Halliday, Resnick, and Walker *Fundamentals of Physics 10e* Problem Answers
Volume 2

Chapter 21 Answers

1	0.500
2	0.375
3	1.39 m
4	0.50 C
5	2.81 N
6	(a) 4.9×10^{-7} kg; (b) 7.1×10^{-11} C
7	-4.00
8	0.375
9	(a) -1.00 μC; (b) 3.00 μC
10	(a) -2.83; (b) no
11	(a) 0.17 N; (b) –0.046 N
12	(a) –83 μC; (b) 55 μC
13	(a) -14 cm; (b) 0
14	(a) 9.0; (b) –25
15	(a) 35 N; (b) -10°; (c) -8.4 cm; (d) +2.7 cm
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	3.8×10^{-8} C
22	(a) 1.92 cm; (b) less than

23	(a) 0; (b) 12 cm; (c) 0; (d) 4.9×10^{-26} N
24	(a) 8.99×10^{-19} N; (b) 625
25	6.3×10^{11}
26	2.89×10^{-9} N
27	(a) 3.2×10^{-19} C; (b) 2
28	2.25×10^{20}
29	(a) -6.05 cm; (b) 6.05 cm
30	(a) 2.00 cm; (b) 9.21×10^{-24} N
31	122 mA
32	+13*e*
33	1.3×10^{7} C
34	(a) 0.654 rad; (b) 0.889 rad; (c) 0.988 rad
35	(a) 0; (b) 1.9×10^{-9} N
36	(a) positron; (b) electron
37	(a) ^{9}B; (b) ^{13}N; (c) ^{12}C
38	+16*e*
39	1.31×10^{-22} N
40	-2.25
41	(a) 5.7×10^{13} C; (b) cancels out; (c) 6.0×10^{5} kg
42	(b) 2.4×10^{-8} C
43	(b) 3.1 cm
44	11.9 cm
45	0.19 MC
46	(a) $(3.52 \times 10^{-25}$ N)$\hat{\imath}$; (b) 0
47	-45 μC
48	(a) 3.60 μN; (b) 2.70 μN; (c) 3.60 μN

49	3.8 N
50	(a) $(L/2)(1 + kqQ/Wh^2)$; (b) $(3kqQ/W)^{0.5}$
51	(a) 2.00×10^{10} electrons; (b) 1.33×10^{10} electrons
52	$-11.1\ \mu$C
53	(a) 8.99×10^9 N; (b) 8.99 kN
54	9.0 kN
55	(a) 0.5; (b) 0.15; (c) 0.85
56	(a) 1.25×10^{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	1.7×10^8 N
58	(a) $(89.9\ \text{N})\hat{\text{i}}$; (b) $(-2.50\ \text{N})\hat{\text{i}}$; (c) 68.3 cm; (d) 0
59	-1.32×10^{13} C
60	0
61	(a) $(0.829\ \text{N})\hat{\text{i}}$; (b) $(-0.621\ \text{N})\hat{\text{j}}$
62	(a) 6.16×10^{-24} N; (b) 208°
63	2.2×10^{-6} kg
64	1.2×10^{-5} C
65	4.68×10^{-19} N
66	-5.1 m
67	(a) $2.72L$; (b) 0
68	10^{18} N
69	(a) 5.1×10^2 N; (b) 7.7×10^{28} m/s^2
70	0.707
71	(a) 0; (b) 3.43×10^9 m/s^2
72	1.6 nm

73	(a) 2.19×10^6 m/s; (b) 1.09×10^6 m/s; (c) decrease
74	1.3 days
75	4.16×10^{42}

Chapter 22 Answers

1	---
2	(a) 6.4×10^{-18} N; (b) 20 N/C
3	(a) 3.07×10^{21} N/C (b) outward
4	$(-6.39 \times 10^5 \text{ N/C})\hat{i}$
5	56 pC
6	0.111 nC
7	$(1.02 \times 10^5 \text{ N/C})\hat{j}$
8	0
9	(a) 1.38×10^{-10} N/C; (b) 180°
10	(a) 34 cm; (b) 2.2×10^{-8} N/C
11	-30 cm
12	(a) 3.93×10^{-6} N/C; (b) -76.4°
13	(a) 3.60×10^{-6} N/C; (b) 2.55×10^{-6} N/C; (c) 3.60×10^{-4} N/C; (d) 7.09×10^{-7} 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 N/C; (b) 45°
16	(a) 67.8°; (b) -67.8°
17	(a) -90°; (b) +2.0 μC; (c) –1.6 μC
18	$qd^3/4\pi\varepsilon_0 z^5$
19	(a) $qd/4\pi\varepsilon_0 r^3$; (b) –90°
20	0.98
21	---

22	(a) -1.72×10^{-15} C/m; (b) -3.82×10^{-14} C/m^2; (c) -9.56×10^{-15} C/m^2; (d) -1.43×10^{-12} C/m^3
23	0.506
24	(a) 0; (b) 0; (c) 0.707*R*; (d) 3.46×10^{7} N/C
25	(a) 1.62×10^{6} N/C; (b) -45°
26	(a) 20.6 N/C; (b) –90°
27	(a) 23.8 N/C; (b) –90°
28	1.70 cm
29	1.57
30	-4.19*Q*
31	(a) -5.19×10^{-14} C/m; (b) 1.57×10^{-3} N/C; (c) –180°; (d) 1.52×10^{-8} N/C; (e) 1.52×10^{-8} N/C
32	(a) 12.4 N/C; (b) 90°
33	---
34	6.3×10^{3} N/C
35	0.346 m
36	2.4×10^{-16} C
37	28%
38	6.9 cm
39	-5*e*
40	(a) 7.12 cm; (b) 28.5 ns; (c) 0.112
41	(a) 1.5×10^{3} N/C; (b) 2.4×10^{-16} N; (c) up; (d) 1.6×10^{-26} N; (e) 1.5×10^{10}
42	(a) 4.8×10^{-13} N; (b) 4.8×10^{-13} N
43	3.51×10^{15} m/s^2

44	(a) 2.03×10^{-7} N/C; (b) up
45	6.6×10^{-15} N
46	(a) 1.02×10^{-2} N/C; (b) west
47	(a) 1.92×10^{12} m/s^2; (b) 1.96×10^{5} m/s
48	(a) 1.16×10^{16} m/s^2; (b) 3.94×10^{16} m/s^2; (c) 3.97×10^{16} m/s^2; (d) because the net force due to the charged particles near the edge of the disk decreases
49	(a) 0.245 N; (b) -11.3°; (c) 108 m; (d) -21.6 m
50	(a) $(-2.1 \times 10^{13}$ m/s$^2)\hat{j}$; (b) $(1.5 \times 10^{5}$ m/s$)\hat{i} - (2.8 \times 10^{6}$ m/s$)\hat{j}$
51	(a) 2.6×10^{-10} N; (b) 3.1×10^{-8} N; (c) moves to stigma
52	(a) 27 km/s; (b) 50 μm
53	27 μm
54	$(1.53 \times 10^{6}$ m/s$)\hat{i} - (4.34 \times 10^{5}$ m/s$)\hat{j}$
55	(a) 2.7×10^{6} m/s; (b) 1.0 kN/C
56	(a) 0; (b) 8.5×10^{-22} N·m; (c) 0
57	(a) 9.30×10^{-15} C·m; (b) 2.05×10^{-11} J
58	5.0×10^{-28} C·m
59	1.22×10^{-23} J
60	2.5×10^{-28} C·m
61	$(1/2\pi)(pE/I)^{0.5}$
62	(a) 2.46×10^{17} m/s^2; (b) 0.122 ns; (c) 1.83 mm
63	(a) 8.87×10^{-15} N; (b) 120
64	$Q/3\pi\varepsilon_0 d^2$
65	217°
66	3.6×10^{2} N/C

67	61 N/C
68	$(1.08 \times 10^{-5}\ \text{N/C})\hat{\mathbf{i}}$
69	(a) 47 N/C; (b) 27 N/C
70	1.64×10^{-19} C (approx 2% high)
71	38 N/C
72	---
73	(a) -1.0 cm; (b) 0; (c) 10 pC
74	(a) 0.10 μC; (b) 1.3×10^{17}; (c) 5.0×10^{-6}
75	+1.00 μC
76	-3.28×10^{-21} J
77	(a) 6.0 mm; (b) 180°
78	(a) $(2q/4\pi\varepsilon_0 d^2)\alpha/(1 + \alpha^2)^{1.5}$; (c) 0.71; (d) 0.20 and 2.0
79	9:30
80	6.88×10^{-28} C·m
81	(a) -0.029 C; (b) repulsive forces would explode the sphere
82	5.39 N/C
83	(a) -1.49×10^{-26} J; (b) $(-1.98 \times 10^{-26}\ \text{N·m})\hat{\mathbf{k}}$; (c) 3.47×10^{-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) 1.63×10^{-19} C
86	(a) 0°; (b) 9.96 pN
87	(a) $(-1.80\ \text{N/C})\hat{\mathbf{i}}$; (b) $(43.2\ \text{N/C})\hat{\mathbf{i}}$; (c) $(-6.29\ \text{N/C})\hat{\mathbf{i}}$

Chapter 23 Answers

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 nC
7	$2.0 \times 10^5\ \text{N}\cdot\text{m}^2/\text{C}$
8	(a) $-1.3 \times 10^{-8}\ \text{C/m}^3$; (b) 8.2×10^{10} charges/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 nC
12	$(-2.8 \times 10^4\ \text{N/C})\hat{\text{i}}$
13	3.54 μC
14	(a) +1.8 μC; (b) –5.3 μC; (c) +8.9 μC
15	(a) 0; (b) 0.0417
16	2.00 N/C·m
17	(a) 37 μC; (b) $4.1 \times 10^6\ \text{N}\cdot\text{m}^2/\text{C}$
18	$2.0\ \mu\text{C/m}^2$
19	(a) $4.5 \times 10^{-7}\ \text{C/m}^2$; (b) 5.1×10^4 N/C
20	(a) –8.0 μC; (b) +12 μC; (c) –5.3 μC
21	(a) -3.0×10^{-6} C; (b) $+1.3 \times 10^{-5}$ C

22	2.1×10^{17} m/s^2
23	(a) 0.32 μC; (b) 0.14 μC
24	(a) 0; (b) 5.99×10^3 N/C
25	5.0 μC/m
26	–5.8 nC/m
27	3.8×10^{-8} C/m^2
28	(a) 0.24 kN/C; (b) -6.4 nC/m^2; (c) +3.2 nC/m^2
29	(a) 0.214 N/C; (b) inward; (c) 0.855 N/C; (d) outward; (e) -3.40×10^{-12} C; (f) -3.40×10^{-12} C
30	8.0 cm
31	(a) 2.3×10^6 N/C; (b) outward; (c) 4.5×10^5 N/C; (d) inward
32	(a) 1.9 N/C; (b) 3.6 N/C
33	(a) 0; (b) 0; (c) $(-7.91 \times 10^{-11}$ N/C)$\hat{i}$
34	(0.208 N/C)$\hat{k}$
35	-1.5
36	(a) $(2.00 \times 10^{-11}$ N/C)$\hat{j}$; (b) 0; (c) $(-2.00 \times 10^{-11}$ N/C)$\hat{j}$
37	(a) 5.3×10^7 N/C; (b) 60 N/C
38	2.9 μC/m^2
39	5.0 nC/m^2
40	(a) +69.1 cm; (b) –69.1 cm; (c) +69.1 cm
41	0.44 mm
42	4.9×10^{-10} C

