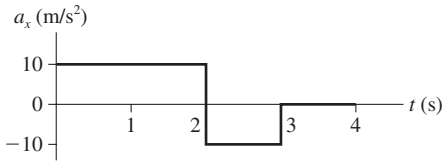
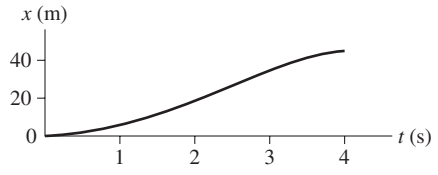
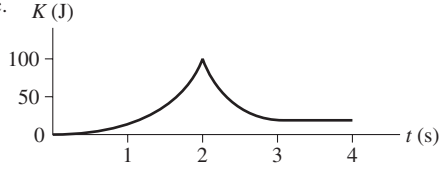
41. a.



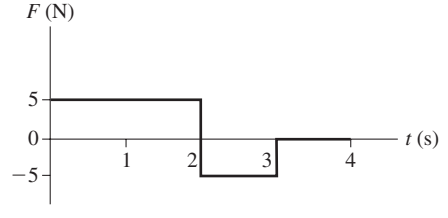
b.



c.

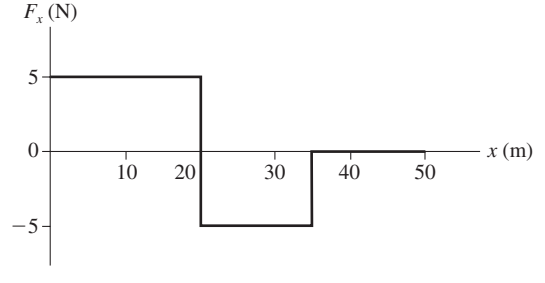


d.



e. 10 N s, −5 N s f. 20 m/s, 10 m/s

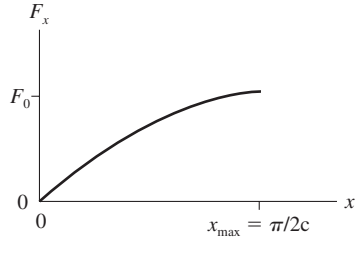
g.



h. 100 J, –75 J i. 20 m/s, 10 m/s

43. a. 2.3×10^2 J b. 2.3×10^2 N c. 6.8 kW
45. 16 m/s
47. 0.54 m
49. 0.12 km
51. a. $v_f = \sqrt{2gh(m - \mu_k M)/(M + m)}$ b. $v_f = \sqrt{2gmh/(M + m)}$
53. 10 m/s
55. a. 0.51 m b. 0.38 m
57. a. 14 m/s b. 32 m
61. a. N b. m^{-1} c. $\pi/(2c)$

d.



e. $\sqrt{v_0^2 + 2F_0/(mc)}$

63. a. 78 J b. 1.3 W
65. a. −0.25 kJ b. 2.6×10^5 kg
67. a. 6.53 m/s^2 b. 11/7 m/s c. 1.79 s
69 c. 6.3 m/s
71. c. 3.2 kW
73. 6.7 m
75. 24 W

Chapter 12

1. 13.2 m/s
3. a. 1.5 m/s b. 13 rev
5. 4.7×10^6 m
7. $x_{cm} = 6.7$, $y_{cm} = 5.0$
9. 2.57×10^{29} J
11. a. 0.032 kg m^2 b. 16 J
13. a. (5.7 cm, 4.6 cm) b. 0.0066 kg m^2
15. a. (0.060 m, 0.040 m) b. 0.0020 kg m^2 c. 0.0013 kg m^2
17. a. 3.8×10^{-5} kg m^2 b. 1.14×10^{-4} kg m^2
19. 4.3 N m
21. 12.5 kN m
23. 8.0 N m
25. 0.28 N m in the ccw direction
27. 8.0 rad/s
29. No
31. 1.5 m
33. 0.38 J
35. 43 cm
37. a. (21, into the page) b. (24, out of the page)
39. a. $-\hat{j}$ b. $\vec{0}$
41. a. $n\hat{i}$ b. $2\hat{j}$ c. $1\hat{k}$
43. $1.20\hat{k}$ kg m^2/s
45. (2.1 kg m^2/s, out of the page)
47. 91 rpm
49. 7.5 cm
51. 28 m/s
53. a. 0.010 kg m^2 b. 0.030 kg m^2
55. $\frac{M}{3L}[(L - d)^3 + d^3]$
57. $\frac{1}{6}ML^2$
59. 0.91 m
61. $F_1 = 750$ N, $F_2 = 1000$ N
63. 1.0 m
65. 31 kg
67. a. 39 mN b. 38 rpm
69. 1.1 s
71. 1.6 N
73. 4.3 m
75. a. $\sqrt{2g/R}$ b. $\sqrt{8gR}$
77. $\frac{20Tr}{13MR^2}$
79. 1.2 rad/s
81. 22 rpm
83. 4.0 rpm
85. Emily
87. 67°

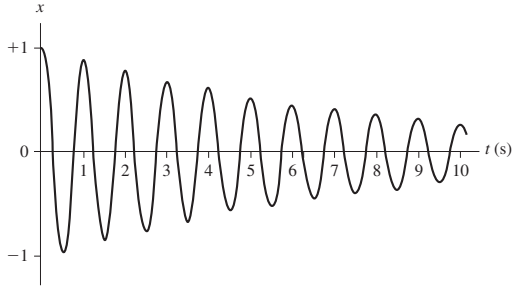
Chapter 13

1. 6.00×10^{-4}
3. 2.18
5. 2.3×10^{-7} N

7. a. 274 m/s^2 b. 5.90×10^{-3} m/s^2
9. 2.4 km
11. a. 3.0×10^{24} kg b. 0.89 m/s^2
13. 60.2 km/s
15. 4.21×10^4 m/s
17. 4.4×10^{11} m, 1.7×10^4 m/s
19. 1600 earth days
21. a. $T_2 = 250$ min, $T_3 = 459$ min b. $F_2 = 20{,}000$ N, $F_3 = 4{,}440$ N c. 1.50
23. 4.2 h
25. 46 kg and 104 kg
27. $3.0 \times 10^{-7}\hat{j}$ N
29. -1.96×10^{-7} J
31. 12 cm
33. a. 3.02 km/s b. 3.13 km/s c. 3.6%
35. 4.2×10^5 m
37. 33 km/s
39. 2.78 km/s
41. 3.0×10^4 m/s
43. 3.7×10^5 m/s
45. 6.7×10^8 J
47. a. 7.0 m/s b. 12 m/s
49. 6.71×10^7 m
51. a. $y = \left(\frac{q}{p}\right)x + \frac{\log C}{p}$ b. Straight line c. q/p d. 1.996×10^{30} kg
53. a. 2.1×10^8 y b. 24 c. 1.9×10^{41} kg d. 9.4×10^{10}
55. 3.71 km/s
57. 4.49 km/s
59. c. 6.21×10^7 m
61. c. 1680 m/s
63. 1.50×10^9 m
65. Crash
67. 11.8%
69. a. $-\frac{GMm}{L}\ln\left(\frac{x + L/2}{x - L/2}\right)$ b. $-GMm\left(\frac{4}{4x^2 - L^2}\right), x \geq \frac{L}{2}$

Chapter 14

1. 2.27 ms
3. a. 13 cm b. 9.0 cm
5. a. 10 cm b. 0.50 Hz c. +120°
9. $x(t) = (8.0 \text{ cm})\cos[(\pi \text{ rad/s})t - \pi \text{ rad}]$
11. a. 2.8 s b. 1.4 s c. 2.0 s d. 1.4 s
13. a. 0.50 s b. 4π rad/s c. 5.5 cm d. 0.45 rad e. 70 cm/s f. 8.8 m/s^2 g. 0.049 J h. 3.8 cm
15. a. 10 cm b. 35 cm/s
17. a. 0.17 kg b. 0.57 m/s
19. a. 4.0 s b. 5.7 s c. 2.8 s d. 4.0 s
21. a. 2.0 s b. 2.1 s
23. 3.67 m/s^2
25. 0.079 N/m
27.



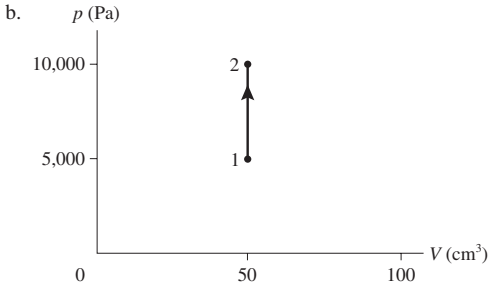
29. 250 N/m
31. a. $\frac{2}{3}\pi$ rad b. −13.6 cm/s c. 15.7 cm/s
33. 0.41 s
35. a. 55 kg b. 0.73 m/s
37. a. $\frac{3}{4}$ b. $\frac{A}{\sqrt{2}}$
39. a. 6.4 cm b. 160 cm/s^2 c. −6.4 cm d. 28 cm/s
41. 1.02 m/s
43. a. 3.2 Hz b. 7.1 cm 5.0 J
45. a. 1.1 Hz b. 23 cm c. 4.1 cm below equilibrium point
47. 1.7 Hz
49. 0.72
51. a. 7.5 m b. 0.45 m/s
53. 0.65 m/s
55. 0.66 s
57. $\frac{1}{2\pi}\sqrt{\frac{5}{7}\frac{g}{R}}$
59. 8.7×10^{-2} kg m^2
61. a. 2.0 Hz b. 1.2 cm
63. 7.9×10^{13} Hz
65. a. Highest point b. 2.5 Hz
67. a. 9.5 N/m b. 0.010 kg/s
69. 25 s
71. 236 oscillations
75. 1.6 Hz
77. 1.8 Hz
79. a. $\Delta T = \frac{T}{2}\frac{\Delta m}{m}$ b. 2.001s

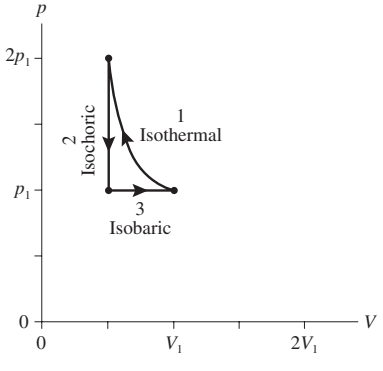
Chapter 15

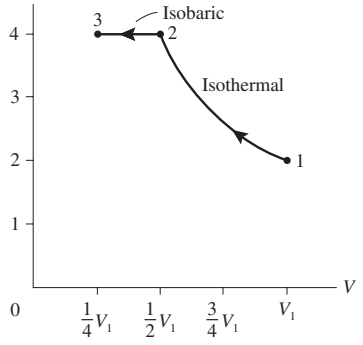
1. 50 mL
3. 1.4×10^5 kg
5. 1.1×10^3 atmospheres
7. a. 6.3 m^3 b. 1.2×10^5 Pa
9. 3.2 km
11. 10.3 m
13. 3.5 cm
15. 6.7×10^2 kg/m^3
17. 44 N
19. 8.4 cm
21. 56 kg
23. a. 1.0 m/s, 16 m/s b. 3.1×10^{-4} m^3/s
25. 110 kPa
27. 5.5×10^9 N/m^2
29. 1 mm
31. 0.20%
33. a. 5.8 kN b. 6.0 kN
35. 27 psi
37. 5.27×10^{18} kg
39. a. 106 kPa b. 4.4 kPa 4.4 kPa
41. 55 cm
43. 7.5 cm
45. a. $F = \rho gDWL$ b. $F = \frac{1}{2}\rho gD^2L$ c. 0.78 kN, 1.4 kN
47. 8.01%
49. a. $\rho_{\text{liq}}Agx$ b. 0.62 J
51. 8.9×10^2 kg/m^3
53. 18 cm
55. 5.2 cm
57. 3.5 m/s
59. 187 nm/s
61. 28 cm
63. 4.4 cm

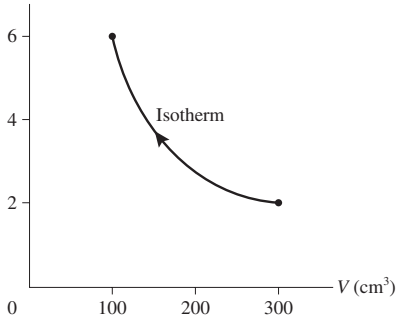
65. a. $v = \sqrt{2g(h-y)}$ b. $x = v\sqrt{2y/g}$ c. $y = h/2$, $x_{max} = h/2$,
67. 1 mm
69. 1 L
71. $\frac{h}{l} = \left(1 - \frac{\rho_0}{\rho_f}\right)^{1/3}$
73. b. $(F_{net})_y = -\rho_f A g y$ c. $\rho_f A g$ e. 18.9 s

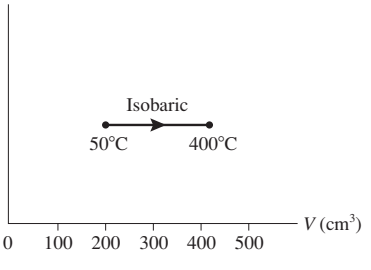
Chapter 16

1. 1900 cm^3
3. 8.0 cm
5. 4.8×10^{23} atoms
7. a. 6.02×10^{28}atoms/m^3 b. 3.28×10^{28} atoms/m^3
9. 6.8 cm^3
11. $-127°F = 88°C = 185$ K; $136°F = 58°C = 331$ K
13. a. 171°Z b. $671°C = 944$ K
15. a. 2 b. Unchanged
17. a. $1.27V_0$ b. $2V_0$
19. 2.4×10^{22} molecules
21. 7.4 kg/m^3
23. a. $V_2 = V_1$ b. $T_2 = \frac{T_1}{3}$
25. 2.6 atm
27. a. 9500 kPa
    b. 

