Chapter 23

P23.2 (a) 2.62×10^{24}; (b) 2.38 electrons for every 10^9 present

P23.4 57.5 N

P23.6 2.51×10^{-9}

P23.8 514 kN

P23.10 $x = 0.634d$. The equilibrium is stable if the third bead has positive charge.

P23.12 (a) period $= \frac{\pi}{2}\sqrt{\frac{md^3}{k_e qQ}}$ where m is the mass of the object with charge $-Q$; (b) $4a\sqrt{\frac{k_e qQ}{md^3}}$

P23.14 1.49 g

P23.16 720 kN/C down

P23.18 (a) $\left[18.0\hat{\mathbf{i}} - 218\hat{\mathbf{j}}\right]$ kN/C;
(b) $\left(36.0\hat{\mathbf{i}} - 436\hat{\mathbf{j}}\right)$ mN

P23.20 (a) $12.9\hat{\mathbf{j}}$ kN/C; (b) $-38.6\hat{\mathbf{j}}$ mN

P23.22 see the solution

P23.24 $-\frac{\pi^2 k_e q}{6a^2}\hat{\mathbf{i}}$

P23.26 $\frac{k_e \lambda_0}{x_0}\left(-\hat{\mathbf{i}}\right)$

P23.28 $\frac{k_e \lambda_0}{2x_0}\left(-\hat{\mathbf{i}}\right)$

P23.30 (a) 383 MN/C away; (b) 324 MN/C away; (c) 80.7 MN/C away; (d) 6.68 MN/C away

P23.32 see the solution

P23.34 (a) $\frac{k_e Q\hat{\mathbf{i}}}{h}\left[\left(d^2 + R^2\right)^{-1/2} - \left((d+h)^2 + R^2\right)^{-1/2}\right]$;
(b) $\frac{2k_e Q\hat{\mathbf{i}}}{R^2 h}\left[h + \left(d^2 + R^2\right)^{1/2} - \left((d+h)^2 + R^2\right)^{1/2}\right]$

P23.36 (a) 200 pC; (b) 141 pC; (c) 58.9 pC

P23.38 see the solution

P23.40 (a) $-\frac{1}{3}$; (b) q_1 is negative and q_2 is positive

P23.42 electron: 4.39 Mm/s; proton: 2.39 km/s

P23.44 (a) $-57.6\hat{\mathbf{i}}$ Tm/s^2; (b) $2.84\hat{\mathbf{i}}$ Mm/s; (c) 49.3 ns

P23.46 (a) down; (b) 3.43 μC

P23.48 The particle strikes the negative plate after moving in a parabola 0.181 mm high and 0.961 mm.

P23.50 Possible only with $+51.3\ \mu$C at $x = -16.0$ cm

P23.52 (a) 24.2 N/C at 0°; (b) 9.42 N/C at 117°

P23.54 5.25 μC

P23.56 (a) $\frac{mg}{A\cot\theta + B}$; (b) $\frac{mgA}{A\cos\theta + B\sin\theta}$

P23.58 0.205 μC

P23.60 $\frac{k_e qQ}{a^2}$ toward the 29th vertex

P23.62 $443\,\hat{\mathbf{i}}$ kN/C

P23.64 $0.072\,9a$

P23.66 see the solution; the period is $\frac{\pi}{8^{1/4}}\sqrt{\frac{mL^3}{k_e Qq}}$

P23.68 $R\left(\frac{mg}{k_e\sqrt{3}}\right)^{1/2}$

P23.70 (a) see the solution; (b) $\hat{\mathbf{k}}$

P23.72 $\left(-1.36\hat{\mathbf{i}} + 1.96\hat{\mathbf{j}}\right)$ kN/C

P24.2 $355 \text{ kN}\cdot\text{m}^2/\text{C}$

P24.4 (a) $-2.34 \text{ kN}\cdot\text{m}^2/\text{C}$; (b) $+2.34 \text{ kN}\cdot\text{m}^2/\text{C}$; (c) 0

P24.6 $\frac{q}{\epsilon_0}$

P24.8 ERh

P24.10 (a) -55.6 nC; (b) The negative charge has a spherically symmetric distribution.

P24.12 (a) $\frac{q}{2\epsilon_0}$; (b) $\frac{q}{2\epsilon_0}$; (c) Plane and square both subtend a solid angle of a hemisphere at the charge.

