.30 \times 10^3 \text{ K}$
16. (a)  $2.7 \times 10^{25} \text{ m}^{-3}$ ; (b)  $8.43 \times 10^{28} \text{ m}^{-3}$ ; (c)  $3.1 \times 10^3$ ; (d) 3.3 nm; (e) 0.23 nm
17. 3
18.  $7.2 \times 10^{24}$
19. (a) 1.0; (b) 0.99; (c) 0.50; (d) 0.014; (e)  $2.4 \times 10^{-17}$ ; (f)  $7.0 \times 10^2 \text{ K}$
20.  $5.1 \times 10^{15}$
21. (a) 0.0055; (b) 0.018
22. 472 K
23. ---
24.  $0.84 \text{ g/cm}^3$
25. (a) 19.7 kJ; (b) 197 s
26. 57 meV
27. (a)  $1.31 \times 10^{29} \text{ m}^{-3}$ ; (b) 9.43 eV; (c)  $1.82 \times 10^3 \text{ km/s}$ ; (d) 0.40 nm
28. 5.52 eV
29. 57.1 kJ
30.  $6.9 \times 10^{19}$
31. (a) 226 nm; (b) ultraviolet
32. (a)  $+3e$ ; (b)  $+5e$ ; (c) 2
33. (a)  $1.5 \times 10^{-6}$ ; (b)  $1.5 \times 10^{-6}$
34. ---
35.  $0.22 \mu\text{g}$
36. (a) above; (b) 0.744 eV; (c)  $7.13 \times 10^{-7}$
37. (a)  $4.79 \times 10^{-10}$ ; (b) 0.0140; (c) 0.824
38. (a) *n*-type; (b)  $5 \times 10^{21} \text{ m}^{-3}$ ; (c)  $5 \times 10^5$
39.  $6.0 \times 10^5$
40. (b)  $2.5 \times 10^8$
41. 4.20 eV
42. Opaque
43. 13  $\mu\text{m}$
44. (a)  $5.0 \times 10^{-17} \text{ F}$ ; (b)  $3.1 \times 10^2$
45. ---
46. (a)  $+8 \times 10^{-11} \Omega\cdot\text{m/K}$ ; (b)  $-2 \times 10^2 \Omega\cdot\text{m/K}$
47. (a)  $109.5^\circ$ ; (b) 238 pm
48. ---

49. (b)  $1.8 \times 10^{28} \text{ m}^{-3} \text{ eV}^{-1}$   
 50. 0.03  
 51. ---  
 52. ---  
 53.  $3.49 \times 10^3 \text{ atm}$

### **Chapter 42**

1.  $1.3 \times 10^{-13} \text{ m}$
2. 15.8 fm
3. 46.6 fm
4. 28.3 MeV
5. (a) 0.390 MeV;(b) 4.61 MeV
6. (b) 0.05%;(c) 0.81%;(d) 0.81%;(e) 0.74%;(f) 0.71%;(g) no
7. (a)  $2.3 \times 10^{17} \text{ kg/m}^3$ ; (b)  $2.3 \times 10^{17} \text{ kg/m}^3$ ;(d)  $1.0 \times 10^{25} \text{ C/m}^3$ ;(e)  $8.8 \times 10^{24} \text{ C/m}^3$
8. (a) yttrium;(b) iodine;(c) 50;(d) 74;(e) 19
9. (a) 6;(b) 8
10. (a)  $+7.825 \times 10^{-3} \text{ u}$ ;(b)  $+7.290 \text{ MeV}/c^2$ ;(c)  $+8.664 \times 10^{-3} \text{ u}$ ;(d)  $+8.071 \text{ MeV}/c^2$ ;(e)  $-9.780 \times 10^{-2} \text{ u}$ ;(f)  $-91.10 \text{ MeV}/c^2$
11. (a) 6.2 fm;(b) yes
12. (a) blow apart;(b) 1.15 GeV;(c) 12.2 MeV/proton;(d) 4.81 MeV/nucleon;(e) strong force is strong
13. 13 km
14. 7.52 MeV/nucleon
15. ---
16. 8.23 MeV/nucleon
17. 1.0087 u
18. 7.38 MeV/nucleon
19. (a) 9.303%;(b) 11.71%
20. 7.31 MeV/nucleon
21. (b) 7.92 MeV/nucleon
22. (a) 19.8 MeV;(b) 6.26 MeV;(c) 2.23 MeV;(d) 28.3 MeV;(e) 7.07 MeV;(f) no
23. ---
24.  $1.6 \times 10^{25} \text{ MeV}$
25.  $5.3 \times 10^{22}$
26. 280 d
27. (a) 0.250;(b) 0.125
28. (a)  $5.04 \times 10^{18}$ ;(b)  $4.60 \times 10^6 \text{ s}^{-1}$
29. (a) 64.2 h;(b) 0.125;(c) 0.0749
30.  $3.0 \times 10^{19}$
31. (a)  $7.5 \times 10^{16} \text{ s}^{-1}$ ;(b)  $4.9 \times 10^{16} \text{ s}^{-1}$
32. 0.49
33.  $1 \times 10^{13} \text{ atoms}$
34. 0.66 g
35. ---
36. 87.9 mg
37. 265 mg