29. a. 48 atm
31. a. Isobaric b. 118°C c. 9.35×10^{-3} mol
33. 0.228 nm
35. 3.3×10^{26} protons
37. 1.1×10^{15} particles/m^3
39. 380 K = 107°C
41. 1.8 g
43. $\frac{3}{2}T_0$
45. 2.4 m
47. 35 psi
49. 155 cm^3
51. 24 cm
53. No
55. 

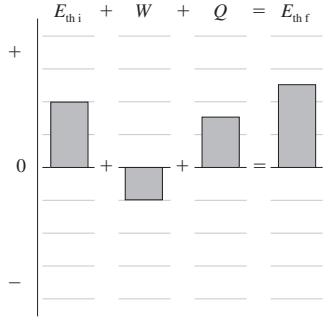
57. a. 880 kPa b. $T_2 = 323°C$, $T_3 = -49°C$, $T_4 = 398°C$
59. a. $T_1 = 122$ K, $T_2 = 366$ K b. Isobaric c. 3 atm
61. 2364°C
63. a. 4.0 atm, −73°C
    b. 

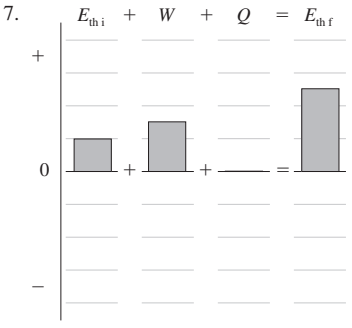
65. b. 

    c. 6 atm
67. b. p c. 417 cm^3


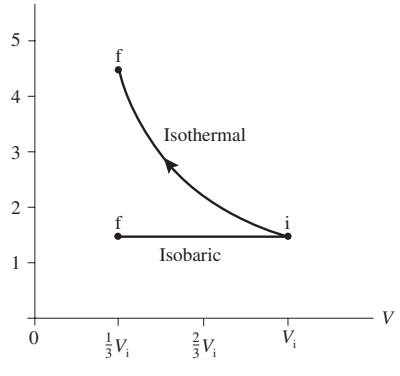
69. a. 23 cm b. 7.5 cm
71. 93 cm^3
73. a. 4.0×10^5 Pa b. Irreversible

Chapter 17

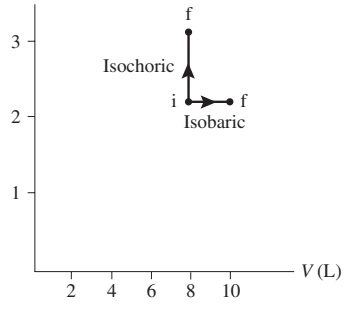
1. 60 J
3. 200 cm^3
5. 

7. 

9. 60 J
11. 52 kJ
13. a. 36°C b. 3000 J
15. 0.98 g
17. 272°C, 522°F
19. Iron
21. a. 31 J b. 60°C
23. 2.5 kJ
25. a. 1.9×10^{-3} m^3 b. 74°C
27. 16 kW
29. 230 W
31. 16 kJ
33. 15 m
35. 6.6 h
37. 12 J/s
39. −56°C
41. Aluminum
43. 650 J/kg K
45. a. 2.0 kJ/kg K b. 2.7 kJ/kg K c. −20°C, 40°C
    d. 4.0×10^4 J/kg, 1.2×10^5 J/kg
47. 2.4×10^6 L
49. a. 5.5 kJ b. 3.4 kJ
    c. p (atm)



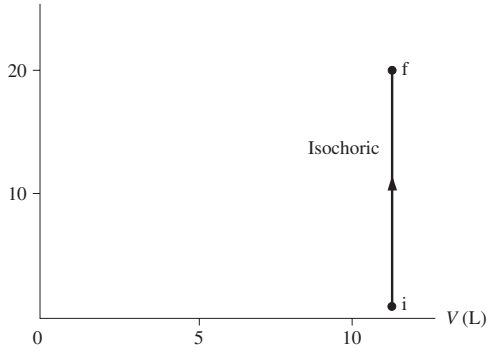
51. a. 350 Pa b. 4.9×10^{20} c. 110°C d. 26 cm e. −0.57 J
53. a. 3.1 atm b. 9.7 L
    c. p (atm)



55. a. T_1 b. $-nRT_1\ln 2$ c. $nRT_1\ln 2$
59. −330 J, 0 J
61. $\gamma = 1.29$
63. a. 0.15 kJ b. −91 J
65. a.

Point	p (atm)	T (°C)	V (cm^3)
1	1.0	133	1000
2	5.0	1757	1000
3	1.0	1757	5000

    b. $W_{1\to2} = 0$, $W_{2\to3} = -815$ J, $W_{3\to1} = 405$ J c. $Q_{1\to2} = 609$ J, $Q_{2\to3} = 815$ J, $Q_{3\to1} = -1.01$ kJ
67. 28°C
69. a. 5.5 kK b. 0 J c. 54 kJ d. 20
    e. p (atm)



71. 110°C
73. −18°C
75. b. 217°C
77. a.

Point	p (atm)	T (°C)	V (cm^3)
1	3.0	946	1000
2	1.0	946	3000
3	0.48	310	3000

    b. −334 J, 0 J, 239 J c. 334 J, −239 J, 0 J
79. 15 atm
81. 150 J

Chapter 18

1. 5.5×10^{24}
3. 0.023 Pa
5. a. 300 nm b. 600 nm
7. 13 cm
9. a. $(0\hat{\imath} + 0\hat{\jmath})$ b. 57 m/s c. 60 m/s
11. a. 289 K b. 200 kPa
13. 6.5×10^{25} s^{-1}
15. 283 m/s
17. −246°C
19. 300 m/s
21. 0.43 cm/s
23. a. Doubles b. $\sqrt{2}$ c. Same
25. a. 4.1×10^{-16} J b. 7.0×10^5 m/s
27. 580 m/s
29. 3.6×10^7 J
31. 93 kJ
33. a. 3.80×10^5 J b. 2.25×10^{-9} m c. 0 J
35. 5000 J
37. 61
39. a. Helium b. 1370 m/s c. 1.86 μm

41. a. 4×10^{-22} atm b. 270 m/s c. 2.5×10^5 m
43. 1.004
45. 1.9×10^4 Pa
47. 29 J/mol K
49. a. $(E_{He})_i = 1900$ J, $(E_O)_i = 3100$ J
    b. $(E_{He})_f = 2700$ J, $(E_O)_f = 2300$ J
    c. 850 J from oxygen to helium d. 436 K
51. 7
55. a. Increase factor of 2 b. Increase by factor of 4
    c. Increase by factor of 4 d. Same
57. a. 4 b. 1 c. 16
59. a. 141,000 K b. 10,100 K
61. a. 2.0×10^6 J b. 4.8×10^{-6} c. 0.0013 K
63. $\frac{15n+3}{2} p_i V_i$
65. c. 436 K; 850 J is transferred from oxygen to helium

Chapter 19

1. a. 250 J b. 150J
3. a. 0.27 b. 15 kJ
5. a. 200 J b. 250 J
7. 96,000
9.

	ΔE_{th}	W_s	Q
A	+	0	+
B	−	+	0
C	0	+	+
D	−	−	−

11. 40 J
13. a. 30 J, 0.15 kJ b. 0.21
15. 285 J
17. 0.24
19. a. (b) b. (a)
21. 7°C
23. a. 25% b. 232°C
25. 135°C
27. 1.7
29. a. 60 J b. −23°C
31. 1.7 MJ
37. 8.3%
39. 47°C
41. 218
43. 8.57 J
45. No
47. a. 48 m b. 32%
49. 37%
51. a. 5.0 kW b. 1.7
53. a.

	W_s (J)	Q (J)	ΔE_{th}
1 → 2	3.04	16.97	13.93
2 → 3	0	−10.13	−10.13
3 → 1	−1.52	−5.32	−3.80
Net	1.52	1.52	0

    b. 9.0% c. 13 W
55. a.

	W_s (kJ)	Q (kJ)	ΔE_{th} (kJ)
1 → 2	0.991	2.476	1.486
2 → 3	0	−1.693	−1.693
3 → 1	−0.207	0	0.207
Net	0.783	0.783	0

    b. 0.32
57. a. $p_1 = 100$ kPa $V_1 = 2690$ cm^3 $T_1 = 269$ K
    b.

	ΔE_{th} (J)	W_s (J)	Q (J)
1 → 2	327	−327	0
2 → 3	0	553	553
3 → 1	−327	−131	−458
Net	0	95	95

    c. 17%
59. a.

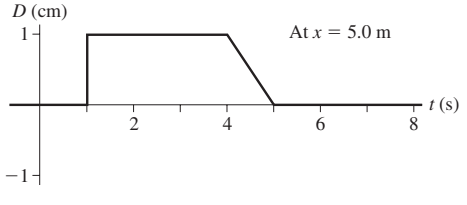
	p (atm)	T (K)	V (cm^3)
1	1.0	406	1000
2	5.0	2030	1000
3	1.0	2030	5000

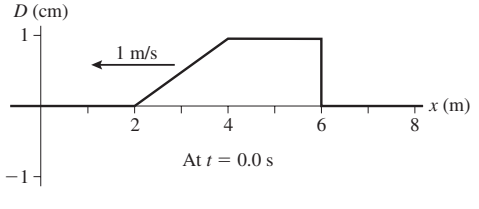
    b. 29% c. 80%
61. a. $T_1 = 1620$ K $T_2 = 2407$ K $T_3 = 6479$ K
    b.

	ΔE_{th} (J)	W_s (J)	Q (J)
1 → 2	327	−327	0
2 → 3	1692	677	2369
3 → 1	−2019	0	−2019
Net	0	350	350

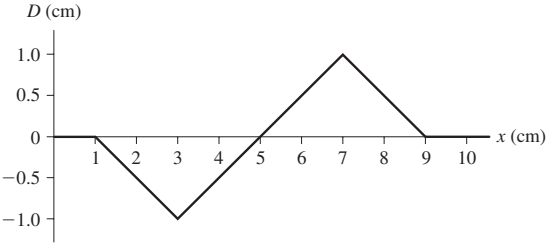
    c. 15%
63. a. $W_{net} = 350$ J b. $\eta = 0.24$
65. b. 1.1×10^{3}°C
67. b. $Q_C = 80$ J
69. b. 10 J c. 0.13

Chapter 20

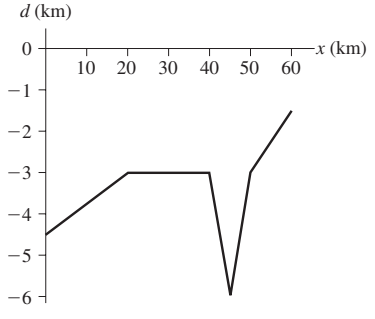
1. 110 N
3. 2.0 m
5. 

7. 