43	(a) 0; (b) 1.31 μN/C; (c) 3.08 μN/C; (d) 3.08 μN/C
44	2.2 μC
45	(a) 2.50×10^4 N/C; (b) 1.35×10^4 N/C
46	(a) 0.41R; (b) 0.50R
47	-7.5 nC
48	+6.6 μC
49	(a) 0; (b) 56.2 mN/C; (c) 112 mN/C; (d) 49.9 mN/C; (e) 0; (f) 0; (g) –5.00 fC; (h) 0
50	-3.3 cm
51	1.79×10^{-11} C/m^2
52	(a) 0; (b) 0; (c) 0; (d) 7.32 N/C; (e) 12.1 N/C; (f) 1.35 N/C
53	(a) 7.78 fC; (b) 0; (c) 5.58 mN/C; (d) 22.3 mN/C
54	1.125
55	$6K\varepsilon_0 r^3$
56	(a) 0.50 N·m^2/C; (b) 2.2 pC
57	(a) 0; (b) 2.88×10^4 N/C; (c) 200 N/C
58	7.1 N·m^2/C
59	(a) 5.4 N/C; (b) 6.8 N/C

60	(a) $E = \lvert\rho\rvert r/2\varepsilon_0$; (b) increases; (c) inward; (d) 3×10^6 N/C, at inside pipe surface; (e) yes, along inside pipe surface
61	(a) 0; (b) $q_a/4\pi\varepsilon_0 r^2$; (c) $(q_a + q_b)/4\pi\varepsilon_0 r^2$
62	(a) 4.0×10^6 N/C; (b) 0
63	-1.04 nC
64	---
65	(a) 0.125; (b) 0.500
66	(a) -750 N·m^2/C; (b) -6.64 nC
67	(a) +2.0 nC; (b) –1.2 nC; (c) +1.2 nC; (d) +0.80 nC
68	26.6 nC
69	$(5.65 \times 10^4$ N/C)$\hat{\mathrm{j}}$
70	(a) 4.2 kN/C; (b) 2.4 kN/C
71	(a) -2.53×10^{-2} N·m^2/C; (b) $+2.53 \times 10^{-2}$ N·m^2/C
72	-4.2×10^{-10} C
73	---
74	(a) 3.62 N·m^2/C; (b) 51.1 N·m^2/C
75	3.6 nC
76	(b) $\rho R^2/2\varepsilon_0 r$
77	(a) +4.0 μC; (b) –4.0 μC
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) 0.25*R*; (b) 2.0*R*

Chapter 24 Answers

1	(a) 3.0×10^5 C; (b) 3.6×10^6 J
2	1.2×10^9 eV
3	(a) 3.0×10^{10} J; (b) 7.7×10^3 m/s
4	(a) 2.4×10^4 V/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) 1.87×10^{-21} 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 nC/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	-32*e*
19	(a) 6.0 cm; (b) -12.0 cm
20	none
21	16.3 μV
22	5.6×10^{-37} C·m
23	(a) 24.3 mV; (b) 0
24	-6.20 V
25	(a) -2.30 V; (b) –1.78 V

26	2.18×10^4 V
27	13 kV
28	7.39 mV
29	32.4 mV
30	0
31	47.1 μV
32	(a) 36 V; (b) 18 V
33	18.6 mV
34	6.7×10^2 V/m
35	(-12 V/m)$\hat{\mathrm{i}}$ + (12 V/m)$\hat{\mathrm{j}}$
36	(a) 39 V/m (b) toward
37	150 N/C
38	(a) (2.90 mV) ln(1 + (0.135 m)/d); (b) (0.392 mN·m^2/C)/[x(x + 0.135 m)]; (c) 180°; (d) 32.1 mN/C; (e) 0
39	$(-4.0 \times 10^{-16}\ \mathrm{N})\hat{\mathrm{i}} + (1.6 \times 10^{-16}\ \mathrm{N})\hat{\mathrm{j}}$
40	(a) 31.6 mV; (b) 0.298 N/C
41	(a) 0.90 J; (b) 4.5 J
42	(a) 1.15×10^{-19} J; (b) decrease
43	-0.192 pJ
44	2.1×10^{-25} J
45	2.5 km/s
46	1.8×10^{-10} J
47	22 km/s
48	6.63×10^6 m/s
49	0.32 km/s
50	0
51	(a) $+6.0 \times 10^4$ V; (b) -7.8×10^5 V; (c) 2.5 J; (d) increase; (e) same; (f) same
52	4.5×10^{-12} C·m
53	(a) 0.225 J; (b) A 45.0 m/s^2, B 22.5 m/s^2; (c) A 7.75 m/s, B 3.87 m/s

54	(a) 0; (b) 1.0×10^{7} m/s
55	1.6×10^{-9} m
56	-5.7 μC
57	(a) 3.0 J; (b) -8.5 m
58	(a) 1.7 cm; (b) 20 km/s; (c) 4.8×10^{-17} N; (d) positive; (e) 3.2×10^{-17} N; (f) negative
59	(a) proton; (b) 65.3 km/s
60	(a) –12.0 μC; (b) +0.216 pJ
61	(a) 12; (b) 2
62	(a) equal; (b) 0.333; (c) 0.667; (d) 2.00
63	(a) -1.8×10^{2} V; (b) 2.9 kV; (c) -8.9 kV
64	400 V
65	2.5×10^{-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) $V = \rho(R^2 - r^2)/4\varepsilon_0$; (b) 78 kV

71	$p/2\pi\varepsilon_0 r^3$
72	$(2.9 \times 10^{-2}\ \text{m}^{-3})A$
73	(a) 3.6×10^5 V; (b) no
74	(a) –24 J; (b) 0
75	6.4×10^8 V
76	3.71×10^4 V
77	2.90 kV
78	0.956 V
79	7.0×10^5 m/s
80	10.3 mV
81	(a) 1.8 cm; (b) 8.4×10^5 m/s; (c) 2.1×10^{-17} N; (d) positive; (e) 1.6×10^{-17} N; (f) negative
82	(a) -0.12 V; (b) 1.8×10^{-8} N/C; (c) inward
83	(a) $+7.19 \times 10^{-10}$ V; (b) $+2.30 \times 10^{-28}$ J; (c) $+2.43 \times 10^{-29}$ J
84	(a) 3.6 kV; (b) 3.6 kV
85	2.30×10^{-28} J
86	240 kV
87	2.1 days
88	(a) 2.5 MV; (b) 5.1 J; (c) 6.9 J
89	2.30×10^{-22} J
90	$(qQ/8\pi\varepsilon_0)(1/r_1 - 1/r_2)$
91	1.48×10^7 m/s
92	0.334 mV
93	-1.92 MV
94	(a) spherical, centered on q, radius 4.5 m; (b) no
95	(a) $Q/4\pi\varepsilon_0 r$; (b) $(\rho/3\varepsilon_0)(1.5r_2^2 - 0.50r^2 - r_1^3 r^{-1})$, $\rho = Q/[(4\pi/3)(r_2^3 - r_1^3)]$; (c) $(\rho/2\varepsilon_0)(r_2^2 - r_1^2)$, with ρ as in (b); (d) yes

96	(a) $q(3R^2 - r^2)/8\pi\varepsilon_0 R^3$; (b) $q/8\pi\varepsilon_0 R$
97	(a) 38 s; (b) 280 days
98	(a) 749 kV; (b) 0; (c) 20 μC
99	---
100	8.8×10^{-14} m
101	(a) 0.484 MeV; (b) 0
102	843 V
103	–1.7

Chapter 25 Answers

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^2
5	0.280 pF
6	(a) 8.85×10^{-12} m
7	6.79×10^{-4} F/m^2
8	9.09×10^3
9	315 mC
10	7.33 μF
11	3.16 μF
12	(a) 60 μC; (b) 60 μC
13	43 pF
14	(a) 100 μC; (b) 20.0 μC
15	(a) 3.00 μF; (b) 60.0 μC; (c) 10.0 V; (d) 30.0 μC; (e) 10.0 V; (f) 20.0 μC; (g) 5.00 V; (h) 20.0 μC
16	12 μC

17	(a) 789 μC; (b) 78.9 V
18	(a) 2.0 μF; (b) 0.80 μF
19	(a) 4.0 μF; (b) 2.0 μF
20	2.28 pF
21	(a) 50 V; (b) 5.0×10^{-5} C; (c) 1.5×10^{-4} C
22	20 μC
23	(a) 4.5×10^{14}; (b) 1.5×10^{14}; (c) 3.0×10^{14}; (d) 4.5×10^{14}; (e) up; (f) up
24	(a) 2.0×10^{7}; (b) away
25	3.6 pC
26	(a) 10 V; (b) 8.0 μF; (c) 2.0 μF
27	(a) 9.00 μC; (b) 16.0 μC; (c) 9.00 μC; (d) 16.0 μC; (e) 8.40 μC; (f) 16.8 μC; (g) 10.8 μC; (h) 14.4 μC
28	(a) 32.0 μC; (b) 16.0 μC; (c) 16.0 μC
29	72 F
30	99.6 nJ
31	0.27 J
32	(a) 35 pF; (b) 21 nC; (c) 6.3 μJ; (d) 0.60 MV/m; (e) 1.6 J/m^3
33	0.11 J/m^3

34	(a) 400 μC; (b) 100 V; (c) 20.0 mJ; (d) 333 μC; (e) 33.3 V; (f) 5.55 mJ; (g) 333 μC; (h) 66.7 V; (i) 11.1 mJ
35	(a) 9.16×10^{-18} J/m^3; (b) 9.16×10^{-6} J/m^3; (c) 9.16×10^{6} J/m^3; (d) 9.16×10^{18} J/m^3; (e) ∞
36	(a) -0.50 μC; (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 μC; (b) 50.0 V; (c) 18.8 mJ (d) 500 μC; (e) 50.0 V; (f) 12.5 mJ; (g) 250 μC; (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 μJ
46	1.06 nC
47	0.63 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) 1.13×10^4 N/C; (d) 4.33×10^3 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 μJ
54	(a) 7.2; (b) 0.77 μC
55	(a) 0.107 nF; (b) 7.79 nC; (c) 7.45 nC
56	(a) 100 μC; (b) 20.0 μC
57	45 μC
58	(a) 41 μF; (b) 42 μF
59	16 μC
60	(a) 4.9 mJ; (b) no
61	(a) 7.20 μC; (b) 18.0 μC; (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 μF; (b) 6.0 μF
63	(a) 10 μC; (b) 20 μC
64	(a) 36 μC; (b) 12 μC
65	1.06 nC
66	---