P24.14 (a) $1.36 \text{ MN}\cdot\text{m}^2/\text{C}$; (b) $678 \text{ kN}\cdot\text{m}^2/\text{C}$; (c) No; see the solution.

P24.16 $1.77 \text{ pC}/\text{m}^3$ positive

P24.18 $\frac{Q-6|q|}{6\epsilon_0}$

P24.20 $28.2 \text{ N}\cdot\text{m}^2/\text{C}$

P24.22 $\frac{-q}{24\epsilon_0}$

P24.24 (a) 0; (b) $365 \text{ kN}/\text{C}$; (c) $1.46 \text{ MN}/\text{C}$; (d) $649 \text{ kN}/\text{C}$

P24.26 (a) 913 nC; (b) 0

P24.28 $4.86 \text{ GN}/\text{C}$ away from the wall. It is constant close to the wall

P24.30 $76.4 \text{ kN}/\text{C}$ radially inward

P24.32 3.50 kN

P24.34 (a) $\frac{Qr^3}{\epsilon_0 a^3}$; (b) $\frac{Q}{\epsilon_0}$; (c) see the solution

P24.36 713 nC; (b) 5.70 μC

P24.38 (a) $16.2 \text{ MN}/\text{C}$ toward the filament; (b) $8.09 \text{ MN}/\text{C}$ toward the filament; (c) $1.62 \text{ MN}/\text{C}$ toward the filament

P24.40 $-1.15 \text{ nC}/\text{m}^2$

P24.42 (a) 0; (b) $12.4 \text{ kN}/\text{C}$ radially outward; (c) $639 \text{ N}/\text{C}$ radially outward; (d) Nothing would change.

P24.44 (a) 0; (b) $79.9 \text{ MN}/\text{C}$ radially outward; (c) 0; (d) $7.34 \text{ MN}/\text{C}$ radially outward

P24.46 (a) $248 \text{ nC}/\text{m}^2$; (b) $496 \text{ nC}/\text{m}^2$

P24.48 (a) $2.56 \text{ MN}/\text{C}$ radially inward; (b) 0

P24.50 (a) $\frac{-q}{4\pi a^2}$; (b) $\frac{Q+q}{4\pi b^2}$

P24.52 see the solution

P24.54 $\frac{chw^2}{2}$

P24.56 see the solution

P24.58 (a) -4.00 nC; (b) $+9.56$ nC; (c) $+4.00$ nC and $+5.56$ nC

P24.60 (a, b) see the solution; (c) $\frac{1}{2\pi}\sqrt{\frac{k_e e^2}{m_e R^3}}$; (d) 102 pm

P24.62 (a) 0; (b) $\frac{\sigma}{\epsilon_0}$ to the right; (c) 0

P24.64 see the solution

P24.66 $0.269 \text{ N}\cdot\text{m}^2/\text{C}$; 2.38 pC

P24.68 see the solution

P24.70 (a) $\frac{\rho_0 r}{2\epsilon_0}\left(a-\frac{2r}{3b}\right)$; (b) $\frac{\rho_0 R^2}{2\epsilon_0 r}\left(a-\frac{2R}{3b}\right)$

P24.72 (a) $\mathbf{E}=\frac{Cd^3}{24\epsilon_0}\hat{\mathbf{i}}$ for $x>\frac{d}{2}$; $\mathbf{E}=-\frac{Cd^3}{24\epsilon_0}\hat{\mathbf{i}}$ for $x<-\frac{d}{2}$; (b) $\mathbf{E}=\frac{Cx^3}{3\epsilon_0}\hat{\mathbf{i}}$ for $x>0$; $\mathbf{E}=-\frac{Cx^3}{3\epsilon_0}\hat{\mathbf{i}}$ for $x<0$

P25.2 6.41×10^{-19} C

P25.4 -0.502 V

P25.6 1.67 MN/C

P25.8 (a) 59.0 V; (b) 4.55 Mm/s

P25.10 see the solution

P25.12 40.2 kV

P25.14 0.300 m/s

P25.16 (a) 0; (b) 0; (c) 45.0 kV

P25.18 (a) -4.83 m; (b) 0.667 m and -2.00 m

P25.20 (a) -386 nJ; (b) 103 V

P25.22 (a) 32.2 kV; (b) -96.5 mJ

P25.24 $-\dfrac{5k_e q}{R}$

P25.26 (a) 10.8 m/s and 1.55 m/s; (b) greater

P25.28 (a) $-45.0\ \mu$J; (b) 34.6 km/s

P25.30 see the solution

P25.32 27.4 fm

P25.34 -3.96 J

P25.36 $22.8\dfrac{k_e q^2}{s}$

P25.38 (a) 0; (b) $\dfrac{k_e Q}{r^2}$ radially outward

P25.40 (a) larger at A; (b) 200 N/C down; (c) see the solution

P25.42 $-0.553\dfrac{k_e Q}{R}$

P25.44 $-\dfrac{k_e \alpha L}{2}\ln\left[\dfrac{\sqrt{b^2+\left(L^2/4\right)}-L/2}{\sqrt{b^2+\left(L^2/4\right)}+L/2}\right]$