9. Equilibrium
$t = 0$ s



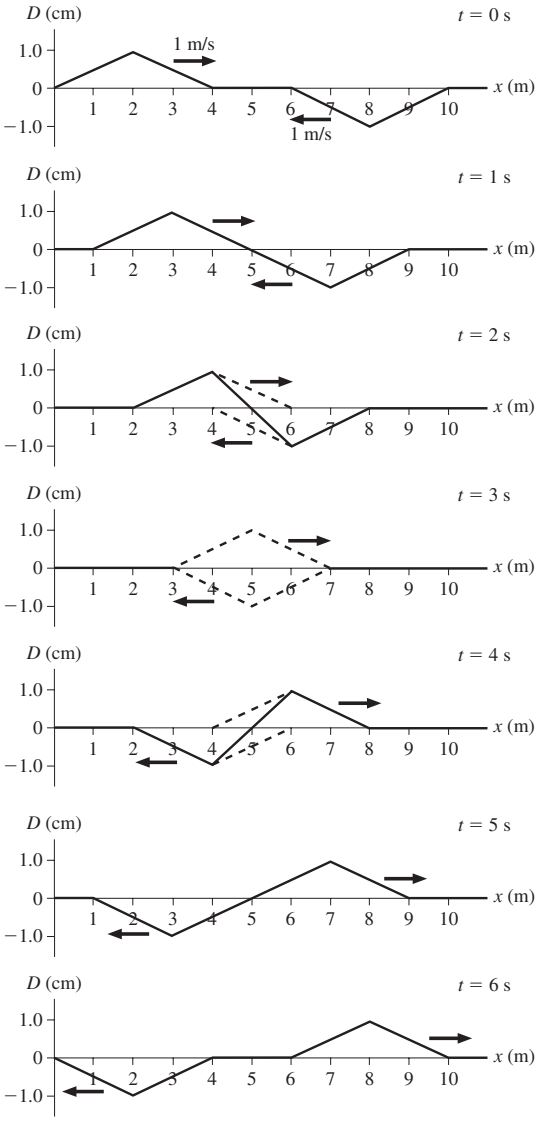
11. a. 3.1 rad/m b. 9.5 m/s
13. a. 11 Hz b. 1.1 m c. 13 m/s
15. $\frac{\pi}{2}$ rad, $\frac{3}{2}\pi$ rad
17. 2.5 m
19. 1500 m/s
21. a. 1.5 GHz b. 990 nm
23. a. 2.96 m b. 116 Hz
25. a. 1.5×10^{-11} s b. 3.4 mm
27. a. 1.88×10^{8} m/s b. 4.48×10^{14} Hz
29. 6.0×10^{5} J
31. 110 dB
33. a. 65 dB b. 105 dB
35. 5.0 W
37. a. 650 Hz b. 560 Hz
39. 38.1 m/s
41. a. 0.80 m b. $\frac{1}{2}\pi$ rad
c. $D(x, t) = (2.0 \text{ mm})\sin(2.5\pi x - 10\pi t + \frac{1}{2}\pi)$
43. $\frac{v_0}{2}$
45.



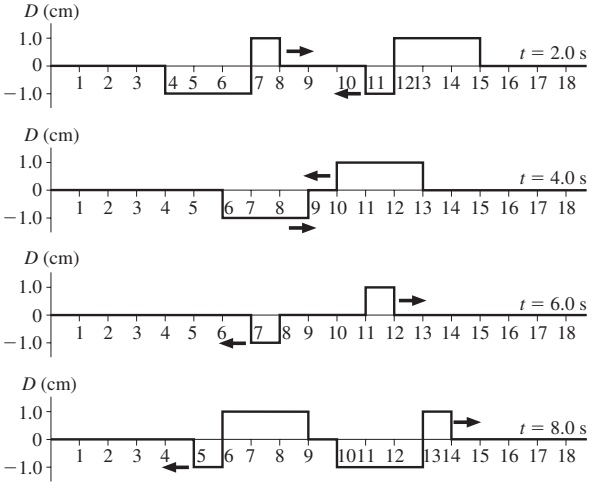
47. 410 ms
49. a. 440 Hz b. 3.4 m
51. a. $-y$-direction b. y-axis c. 0.701 m, 350 m/s, 2.00 ms
53. a. 12.6 N b. 2.00 cm c. 12.8 m/s
55. $D(x, t) = (0.010 \text{ mm})\sin[(\pi \text{ rad/m})x - (400\pi \text{ rad/s})t + \frac{1}{2}\pi \text{ rad}]$
57. −19 m/s, 0 m/s, 19 m/s
59. 8
61. 9.4 m/s
63. a. 0.095 W/m^2 b. 1.6 MW/m^2
65. a. 6.67×10^{4} W b. 8.5×10^{10} W/m^2
67. 50 m
69. 1.3
71. 21 min
75. Receding at 1.5×10^{6} m/s
77. 0.07°C
81. 29 s

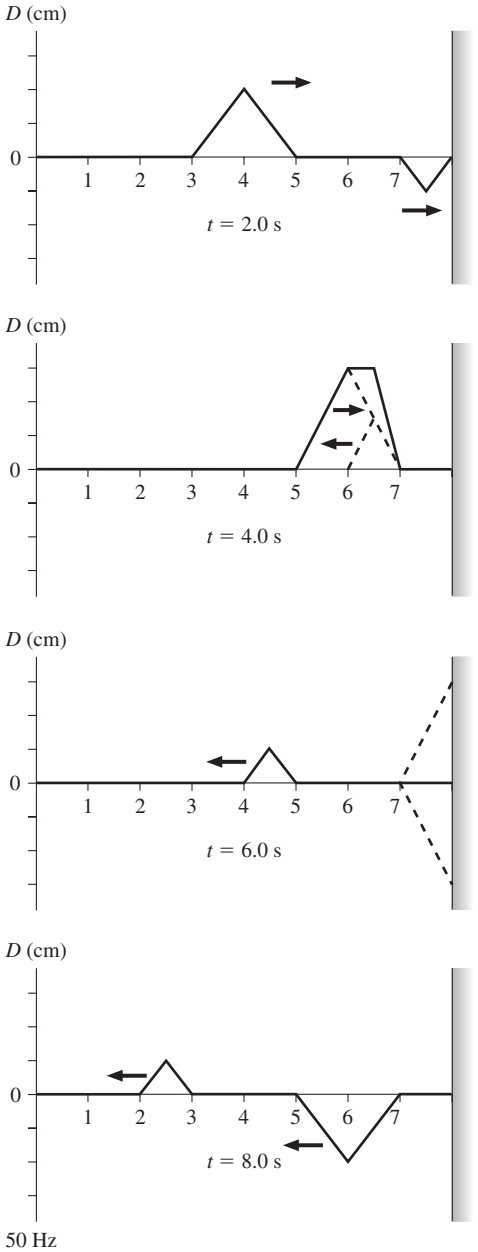
Chapter 21

1.



3.



5. 

7. 50 Hz
9. a. 4.8 m, 2.4 m, 1.6 m b. 75 Hz
11. 12 kg
13. a. 2.42 m, 1.21 m, 0.807 m b. 4.84 m, 1.61 m, 0.968 m
15. 512 Hz
17. 2180 N
19. a. 80 cm b. 100 cm
21. 216 nm
23. a. In phase
    b.

	r_1	r_2	Δr	C/D
P	3λ	4λ	λ	C
Q	$\frac{7}{2}\lambda$	2λ	$\frac{3}{2}\lambda$	D
R	$\frac{5}{2}\lambda$	$\frac{7}{2}\lambda$	λ	C

25. Perfect destructive
27. 203 Hz
29. 1.26 cm
31. $A(x = 10\text{ cm}) = 0.62$ cm, $A(x = 20\text{ cm}) = 1.18$ cm, $A(x = 30\text{ cm}) = 1.62$ cm, $A(x = 40\text{ cm}) = 1.90$ cm, $A(x = 50\text{ cm}) = 2.00$ cm
33. 1.4 cm
35. 180 Hz
37. 28.4 cm
39. 18 cm
41. 140 N/m
43. 6.1 cm
45. $9\mu_0/4$
47. 13.0 cm
49. 580 Hz, 4.9 kHz
51. 12.1 kHz
53. 450 N
55. 93 m
57. 7.9 cm
59. a. 850 Hz b. $-\pi/2$ rad
61. 7.2 cm
63. 20
65. 170 Hz
67. 1/3
69. a. a b. 1.0 m c. 9
71. a. 5 b. 4.6 mm
73. 7.0 m/s
75. 4.0 cm, 35 cm, 65 cm
77. 2.0 kg
79. a. $\lambda_1 = 20.0$ m, $\lambda_2 = 10.0$ m, $\lambda_3 = 6.67$ m
    b. $v_1 = 5.59$ m/s, $v_2 = 3.95$ m/s, $v_3 = 3.22$ m/s
    d. $T_1 = 3.58$ s, $T_2 = 2.53$ s, $T_3 = 2.07$ s

Chapter 22

1. 0.023 rad = 1.3°
3. 1000 nm
5. 0.36 mm
7. 0.286°
9. 1.6°, 3.2°
11. 530
13. 7.9 μm
15. 0.20 mm
17. 0.50 mm
19. 4.0 mm
21. 7.6 m
23. 0.015 rad = 0.87°
25. 0.25 mm
27. 400 nm
29. 0.2895 mm
31. a. Single slit b. 0.15 mm
33. 1.67 m
35. 3 mW/m^2
37. 12.0 μm
39. 667.8 nm
41. 25 cm
43. 3
45. a. 1230 lines/mm b. 46.5°
47. 670 lines/mm
49. 16°
51. 800 lines/mm
53. a. 2 b. 1.15 c. 1
55. 670 nm
57. 0.12 mm
59. a. 550 nm b. 0.40 mm
61. 50 cm

63. a. 22.3° b. 16.6°
65. 19
67. a. Dark b. 1.597
69. a. No b. 0.044° c. 4.6 mm d. 1.5 m
71. b. 0.022°, 0.058°
73. b. −11.5°, −53.1°
75. a. 0.52 mm b. 0.074° c. 1.3 m

Chapter 23

1. a. 3.3 ns b. 75 cm, 67 cm, 46 cm
3. 0.40 ns
5. 30°
7. 6.1 m
9. 433 cm
11. 16°
13. 1.39
15. 76.7°
17. 3.2 cm
19. 1.52
21. 1.48
23. 1600 nm
25. 6.0 cm behind the lens, inverted
27. 7.5 cm in front of the lens, upright
29. 68 cm
31. 200 cm
33. 36 cm
35. 40 cm in front of mirror, inverted
37. 12 cm behind mirror, upright
39. a. 3 b. B(+1.0 m, −2.0 m), C(−1.0 m, +2.0 m), D(+1.0 m, +2.0 m)
41. 10 m
43. 1.7
45. a. 87 cm b. 65 cm c. 43 cm
47. 4.0 m
49. a. Total internal reflection b. Refraction at 72° c. 18 cm
51. 1.58
53. 1.0°
55. 2.00
57. b. −15 cm, 1.5 cm, agree
59. b. 50 cm, 0.67 cm, agree
61. b. −20 cm, 0.33 cm, agree
63. 15.1 cm
65. −15 cm, 0.75 cm, behind, upright
67. Concave, 3.6 cm
69. 67 cm, 1.0 m
71. a. 5.9 cm b. 6.0 cm
73. 16 cm
75. 13 cm
79. a. $t = \frac{n_1}{c}\sqrt{x^2 + a^2} + \frac{n_2}{c}\sqrt{(w-x)^2 + b^2}$

    b. $0 = \frac{n_1 x}{c\sqrt{x^2 + a^2}} - \frac{n_2(w-x)}{c\sqrt{(w-x)^2 + b^2}}$
81. b. 1.574

Chapter 24

1. b. $s_2' = 49$ cm, $h_2' = 4.6$ cm
3. b. $s_2' = 30$ cm, $h_2' = 6.0$ cm
5. b. $s_2' = -3.33$ cm, $h_2' = 0.66$ cm
7. 5.0
9. 3.0 mm
11. 6.0 mm
13. a. Myopia b. 100 cm
15. 6.3 cm
17. 5.0 cm
19. 6.0 mm
21. a. 8.0 cm b. 1.2 cm
23. Upright image, 1.0 cm tall, 6.4 cm to left of the second lens
25. a. Both images 2.0 cm tall; one upright 10 cm left of lens, the other inverted 20 cm to right of lens.
27. a. $f_2 + f_1$ b. $\frac{f_2}{|f_1|}w_1$
29. 16 cm placed 80 cm from screen
31. 23 cm
33. 5.0 cm
35. a. +3.0 D as objective b. −1.5 c. 0.56 m
37. 4.6 mm
39. 15 km
41. a. 3.8 cm b. Sun is too bright
43. 3.5 m
45. b. $\Delta n_2 = \frac{1}{2}\Delta n_1$ c. Crown converging, flint diverging d. 4.18 cm