38.  $4.96 \times 10^9$
39. (a)  $8.88 \times 10^{10} \text{ s}^{-1}$ ; (b)  $1.19 \times 10^{15}$ ; (c)  $0.111 \mu\text{g}$
40. 209 d
41.  $1.12 \times 10^{11} \text{ y}$
42.  $4.9 \times 10^{13} \text{ Bq}$
43.  $9.0 \times 10^8 \text{ Bq}$
44. 60 Bq
45. (a)  $3.2 \times 10^{12} \text{ Bq}$ ; (b) 86 Ci
46. (a)  $\beta^-$  decay; (b)  $8.2 \times 10^7 \text{ s}^{-1}$ ; (c)  $1.2 \times 10^6$
47. (a)  $2.0 \times 10^{20}$ ; (b)  $2.8 \times 10^9 \text{ s}^{-1}$
48. (a) 4.25 MeV; (b) -24.1 MeV; (c) 28.3 MeV
49. (a)  $1.2 \times 10^{-17}$ ; (b) 0
50. (a) -9.50 MeV; (b) 4.66 MeV; (c) -1.30 MeV
51. 4.269 MeV
52. (a) 31.8 MeV; (b) 5.98 MeV; (c) 86 MeV
53. 1.21 MeV
54. ---
55. 0.783 MeV
56. (a) 0.90 pm; (b) 6.4 fm; (c) no; (d) yes
57. (b) 0.961 MeV
58. (b)  $2.7 \times 10^{13} \text{ W}$
59. 78.3 eV
60.  $1.61 \times 10^3 \text{ y}$
61. (a)  $1.06 \times 10^{19}$ ; (b)  $0.624 \times 10^{19}$ ; (c)  $1.68 \times 10^{19}$ ; (d)  $2.97 \times 10^9 \text{ y}$
62. 132  $\mu\text{g}$
63. 1.7 mg
64.  $4.28 \times 10^9 \text{ y}$
65. 1.02 mg
66. (a) 145 Bq; (b) 3.92 nCi
67. 2.50 mSv
68. (a) 18 mJ; (b) 2.9 mSv; (c) 0.29 rem
69. (a)  $6.3 \times 10^{18}$ ; (b)  $2.5 \times 10^{11}$ ; (c) 0.20 J; (d) 2.3 mGy; (e) 30 mSv
70.  $3.87 \times 10^{10} \text{ K}$
71. (a) 6.6 MeV; (b) no
72. (a)  $^{18}\text{O}$ ,  $^{60}\text{Ni}$ ,  $^{92}\text{Mo}$ ,  $^{144}\text{Sm}$ ,  $^{207}\text{Pb}$ ; (b)  $^{40}\text{K}$ ,  $^{91}\text{Zr}$ ,  $^{121}\text{Sb}$ ,  $^{143}\text{Nd}$ ; (c)  $^{13}\text{C}$ ,  $^{40}\text{K}$ ,  $^{49}\text{Ti}$ ,  $^{205}\text{Tl}$ ,  $^{207}\text{Pb}$
73. (a) 25.4 MeV; (b) 12.8 MeV; (c) 25.0 MeV
74.  $1.7 \times 10^9 \text{ y}$
75.  $^7\text{Li}$
76. 13 mJ
77.  $3.2 \times 10^4 \text{ y}$
78. 19.7 d
79. 730  $\text{cm}^2$
80. (a)  $7 \times 10^7$  electrons; (b)  $(7 \times 10^7 \text{ electrons}) \exp[-(\ln 2)(D - 1996)/T_{1/2}]$ , where  $D$  is the current year and  $T_{1/2} = 30.2 \text{ y}$