67	(a) 2.40 μF; (b) 0.480 mC; (c) 80 V; (d) 0.480 mC; (e) 120 V
68	(a) 10.0 μF; (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) 1.02×10^{-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 μF
76	4
77	(a) 200 kV/m; (b) 200 kV/m; (c) 1.77 μC/m^2; (d) 4.60 μC/m^2; (e) –2.83 μC/m^2
78	(a) five capacitors in series; (b) one possible answer: three rows in parallel, each row containing five capacitors in series
79	(a)$q^2/2\varepsilon_0 A$

80	(a) 2.00 J; (b) thermal energy in the wires or radiated as a brief electromagnetic wave

Chapter 26

1	(a) 1.2 kC; (b) 7.5×10^{21}
2	5.6 ms
3	6.7 μC/m^2
4	14
5	(a) 6.4 A/m^2; (b) north; (c) cross-sectional area
6	(a) yes; (b) 4.0×10^2 A/m^2
7	0.38 mm
8	(a) 2.4×10^{-5} A/m^2; (b) 1.8×10^{-15} m/s
9	18.1 μA
10	2.59 mA
11	(a) 1.33 A; (b) 0.666 A; (c) J_a
12	(a) 0.654 μA/m^2; (b) 83.4 MA
13	13 min
14	100 V
15	2.4 Ω
16	(a) 5.32×10^5 A/m^2; (b) 1.01 kg/m; (c) 3.27×10^5 A/m^2; (d) 0.495 kg/m
17	2.0×10^6 (Ω·m)$^{-1}$
18	(a) 1.53 kA; (b) 54.1 MA/m^2; (c) 10.6×10^{-8} Ω·m; (d) platinum
19	2.0×10^{-8} Ω·m
20	2R
21	(1.8×10^3)°C
22	9.42 mA
23	8.2×10^{-8} Ω·m

24	(a) 1.55 mm; (b) 1.22 mm
25	54 Ω
26	(a) 6.00×10^{7} $(\Omega \cdot m)^{-1}$; (b) 7.50×10^{6} $(\Omega \cdot m)^{-1}$
27	3.0
28	3.0 mA
29	3.35×10^{-7} C
30	0.40 Ω
31	(a) 6.00 mA; (b) 1.59×10^{-8} V; (c) 21.2 nΩ
32	(a) 3.24 pA/m^2; (b) 1.73 cm/s
33	(a) 38.3 mA; (b) 109 A/m^2; (c) 1.28 cm/s; (d) 227 V/m
34	5.44×10^{-9} m/s
35	981 kΩ
36	52 mA
37	---
38	0.10 V
39	150 s
40	11.1 Ω
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 Ω; (c) 4.50 MJ
46	(a) 16.9 mV/m; (b) 243 J
47	(a) 5.85 m; (b) 10.4 m
48	13.0 A
49	(a) US$4.46; (b) 144 Ω; (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 Ω; (b) 2.60×10^{19} s^{-1}
54	0.224 m
55	660 W
56	(a) 1.74 A; (b) 2.15 MA/m^2; (c) 36.3 mV/m; (d) 2.09 W
57	28.8 kC
58	(a) 1.3 mΩ; (b) 4.6 mm
59	(a) silver; (b) 51.6 nΩ
60	(a) $\rho\pi R^2 v$; (b) 17 μA; (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) 2.3×10^{12}; (b) 5.0×10^{3}; (c) 10 MV
62	13.3 Ω
63	2.4 kW
64	(a) 1.3×10^{5} 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 Ω

73	3.0×10^6 J/kg
74	3.4×10^4 s
75	560 W
76	(a) 0.67 A; (b) toward
77	0.27 m/s
78	6.7 μC/m^2
79	(a) 10 A/cm^2; (b) eastward
80	(a) 0.0017%; (b) 0.0034%; (c) 0.43%
81	(a) 9.4×10^{13} s^{-1}; (b) 2.40×10^2 W
82	(a) 3.1×10^{11}; (b) 25 μA; (c) 25 MW; (d) 1.3 kW
83	112 min
84	(a) 28 min; (b) 1.6 h
85	(a) 225 μC; (b) 60.0 μA; (c) 0.450 mW

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) 1.0×10^2 W; (c) 6.0×10^2 W; (d) 10 V; (e) 1.0×10^2 W
4	(a) 80 Ω; (b) 200 Ω
5	11 kJ
6	(a) US3.2×10^2; (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) 9.9×10^2 Ω; (b) 9.9×10^{-4} 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 Ω
14	(a) 0.20 Ω; (b) 0.30 Ω
15	8.0 Ω
16	(a) 1.0 kΩ; (b) 0.30 V; (c) 0.23%
17	(a) 0.004 Ω; (b) 1
18	0.25 V
19	(a) 4.00 Ω; (b) parallel
20	(a) 4.0 Ω; (b) 12 Ω
21	5.56 A
22	(a) 2.50 Ω; (b) 3.13 Ω
23	(a) 50 mA; (b) 60 mA; (c) 9.0 V
24	4.50 Ω
25	$3d$
26	$100R\mathcal{E}^2x^2R_0^{-2}(100RR_0^{-1} + 10x - x^2)^{-2}$, x in cm
27	3.6×10^3 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 Ω; (c) 40 Ω
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 Ω
38	(a) providing; (b) 3.6×10^2 W
39	(a) 0.150 Ω; (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 Ω; (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 kΩ; (b) 4.0 kΩ

47	(a) 1.11 A; (b) 0.893 A; (c) 126 m
48	(a) 19.5 Ω; (b) 0; (c) ∞; (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 Ω; (d) decrease
52	(a) 13.5 kΩ; (b) 1.50 kΩ; (c) 167 Ω; (d) 1.48 kΩ
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 Ω; (d) decrease
57	0.208 ms
58	(a) 2.52 s; (b) 21.6 μC; (c) 3.40 s
59	4.61
60	(a) 0.41; (b) 1.1
61	(a) 2.41 μs; (b) 161 pF
62	2.35 MΩ
63	(a) 1.1 mA; (b) 0.55 mA; (c) 0.55 mA; (d) 0.82 mA; (e) 0.82 mA; (f) 0; (g) 4.0×10^2 V; (h) 6.0×10^2 V

64	(a) 2.17 s; (b) 39.6 mV
65	411 μA
66	162 μs
67	0.72 MΩ
68	(a) 1.0×10^{-3} C; (b) 1.0×10^{-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
69	(a) 0.955 μC/s; (b) 1.08 μW; (c) 2.74 μW; (d) 3.82 μW
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) 1.32×10^{7} A/m^2; (b) 8.90 V; (c) copper; (d) 1.32×10^{7} A/m^2; (e) 51.1 V; (f) iron
74	(a) 4.0 A; (b) up
75	(a) 3.0 kV; (b) 10 s; (c) 11 GΩ

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 Ω; (b) 915 Ω
78	0.90%
79	---
80	250 μJ
81	4.0 V
82	2.5 V
83	(a) 24.8 Ω; (b) 14.9 kΩ
84	(a) 80 mA; (b) 0.13 A; (c) 0.40 A
85	the cable
86	(a) 38 Ω; (b) 260 Ω
87	-13 μC
88	13.3 Ω
89	20 Ω
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 mΩ
94	(a) 6.67 Ω; (b) 6.67 Ω; (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
100	(a) 7.50 A; (b) left; (c) 10.0 A; (d) left; (e) 87.5 W; (f) supplied
101	7.50 V
102	(a) $V_T = \mathcal{E} - ir$; (b) 13.6 V; (c) 0.060 Ω
103	(a) 60.0 mA; (b) down; (c) 180 mA; (d) left; (e) 240 mA; (f) up
104	(a) low position connects larger resistance, middle position connects smaller resistance, high position connects filaments in parallel; (b) 72 Ω; (c) 144 Ω
105	(a) 4.0 A; (b) up; (c) 0.50 A; (d) down; (e) 64 W; (f) 16 W; (g) supplied; (h) absorbed

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) 6.2×10^{-18} N; (b) 9.5×10^{8} m/s^2; (c) same
5	-2.0 T
6	(a) -3.5 km/s; (b) 7.0 km/s
7	(-11.4 V/m)$\hat{i}$ - (6.00 V/m)$\hat{j}$ + (4.80 V/m)$\hat{k}$
8	3.75 km/s
9	-(0.267 mT)$\hat{k}$
10	(a) $(1.44 \times 10^{-18}$ N)$\hat{k}$; (b) $(1.60 \times 10^{-19}$ N)$\hat{k}$; (c) $(6.41 \times 10^{-19}$ N)$\hat{i}$ + $(8.01 \times 10^{-19}$ N)$\hat{k}$
11	0.68 MV/m
12	(a) 1.25 V/m; (b) (25.0 mT)$\hat{k}$
13	7.4 μV
14	38.2 cm/s
15	(a) (-600 mV/m)$\hat{k}$; (b) 1.20 V
16	(a) 25 cm; (b) 30 cm; (c) 20 cm
17	(a) 2.60×10^{6} m/s; (b) 0.109 μs; (c) 0.140 MeV; (d) 70.0 kV
18	(a) 4.99×10^{6} m/s; (b) 7.10 mm; (c) 8.93 ns
19	1.2×10^{-9} kg/C
20	6.7×10^{-2} T
21	(a) 2.05×10^{7} m/s; (b) 467 μT; (c) 13.1 MHz; (d) 76.3 ns
22	(a) 1.0 MeV; (b) 0.50 MeV
23	21.1 μT
24	(a) 1.11×10^{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	2.09×10^{-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	2.4×10^{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 μN
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	$(-4.3 \times 10^{-3} \text{ N·m})\hat{j}$
50	6.58×10^{-26} N·m

51	2.45 A
52	3.0 mA
53	---
54	(a) 77°; (b) 77°
55	(a) 2.86 A·m^2; (b) 1.10 A·m^2
56	(a) 0.184 A·m^2; (b) 1.45 N·m
57	(a) 12.7 A; (b) 0.0805 N·m
58	2.08 GA
59	(a) 0.30 A·m^2; (b) 0.024 N·m
60	$(0.150\hat{j} - 0.300\hat{k})$ A·m^2
61	(a) –72.0 μJ; (b) $(96.0\hat{i} + 48.0\hat{k})$ μN·m
62	4.8×10^{-5} A·m^2
63	(a) $-(9.7 \times 10^{-4}$ N·m$)\hat{i} - (7.2 \times 10^{-4}$ N·m$)\hat{j} + (8.0 \times 10^{-4}$ N·m$)\hat{k}$; (b) -6.0×10^{-4} J
64	110°
65	(a) 90°; (b) 1; (c) 1.28×10^{-7} N·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) 5.9×10^{-2} N·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) 6.3×10^{14} m/s^2; (b) 3.0 mm
74	$(-3.0\hat{i} - 3.0\hat{j} - 4.0\hat{k})$ T
75	(a) 1.4; (b) 1.0
76	---
77	$(-500\ \text{V/m})\hat{j}$
78	(b) 2.84×10^{-3}