Chapter 25

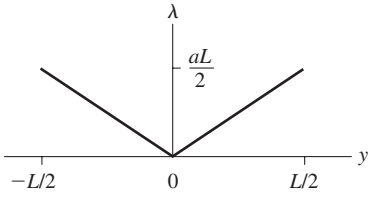
1. a. Electrons added b. 7.5×10^{10}
3. 2.5×10^{10}
5. 1.9×10^{5}
9. Right negatively charged, left positively charged
13. a. 0.056 N b. 2.9
15. a. 58 N b. 4.7×10^{-35} N c. 1.2×10^{36}
17. $-(4.1 \times 10^{-4}\ \text{N})\hat{j}$
19. a. 1.3×10^{14} m/s^2 toward bead b. 2.4×10^{17} m/s^2 away from bead
21. a. $(6.4\hat{i} + 1.6\hat{j}) \times 10^{-17}$ N

    b. $-(6.4\hat{i} + 1.6\hat{j}) \times 10^{-17}$ N c. 4.0×10^{10} m/s^2 d. 7.3×10^{13} m/s^2
23. $-4.5 \times 10^{4}\,\hat{r}$ N/C (i.e., toward the bead)
25. 3.3×10^{6} N/C, downward
27. $-6.8 \times 10^{4}\hat{i}$ N/C, $3.0 \times 10^{4}\hat{i}$ N/C, $(8.1 \times 10^{3}\,\hat{i} - 3.9 \times 10^{4}\hat{j})$ N/C
29. a. 0.36 m/s^2 toward glass bead b. 0.18 m/s^2 toward plastic bead
31. 82 nC
33. 3.1×10^{-4} N, upward
35. 4.3×10^{-3} N, 253° ccw
37. 2.0×10^{-4} N, 45° cw
39. $-1.0 \times 10^{-3}\hat{i}$ N
41. $(1.02 \times 10^{-5}\hat{i} + 2.2 \times 10^{-5}\hat{j})$ N
43. 0.68 nC
45. $(F_{\text{net}})_x = \frac{-2KQqa}{(a^2 + y^2)^{3/2}}$
47. $(2 - \sqrt{2})\frac{KQq}{L^2}$
49. $-\frac{4}{9}q$, $x = \frac{1}{3}L$
51. 6.6×10^{15} rev/s
53. a. 2.3×10^{-6} b. 4.3×10^{7} N/C, upward
55. 33 nC
57. a. 1.1×10^{18} m/s^2 b. 1.0×10^{-12} N c. 6.3×10^{6} N/C d. 69 nC
59. 0.75 μC
61. 1.8×10^{5} N/C, 60° ccw from the $+x$-axis; 1.8×10^{5} N/C, 60° cw from the $-x$-axis
63. a. (4.0 cm, 1.0 cm) b. (0.0 cm, 2.0 cm) c. (−2.0 cm, −2.0 cm)
65. a. $\vec{E}_1 = (8.5\hat{i} - 2.8\hat{j})$ kN/C, $\vec{E}_2 = 10\,\hat{i}$ kN/C,
    $\vec{E}_3 = (8.5\hat{i} + 2.8\hat{j})$ kN/C c. $27\hat{i}$ kN/C
67. 14°
69. b. 22 nC
71. b. 5.1 nC

73. 0.11 μC
75. 1.7×10^{-4} N

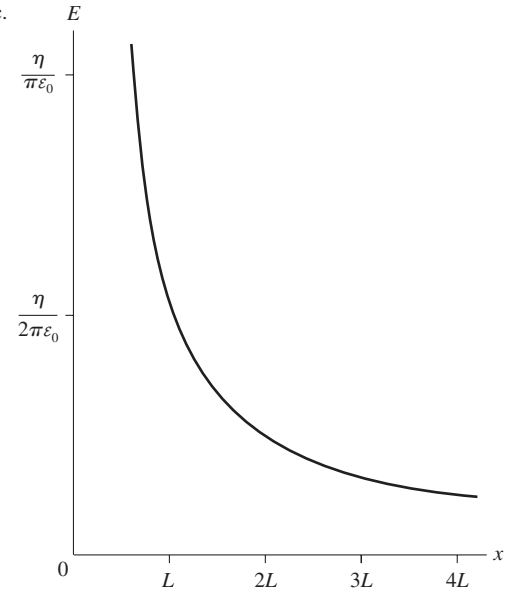
Chapter 26

1. 7.6×10^3 N/C along the $+x$-axis
3. 1.0×10^4 N/C at 11° below the $+x$-axis
5. a. 36 N/C b. 18 N/C
7. 4000 N/C
9. 1.3×10^5 N/C, 0.0 N/C, 1.3×10^5 N/C
11. a. 2.6×10^4 N/C, left b. 2.6×10^{-5} N, right
13. a. 7.6×10^4 N/C, left b. 7.6×10^{-5} N, right
15. 27 nC
17. 1.9 cm
19. 2.7×10^{11}
21. a. 3.6×10^6 N/Cb. 8.3×10^5 m/s
23. 18 cm
25. 3.1×10^{-21} N m
27. 9.0×10^{-13} N$\vec{p}$
29. a. $(-9.7 \times 10^4\hat{\imath} + 9.2 \times 10^4\hat{\jmath})$ N/C
    b. 1.34×10^5 N/C, 136°ccw from the $+x$-axis
31. $\dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{L^2}(\sqrt{2}-1)(\hat{\imath}+\hat{\jmath})$
33. a. $\dfrac{2qx}{4\pi\epsilon_0(x^2+s^2/4)^{3/2}}$
    b. 0 N/C, 768,000 N/C, 576,000 N/C, 358,000 N/C, 158,000 N/C
35. a. $\dfrac{2q}{4\pi\epsilon_0}\left[\dfrac{1}{x^2}-\dfrac{x}{(x^2+d^2)^{3/2}}\right]\hat{\imath}$
37. $\dfrac{1}{4\pi\epsilon_0}\dfrac{8\lambda d}{4y^2+d^2}$
39. −0.056 nC
41. $\dfrac{Q}{4\pi\epsilon_0}\dfrac{1}{x\sqrt{x^2+L^2}}\hat{\imath} - \dfrac{Q}{4\pi\epsilon_0 Lx}\left(1-\dfrac{x}{\sqrt{x^2+L^2}}\right)\hat{\jmath}$
43. a. $\dfrac{R}{\sqrt{2}}$ b. $\dfrac{2}{3\sqrt{3}}\dfrac{Q}{4\pi\epsilon_0 R^2}$
45. c. $\dfrac{1}{4\pi\epsilon_0}\dfrac{2Q}{\pi R^2}(\hat{\imath}+\hat{\jmath})$
47. 1.41×10^5 N/C
49. 2.2 mm
51. 1.19×10^7 m/s
53. a. $\dfrac{\frac{4}{3}\pi r^3\rho g + qE}{6\pi\eta r}$ b. 0.067 mm/s c. 0.049 mm/s
55. 6.56×10^{15} Hz
57. a. $\dfrac{\text{C}^2\,\text{s}^2}{\text{kg}}$ b. $\left(\dfrac{1}{4\pi\epsilon_0}\right)^2\dfrac{2q^2\alpha}{r^5}$, toward ion
59. b. 1.0 mm
61. b. $\dfrac{R}{\sqrt{3}}$
63. 4.2×10^{-4} N
65. a.



    b. $\dfrac{4Q}{L^2}$ c. $\dfrac{8Q}{4\pi\epsilon_0 L^2}\left[1-\dfrac{x}{\sqrt{x^2+L^2/4}}\right]$
67. a. $\dfrac{2\eta}{4\pi\epsilon_0}\ln\left(\dfrac{2x+L}{2x-L}\right)\hat{\imath}$

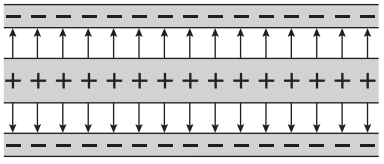
    c.

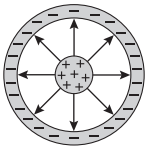


69. −2.3 nC/m
71. a. $k = \dfrac{qQ}{4\pi\epsilon_0 R^3}$ c. 2.0×10^{12} Hz

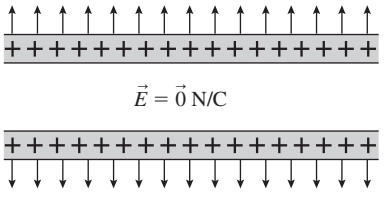
Chapter 27

1.





3.

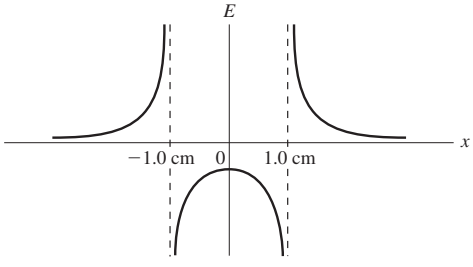


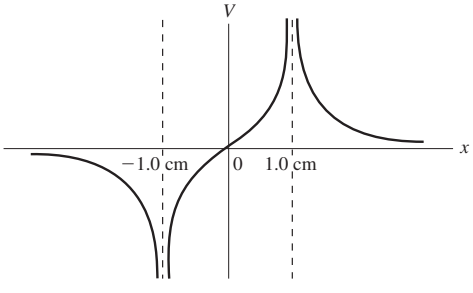
5. No charge
7. Into the front face of the cube; field strength must exceed 5 N/C
9. 1.0 N m^2/C
11. 1.4×10^3 N/C
13. a. 0.0 N m^2/C b. 3.0×10^{-2} N m^2/C
15. 3.5×10^{-4} N m^2/C
19. $+2q$, $+q$, $-3q$
21. 0.11 kN m^2/C
23. −1.00 N m^2/C
25. 2.7×10^{-5} C/m^2
27. a. $\vec{E} = (25\hat{k})$ kN/C, upward from the plate
    b. 0.0 N/C c. 2.5 kN/C, downward from the plate
29. a. −0.39 N m^2/C, 0.23 N m^2/C, 0.39 N m^2/C, −0.23 N m^2/C b. 0 N m^2/C
31. a. −3.5 N m^2/C b. 1.2 N m^2/C
33. 0.19 kN m^2/C
35. a. 2.0 kN/C b. 0.25 kN m^2/C c. 2.2 nC
37. a. −100 nC b. +50 nC

39. a. 2.4×10^{-6} C/m^3
    b. 1 nC, 10 nC, 80 nC c. 5 kN/C, 9.0 kN/C, 1.8×10^4 N/C
41. -4.51×10^5 C
43. 2.5×10^4 N/C, outward; 0 N/C; 7.9×10^3 N/C, outward
45. $\vec{0}$ N/C, $\dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{r^2}\hat{r}$
47. $\vec{0}$ N/C, $(\eta/2\epsilon_0)\hat{j}$, $-(\eta/2\epsilon_0)\hat{j}$, $\vec{0}$ N/C
49. $(\eta/2\epsilon_0)\hat{j}$, $\vec{0}$ N/C, $(\eta/2\epsilon_0)\hat{j}$, $-(\eta/2\epsilon_0)\hat{j}$
51. a. $\dfrac{\lambda}{2\pi\epsilon_0}\dfrac{\vec{r}}{r}$ b. $\dfrac{3\lambda}{2\pi\epsilon_0}\dfrac{\vec{r}}{r}$
53. a. $\dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{r^2}\hat{r}$ b. $\vec{E} = \vec{0}$ c. $\dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{r^2}\left(\dfrac{r^3 - R_{\text{in}}^3}{R_{\text{out}}^3 - R_{\text{in}}^3}\right)\hat{r}$
55. a. $\dfrac{\lambda L^2 dy}{4\pi\epsilon_0\left[y^2 + (L/2^2)\right]}$ b. $\lambda L/(4\epsilon_0)Q_{\text{in}}/\epsilon_0$
57. a. $C = \dfrac{Q}{4\pi R}$ b. $\dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{Rr}\hat{r}$ c. Yes
59. a. $\dfrac{Q}{4\pi\epsilon_0 R^2}$ b. $\dfrac{3Qr^3}{2\pi R^6}$

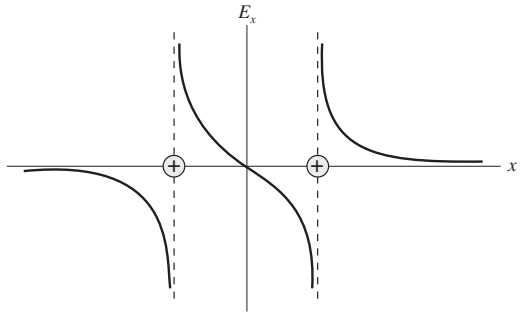
Chapter 28

1. 1.4×10^5 m/s
3. 2.1×10^6 m/s
5. -2.2×10^{-19} J
7. 4.8×10^{-6} J
9. a. $-1.0\ \mu$J b. $1.0\ \mu$J
11. 1.87×10^7 m/s
13. -8.4×10^4 V
15. a. Lower b. -0.712 V
17. a. 1.5 V b. 2.1×10^{-11} C
19. a. 200 V b. 6.3×10^{-9} C
21. a. 1800 V, 1800 V, 900 V b. 0 V, -900 V
23. a. 27 V b. 4.3×10^{-18} J
25. -1600 V
27. a. $\pm\infty$ b. 0, $\pm\infty$
    c.