P25.46 $2\pi k_e \sigma\left[\sqrt{x^2+b^2}-\sqrt{x^2+a^2}\right]$

P25.48 1.56×10^{12} electrons

P25.50 (a) 135 kV; (b) 2.25 MV/m away from the large sphere and 6.74 MV/m away from the small sphere

P25.52 (a) 13.3 μC; (b) 0.200 m

P25.54 (a) $\sim 10^4$ V; (b) $\sim 10^{-6}$ C

P25.56 14.5 Mm/s

P25.58 (a) $\dfrac{k_e Q}{h}\ln\left(\dfrac{d+h+\sqrt{(d+h)^2+R^2}}{d+\sqrt{d^2+R^2}}\right)$;

(b) $\dfrac{k_e Q}{R^2 h}\left[(d+h)\sqrt{(d+h)^2+R^2}-d\sqrt{d^2+R^2} -2dh-h^2+R^2\ln\left(\dfrac{d+h+\sqrt{(d+h)^2+R^2}}{d+\sqrt{d^2+R^2}}\right)\right]$

P25.60 (a) 488 V; (b) 7.81×10^{-17} J; (c) 306 km/s; (d) 390 Gm/s^2 toward the negative plate; (e) 6.51×10^{-16} N toward the negative plate; (f) 4.07 kN/C toward the negative plate

P25.62 (a) 1.42 mm; (b) 9.20 kV/m

P25.64 $\left(\dfrac{k_e q^2}{3am}\right)^{1/2}$

P25.66 (a) $\mathbf{E}_A = 0$; $\mathbf{E}_B = \left(\dfrac{89.9}{r^2}\right)$ V/m radially outward; $\mathbf{E}_C = \left(-\dfrac{45.0}{r^2}\right)$ V/m radially outward; (b) $V_A = 150$ V; $V_B = \left(-450 + \dfrac{89.9}{r}\right)$ V; $V_C = \left(-\dfrac{45.0}{r}\right)$ V

P25.68 $k_e \lambda \ln\left[\dfrac{a+L+\sqrt{(a+L)^2+b^2}}{a+\sqrt{a^2+b^2}}\right]$

P25.70 $E_x = 3E_0 a^3 xz\left(x^2+y^2+z^2\right)^{-5/2}$; $E_y = 3E_0 a^3 yz\left(x^2+y^2+z^2\right)^{-5/2}$; $E_z = E_0 + \dfrac{E_0 a^3\left(2z^2-x^2-y^2\right)}{\left(x^2+y^2+z^2\right)^{5/2}}$ outside and $\mathbf{E} = 0$ inside

P25.72 $\dfrac{3}{5}\dfrac{k_e Q^2}{R}$

P26.2 (a) $1.00\ \mu F$; (b) $100\ V$

P26.4 (a) $8.99\ mm$; (b) $0.222\ pF$; (c) $22.2\ pC$

P26.6 $11.1\ nF$; $26.6\ C$

P26.8 $3.10\ nm$

P26.10 $\frac{(2N-1)\in_0(\pi-\theta)R^2}{d}$

P26.12 $2.13\times10^{16}\ m^3$

P26.14 $\frac{mgd\tan\theta}{q}$

P26.16 (a) $17.0\ \mu F$; (b) $9.00\ V$;
(c) $45.0\ \mu C$ and $108\ \mu C$

P26.18 $1.83C$

P26.20 $\frac{C_p}{2}+\sqrt{\frac{C_p^2}{4}-C_pC_s}$ and $\frac{C_p}{2}-\sqrt{\frac{C_p^2}{4}-C_pC_s}$

P26.22 (a) $2C$; (b) $Q_1>Q_3>Q_2$;
(c) $\Delta V_1>\Delta V_2=\Delta V_3$;
(d) Q_3 and Q_1 increase and Q_2 decreases