79	(a) 0.50; (b) 0.50; (c) 14 cm (d) 14 cm
80	(a) 9.56×10^{-14} N; (b) 0; (c) 0.267°
81	$(0.80\hat{j} - 1.1\hat{k})$ mN
82	(a) 0.67 mm/s; (b) 2.8×10^{29} m^{-3}
83	-40 mC
84	$(-0.600\text{ N})\hat{k}$
85	(a) $(12.8\hat{i} + 6.41\hat{j}) \times 10^{-22}$ N; (b) 90°; (c) 173°
86	(a) 3.8 mm; (b) 19 mm; (c) clockwise
87	(a) up; (b) rim; (c) 47.1 V; (d) 47.1 V; (e) 2.36 kW
88	3.8 C
89	$(2mV/ed^2)^{0.5}$
90	$qvrB/2$
91	$n = JB/eE$
92	$(0.75\text{ T})\hat{k}$

Chapter 29

1	(a) 3.3 μT; (b) yes
2	3.0 μT
3	(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 μT; (b) out
8	(a) 1.67 μT; (b) into

9	(a) opposite; (b) 30 A
10	(a) 0.118 μT; (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 μT; (b) into; (c) 6.7 μT; (d) into
16	144°
17	132 nT
18	2.00 cm
19	5.0 μT
20	(a) (253 nT)$\hat{k}$; (b) (192 nT)$\hat{i}$ + (61.2 nT)$\hat{k}$
21	256 nT
22	(a) 30 cm; (b) 2.0 nT; (c) out; (d) into
23	(-7.75 × 10^{-23} 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 μT)$\hat{j}$
30	(a) –90°; (b) 4.0 A; (c) out; (d) 2.0 A; (e) into
31	(a) 20 μT; (b) into
32	2.3 cm
33	(22.3 pT)$\hat{j}$
34	104°
35	88.4 pN/m

36	(a) (469 μN)$\hat{j}$; (b) (188 μN)$\hat{j}$; (c) 0; (d) (-188 μN)$\hat{j}$; (e) (-469 μN)$\hat{j}$
37	(-125 μN/m)$\hat{i}$ + (41.7 μN/m)$\hat{j}$
38	(a) 0.50 A; (b) out
39	800 nN/m
40	(0.794 mN/m)$\hat{i}$ + (-0.794 mN/m)$\hat{j}$
41	(3.20 mN)$\hat{j}$
42	4.5×10^{-6} T·m
43	(a) 0; (b) 0.850 mT; (c) 1.70 mT; (d) 0.850 mT
44	(a) -2.5 μT·m; (b) -16 μT·m
45	(a) -2.5 μT·m; (b) 0
46	+28.3 nT·m
47	(a) 0; (b) 0.10 μT; (c) 0.40 μT
48	(a) 3.00 mA; (b) into
49	(a) 533 μT; (b) 400 μT
50	5.71 mT
51	0.30 mT
52	108 m
53	0.272 A
54	1.6×10^{6} rev
55	(a) 4.77 cm; (b) 35.5 μT
56	8.78 μT
57	(a) 2.4 A·m^2; (b) 46 cm
58	(a) 4.0; (b) 0.50
59	0.47 A·m^2

60	(a) 0.90 A; (b) 2.7 A
61	(a) 79 μT; (b) 1.1×10^{-6} N·m
62	(a) 0.497 μT; (b) into; (c) 1.06 mA·m^2; (d) into
63	(a) (0.060 A·m^2)$\hat{j}$; (b) (96 pT)$\hat{j}$
64	(a) 27.5 nT; (b) into
65	1.28 mm
66	(a) (-52.0 μT)$\hat{k}$; (b) 8.13 cm; (c) 17.5 cm
67	---
68	(a) 3.2×10^{-16} N; (b) 3.2×10^{-16} N; (c) 0
69	(a) 15 A; (b) -*z*
70	157 nT
71	7.7 mT
72	(a) 5.0 mA; (b) downward
73	(a) 15.3 μT
74	32.1 A
75	(a) (0.24$\hat{i}$) nT; (b) 0; (c) (-43$\hat{k}$) pT; (d) (0.14$\hat{k}$) nT
76	(a) (-400 μT)$\hat{i}$; (b) (400 μT)$\hat{j}$
77	---
78	4.0 mm
79	(a) 4.8 mT; (b) 0.93 mT; (c) 0
80	5.3 mm
81	--
82	(1.25 μT)$\hat{i}$
83	(-0.20 mT)$\hat{k}$

84	(a) 0.17 mN; (b) 0.021 mN
85	---
86	---
87	(a) $\mu_0 ir/2\pi c^2$; (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 km/s

Chapter 30

1	0
2	0.452 V
3	30 mA
4	(a) -11 mV; (b) 0; (c) 11 mV
5	0
6	8.0×10^{-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 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 mΩ
15	(a) 21.7 V; (b) counterclockwise
16	(a) 8.0 μA; (b) counterclockwise

17	(a) 1.26×10^{-4} T; (b) 0; (c) 1.26×10^{-4} T; (d) yes; (e) 5.04×10^{-8} V
18	(a) 85.2 Wb; (b) 56.8 V; (c) 1
19	5.50 kV
20	15.5 μC
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 μV; (b) from *c* to *b*
25	(a) 13 μWb/m; (b) 17%; (c) 0
26	(a) 0.598 μV; (b) counterclockwise
27	(a) 80 μV; (b) clockwise
28	(a) 14 nWb; (b) 10 μA
29	(a) 48.1 mV; (b) 2.67 mA; (c) 0.129 mW
30	1.0 mΩ
31	3.68 μW
32	750 pJ
33	(a) 240 μV; (b) 0.600 mA; (c) 0.144 μW; (d) 2.87×10^{-8} N; (e) 0.144 μW
34	$v_t = mgR/B^2L^2$

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 μV/m; (b) 143 μV/m
38	0.030 T/s
39	0.15 V/m
40	0.10 μWb
41	(a) 2.45 mWb; (b) 0.645 mH
42	(a) 0.27 μT; (b) 8.0 nH
43	1.81 μH/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) $L_{eq} = \Sigma\, L_j$, sum from $j = 1$ to $j = N$
48	(b) $1/L_{eq} = \Sigma\, 1/L_j$, sum from $j = 1$ to $j = N$
49	59.3 mH
50	12.3 s
51	46 Ω
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	7.1×10^2 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) 2.4×10^2 W; (b) 1.5×10^2 W; (c) 3.9×10^2 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 J/m^3
67	(a) 34.2 J/m^3; (b) 49.4 mJ
68	5.58 A
69	1.5×10^8 V/m
70	(a) 23 mA; (b) 70 mA
71	(a) 1.0 J/m^3; (b) 4.8×10^{-15} J/m^3
72	(a) 1.5 μWb; (b) 1.0×10^2 mV; (c) 90 nWb; (d) 12 mV
73	(a) 1.67 mH; (b) 6.00 mWb
74	13 H
75	13 μH
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 Ω

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 μT; (b) out; (c) 3.3 μT; (d) out
82	$(\pi B_0 r^2/\tau)\exp(-t/\tau)$
83	0.520 ms
84	(a) 25 μT/s; (b) 13 μT/s (c) increasing
85	(a) $(4.4 \times 10^7\ \text{m/s}^2)\hat{\imath}$; (b) 0; (c) $(-4.4 \times 10^7\ \text{m/s}^2)\hat{\imath}$
86	81.1 μs
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) 1.0×10^2 J
90	1.54 s
91	(a) 0; (b) 8.0×10^2 A/s; (c) 1.8 mA; (d) 4.4×10^2 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
99	3×10^{36} J
100	(a) 3.4(2 + θ) mΩ; (b) 4.3θ mWb; (c) 2.0 rad; (d) 2.2 A
101	(a) 13.9 H; (b) 120 mA

Chapter 31

1	(a) 1.17 μJ; (b) 5.58 mA
2	(a) 5.00 μs; (b) 2.50 μs; (c) 1.25 μs
3	(a) 6.00 μs; (b) 167 kHz; (c) 3.00 μs
4	9.14 nF
5	45.2 mA
6	(a) 89 rad/s; (b) 70 ms; (c) 25 μF
7	(a) 1.25 kg; (b) 372 N/m; (c) 1.75×10^{-4} m; (d) 3.02 mm/s
8	---
9	7.0×10^{-4} s
10	38 μH
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 μs; (c) 66.7 W

14	(a) 6.0×10^2 Hz; (b) 7.1×10^2 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 μs; (b) 6.88 nJ; (c) 6.88 nJ; (d) 1.02×10^3 A/s; (e) 0.938 mW
19	---
20	(a) 3.60 mH; (b) 1.33 kHz; (c) 0.188 ms
21	(a) 356 μs; (b) 2.50 mH; (c) 3.20 mJ
22	ω
23	(a) 1.98 μJ; (b) 5.56 μC; (c) 12.6 mA; (d) -46.9°; (e) +46.9°
24	(a) 5.85 μC; (b) 5.52 μC; (c) 1.93 μC
25	8.66 mΩ
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 Ω
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 Ω
36	(a) 500 Ω; (b) 40 μF
37	7.61 A
38	(a) 8.0 μF; (b) 2.0 Ω
39	(a) 267 Ω; (b) -41.5°; (c) 135 mA
40	-8.00 V
41	(a) 206 Ω; (b) 13.7°; (c) 175 mA
42	(a) 40 Ω; (b) 60 mH
43	(a) 218 Ω; (b) 23.4°; (c) 165 mA
44	(a) 16.6 Ω; (b) 422 Ω; (c) 0.521 A; (d) increase; (e) decrease; (f) increase
45	(a) yes; (b) 1.0 kV
46	(b) 159 Hz; (c) –45°; (d) 1.00×10^3 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 Ω; (b) 30.6 μF; (c) 301 mH
49	(a) 796 Hz; (b) no change; (c) decreased; (d) increased
50	(b) 318 Hz; (c) +45°; (d) 2.00×10^3 rad/s; (e) 53.0 mA
51	---
52	100 V
53	(a) 12.1 Ω; (b) 1.19 kW
54	141 V
55	1.84 A
56	(a) 76.4 mH; (b) yes; (c) 17.8 Ω
57	(a) 117 μF; (b) 0; (c) 90.0 W; (d) 0°; (e) 1; (f) 0; (g) -90°; (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) 5.9×10^2 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 μF
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 kΩ; (d) 0.650 kΩ
71	(a) 64.0 Ω; (b) 50.9 Ω; (c) capacitive
72	(a) 0.588 rad; (b) inductive; (c) 12.0 V