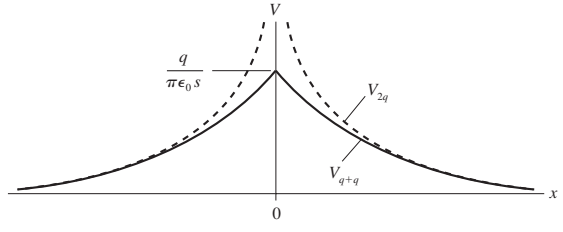




29. a. Positive, positive b. 1
    c.



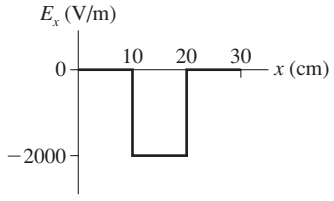
31. 1.4×10^{-3} N
33. a. +103 V b. 5.40×10^4 V/m
35. ± 12 cm
37. 0.49 m/s
39. a. 1.1×10^{-20} J b. 2×10^{21} ions
41. 54 kHz
43. a. 2.1×10^6 V/m b. 9.4×10^7 m/s
45. a. 0.85 m b. 2.6 m
47. 8.0×10^7 m/s
49. -5.1×10^{-19} J
51. 310 nC
53. 6.8 fm
55. a. Yes c. 8.21×10^8 m/s
57. a. 2.1×10^{-10} C, 3.0 kV/m, 15 V b. 2.1×10^{-10} C, 3.0 kV/m, 30 V
    c. 2.1×10^{-10} C, 0.75 kV/m, 3.8 V
59. a. $\dfrac{V_0}{R}$ b. 100 kV/m
61. a. $8.3\ \mu$C b. 3.3×10^6 V/m
63. 2.1 kV, b is higher
65. a. $\dfrac{2q}{4\pi\epsilon_0 x}\dfrac{1}{\sqrt{1 + s^2/4x^2}}$
    b.

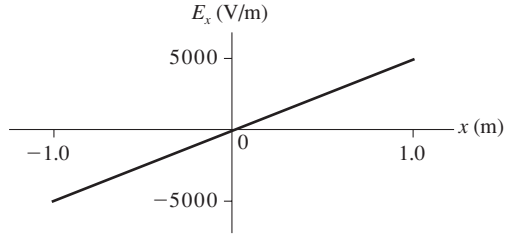


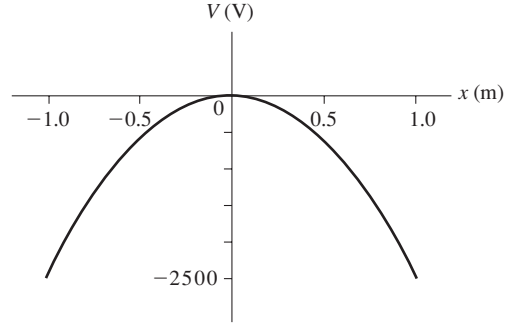
67. $(Q/4\pi\epsilon_0 L)\ln\left[(x + L/2)/(x - L/2)\right]$
69. $Q/4\pi\epsilon_0 R$
71. b. q_1 and q_2 are 10 nC and 30 nC
73. b. 6.0 cm
75. $v_A = 0.018$ m/s, $v_B = 0.011$ m/s
79. a. $\dfrac{1}{4\pi\epsilon_0}\dfrac{q}{R}dq$ b. $\dfrac{1}{4\pi\epsilon_0}\dfrac{Q^2}{2R}$ c. 2.3×10^{-13} J
81. $\dfrac{3Q}{8\pi\epsilon_0 R^3}\left(R\sqrt{R^2 + z^2} + \ln\left(\dfrac{|z|}{R + \sqrt{R^2 + z^2}}\right)\right)$

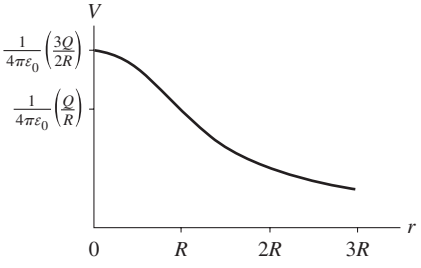
Chapter 29

1. -200 V
3. -0.30 kV
5. 1.5×10^{-6} J
7. 3.0 C
9. $-(20\hat{j})$ kV/m

11. 

13. −1.0 kV/m
15. a. 27 V/m b. 3.7 V/m
17. a. 13 pF b. 1.3 nC
19. 3.0 V
21. 32 μF
23. 150 μF, in series
25. 1.4 kV
27. 1/2
29. a. 1.1×10^{-7} J b. 0.71 J/m^3
31. a. 62 pC, 9.0 V, 29 kV/m b. 20 pC, 9.0 V, 90 kV/m
33. a. A b. −70 V
35. a. 



b. $V(x) = -(2500\,x^2)$ V
37. a. $\vec{E} = -(1.4 \times 10^7 \hat{i})$ V/m, $V = 7 \times 10^4$ V
b. $E = 0.0$ V/m, $V = 1.4 \times 10^5$ V
c. $\vec{E} = 1.4 \times 10^7 \hat{i}$ V/m, $V = 7 \times 10^4$ V
39. $\vec{E}_{\text{disk}}(z) = \dfrac{Q}{2\pi\epsilon_0 R^2}\left[1 - \dfrac{z}{\sqrt{R^2 + z^2}}\right]\hat{k}$
41. Point 1: 3750 V/m, downward; point 2: 7500 V/m, upward
43. 1000 V/m, 127° ccw from the $+x$-axis
45. $Q_{1f} = 2$ nC, $Q_{2f} = 4$ nC
47. 1.1 nC
49. a. $\pm$32pC, 9.0 V b. $\pm$16pC, 9.0 V
51. 7.5 μF
53. 5.0 V, 15 V, 10 V
55. $Q_1 = 45\ \mu$C, $V_1 = 9$ V; $Q_2 = 22\ \mu$C $V_2 = 5.4$ V; and $Q_3 = 22\ \mu$C, $V_3 = 3.6$ V
57. a. $\dfrac{3}{2}C$ b. 0 V
59. $Q_1 = 0.83$ mC, $Q_2 = Q_3 = 0.67$ mC, $\Delta V_1 = 55$ V, $\Delta V_2 = 34$ V, $\Delta V_3 = 22$ V
61. $Q_1 = 33\ \mu$C, $Q_2 = 67\ \mu$C, $\Delta V_1' = \Delta V_2' = 3.3$ V
63. a. 5.7×10^{-7} J b. 11.4×10^{-7} J
c. Work was done on the capacitor.
65. 0.85 kV
67. 0.13 F
69. 2.4×10^{-14} J
73. b. $(10 - z^2)$ V, with z in meters
75. b. 2 μF
77. a. $V = \dfrac{q}{4\pi\epsilon_0}\left[\dfrac{1}{\sqrt{x^2 + (y - s/2)^2}} - \dfrac{1}{\sqrt{x^2 + (y + s/2)^2}}\right]$
b. $V = \dfrac{qsy}{4\pi\epsilon_0(x^2 + y^2)^{3/2}}$
c. $E_x = \dfrac{qs(3xy)}{4\pi\epsilon_0(x^2 + y^2)^{5/2}}$, $E_y = \dfrac{qs(2y^2 - x^2)}{4\pi\epsilon_0(x^2 + y^2)^{5/2}}$
d. $\vec{E}_{\text{on-axis}} = \dfrac{2p}{4\pi\epsilon_0 r^3}\hat{j}$, yes
e. $E_{\text{bisecting axis}} = -\dfrac{p}{4\pi\epsilon_0 r^3}\hat{j}$, yes
79. a. $V_r = \dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{R}\left[\dfrac{3}{2} - \dfrac{r^2}{2R^2}\right]$ b. 3/2
c. 

81. a. $\dfrac{2\pi\epsilon_0}{\ln(R_2/R_1)}$ b. 31 pF/m

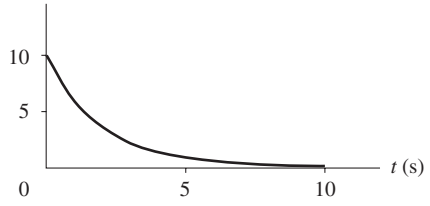
Chapter 30

1. 3.0 d
3. 7.6×10^{26} electrons
5. 0.023 V/m
7. 1.0×10^{19} s^{-1}
9. a. 0.80 A b. 7.0×10^7 A/m^2
11. 130 C
13. 1.88×10^{22}
15. 2.6 mA
17. a. 6.3×10^5 A/m^2 b. 6.5×10^{-5} m/s
19. 1.68 A
21. $5.0 \times 10^{-8}\ \Omega$ m
23. a. 1.64×10^{-3} V/m b. 1.10×10^{-5} m/s
25. Tungsten
27. $\dfrac{1}{2}$
29. Tungsten
31. a. 30 m b. 1.0 A
33. 4100 Ω
35. 380
37. 0.64 mm
39. Yes, $2.2 \times 10^5\ \Omega^{-1}\text{m}^{-1}$
41. a. 75 nA b. 130 s
43. a. 6.6×10^{15} Hz b. 1.05×10^{-3} A
45. a. 120 C b. 0.45 mm
47. 1.4 Ω m
49. 0.50 mm

51. a. $E = \dfrac{I}{4\pi\sigma r^2}$ b. $E_{\text{inner}} = 3.3 \times 10^{-4}$ V/m, $E_{\text{outer}} = 5.3 \times 10^{-5}$ N/C

53. a. $I(t) = (10\text{ A})e^{-t/2.0\text{ s}}$ b. 10 A

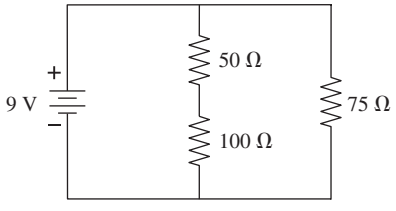
c. I (A)



55. 2.0 A, 5.0×10^{-5} m/s
57. 7.2 mm
59. 0.16 V/m
61. $2R$
63. a. 4.2×10^5 A b. Decrease c. 1.1×10^{-5} J
65. 1.8×10^8 A/m^2
67. a. 2.5 C b. 1.8 cm
69. 1.01×10^{23}
71. a. 9.4×10^{15} b. 115 A/m^2
73. a. $\eta = \dfrac{\epsilon_0 I}{A}\left(\dfrac{1}{\sigma_2} - \dfrac{1}{\sigma_1}\right)$ b. 3.7×10^{-18} C

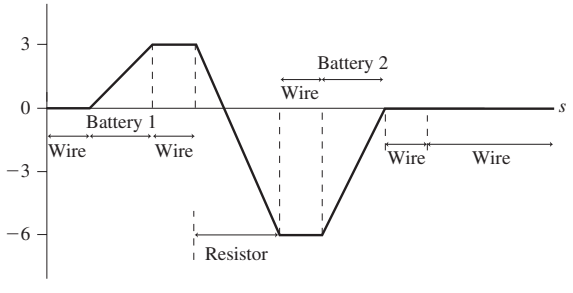
Chapter 31

1.



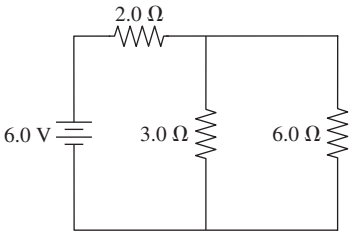
3. 1 A to left
5. a. 0.9 A ccw

b. V (V)



7. 9.60 Ω, 12.5 A
9. 60 W bulb is brighter
11. a. 11.6 A b. 10.4 Ω
13. 75 Ω
15. a. 0.65 Ω b. 3.5 W
17. 3.2%
19. 240 Ω
21. 40 Ω
23. 183 Ω
25. 9 V, 1 V
29. 2 ms
31. a. 36 μC, 0.36 A b. 22 μC, 0.22 A c. 4.9 μC, 49 mA
33. 18 μF
35. D
37. 93 W

39.



41. 7 Ω
43. 60 V, 10 Ω
45. 9.0 V, 0.50 Ω
47. 1.8 V
49. 1.0 A, 2.0 A, 15 V
51. \$65 for the incandescent bulb, \$20 for the fluorescent tube
53. a. 0.231 A b. 0.214 S c. 7.4%
55. 900 Ω
57. a. 0.505 Ω b. 0.500 Ω
59.

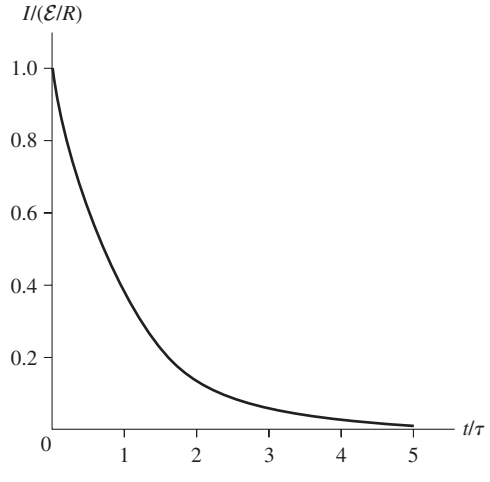
Resistor	Potential difference (V)	Current (A)
3 Ω	6.0	2.0
4 Ω	6.0	1.5
48 Ω	6.0	0.125
16 Ω	6.0	0.375

61.