81.  $^{225}\text{Ac}$   
 82. ---  
 83. 30 MeV  
 84. (a)  $3.66 \times 10^7$  Bq;(b)  $3.66 \times 10^7$  Bq;(c) 6.42 ng  
 85. ---  
 86. 6.79 MeV  
 87. ---  
 88.  $4 \times 10^{-22}$  s  
 89. 27  
 90. (a)  $^{142}\text{Nd}$ ,  $^{143}\text{Nd}$ ,  $^{144}\text{Nd}$ ,  $^{145}\text{Nd}$ ,  $^{146}\text{Nd}$ ,  $^{148}\text{Nd}$ ,  $^{150}\text{Nd}$ ;(b)  $^{97}\text{Rb}$ ,  $^{98}\text{Sr}$ ,  $^{99}\text{Y}$ ,  $^{100}\text{Zr}$ ,  $^{101}\text{Nb}$ ,  
 $^{102}\text{Mo}$ ,  $^{103}\text{Tc}$ ,  $^{105}\text{Rh}$ ,  $^{109}\text{In}$ ,  $^{110}\text{Sn}$ ,  $^{111}\text{Sb}$ ,  $^{112}\text{Te}$ ,  $^{113}\text{I}$ ,  $^{114}\text{Xe}$ ,  $^{115}\text{Cs}$ ,  $^{116}\text{Ba}$ (c)  $^{60}\text{Zn}$ ,  
 $^{60}\text{Cu}$ ,  $^{60}\text{Ni}$ ,  $^{60}\text{Co}$ ,  $^{60}\text{Fe}$ ,  $^{60}\text{Mn}$ ,  $^{60}\text{Cr}$ ,  $^{60}\text{V}$   
 91. (a) 11.906 83 u;(b) 236.2025 u  
 92. (b)  $4n + 3$ ;(c)  $4n$ ;(d)  $4n + 2$ ;(e)  $4n + 3$ ;(f)  $4n$ ;(g)  $4n + 1$ ;(h)  $4n + 2$ ;(i)  $4n + 1$ (j)  $4n + 1$   
 93. 600 keV  
 94. ---  
 95. (a) 59.5 d;(b) 1.18  
 96. (a)  $4.8 \times 10^{-18} \text{ s}^{-1}$ ;(b)  $4.6 \times 10^9$  y

### **Chapter 43**

1. (a)  $16 \text{ day}^{-1}$ ;(b)  $4.3 \times 10^8$   
 2. Yes  
 3. 4.8 MeV  
 4.  $4.54 \times 10^{26}$  MeV  
 5.  $1.3 \times 10^3$  kg  
 6. (a)  $^{95}\text{Sr}$ ;(b)  $^{95}\text{Y}$ ;(c)  $^{134}\text{Te}$ ;(d) 3  
 7.  $3.1 \times 10^{10} \text{ s}^{-1}$   
 8. (a) +5.00 MeV  
 9. (a)  $2.6 \times 10^{24}$ ;(b)  $8.2 \times 10^{13}$  J;(c)  $2.6 \times 10^4$  y  
 10. 181 MeV  
 11. -23.0 MeV  
 12. (a) 10;(b) 226 MeV  
 13. (a) 251 MeV;(b) typical fission energy is 200 MeV  
 14. (a) +25%;(b) 0;(c) -36%  
 15. (a) 84 kg;(b)  $1.7 \times 10^{25}$ ;(c)  $1.3 \times 10^{25}$   
 16. (a) 44 kton  
 17. (a)  $^{153}\text{Nd}$ ;(b) 110 MeV;(c) 60 MeV;(d)  $1.6 \times 10^7$  m/s;(e)  $8.7 \times 10^6$  m/s  
 18. 462 kg  
 19. ---  
 20.  $8.03 \times 10^3$  MW  
 21. 557 W  
 22.  $1.6 \times 10^{16}$   
 23. 0.99938  
 24. (a) 1.2 MeV;(b) 3.2 kg  
 25. (b) 1.0;(c) 0.89;(d) 0.28;(e) 0.019;(f) 8