73	(a) 2.41 μH; (b) 21.4 pJ; (c) 82.2 nC
74	(a) 5.77×10^3 rad/s; (b) 1.09 ms
75	(a) 39.1 Ω; (b) 21.7 Ω; (c) capacitive
76	(a) 8.84 kHz; (b) 6.00 Ω
77	---
78	(a) 177 Ω; (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°; (b) 70.7 Ω
82	0.115 A
83	1.84 kHz
84	(a) 707 Ω; (b) 32.2 mH; (c) 21.9 nF
85	(a) 0.689 μH; (b) 17.9 pJ; (c) 0.110 μC
86	69.3 Ω
87	(a) 165 Ω; (b) 313 mH; (c) 14.9 μF
88	(a) 1.27 μC; (b) 83.1 μs; (c) 5.44 mW
89	---
90	1.59 μF
91	---
92	---
93	(a) 36.0 V; (b) 29.9 V; (c) 11.9 V; (d) -5.85 V

Chapter 32

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

24	(a) 2.1×10^{-8} A; (b) downward; (c) clockwise
25	(a) 0.63 μT; (b) 2.3×10^{12} V/m·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) 6.4×10^{-22} T; (e) 6.4×10^{-22} T; (f) 0; (g) out; (h) out
29	(a) 7.60 μA; (b) 859 kV·m/s; (c) 3.39 mm; (d) 5.16 pT
30	(a) 13 MWb; (b) outward
31	55 μT
32	(a) 0; (b) –1, 0, 1; (c) 4.64×10^{-24} J
33	(a) 0; (b) 0; (c) 0; (d) $\pm 3.2 \times 10^{-25}$ J; (e) -3.2×10^{-34} J·s; (f) 2.8×10^{-23} J/T; (g) -9.7×10^{-25} J; (h) $\pm 3.2 \times 10^{-25}$ J
34	4.6×10^{-24} J
35	(a) -9.3×10^{-24} J/T; (b) 1.9×10^{-23} J/T
36	32.3 mT
37	(b) +*x*; (c) clockwise; (d) +*x*

38	$e^2r^2B/4m$
39	yes
40	(a) 1.5×10^2 T; (b) 6.0×10^2 T; (c) no
41	20.8 mJ/T
42	0.48 K
43	(b) K_i/B; (c) -z; (d) 0.31 kA/m
44	0.30
45	---
46	3.19×10^{-9} kg·m^2
47	(a) 1.8×10^2 km; (b) 2.3×10^{-5}
48	(a) 8.9 A·m^2; (b) 13 N·m
49	(a) 3.0 μT; (b) 5.6×10^{-10} eV
50	(a) 1.49×10^{-4} N·m; (b) –72.9 μJ
51	5.15×10^{-24} A·m^2
52	25 km
53	(a) 0.14 A; (b) 79 μC
54	(a) 1.66×10^3 km; (b) 383 μT; (c) 61.1 μT; (d) 84.2°
55	(a) 6.3×10^8 A; (b) yes; (c) no
56	(b) in the direction of the angular momentum vector
57	0.84 kJ/T
58	(a) 222 μT; (b) 167 μT; (c) 22.7 μT; (d) 1.25 μT; (e) 3.75 μT; (f) 22.7 μT
59	(a) $(1.2 \times 10^{-13}$ T) exp[-t/(0.012 s)]; (b) 5.9×10^{-15} T

60	(a) 9.2 mWb; (b) inward
61	---
62	(a) 31.0 μT; (b) 0°; (c) 55.9 μT; (d) 73.9°; (e) 62.0 μT; (f) 90.0°
63	(a) 27.5 mm; (b) 110 mm
64	(a) 4 K; (b) 1 K
65	8.0 A
66	3.5×10^{-5} A
67	(a) -8.8×10^{15} V/m·s; (b) 5.9×10^{-7} T·m
68	(a) -2.78×10^{-23} J/T; (b) 3.71×10^{-23} J/T
69	(b) sign is minus; (c) no, because there is compensating positive flux through open end nearer to magnet
70	(a) 5.3×10^{11} V/m; (b) 20 mT; (c) 6.6×10^{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) 3.71×10^{-23} J/T; (c) $+9.27 \times 10^{-24}$ J; (d) -9.27×10^{-24} J
76	(a) -2.78×10^{-23} J/T; (b) 3.71×10^{-23} J/T

Chapter 33

1	7.49 GHz
2	(a) 4.7×10^{-3} Hz; (b) 3 min 32 s
3	(a) 515 nm; (b) 610 nm; (c) 555 nm; (d) 5.41×10^{14} Hz; (e) 1.85×10^{-15} s
4	30 cm
5	5.0×10^{-21} H
6	4.74 m
7	1.2 MW/m^2
8	4.8×10^{-29} W/m^2
9	0.10 MJ
10	(a) 1.91×10^{8} Hz; (b) 18.2 V/m; (c) 0.878 W/m^2
11	(a) 6.7 nT; (b) *y*; (c) negative direction of *y*
12	(a) 16.7 nT; (b) 33.1 mW/m^2
13	(a) 1.03 kV/m; (b) 3.43 μT
14	3.44×10^{6} T/s
15	(a) 87 mV/m; (b) 0.29 nT; (c) 6.3 kW
16	(a) 1.4×10^{-22} W; (b) 1.1×10^{15} W
17	(a) 6.7 nT; (b) 5.3 mW/m^2; (c) 6.7 W
18	0.25 kW
19	1.0×10^{7} Pa
20	(a) 6.0×10^{8} N; (b) 3.6×10^{22} N
21	5.9×10^{-8} Pa
22	3.3×10^{-8} Pa

23	(a) 4.68×10^{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^2
25	---
26	491 nm
27	(a) 1.0×10^8 Hz; (b) 6.3×10^8 rad/s; (c) 2.1 m^{-1}; (d) 1.0 μT; (e) z; (f) 1.2×10^2 W/m^2; (g) 8.0×10^{-7} N; (h) 4.0×10^{-7} Pa
28	(a) 4.7×10^{-6} Pa; (b) 4.7×10^{-11}
29	1.9 mm/s
30	(a) 3.97 GW/m^2; (b) 13.2 Pa; (c) 1.67×10^{-11} N; (d) 3.14×10^3 m/s^2
31	(a) 0.17 μm; (b) toward the Sun
32	0.045%
33	3.1%
34	19 W/m^2
35	4.4 W/m^2
36	(a) 0.16; (b) 0.84
37	(a) 2 sheets; (b) 5 sheets
38	9.4%
39	(a) 1.9 V/m; (b) 1.7×10^{-11} Pa
40	7.3%
41	20° or 70°
42	44%
43	0.67
44	(a) 19.6°; (b) 70.4°
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°
50	(a) 1.6; (b) need more information; (c) 39°
51	(a) 56.9°; (b) 35.3°
52	(a) 1.7; (b) 38°
53	---
54	(a) 0.33°; (b) 0°
55	1.07 m
56	(a) 3.1°; (b) 0° (no rainbow)
57	182 cm
58	34°
59	(a) 48.9°; (b) 29.0°
60	(a) 54.3°; (b) yes; (c) 51.1°; (d) no
61	(a) 26.8°; (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°; (b) 53.1°
65	23.2°

66	(a) 3; (b) 2; (c) 40°; (d) none; (e) 2; (f) 3; (g) none; (h) 70°
67	(a) 1.39; (b) 28.1°; (c) no
68	(a) 53°; (b) yes
69	49.0°
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 nT) $\sin[(1.00 \times 10^6\ \mathrm{m^{-1}})z + (3.00 \times 10^{14}\ \mathrm{s^{-1}})t]$; (b) 6.28 μm; (c) 20.9 fs; (d) 33.2 mW/m^2; (e) x; (f) infrared
74	(b) 5.8×10^{-7} m
75	1.22
76	0.50 W/m^2
77	(c) 137.6°; (d) 139.4°; (e) 1.7°
78	(b) 230.4°; (c) 233.5°; (d) 3.1°; (e) 317.5°; (f) 321.9°; (g) 4.4°
79	---
80	(a) 0.33 μT; (b) $-x$
81	(a) z axis; (b) 7.5×10^{14} Hz; (c) 1.9 kW/m^2

82	0.031
83	(a) white; (b) white dominated by red end; (c) no refracted light
84	0.125
85	1.5×10^{-9} m/s^2
86	0.21
87	(a) 3.5 μW/m^2; (b) 0.78 μW; (c) 1.5×10^{-17} W/m^2; (d) 1.1×10^{-7} V/m; (e) 0.25 fT
88	1.07 pT
89	(a) 55.8°; (b) 55.5°
90	(a) 0; (b) 20°; (c) 0; (d) 20°
91	(a) 83 W/m^2; (b) 1.7 MW
92	1.3
93	35°
94	(a) 83.3 mV/m; (b) 4.00 mT; (c) 265 W/m^2; (d) $-y$ direction
95	---
96	$E_m^2 A/2\mu_0 cmc_s$
97	$\cos^{-1}(p/50)^{0.5}$
98	$p_{r\perp}\cos^2\theta$
99	$8RI/3c$
100	0.024
101	0.034
102	9.2 μN
103	9.43×10^{-10} T
104	(a) 15 m/s; (b) 8.7 m/s; (c) higher; (d) 72°
105	(a) $-y$; (b) z; (c) 1.91 kW/m^2; (d) E_z = (1.20 kV/m) sin[$(6.67 \times 10^6$ m$^{-1})y + (2.00 \times 10^{15}$ s$^{-1})t$]; (e) 942 nm; (f) infrared

106	(a) 35.1°; (b) 49.9°; (c) 35.1°; (d) 26.1°; (e) 60.7°; (f) 35.3°
107	(a) 1.60; (b) 58.0°
108	---
109	---
110	1.7×10^{-13} N

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) ∞; (c) ∞; (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) ∞
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^2; (c) 4.0 cm
112	---
113	100 cm
114	---
115	2.2 mm^2
116	---
117	---
118	(a) +36 cm; (b) 1.2 cm; (c) real; (d) inverted
119	(a) -30 cm; (b) not inverted; (c) virtual; (d) 1.0
120	(a) -50 cm; (b) 5.0; (c) virtual; (d) inverted
121	(a) -12 cm
122	(a) 0.60 m; (b) +0.20; (c) real; (d) left; (e) not inverted
123	(a) 80 cm; (b) 0 to 12 cm
124	---
125	---