Resistor	Potential difference (V)	Current (A)
24 Ω	6.00	0.25
3 Ω	3.00	1.00
5 Ω	3.75	0.75
4 Ω	2.25	0.56
12 Ω	2.25	0.19

63. 9/25 A, left to right
65. 150 V, bottom
67. 0.41 A, left to right
69. a. 65 kΩ b. 87 V
71. 73 Ω
73. a. $\mathcal{E}$ b. $C\mathcal{E}$ c. $+dQ/dt$

d. $\left(\dfrac{\mathcal{E}}{R}\right)e^{-t/\tau}$



75. 2.0 m, 0.49 mm
77. 20 V
79. a. $\mathcal{E}^2C$ b. $\mathcal{E}^2C/2$ c. $\mathcal{E}^2C/2$ d. Yes
81. 0.60 A

Chapter 32

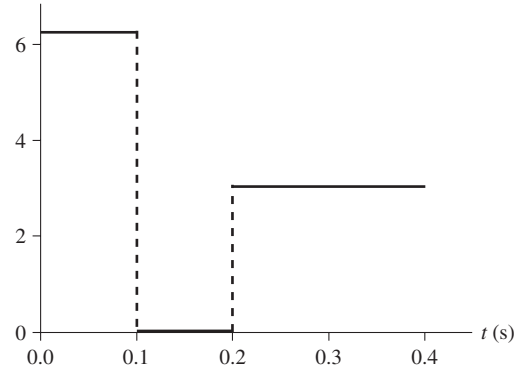
1. $\vec{B}_1 = (2.0\text{ mT, into the page})$, $\vec{B}_2 = (4.0\text{ mT, into the page})$
3. a. 0 T b. $1.60 \times 10^{-15}\hat{k}$ T c. $-4.0 \times 10^{-16}\hat{k}$ T
5. $-1.13 \times 10^{-15}\hat{k}$ T
7. 6.3×10^6 m/s in the $+z$-direction
9. 4.0 cm, 0.40 mm, 20 μm to 2.0 μm, 0.20 μm
11. a. 20 A b. 1.6×10^{-3} m
13. $2.0 \times 10^{-4}\hat{\imath}$ T, $4.0 \times 10^{-4}\hat{\imath}$ T, $2.0 \times 10^{-4}\hat{\imath}$ T
15. a. 0.025 A m^2 b. 1.5 μT
17. 1.4 cm
19. 0.071 T m
21. 7.00 A
23. 1.26×10^{-6} T m
25. 1.0 mm
27. a. $8.0 \times 10^{-13}\hat{\jmath}$ N b. $5.7 \times 10^{-13}(-\hat{\jmath} - \hat{k})$ N
29. 1.6×10^{-3} T
31. 81 mT
33. 0.131 T, out of page
35. 3.0 Ω
37. 7.5×10^{-4} N m
39. a. 1.26×10^{-11} N m b. Rotated by $\pm 90°$
41. 0.040 μA
43. (5.2×10^{-5} T, out of page), $\vec{0}$ T
45. $0.77R$
47. (7.9×10^{-5} T, into page)
49. #18, 4.1 A
51. a. 1.13×10^{10} A b. 0.014 A/m^2 c. 1.3×10^6 A/m^2
53. a. 5.7×10^{-6} A b. 2.9×10^{-8} A m^2
55. $\dfrac{\mu_0 I}{4R}$
57. 0; $\dfrac{\mu_0 I}{2\pi r}\left(\dfrac{r^2 - R_1^2}{R_2^2 - R_1^2}\right)$; $\dfrac{\mu_0 I}{2\pi r}$
59. 1.50 mT, 30° ccw from the $+x$-axis
61. 2.9×10^{-3} T
63. 2.4×10^{10} m/s^2, up
65.

	Ion	Accelerating voltage (V)
a.	O_2^+	96.793
b.	N_2^+	110.25
c.	CO^+	110.29

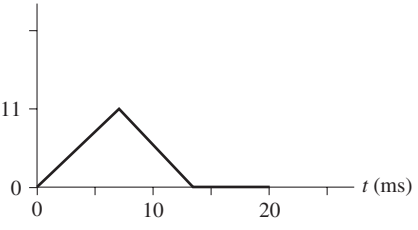
67. 0.12 T
69. 87 mT
71. a. $\dfrac{\mu g \tan\theta}{I}$, down b. 11 mT, down
73. 13 T
75. a. $2\pi RIB \sin\theta$ b. 4.3×10^{-3} N
77. a. $\dfrac{\mu_0 IL}{4\pi d\sqrt{(L/2)^2 + d^2}}$ b. $\dfrac{\sqrt{2}\mu_0 I}{\pi R}$ c. 0.900
79. a. $\dfrac{3I}{2\pi R^2}$ b. $\dfrac{\mu_0}{2\pi}\dfrac{Ir^2}{R^3}$ c. Yes
81. a. Horizontal and to the left above the sheet; horizontal and to the right below the sheet b. $\frac{1}{2}\mu_0 J_s$

Chapter 33

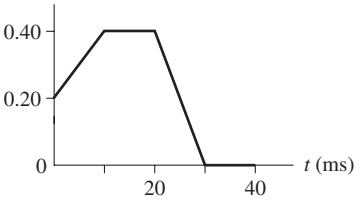
1. 2.0×10^4 m/s
3. a. 1.0 N b. 2.2 T
5. 6.3×10^{-5} Wb in both cases
7. Decreasing
9. Clockwise current
11. a. 3.9 mV, 20 mA, ccw b. 3.9 mV, 20 mA, ccw c. No current
13. 1.6 V
15. E ($\times 10^{-4}$ V/m)



17. a. 4.8×10^4 m/s^2, up b. 0 c. 4.8×10^4 m/s^2, down d. 9.6×10^4 m/s^2, down
19. 1.0 ms
21. 9.5×10^{-5} J
23. 250 kHz to 360 kHz
25. 750 Ω
27. 3.5×10^{-4} Wb
29. 1.6 A, 0.0 A, −1.6 A
31. 8.7 T/s
33. a. −0.0050 V b. 0.0100 V
35. 44 μA
37. a. 0 μA b. 160 μA c. 0 μA
39. a. 0.0 A b. 79 μA
41. a. 0.93 V b. 0 V
43. a. 12 500 b. 2.0 A
45. a. I (A)



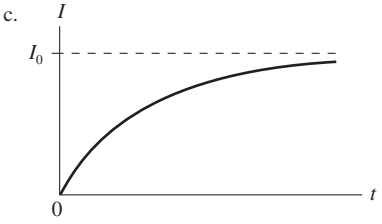
b. 11 A when halfway in
47. a. 4.0 V b. 100 A c. 3.0 V
49. a. $(4.9 \times 10^{-3})f \sin(2\pi ft)$ A b. 4.1×10^2 Hz, not feasible
51. 0.28 T
53. a. $(vlB\cos\theta)/R$ b. $(mgR\tan\theta)/l^2B^2\cos\theta$
55. 2.5×10^{-4} V
57. 12 V
59. $(R^2/2r)/(dB/dt)$
61. a. 3.9×10^{-4} J/m^3 b. 3.1 A
63. 3.0 s
65. I (A)



67. a. $\Delta V_L = \left(\dfrac{LI_0}{\tau}\right)e^{-t/\tau}$ b. 0.37 V
69. 1.0 μF
71. 0.50 m
73. a. 76 mA b. 0.50 ms

75. a. 0.50 A b. 1.0 A
77. a. $\Delta V_{bat}/R$ b. $I = I_0(1 - e^{-t/(L/R)})$
79. $(\mu v_0 I/2\pi)\ln[(d + l)/d]$
81. a. 0.10 s b. $2.93\left(\dfrac{(0.10)^2 - 2[0.0707 + (0.293)t]^2}{\sqrt{(0.10)^2 - [0.0707 + (0.293)t]^2}}\right)$ A

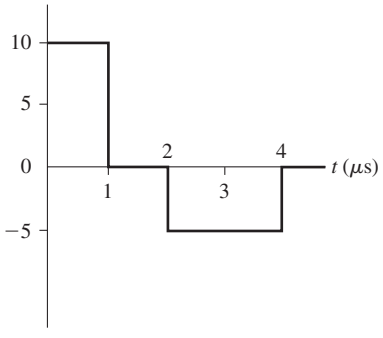
c.



83. a. 32 A b. 1.3 m/s
85. a. $(\mu_0/2\pi)\ln(r_2/r_1)$ b. 0.36 μH/m

Chapter 34

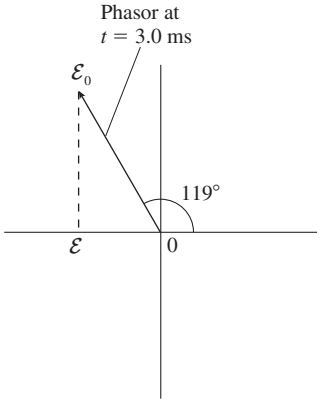
1. a. $(2.0 \times 10^6$ m/s, 45° from the y-axis) 45°
   b. $(1.47 \times 10^6$ m/s, 16.2° from the y'-axis) 16.2°
3. $-1.0 \times 10^6 \hat{k}$ V/m, $-1.11 \times 10^{-5} \hat{\jmath}$ T
5. 16.3° above the $+x$-axis
9. 1.0 μF
11. 17 μA
13. 3.3×10^{-8} T
15. a. 10.0 nm b. 3.00×10^{16} Hz c. 6.67×10^{-8} T
17. a. 3.33×10^{-7} T b. 13.3 W/m^2
19. 980 V/m, 3.3 μT
21. a. 2.2×10^{-6} W/m^2 b. 0.041 V/m
23. 3.3×10^{-6} N
25. 60°
27. 30°
29. $(1.73 \times 10^6$ V/m, left)
31. a. (0.10 T, into page) b. 0 V/m, (0.10 T, into page)
33. 1.0 $\times 10^7$ m/s parallel to the current
35. a. 0.94 V/m b. 10 T
37. b. 1.5×10^{-13} A
39. I_{disp} (A)



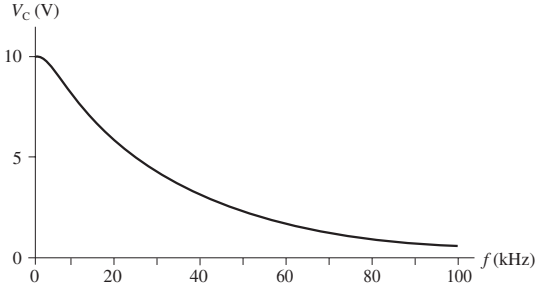
41. 20 V
43. b. 6.67×10^{-6} J/m^3
45. a. 3.85×10^{26} W b. 589 W/m^2
47. a. (1/2)f b. (3/4)f
49. Yes
51. 1.8×10^7 V/m
53. 1.3 m
55. 4.9×10^7 W/m^2
57. 8.8 h
59. $(-6.0 \times 10^5\ \hat{\imath} + 1.0 \times 10^5\ \hat{\jmath})$ V/m
61. 5.2 μV/m
63. a. $E = IR/L$, $B = \dfrac{\mu_0 I}{2\pi r} IR/L$ b. $(I^2R/2\pi rL$, radially inward)

Chapter 35

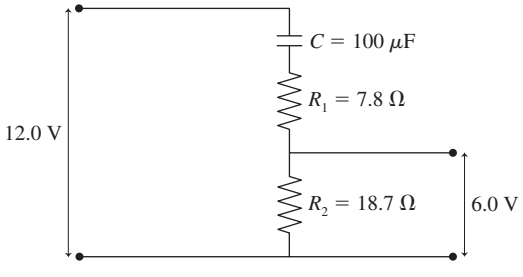
1. a. 22×10^2 rad/s b. −10 V
3.