P26.24 (a) $398\ \mu F$ in series; (b) $2.20\ \mu F$ in parallel

P26.26 $19.8\ \mu C$

P26.28 $83.6\ \mu C$

P26.30 $\left(\sqrt{3}-1\right)\frac{C_0}{2}$

P26.32 $4.47\ kV$

P26.34 energy doubles

P26.36 $2.51\times10^{-3}\ m^3=2.51\ L$

P26.38 (a) $400\ \mu C$; (b) $2.50\ kN/m$

P26.40 (a) $C(\Delta V)^2$; (b) $\frac{4\Delta V}{3}$; (c) $4C\frac{(\Delta V)^2}{3}$;
(d) Positive work is done on the system by the agent pulling the plates apart.

P26.42 (a) $q_1=\frac{R_1Q}{R_1+R_2}$ and $q_2=\frac{R_2Q}{R_1+R_2}$;
(b) see the solution

P26.44 (a) $13.3\ nC$; (b) $272\ nC$

P26.46 $\sim10^{-6}\ F$ and $\sim10^2\ V$ for two 40 cm by 100 cm sheets of aluminum foil sandwiching a thin sheet of plastic.

P26.48 (a) $1.53\ nF$; (b) $18.4\ nC$; (c) $184\ \mu C/m^2$ free; $183\ \mu C/m^2$ induced; (d) $694\ V/m$

P26.50 (a) $\left(-9.10\hat{\mathbf{i}}+8.40\hat{\mathbf{j}}\right)\ pC\cdot m$;
(b) $-20.9\ nN\cdot m\hat{\mathbf{k}}$; (c) $112\ nJ$; (d) $228\ nJ$

P26.52 $579\ V$

P26.54 (a) $3.33\ \mu F$;
(b) $\Delta V_3=60.0\ V$; $\Delta V_6=30.0\ V$;
$\Delta V_2=60.0\ V$; $\Delta V_4=30.0\ V$;
(c) $Q_3=Q_6=180\ \mu C$; $Q_2=Q_4=120\ \mu C$;
(d) $13.4\ mJ$

P26.56 $189\ kV$

P26.58 (a) $40.0\ \mu J$; (b) $500\ V$

P26.60 yes; $1.00\ Mm/s$

P26.62 $23.3\ V$; $26.7\ V$

P26.64 (a) $\frac{\in_0\left[\ell^2+\ell x(\kappa-1)\right]}{d}$;
(b) $\frac{\in_0(\Delta V)^2\left[\ell^2+\ell x(\kappa-1)\right]}{2d}$;
(c) $\frac{\in_0(\Delta V)^2\ell(\kappa-1)}{2d}$ to the left;
(d) $1.55\ mN$ left

P26.66 Gasoline has 194 times the specific energy content of the battery, and 727 000 times that of the capacitor.

P26.68 see the solution; $45\ V$

P26.70 $\frac{2}{3}$

P26.72 $3.00\ \mu F$

P26.74 see the solution

P26.76 see the solution

Chapter 27

P27.2 3.64 h

P27.4 (a) see the solution; (b) 1.05 mA

P27.6 (a) 17.0 A ; (b) 85.0 kA/m^2

P27.8 (a) 99.5 kA/m^2 ; (b) 8.00 mm

P27.10 (a) 221 nm ; (b) no; see the solution

P27.12 30.3 MA/m^2

P27.14 (a) 3.75 kΩ ; (b) 536 m

P27.16 0.018 1 Ω · m

P27.18 2.71 MΩ

P27.20 (a) 777 nΩ ; (b) 3.28 $\mu\text{m}/\text{s}$

P27.22 $\frac{r_{\text{Al}}}{r_{\text{Cu}}} = 1.29$

P27.24 378 Ω

P27.26 (a) nothing; (b) doubles; (c) doubles; (d) nothing

P27.28 1.98 A

P27.30 carbon, 4.44 kΩ ; nichrome, 5.56 kΩ

P27.32 1.71 Ω

P27.34 0.153 Ω

P27.36 5.00 A , 24.0 Ω

P27.38 448 A

P27.40 (a) 0.530; (b) 221 J; (c) 15.1°C

P27.42 (a) 3.17 m ; (b) 340 W

P27.44 (a) 0.660 kWh ; (b) 3.96¢

P27.46 (a) 2.05 W; (b) 3.41 W; no

P27.48 295 metric ton/h

P27.50 672 s

P27.52 (a) \$1.61; (b) \$0.005 82; (c) \$0.416

P27.54 (a) 576 Ω and 144 Ω ;
(b) 4.80 s; The charge is the same. The charge-field system is in a lower-energy configuration.
(c) 0.040 0 s; The energy enters by electric transmission and exits by heat and electromagnetic radiation;
(d) \$1.26; energy; 1.94×10^{-8} \$/J