126	+10.0 cm
127	(a) 8.0 cm; (b) 16 cm; (c) 48 cm
128	28.0 cm
129	(a) α = 0.500 rad: 7.799 cm; α = 0.100 rad: 8.544 cm; α = 0.0100 rad: 8.571 cm; mirror equation: 8.571 cm; (b) α = 0.500 rad: -13.56 cm; α = 0.100 rad: -12.05 cm; α = 0.0100 rad: -12.00 cm; mirror equation: -12.00 cm
130	(a) 1.50 cm; (b) negative; (c) virtual
131	42 mm
132	(a) 0.15 m; (b) 0.30 mm; (c) no
133	(b) P_n
134	(b) 8.4 mm; (c) 2.5 cm
135	(a) $(0.5)(2 - n)r/(n - 1)$; (b) right
136	---
137	2.67 cm
138	(a) convex; (b) 1.60 m
139	(a) 3.33 cm; (b) left; (c) virtual; (d) not inverted
140	(a) -0.50 m; (b) diverging; (c) -2.0 diopters
141	(a) 1 + (25 cm)/f ; (b) (25 cm)/f; (c) 3.5; (d) 2.5

Chapter 35

1	(a) 155 nm; (b) 310 nm
2	(a) 0.25; (b) 0.75; (c) 1.25
3	(a) 3.60 μm; (b) intermediate closer to fully constructive
4	2.0×10^8 m/s
5	4.55×10^7 m/s

6	(a) 5.09×10^{14} Hz; (b) 388 nm; (c) 1.97×10^{8} m/s
7	1.56
8	(a) 2; (b) 0.03
9	(a) 1.55 μm; (b) 4.65 μm
10	(a) 50°; (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°
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°
21	72 μm
22	7.5
23	0
24	(a) 0; (b) 0; (c) ∞; (d) 6.00; (e) 1.71; (f) intermediate closer to minimum
25	7.88 μm
26	(a) 600 nm to 700 nm; (b) decreased; (c) 0.20 μm
27	6.64 μm

28	3.5 μm
29	2.65
30	17 sin(ωt + 13°)
31	27 sin(ωt + 8.5°)
32	(a) 2.33 μV/m; (b) 0.338; (c) between m = 6 maximum (sixth side maximum) and m = 6 minimum (seventh minimum); (d) 1.26×10^{15} rad/s; (e) 39.6 rad
33	(17.1 μV/m) sin[(2.0×10^{14} 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 μm; (b) 0.352 μm
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 μm
70	(a) 10.3 nm/s; (b) 1.09 μm
71	0.012°
72	1.00025
73	140
74	11
75	$[(m + ½)\lambda R]^{0.5}$, for $m = 0, 1, 2, \ldots$
76	(a) 34; (b) 46
77	1.00 m
78	1.67×10^{-11} m^3/s
79	588 nm
80	5.2 μm
81	1.00030
82	0.291 mm
83	(a) 50.0 nm; (b) 36.2 nm
84	(a) ∞; (b) 0; (c) 0; (d) 6.00; (e) 5.80; (f) intermediate closer to maximum
85	0.23°
86	(a) 1.8; (b) 2.2; (c) 1.25
87	(a) 1500 nm; (b) 2250 nm; (c) 0.80
88	(a) 411.4°; (b) 51.4°
89	$x = (D/2a)(m + 0.5)\lambda$, for $m = 0, 1, 2, \ldots$
90	(a) 2.90 (b) intermediate closer to fully constructive

91	(a) 22°; (b) refraction reduces θ
92	(a) 1.6; (b) 1.4
93	600 nm
94	51.6 ns
95	(a) 1.75 μm; (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 μm
102	450 nm
103	(a) bright; (b) 594 nm; (c) Primary reason: the colored bands begin to overlap too much to be distinguished. Secondary reason: the two reflecting surfaces are too separated for the light reflecting from them to be coherent.
104	(a) dark; (b) $2h \sin\theta = (m + 0.5)\lambda$; (c) $2h \cos\theta = m\lambda$
105	---

Chapter 36

1	(a) 2.5 mm; (b) 2.2×10^{-4} rad
2	1.41
3	(a) 70 cm; (b) 1.0 mm
4	(a) decrease; (b) 11°; (c) 0.23°
5	(a) 700 nm; (b) 4; (c) 6

6	(a) 0.430°; (b) 0.118 mm
7	60.4 μm
8	41.2 m
9	1.77 mm
10	24.0 mm
11	160°
12	(a) 2.33 μm; (b) 6; (c) 15.2°; (d) 51.8°
13	(a) 0.18°; (b) 0.46 rad; (c) 0.93
14	(a) 0.256; (b) between center and first minima
15	(d) 52.5°; (e) 10.1°; (f) 5.06°
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) 1.1×10^4 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) 1.3×10^{-4} rad; (b) 10 km
24	31 μm
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	1.6×10^{3} km
28	27 cm
29	(a) 8.8×10^{-7} rad; (b) 8.4×10^{7} km; (c) 0.025 mm
30	91 μm
31	(a) 0.346°; (b) 0.97°
32	(a) 6.8°; (b) no
33	(a) 17.1 m; (b) 1.37×10^{-10}
34	(a) red; (b) 0.13 mm
35	5
36	13
37	3
38	11
39	(a) 5.0 μm; (b) 20 μm
40	(a) 11.1 μm; (b) 51; (c) 0°; (d) 79.0°
41	(a) 7.43×10^{-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; (c) two
43	(a) 9; (b) 0.255
44	2 μm
45	(a) 62.1°; (b) 45.0°; (c) 32.0°
46	635 nm
47	3
48	(a) 3; (b) 0.051°

49	(a) 6.0 μm; (b) 1.5 μm; (c) 9; (d) 7; (e) 6
50	523 nm
51	(a) 2.1°; (b) 21°; (c) 11
52	(a) third (overlaps with fourth); (b) ninth; (c) 41.5°; (d) 67.2°; (e) 73.1°
53	(a) 470 nm; (b) 560 nm
54	---
55	3.65×10^3
56	(a) 23 100; (b) 28.7°
57	(a) 0.032°/nm; (b) 4.0×10^4; (c) 0.076°/nm; (d) 8.0×10^4; (e) 0.24°/nm; (f) 1.2×10^5
58	(a) 56 pm; (b) none
59	0.15 nm
60	491
61	(a) 10 μm; (b) 3.3 mm
62	(a) tan θ; (b) 0.89
63	1.09×10^3 rulings/mm
64	2.9°
65	(a) 0.17 nm; (b) 0.13 nm
66	39.8 pm
67	(a) 25 pm; (b) 38 pm
68	6.8°
69	0.26 nm
70	0.570 nm

71	(a) 15.3°; (b) 30.6°; (c) 3.1°; (d) 37.8°
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) 1.3×10^{-4} rad; (b) 21 m
75	(a) 625 nm; (b) 500 nm; (c) 416 nm
76	4.84×10^3
77	3.0 mm
78	11
79	---
80	30.5 μm
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	1.36×10^4
90	53.4 cm
91	2
92	4×10^{-13}
93	4.7 cm
94	500 nm
95	---
96	691 nm
97	36 cm
98	164 m
99	(a) fourth; (b) seventh

100	(a) 625 nm, 500 nm, 416 nm; (b) orange, blue-green, violet
101	---
102	(a) 80 cm; (b) 1.8 mm
103	(a) 2.4 μm; (b) 0.80 μm; (c) 2
104	106°
105	---
106	2.27 m
107	9
108	---
109	---
110	---
111	---
112	2
113	---
114	---

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	2.68×10^3 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) 6.54×10^8 m; (d) 3.16 s
17	(a) 138 km; (b) -374 μs
18	(a) 0; (b) -2.5 μs; (c) reverse
19	(a) 25.8 μs; (b) small flash
20	0.63 μs
21	(a) γ[1.00 μs – β(400 m)/(2.998×10^8 m/s)]; (d) 0.750; (e) $0 < \beta < 0.750$; (f) $0.750 < \beta < 1$; (g) no
22	(a) γ[400 m – βc(1.00 μs)]; (d) 0.750; (e) 265 m
23	(a) 1.25; (b) 0.800 μs
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 μs
26	2.40 μs
27	0.81c
28	(a) 0.84$c\hat{\imath}$; (b) 1.1$c\hat{\imath}$; (c) 0.21$c\hat{\imath}$; (d) 0.15$c\hat{\imath}$
29	(a) 0.35; (b) 0.62
30	0.588
31	1.2 μs

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) 1×10^6 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	1.01×10^7 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) 7.310×10^{-2}
51	$2.83mc$
52	(a) $mv^2/2 + 3mv^4/8c^2$; (b) 1.0×10^{-16} J; (c) 1.9×10^{-19} J; (d) 2.6×10^{-14} J; (e) 1.3×10^{-14} 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) 1.2×10^8 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) $\gamma[1.00\ \mu s - \beta(240\text{ m})/(2.998 \times 10^8\text{ m/s})]$; (d) 0.801; (e) 0.599 μs; (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 μs; (b) 0.572 μs; (c) 2.59 μs; (d) 16.0 μs

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) 2.21×10^{-12}; (b) 5.25 d
71	(a) 5.4×10^{4} km/h; (b) 6.3×10^{-10}
72	0.75
73	189 MeV
74	55 m
75	8.7×10^{-3} ly
76	0.999 90
77	7
78	(a) 1.87×10^{4} km/s; (b) receding
79	2.46 MeV/c
80	6.4 cm
81	0.27c
82	(a) 2.24×10^{-13} s; (b) 64.4 μm
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) 2.7×10^{14} J; (b) 1.8×10^{7} kg; (c) 6.0×10^{6}
87	(a) 256 kV; (b) 0.745c
88	0.678c
89	(a) 0.858c; (b) 0.185c
90	1.38 μs
91	0.500c

92	(a) 87.2 m; (b) FF; (c) 0.418 μs; (d) yes; (e) 87.2 m; (f) RN; (g) 0.418 μs; (h) yes
93	(a) 119 MeV; (b) 64.0 MeV/*c*; (c) 81.3 MeV; (d) 64.0 MeV/*c*
94	(a) 2*D*/*c*; (b) 4*D*/*c*; (b) 6*D*/*c*; (d) *D*/5*c*; (e) *D*/6*c*; (f) *D*/5*c*
95	4.00 u, probably a helium nucleus
96	330 mT
97	(a) 534; (b) 0.999 998 25; (c) 2.23 T
98	(a) 65.4 per minute; (b) 1570 m
99	(a) 415 nm; (b) blue
100	(b) 0.80*c*
101	(a) 88 kg; (b) no
102	(a) 6.7×10^{-10} s; (b) 2.2×10^{-18} m; (c) acceptable
103	(a) 3×10^{-18}; (b) 2×10^{-12}; (c) 8.2×10^{-8}; (d) 6.4×10^{-6}; (e) 1.1×10^{-6}; (f) 3.7×10^{-5}; (g) 9.9×10^{-5}; (h) 0.10