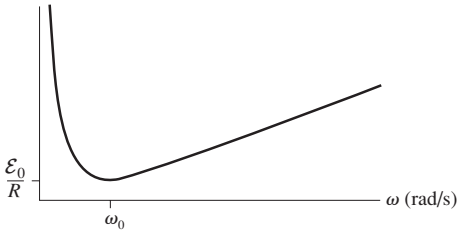
5. a. 50 mA b. 50 mA
7. a. 1.9 mA b. 1.9 A
9. a. 80 Hz b. 0 V
11. a. 95 pF b. 660 μA
13. 1.6 μF
15. $V_R = 6.0$ V, $V_C = 8.0$ V
17. a. 1000 Hz b. 2.24 V, 3.53 V, 4.47 V
19. a. 0.80 A b. 0.80 mA
21. a. 3.2×10^4 Hz b. 0 V
23. a. 200 kHz b. 141 kHz
25. 1.3 μF
27. a. 70 Ω, 72 mA, −44° b. 50 Ω, 0.10 A, 0° c. 62 Ω, 80 mA, 37°
29. 9.6 Ω
31. 30°
33. 44 Ω
35. a. $(\sqrt{3}RC)^{-1}$ b. $\sqrt{3}\mathcal{E}_0/2$
37. a. 9.95 V, 9.57 V, 7.05 V, 3.15 V, 0.990 V
    b. V_C (V)



43. 44 Hz
45. a. 50 Hz b. 4.8 μF
47. a. $\mathcal{E}_0/\sqrt{R^2 + \omega^2L^2}$, $\mathcal{E}_0 R/\sqrt{R^2 + \omega^2L^2}$, $\mathcal{E}_0\omega L/\sqrt{R^2 + \omega^2L^2}$
    b. $V_R \to \mathcal{E}_0$, $V_R \to 0$ c. Low pass d. R/L
49. a. 69 V b. 24° c. 0.17 kW
51. a. 5.0×10^3 Hz b. 10 V, 32 V
53. 0.17 A
55. a. 3.6 V b. 3.5 V c. −3.6 V
59. a. 11.6 pF b. 1.49×10^{-3} Ω
61. 14 W in 40 W bulb, 9.6 W in 60 W bulb, 100 W in 100 W bulb
65.



67. a. 0.44 kA b. 1.8×10^{-4} F c. 7.4 MW
69. b. 10 V, 12 V
71. b. ∞, ∞ c. $1/\sqrt{LC}$
d. I (A)



Chapter 36

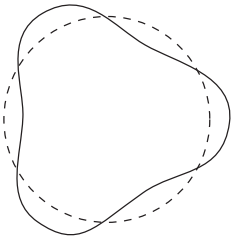
1. $x_1' = 5.0$ m at $t = 1.0$ s, $x_2' = -5.0$ m at $t = 5.0$ s
3. $v_{\text{sound}} = 345$ m/s, $v_{\text{sprinter}} = 15$ m/s
5. a. 13 m/s b. 3.0 m/s c. 9.4 m/s
7. 3.0×10^8 m/s
9. 167 ns
11. 2.0 μs
13. No, bolt 2 hits 20 μs before bolt 1.
15. Yes
17. 0.866c
19. a. 0.9965c b. 59.8 ly
21. 46 m/s
23. Yes
25. 4600 kg/m^3
27. 3.0×10^6 m/s
29. $x = 8.3 \times 10^{10}$ m, $t = 330$ s
31. 0.36c
33. 0.71c
35. 0.80c
37. 0.707c
39. a. 1.8×10^{16} J b. 9.0×10^9
41. 0.943c
43. $u_{50\text{ final}} = 1.33$ m/s to the right, $u_{100\text{ final}} = 3.33$ m/s to the right
45. 11.2 h
47. a. No b. 67.1 y
49. a. 0.80c b. 16 y
51. 0.78 m
53. a. 17 y b. 15 y c. Both
55. 0.96c
57. 3.1×10^6 V
59. a. 0.98c b. 8.5×10^{-11} J
61. b. Lengths perpendicular to the motion are not affected.
63. a. $u_y' = u_y/\gamma\left(1 - u_x v/c^2\right)$ b. 0.877c
65. a. 3.5×10^{-18} kg m/s, 1.1×10^{-9} J b. 1.6×10^{-18} kg m/s
67. a. 7.6×10^{16} J b. 0.84 kg
69. 7.5×10^{13} J
71. 1 pm
73. 22 m
75. 0.85c

Chapter 37

1. a. $(m, n) = (2, 3), (2, 4), (2, 5), (2, 6)$ b. 397.1 nm
3. 121.6 nm, 102.6 nm, 97.3 nm, 95.0 nm
5. a. 9.39×10^4°C b. 694°C
7. 2.4 μm
9. a. 6.0×10^7 m/s b. 17 cm
11. a. 2.4×10^{-16} kg b. 1.3×10^{-18} C c. 8
13. 1.33×10^{19} C
15. a. 3.7×10^7 m/s b. 2.7×10^7 m/s c. Electron
17. a. 10 keV b. 0.14 MeV c. 1.2×10^{19} eV
19. a. 3 electrons, 3 protons, 3 neutrons
    b. 7 electrons, 8 protons, 8 neutrons
    c. 5 electrons, 7 protons, 6 neutrons
21. a. ^{11}B b. ^{14}C$^+$
23. a. 79 electrons, 79 protons, 118 neutrons
    b. 2.29×10^{17} kg/m^3
    c. 2.01×10^{13}
25. a. 6660 MeV b. 3.6 MeV
27. a. 0.512 MeV b. 939 MeV
29. 173 MeV
31. 46 mT, into the page
33. 1.2 μA
35. 0.000000000058% contains mass, 99.999999999942% empty space
37. a. 5.0×10^4 kg/m^3
    b. 1.7×10^{-29} m^3, 1.6×10^{-10} m
    c. 1.7×10^{17} kg/m^3, 6.2×10^{13}
39. a. 58 N b. 4.7×10^{-35} N
41. Aluminum
43. a. 2.3×10^7 m/s b. 2.9 MeV
45. 2.52×10^5 m/s, 65.1° below $+x$-axis
47. a. mg/E_0 b. mg/b d. 2.4×10^{18} C e. 15

Chapter 38

1. 6.25×10^{13} electrons/s
3. 3.20 eV
5. 1.78 eV
7. a. 2.26 eV b. 0.166 nm
9. a. 1.86×10^{-6} eV b. 2.76 eV c. 27.6 keV
11. 497 nm
13. 1×10^{19} photons/s
15. 6.0×10^{-6} V
17. a. 1.1×10^{-34} m b. 1.7×10^{-23} m/s
19. 6
21. 0.427 nm
23. a. Yes b. 0.50 eV
25. $n = 2$: yes; $n = 3$: no
27. 1.90 nm
29. a. 0.332 nm, 0.665 nm, 0.997 nm
c.

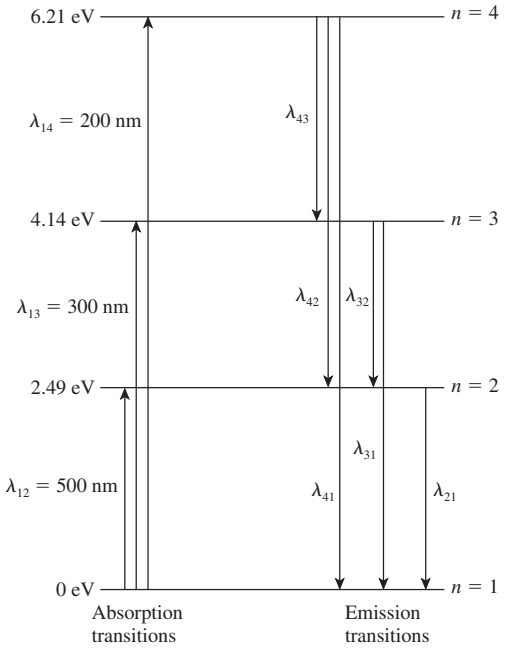


33. 97.26 nm
35.

n	r_n (nm)	v_n (m/s)	E_n (eV)
1	0.026	4.38×10^6	−54.4
2	0.106	2.19×10^6	−13.6
3	0.238	1.46×10^6	−6.0

37. 1.24 V
39. 4.3×10^{-10} W
41. a. 2.3 eV b. 244 nm
43. a. 4.14 eV b. 6.4×10^{-34} J s
45. a. Potassium b. 4.24×10^{-15} eV s
47. 2.0×10^{-18} m, no
49. 200 m/s
51. 0.35 nm

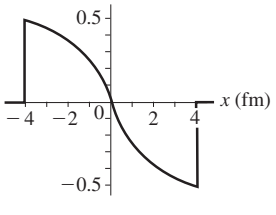
53. 18 fm
55. a.



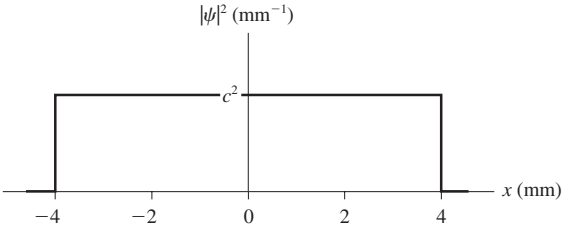
b. 200 nm, 300 nm, 334 nm, 500 nm, 601 nm, 753 nm
57. 6.2×10^5 m/s
59. 410.3 nm, 434.2 nm, 486.3 nm, 656.5 nm
61. a. 0.362 m b. 0.000368 nm
63. $3 \rightarrow 2$:10.28 nm, $4 \rightarrow 2$:7.62 nm, $5 \rightarrow 2$: 6.80 nm; all ultraviolet
65. a. 2.06×10^6 m/s b. 12.09 V
67. a. 1.0 m/s b. 3.2° c. 1.1 cm
69. b. 25.7 nm, 36.3 nm, 44.5 nm, 51.4 nm c. $n(\pi\hbar f_{cyc})$

Chapter 39

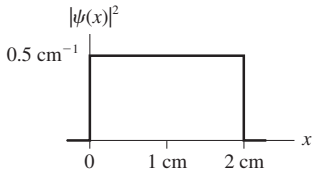
1. $P_C = 0.20$, $P_D = 0.10$
3. a. 7.7% b. 25%
5. a. 1/6 b. 1/6 c. 5/18
7. 100 V/m
9. 4.0 m^{-1}
11. a. 3300 b. 1100
13. a. 5.0×10^{-3} b. 2.5×10^{-3} c. 0 d. 2.5×10^{-3}
15. a. 0.25 fm^{-1} b.



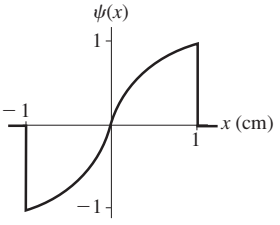
c. 0.75
17. a. 0.354 $mm^{-1/2}$
b.



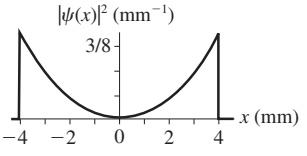
c. 0.25
19. 25 ns
21. 1.0×10^5
23. -0.65×10^{-36} m/s $\leq v_x \leq 0.65 \times 10^{-36}$ m/s
25. 0.0 m/s $\leq v_x \leq 2.5 \times 10^7$ m/s
27. 9.5 GHz $\leq f \leq$ 10.5 GHz
29. 1.0×10^5 pulses/s
31. a.



b. 1% c. 10^4 d. 0.5 cm^{-1}
33. a. Yes b.

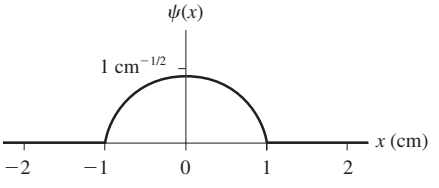


c. 0.000, 0.00050, 0.0010 d. 900
35. a. $\sqrt{3/8}$ $mm^{-1/2}$
b.

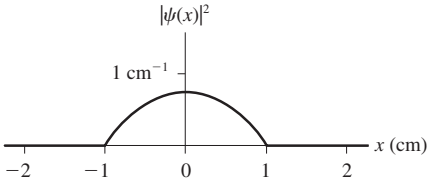


c.

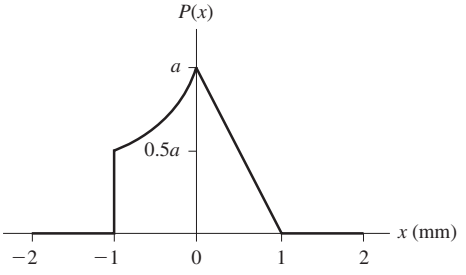
d. 0.13
37. a. 0.27% b. 32%
39. a. 0.87 $cm^{-1/2}$
b.



c.

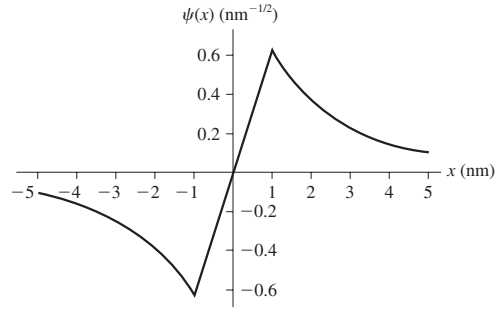


d. 3.4×10^3
41. a. $a = b$ b. $a = b = 0.84$
c.