26.  $3.6 \times 10^9$  y
27. (a) 75 kW;(b)  $5.8 \times 10^3$  kg
28. ---
29.  $1.7 \times 10^9$  y
30. ---
31. 170 keV
32. (a) 170 kV
33. 1.41 MeV
34. 0.151
35.  $10^{-12}$  m
36. 5.49 MeV
37. (a)  $4.3 \times 10^9$  kg/s;(b)  $3.1 \times 10^{-4}$
38. ---
39. ---
40. (a)  $4.0 \times 10^{27}$  MeV;(b)  $5.1 \times 10^{26}$  MeV
41.  $1.6 \times 10^8$  y
42. ---
43. (a) 24.9 MeV;(b) 8.65 megatons TNT
44.  $5 \times 10^9$  y
45. (a)  $1.8 \times 10^{38}$  s<sup>-1</sup>;(b)  $8.2 \times 10^{28}$  s<sup>-1</sup>
46. ---
47. (a) 4.1 eV/atom;(b) 9.0 MJ/kg;(c)  $1.5 \times 10^3$  y
48. ---
49. 14.4 kW
50. (a)  $6.3 \times 10^{14}$  J/kg;(b)  $6.2 \times 10^{11}$  kg/s;(c)  $4.3 \times 10^9$  kg/s;(e)  $1.5 \times 10^{10}$  y
51.  $^{238}\text{U} + \text{n} \rightarrow ^{239}\text{U} \rightarrow ^{239}\text{Np} + \text{e} + \nu$ ,  $^{239}\text{Np} \rightarrow ^{239}\text{Pu} + \text{e} + \nu$
52. (a) 3.5 MeV; (b) 14.1 MeV
53. ---
54. ---
55. (a)  $3.1 \times 10^{31}$  protons/m<sup>3</sup>;(b)  $1.2 \times 10^6$
56. (b)  $5.0 \times 10^5$  m/s

#### **Chapter 44**

1.  $\pi^- \rightarrow \mu^- + \bar{\nu}$
2. 1
3. 2.4 pm
4. 18.4 fm
5.  $2.4 \times 10^{-43}$
6. ---
7. 769 MeV
8. (a)  $1.90 \times 10^{-18}$  kg·m/s;(b) 9.90 m
9. 2.7 cm/s
10. 31 nm
11. (a) angular momentum,  $L_e$ ;(b) charge,  $L_\mu$ ;(c) energy,  $L_\mu$
12. (a)  $2e^+$ ,  $e^-$ ,  $5\nu$ ,  $4\bar{\nu}$ ;(b) boson;(c) meson;(d) 0

13. ---
14. (a) 605 MeV;(b) -181 MeV
15. (a) energy;(b) strangeness;(c) charge
16. (a) yes; (b)-(e) no; (f) yes
17. (a) yes; (b)-(d) no
18. b and d
19. (a) 0;(b) -1;(c) 0
20. (a) 37.7 MeV;(b) 5.35 MeV;(c) 32.4 MeV
21. (a)  $K^+$ ;(b)  $\bar{n}$ ;(c)  $K^0$
22. 338 MeV
23. (a) not possible;(b) uuu
24. ---
25. (a)  $\bar{u}\bar{u}\bar{d}$ ;(b)  $\bar{u}\bar{d}\bar{d}$
26. (a) n;(b)  $\Sigma^+$ ;(c)  $\Xi^-$
27.  $\bar{s}\bar{d}$
28. (a) sud(b) uss
29. (a)  $\Xi^0$ ;(b)  $\Sigma^-$
30. (a)  $\Sigma^0$ ;(b)  $7.51 \times 10^6$  m/s
31.  $2.77 \times 10^8$  ly
32.  $8.3 \times 10^9$  ly
33. 668 nm
34. (a)  $1.0 \times 10^{10}$  m;(b)  $3.3 \times 10^2$  m/s
35.  $1.4 \times 10^{10}$  ly
36. (b) 5.7 H atoms/m<sup>3</sup>
37. (b) 0.934;(c)  $1.28 \times 10^{10}$  ly
38.  $4.57 \times 10^3$
39. (a) 0.26 meV;(b) 4.8 mm
40.  $102M_{\odot}$
41. (a) 121 m/s;(b) 0.00406;(c) 248 y
42. (b)  $2\pi^{1.5}(GM)^{-0.5}$
43. (a) 2.6 K;(b) 976 nm
44. (b)  $2.39 \times 10^9$  K
45. ---
46.  $13 \times 10^9$  y
47.  $1.08 \times 10^{42}$  J
48. (a) A;(b) J;(c) I;(d) F;(e) G;(f) C;(g) H;(h) D;(i) E
49. (a) 0.785c;(b) 0.993c;(c) C2;(d) C1;(e) 51 ns;(f) 40 ns