Chapter 38

1	(a) 2.1 μm; (b) infrared
2	8.6×10^{5} m/s
3	1.0×10^{45} photons/s
4	1.7×10^{21} photons/m^2·s
5	2.047 eV
6	2.11 eV
7	1.1×10^{-10} W
8	3.3×10^{18} photons/s
9	(a) 2.96×10^{20} photons/s; (b) 4.86×10^{7} m; (c) 5.89×10^{18} photons/m^2·s
10	(a) 3.61 kW; (b) 1.00×10^{22} photons/s; (c) 60.2 s
11	(a) infrared; (b) 1.4×10^{21} photons/s
12	3.6×10^{-17} W
13	4.7×10^{26} photons
14	6 s^{-1}
15	170 nm
16	10 eV
17	676 km/s

18	barium and lithium
19	(a) 1.3 V; (b) 6.8×10^{2} km/s
20	9.68×10^{-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) 4.12×10^{-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) 1.24×10^{20} Hz
29	(a) 8.57×10^{18} Hz; (b) 3.55×10^{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°
33	(a) -8.1×10^{-9}%; (b) -4.9×10^{-4}%; (c) -8.9%; (d) -66%
34	3.0×10^{-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°
40	1.1 keV
41	(a) 2.43 pm; (b) 4.11×10^{-6}; (c) -8.67×10^{-6} eV; (d) 2.43 pm; (e) 9.78×10^{-2}; (f) -4.45 keV
42	(a) 500 nm; (b) visible; (c) 2.73 K
43	(a) 2.9×10^{-10} m; (b) x ray; (c) 2.9×10^{-8} m; (d) ultraviolet
44	(a) 3.60×10^{6}; (b) 1.02; (c) longer
45	(a) 9.35 μm; (b) 1.47×10^{-5} W; (c) 6.93×10^{14} photons/s; (d) 2.33×10^{-37} W; (e) 5.87×10^{-19} photons/s
46	(a) 38.8 pm; (b) 1.24 nm; (c) 906 fm
47	7.75 pm
48	9.76 kV
49	(a) 1.9×10^{-21} kg·m/s; (b) 346 fm
50	(a) 0.025 fm; (b) 2.0×10^{2}
51	4.3 μeV
52	$(4.0 \times 10^{-6})^{o}$
53	(a) 1.24 μm; (b) 1.22 nm; (c) 1.24 fm; (d) 1.24 fm
54	(a) 3.3×10^{-24} kg·m/s; (b) 3.3×10^{-24} kg·m/s; (c) 38 eV; (d) 6.2×10^{3} eV
55	(a) 15 keV; (b) 120 keV
56	(a) 5.2 fm; (b) no, the de Broglie wavelength is much less than the distance of closest approach
57	neutron

58	(a) 1.24 keV; (b) 1.50 eV; (c) 1.24 GeV; (d) 1.24 GeV
59	(a) 3.96×10^6 m/s; (b) 81.7 kV
60	---
61	---
62	---
63	---
64	---
65	---
66	(d) $x = n(\lambda/2)$, with $n = 0, 1, 2, 3, \ldots$
67	2.1×10^{-24} kg·m/s
68	(a) 124 keV; (b) 40.5 keV
69	---
70	(a) 300 eV; (b) 9.36×10^{-24} kg · m/s; (c) 1.03×10^7 m/s; (d) 7.08×10^{-11} m; (e) 8.87×10^{10} m^{-1}
71	(a) 1.45×10^{11} m^{-1}; (b) 7.25×10^{10} m^{-1}; (c) 0.111; (d) 5.56×10^4
72	(a) 1.38×10^{11} m^{-1}; (b) 7.73×10^{10} m^{-1}; (c) 0.0798; (d) 2.39×10^8
73	4.81 mA
74	5.1 eV
75	(a) 9.02×10^{-6}; (b) 3.0 MeV; (c) 3.0 MeV; (d) 7.33×10^{-8}; (e) 3.0 MeV; (f) 3.0 MeV
76	(a) 10^{104} y; (b) 2×10^{-19} s
77	(a) –20%; (b) -10%; (c) +15%
78	1.78 mA
79	(a) no; (b) plane wavefronts of infinite extent, perpendicular to *x* axis
80	5.9 μeV
81	---
82	---
83	(a) 38.8 meV; (b) 146 pm

84	(a) 73 pm; (b) 3.4 nm; (c) yes, their average de Broglie wavelength is smaller than their average separation
85	(a) 4.14×10^{-15} eV·s; (b) 2.31 eV
86	---
87	---
88	1.7×10^{-35} m
89	(a) no; (b) 544 nm; (c) green
90	0.19 m
-	---
-	---
-	$T = 10^{-x}$, where $x = 7.2 \times 10^{39}$ (T is very small)
-	0.80 nm

Chapter 39

1	1.41
2	(a) 9.42 eV; (b) 5.13×10^{-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	2.86×10^{-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	2.2×10^{-20} J
25	1.4×10^{-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) 6.45×10^{-27} kg·m/s; (c) 102 nm

34	(a) 0; (b) 10.2 nm^{-1}; (c) 5.54 nm^{-1}
35	(a) 291 nm^{-3}; (b) 10.2 nm^{-1}
36	(a) -3.4 eV; (b) 3.4 eV
37	---
38	2.6 eV
39	---
40	(a) 31 nm; (b) 8.2×10^{14} Hz; (c) 0.29 μm; (d) 3.7×10^{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	4.3×10^3
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) $(r^2/8a^3)(2\text{-}r/a)^2 \exp(\text{-}r/a)$
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) 1.3×10^{-19} eV; (b) 1.2×10^{19}; (c) 1.2×10^{13}; (d) yes
61	(b) meter$^{-2.5}$
62	(a) 658 nm; (b) 366 nm
63	(a) n; (b) $2\ell + 1$; (c) n^2
64	---
65	(a) $nh/\pi md^2$; (b) $n^2h^2/4\pi^2md^2$
66	1.2×10^{-14}
67	(a) 3.9×10^{-22} eV; (b) 10^{20}; (c) 3.0×10^{-18} K
68	-
69	-
70	(a) $-e/\pi a_0^3$; (b) $5e \exp(-2)/4\pi\varepsilon_0 a_0^2$; (c) radially outward
71	(a) $e^2r/4\pi\varepsilon_0 a^3$; (b) $e/(4\pi\varepsilon_0 ma_0^3)^{0.5}$
72	(a) 27.2 eV; (b) -27.2 eV (c) 13.6 eV; (d) 13.6 eV
73	18.1, 36.2, 54.3, 66.3, 72.4 μeV

Chapter 40

1	24.1°
2	50
3	(a) 3.65×10^{-34} J·s; (b) 3.16×10^{-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°; (g) 54.7°; (h) 150°
10	(a) 3; (b) 5; (c) 2; (d) 18; (e) 3
11	---
12	4.3×10^{-5} rad/s
13	72 km/s^2
14	(a) 1.5×10^{-21} N; (b) 20 μm
15	(a) 54.7°; (b) 125°
16	(a) 58 μeV; (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, +½), (2, 0, 0, -½); (b) (2, 1, 1, +½), (2, 1, 1, -½), (2, 1, 0, +½), (2, 1, 0, -½), (2, 1, -1, +½), (2, 1, -1, -½)
28	---
29	*g*
30	(a) (1, 0, 0, +½); (b) (1, 0, 0, -½)
31	(a) 4*p*; (b) 4; (c) 4*p*; (d) 5; (e) 4*p*; (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) 2.07×10^3
41	80.3 pm
42	2.2 keV
43	(a) 69.5 kV; (b) 17.8 pm; (c) 21.3 pm; (d) 18.5 pm

44	(a) 5.7 keV; (b) 87 pm; (c) 14 keV; (d) 2.2×10^2 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	2.0×10^{16} s^{-1}
48	4.7 km
49	2×10^7
50	1.0×10^4 K
51	9.0×10^{-7}
52	3.0×10^{18}
53	7.3×10^{15} s^{-1}
54	1.3×10^{15} mol
55	(a) 3.60 mm; (b) 5.24×10^{17}
56	-2.75×10^5 K
57	(a) 0; (b) 68 J
58	1.8 pm
59	3.0 eV
60	(a) 7.33 μm; (b) 7.07×10^5 W/m^2; (c) 2.49×10^{10} W/m^2
61	(a) 3.03×10^5; (b) 1.43 GHz; (d) 3.31×10^{-6}
62	1.1 MW
63	186
64	(a) 4.3 μm; (b) 10 μm; (c) infrared
65	(a) 2.13 meV; (b) 18 T

66	(a) 6.9 μeV; (b) radio waves
67	---
68	(a) 2.55 s; (b) 0.50 ns; (c) $(4.5 \times 10^{-4})°$ or 1.6" of arc
69	(a) no; (b) 140 nm
70	(a) 20 keV; (b) 18 keV; (c) Zr; (d) Nb
71	$n > 3$; $\ell = 3$; $m_\ell = +3, +2, +1, 0, -1, -2, -3$; $m_s = \pm ½$
72	---
73	(a) 6.0; (b) 3.2×10^6 y
74	---
75	argon
76	(a) 3×10^{74}; (b) 6×10^{74}; (c) 6×10^{-38} rad
77	---
78	0.20 nm
79	$(Ze/4\pi\varepsilon_0)(r^{-2} - rR^{-3})$

Chapter 41

1	---
2	1.9×10^{28} m^{-3} eV^{-1}
3	8.49×10^{28} m^{-3}
4	0.91
5	(b) 6.81×10^{27} m^{-3} eV$^{-3/2}$; (c) 1.52×10^{28} m^{-3} eV^{-1}
6	---
7	(a) 0; (b) 0.0955
8	5.90×10^{28} m^{-3}
9	(a) 5.86×10^{28} m^{-3}; (b) 5.49 eV; (c) 1.39×10^3 km/s; (d) 0.522 nm
10	---

11	(a) 1.36×10^{28} m^{-3} eV^{-1}; (b) 1.68×10^{28} m^{-3} eV^{-1}; (c) 9.01×10^{27} m^{-3} eV^{-1}; (d) 9.56×10^{26} m^{-3} eV^{-1}; (e) 1.71×10^{18} m^{-3} eV^{-1}
12	about 10^{-42}
13	(a) 6.81 eV; (b) 1.77×10^{28} m^{-3} eV^{-1}; (c) 1.59×10^{28} m^{-3} eV^{-1}
14	(a) 90.0%; (b) 12.4%; (c) sodium
15	(a) 2.50×10^{3} K; (b) 5.30×10^{3} K
16	(a) 2.7×10^{25} m^{-3}; (b) 8.43×10^{28} m^{-3}; (c) 3.1×10^{3}; (d) 3.3 nm; (e) 0.23 nm
17	3
18	7.2×10^{24}
19	(a) 1.0; (b) 0.99; (c) 0.50; (d) 0.014; (e) 2.4×10^{-17}; (f) 7.0×10^{2} K
20	5.1×10^{15}
21	(a) 0.0055; (b) 0.018
22	472 K
23	---
24	0.84 g/cm^3
25	(a) 19.7 kJ; (b) 197 s
26	57 meV
27	(a) 1.31×10^{29} m^{-3}; (b) 9.43 eV; (c) 1.82×10^{3} km/s; (d) 0.40 nm
28	5.52 eV
29	57.1 kJ
30	6.9×10^{19}