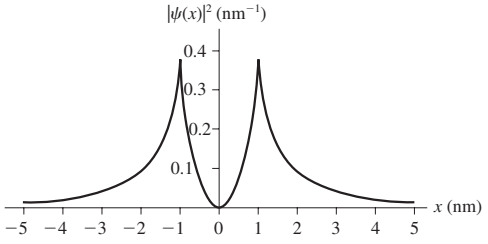


d. 58.1%

43. 18 μm
45. a. 0 m/s to 1.8×10^{10} m/s
    b. The speed in part a exceeds the speed of light, so it is impossible.
47. a. 1.5×10^{-13} m b. 4.4×10^{11} m
49. 50%
51. a. $c = \sqrt{3/8}$
    b.



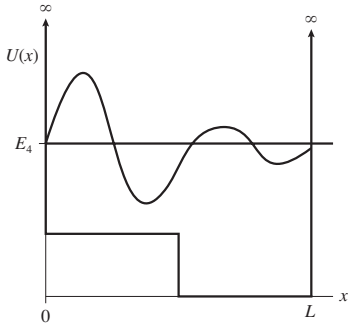
    c.



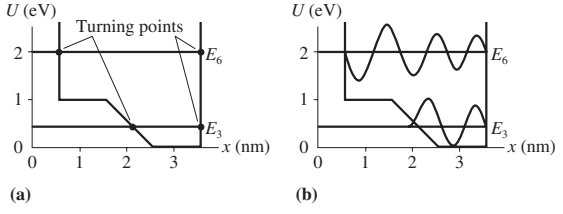
    d. 2.5×10^5

Chapter 40

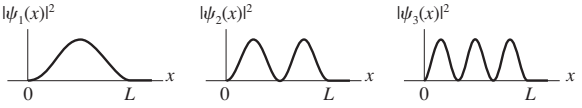
1. 0.739 nm
3. 1.0 nm
7. a. 0.159 nm b. 0.159 nm c. 0.275 nm
9. 0.38 nm
11.



13.

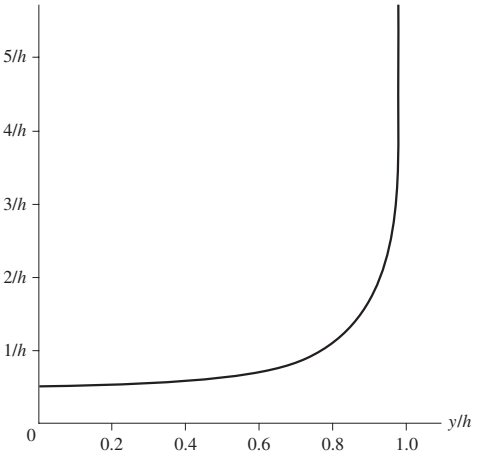


15. 200 nm
17. 519 nm
19. 1.4 N/m
21. a. 4.95 eV b. 4.80 eV c. 4.55 eV
25. a. $\lambda_{2\to1} = 8mcL^2/3h$ b. 0.795 nm
29. a.

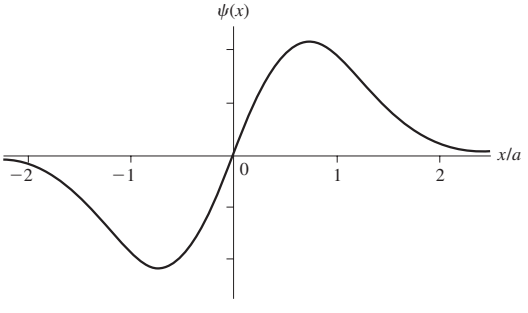


$n =$	1	2	3
b. Most likely	$\frac{1}{2}L$	$\frac{1}{4}L, \frac{3}{4}L$	$\frac{1}{6}L, \frac{3}{6}L, \frac{5}{6}L$
c. Least likely	$0, L$	$0, \frac{1}{2}L, L$	$0, \frac{1}{3}L, \frac{2}{3}L, L$
d. Prob in left $\frac{1}{3}$ from graph	$> \frac{1}{3}$	$> \frac{1}{3}$	$\frac{1}{3}$
e. Prob in left $\frac{1}{3}$ calculated	0.195	0.402	0.333

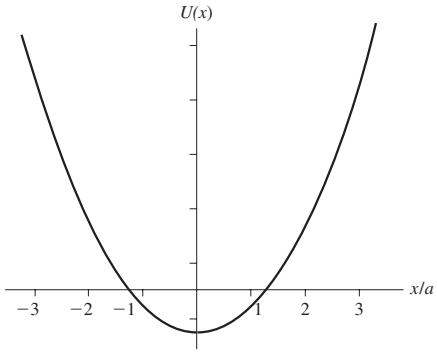
31. 10%
35. a. $A_1 = \dfrac{1}{(\pi b^2)^{1/4}}$ b. $\text{Prob}(x < -b \text{ or } x > b) = \dfrac{2}{\sqrt{\pi b^2}} \displaystyle\int_b^\infty e^{-x^2/b^2} dx$
    c. 15.7%
37. a. $P_{\text{class}}(x) = \dfrac{1}{2h\sqrt{1 - (y/h)}}$
    b. $P_{\text{class}}(y)$



39. 10^{-463}
41. a. 0.136 nm b. One atomic diameter
43. a.



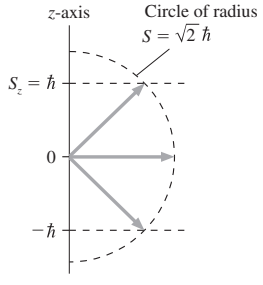
b. $\pm a/\sqrt{2}$ c. $U(x) = \dfrac{2\hbar^2}{ma^2}\left(\left(\dfrac{x}{a}\right)^2 - \dfrac{3}{2}\right)$



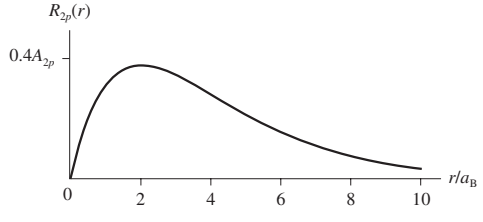
45. a. 3.4×10^{-5} b. 2.8 c. 0.005 nm

Chapter 41

1. a. 0 b. $\sqrt{12}\hbar$
3. a. f b. −0.85 eV
5. −0.378 eV; $\sqrt{12}\hbar$
7. a. 2 b. 1
9. $1s^2 2s^2 2p^6 3s^2 3p$, $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p$, $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p$
11. a. Excited state of Ne b. Ground state of Ti
13. $1s^2 3s$
15. a. Yes, 2.21 μm b. No
17. a. 5.6×10^5 b. 1.7×10^5 c. 3.0×10^3
19. a. 9.0×10^5 b. 8.7 ns
21. $3.2 \times 10^{15}\ \text{s}^{-1}$
23. a. 1.06 μm b. 1.9 W
25. a. $\sqrt{2}\hbar$ b. −1, 0, 1
    c.

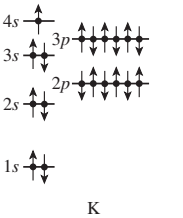


27. a. $\sqrt{2}\hbar$ b. $\sqrt{6}\hbar$
29. a. 3.7×10^{-3} b. 5.4×10^{-3} c. 2.9×10^{-3}
33. a. $R_{2p}(r) = \dfrac{A_{2p}}{2a_B} r e^{-r/2a_B}$

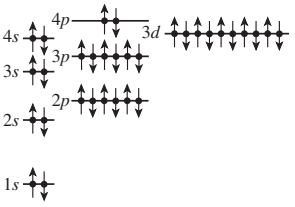


b. $2a_B$

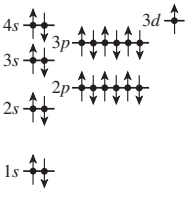
35.



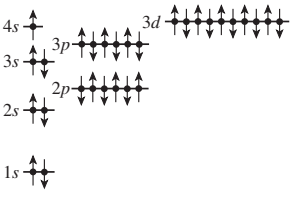
K
$(1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1)$



Ge
$(1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^2)$



Sc
$(1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d)$



Cu
$(1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s\ 3d^{10})$

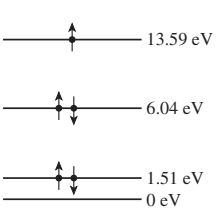
37. a.

Transition	$6s \rightarrow 5p$	$6s \rightarrow 4p$	$6s \rightarrow 3p$
b. λ(nm)	7290	1630	515

39. 1.13×10^6 m/s
41.

Transition	(a) Wavelength	(b) Type	(c) Absorption
$2p \rightarrow 2s$	670 nm	VIS	Yes
$3s \rightarrow 2p$	816 nm	IR	No
$3p \rightarrow 2s$	324 nm	UV	Yes
$3p \rightarrow 3s$	2696 nm	IR	No
$3d \rightarrow 2p$	611 nm	VIS	No
$3d \rightarrow 3p$	24800 nm	IR	No
$4s \rightarrow 2p$	498 nm	VIS	No
$4s \rightarrow 3p$	2430 nm	IR	No

43. a.



b. 28.7 eV

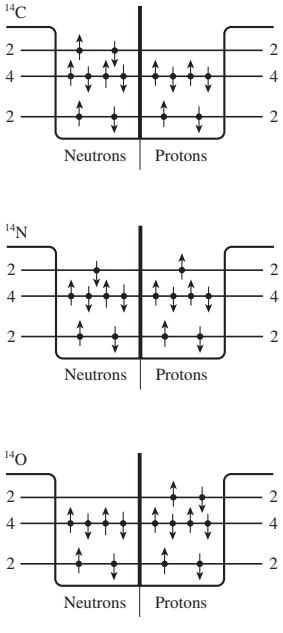
45. a. $6.3 \times 10^8\ \text{s}^{-1}$ b. 0.17 ns
47. a. $\tau \ln 2$ b. 12 ns
49. 5.0×10^{16}
51. b. 0.021 nm
55. $1.5a_B$, $5.0a_B$

57. a. $p_{atom} = 7.0 \times 10^{-23}$ kg m/s; $p_{photon} = -8.5 \times 10^{-28}$ kg m/s
b. 82 000 photons c. 1.2 ms d. -5.7×10^{-20} N, -4.0×10^{5} m/s^2
e. 31 cm

Chapter 42

1.

		Protons	Neutrons
a.	^{3}He	2	1
b.	^{32}P	15	17
c.	^{32}S	16	16
d.	^{238}U	92	146

3. a. 3.8 fm b. 8.2 fm c. 14.5 fm
5. a. $m = 9.988 \times 10^{-27}$ kg; $r = 2.2 \times 10^{-15}$ m; $\rho = 2.3 \times 10^{17}$ kg/m^3
b. $m = 3.437 \times 10^{-25}$ kg; $r = 7.1 \times 10^{-15}$ m; $\rho = 2.3 \times 10^{17}$ kg/m^3
7. a. ^{36}S and ^{36}Ar b. 5, 8
9. ^{54}Cr: 474 MeV, 8.78 MeV; ^{54}Fe: 472 MeV, 8.74 MeV
11. ^{14}O = 7.05 MeV; ^{16}O = 7.98 MeV; ^{16}O is more tightly bound
13. 8000 N
15. 2.3×10^{-38}
17. a. 

b. ^{14}N is stable; ^{14}C undergoes beta-minus decay and ^{14}O undergoes beta-plus decay

19. a. 236 μg b. 140 μg c. 0.775 μg
21. 4.6×10^{9}
23. 80 d
25. a. ^{228}Th b. ^{207}Tl c. ^{7}Li d. ^{60}Ni
27. a. ^{19}O, ^{19}F, ^{19}Ne b. ^{19}F
c. ^{19}O decays by β^- to ^{19}F; ^{19}Ne decays by β^+ to ^{19}F
29. ^{228}Th
31. 5.51 MeV
33. 0.225 J
35. 60 mrem
37. a. 3.5×10^{7} m/s b. 25 MeV
39. a. 12.7 km b. 780 μs
41. a. 1.46×10^{-8} u, 1.45×10^{-6}% b. 0.0304 u, 0.76%
43. 6.0 MeV
45. 0.93 MeV
47. 2.7×10^{17}
49. a. 19 s b. No
51. 1.2 h
53. 210 million years
55. 3.3×10^{12}
57. a. 2.6×10^{7} b. 0.024 Bq c. 1.9×10^{5} mSv
d. Yes, many times more than the background radiation
59. 15 cm
61. $\approx$ 6 billion years ago
63. a. $K_{in} = 65.0$ MeV; $K_{out} = 5.0$ MeV b. 3.7×10^{21} collisions/s
c. 6.6×10^{-39} d. 650 million years

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