31	(a) 226 nm; (b) ultraviolet
32	(a) +3*e*; (b) +5*e*; (c) 2
33	(a) 1.5×10^{-6}; (b) 1.5×10^{-6}
34	---
35	0.22 μg
36	(a) above; (b) 0.744 eV; (c) 7.13×10^{-7}
37	(a) 4.79×10^{-10}; (b) 0.0140; (c) 0.824
38	(a) *n*-type; (b) 5×10^{21} m^{-3}; (c) 5×10^{5}
39	6.0×10^{5}
40	(b) 2.5×10^{8}
41	4.20 eV
42	opaque
43	13 μm
44	(a) 5.0×10^{-17} F; (b) 3.1×10^{2}
45	---
46	(a) $+8 \times 10^{-11}$ Ω·m/K; (b) -2×10^{2} Ω·m/K
47	(a) 109.5°; (b) 238 pm
48	---
49	(b) 1.8×10^{28} m^{-3} eV^{-1}
50	0.03
51	---
52	---
53	3.49×10^{3} atm

Chapter 42

1	1.3×10^{-13} m
2	15.8 fm
3	46.6 fm
4	28.3 MeV

5	(a) 0.390 MeV; (b) 4.61 MeV
6	(a) yttrium; (b) iodine; (c) 50; (d) 74; (e) 19
7	(a) 2.3×10^{17} kg/m^3; (b) 2.3×10^{17} kg/m^3; (d) 1.0×10^{25} C/m^3; (e) 8.8×10^{24} C/m^3
8	(b) 0.05%; (c) 0.81%; (d) 0.81%; (e) 0.74%; (f) 0.71%; (g) no
9	(a) 6; (b) 8
10	(a) $+7.825 \times 10^{-3}$ u; (b) +7.290 MeV/c^2; (c) $+8.664 \times 10^{-3}$ u; (d) +8.071 MeV/c^2; (e) -9.780×10^{-2} u; (f) -91.10 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	1.6×10^{25} MeV
25	5.3×10^{22}
26	280 d
27	(a) 0.250; (b) 0.125
28	(a) 5.04×10^{18}; (b) 4.60×10^{6} s^{-1}
29	(a) 64.2 h; (b) 0.125; (c) 0.0749
30	3.0×10^{19}
31	(a) 7.5×10^{16} s^{-1}; (b) 4.9×10^{16} s^{-1}
32	0.49
33	1×10^{13} atoms
34	0.66 g
35	---
36	87.9 mg
37	265 mg
38	4.96×10^{9}
39	(a) 8.88×10^{10} s^{-1}; (b) 1.19×10^{15}; (c) 0.111 μg
40	209 d
41	1.12×10^{11} y
42	4.9×10^{13} Bq
43	9.0×10^{8} Bq
44	60 Bq
45	(a) 3.2×10^{12} Bq; (b) 86 Ci
46	(a) β^- decay; (b) 8.2×10^{7} s^{-1}; (c) 1.2×10^{6}
47	(a) 2.0×10^{20}; (b) 2.8×10^{9} s^{-1}

48	(a) 4.25 MeV; (b) -24.1 MeV; (c) 28.3 MeV
49	(a) 1.2×10^{-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~~ 78 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) 2.7×10^{13} W
59	78.3 eV
60	1.61×10^{3} y
61	(a) 1.06×10^{19}; (b) 0.624×10^{19}; (c) 1.68×10^{19}; (d) 2.97×10^{9} y
62	132 μg
63	1.7 mg
64	4.28×10^{9} 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) 6.3×10^{18}; (b) 2.5×10^{11}; (c) 0.20 J; (d) 2.3 mGy; (e) 30 mSv
70	3.87×10^{10} K

71	(a) 6.6 MeV; (b) no
72	(a) ^{18}O, ^{60}Ni, ^{92}Mo, ^{144}Sm, ^{207}Pb; (b) ^{40}K, ^{91}Zr, ^{121}Sb, ^{143}Nd; (c) ^{13}C, ^{40}K, ^{49}Ti, ^{205}Tl, ^{207}Pb
73	(a) 25.4 MeV; (b) 12.8 MeV; (c) 25.0 MeV
74	1.7×10^9 y
75	^{7}Li
76	13 mJ
77	3.2×10^4 y
78	19.7 d
79	730 cm^2
80	(a) 7×10^7 electrons; (b) (7×10^7 electrons) exp[-(ln 2)(D - 1996)/$T_{1/2}$], where D is the current year and $T_{1/2}$ = 30.2 y
81	^{225}Ac
82	---
83	30 MeV
84	(a) 3.66×10^7 Bq; (b) 3.66×10^7 Bq; (c) 6.42 ng
85	---
86	6.79 MeV
87	---
88	4×10^{-22} s
89	27
90	(a) ^{142}Nd, ^{143}Nd, ^{144}Nd, ^{145}Nd, ^{146}Nd, ^{148}Nd, ^{150}Nd; (b) ^{97}Rb, ^{98}Sr, ^{99}Y, ^{100}Zr, ^{101}Nb, ^{102}Mo, ^{103}Tc, ^{105}Rh, ^{109}In, ^{110}Sn, ^{111}Sb, ^{112}Te; ^{113}I, ^{114}Xe, ^{115}Cs, ^{116}Ba (c) ^{60}Zn, ^{60}Cu, ^{60}Ni, ^{60}Co, ^{60}Fe, ^{60}Mn, ^{60}Cr, ^{60}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	(b) 1.00; (c) 70.8; (d) 0.0100; (e) 0.708; (f) no
97	(a) 4.8×10^{-18} s^{-1}; (b) 4.6×10^{9} y

Chapter 43

1	(a) 16 day^{-1}; (b) 4.3×10^{8}
2	yes
3	4.8 MeV
4	4.54×10^{26} MeV
5	1.3×10^{3} kg
6	(a) ^{95}Sr; (b) ^{95}Y; (c) ^{134}Te; (d) 3
7	3.1×10^{10} s^{-1}
8	(a) +5.00 MeV
9	(a) 2.6×10^{24}; (b) 8.2×10^{13} J; (c) 2.6×10^{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) 1.7×10^{25}; (c) 1.3×10^{25}
16	(a) 44 kton
17	(a) ^{153}Nd; (b) 110 MeV; (c) 60 MeV; (d) 1.6×10^{7} m/s; (e) 8.7×10^{6} m/s
18	462 kg
19	---
20	8.03×10^{3} MW

21	557 W
22	1.6×10^{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	3.6×10^{9} y
27	(a) 75 kW; (b) 5.8×10^{3} kg
28	---
29	1.7×10^{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) 4.3×10^{9} kg/s; (b) 3.1×10^{-4}
38	---
39	---
40	(a) 4.0×10^{27} MeV; (b) 5.1×10^{26} MeV
41	1.6×10^{8} y
42	---
43	(a) 24.9 MeV; (b) 8.65 megatons TNT
44	5×10^{9} y
45	(a) 1.8×10^{38} s^{-1}; (b) 8.2×10^{28} s^{-1}
46	---
47	(a) 4.1 eV/atom; (b) 9.0 MJ/kg; (c) 1.5×10^{3} y
48	---
49	14.4 kW

50	(a) 6.3×10^{14} J/kg; (b) 6.2×10^{11} kg/s; (c) 4.3×10^{9} kg/s; (e) 1.5×10^{10} y
51	$^{238}U + n \rightarrow {}^{239}U \rightarrow {}^{239}Np + e + \nu$, $^{239}Np \rightarrow {}^{239}Pu + e + \nu$
52	(a) 3.5 MeV; (b) 14.1 MeV
53	---
54	---
55	(a) 3.1×10^{31} protons/m^3; (b) 1.2×10^{6}
56	(b) 5.0×10^{5} m/s
57	(a) 35 MJ; (b) 7.6 kg; (c) 3500 MW
58	(a) 9×10^{5} m/s; (b) 9×10^{-7} m

Chapter 44

1	$\pi^- \rightarrow \mu^- + \bar{\nu}$
2	1
3	2.4 pm
4	18.4 fm
5	2.4×10^{-43}
6	---
7	769 MeV
8	(a) 1.90×10^{-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_μ; (c) energy, L_μ
12	(a) $2e^+$, e^-, 5ν, $4\bar{\nu}$; (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	---
21	(a) K^+; (b) $\bar{n}$; (c) K^0
22	338 MeV
23	(a) 37.7 MeV; (b) 5.35 MeV; (c) 32.4 MeV
24	(a) Σ^0; (b) 7.51×10^6 m/s
25	(a) $\bar{u}\bar{u}\bar{d}$; (b) $\bar{u}\bar{d}\bar{d}$
26	(a) n; (b) Σ^+; (c) Ξ^-
27	$s\bar{d}$
28	(a) sud (b) uss
29	(a) Ξ^0; (b) Σ^-
30	(a) not possible; (b) uuu
31	2.77×10^8 ly
32	8.3×10^9 ly
33	668 nm
34	(a) 1.0×10^{10} m; (b) 3.3×10^2 m/s
35	1.4×10^{10} ly
36	$102M_S$
37	(a) 2.6 K; (b) 976 nm
38	(b) 2.39×10^9 K
39	(b) 5.7 H atoms/m^3
40	(b) 0.934; (c) 1.28×10^{10} ly
41	4.57×10^3
42	(a) 0.26 meV; (b) 4.8 mm
43	(a) 121 m/s; (b) 0.00406; (c) 248 y

44	(b) $2\pi r^{1.5}(GM)^{-0.5}$
45	---
46	13×10^9 y
47	1.08×10^{42} J
48	(a) *A*; (b) *J*; (c) *I*; (d) *F*; (e) *G*; (f) *C*; (g) *H*; (h) *D*; (i) *E*
49	(a) 0.785*c*; (b) 0.993*c*; (c) C2; (d) C1; (e) 51 ns; (f) 40 ns
51	(c) $r\alpha/c + (r\alpha/c)^2 + (r\alpha/c)^3 + \ldots$; (d) $r\alpha/c$; (e) $\alpha = H$; (f) 6.5×10^8 ly; (g) 6.9×10^8 y; (h) 6.5×10^8 y; (i) 6.9×10^8 ly; (j) 1.0×10^9 ly; (k) 1.1×10^9 y; (l) 3.9×10^8 ly
52	6.03×10^{-29} kg
53	(a) ssd; (b) $\bar{s}\,\bar{s}\,\bar{d}$
54	7.3×10^{20} Hz