P27.56 27.0 yr

P27.58 50.0 MW

P27.60 (a) 116 V ; (b) 12.8 kW ; (c) 436 W

P27.62 (a) $\mathbf{E} = \frac{V\hat{\mathbf{i}}}{L}$; (b) $R = \frac{4\rho L}{\pi d^2}$; (c) $I = \frac{V\pi d^2}{4\rho L}$;
(d) $\mathbf{J} = \frac{V\hat{\mathbf{i}}}{\rho L}$; (e) see the solution

P27.64 2.00 Ω

P27.66 (a) see the solution;
(b) 1.418 Ω nearly agrees with 1.420 Ω

P27.68 (a) $R = \frac{\rho}{2\pi L}\ln\frac{r_b}{r_a}$; (b) $\rho = \frac{2\pi L\Delta V}{I\ln\left(r_b/r_a\right)}$

P27.70 see the solution

P27.72 see the solution

P27.74 see the solution

Chapter 28

P28.2 (a) 1.79 A ; (b) 10.4 V

P28.4 (a) 12.4 V ; (b) 9.65 V

P28.6 (a) 17.1 Ω ; (b) 1.99 A in 4 Ω and 9 Ω ; 1.17 A in 7 Ω ; 0.818 A in 10 Ω

P28.8 29.5 V

P28.10 (a) see the solution; (b) no

P28.12 see the solution

P28.14 $R_1 = 1.00\ \text{k}\Omega$; $R_2 = 2.00\ \text{k}\Omega$; $R_3 = 3.00\ \text{k}\Omega$

P28.16 470 Ω and 220 Ω

P28.18 (a) 11.0 Ω ; (b) and (d) see the solution; (c) 220 Ω ; (e) Parallel

P28.20 $I_1 = 714\ \text{mA}$; $I_2 = 1.29\ \text{A}$; $\varepsilon = 12.6\ \text{V}$

P28.22 see the solution

P28.24 (a) 0.385 mA in R_1; 2.69 mA in R_3 ; 3.08 mA in R_2 ; (b) c higher by 69.2 V

P28.26 1.00 A up in 200 Ω ; 4.00 A up in 70 Ω ; 3.00 A up in 80 Ω ; 8.00 A down in 20 Ω ; 200 V

P28.28 see the solution

P28.30 800 W to the left-hand resistor; 25.0 W to each 4 Ω ; 450 W to the right-hand resistor

P28.32 (a) −61.6 mA ; (b) 0.235 μC ; (c) 1.96 A

P28.34 0.982 s

P28.36 (a) 1.50 s ; (b) 1.00 s ; (c) $200\ \mu\text{A} + (100\ \mu\text{A})e^{-t/1.00\ \text{s}}$

P28.38 (a) 3.91 s; (b) 0.782 ms

P28.40 $\dfrac{t}{C \ln 2}$

P28.42 0.113 Ω

P28.44 (a) 30.000 mA , 5.400 0 V ; (b) 30.167 mA , 5.381 6 V ; (c) 29.898 mA ; 5.396 6 V

P28.46 see the solution

P28.48 (a) 0.101 W; (b) 10.1 W

P28.50 15.5 A

P28.52 2.22 h

P28.54 a is 4.00 V higher

P28.56 (a) see the solution; 833 mA; 200 W; (b) see the solution; 4.17 A; 1.00 kW

P28.58 587 kΩ

P28.60 and

P28.62 (a) $I_1 = \dfrac{IR_2}{(R_1 + R_2)}$; $I_2 = \dfrac{IR_1}{R_1 + R_2}$; (b) see the solution

P28.64 see the solution

P28.66 $(R_1 + 2R_2)C \ln 2$

P28.68 (a) 222 μC ; (b) increase by 444 μC

P28.70 see the solution

P28.72 (a) 5.00 Ω ; (b) 2.40 A

P28.74 (a) $R_x = R_2 - \dfrac{R_1}{4}$; (b) no; $R_x = 2.75\ \Omega$

P28.76 (a) and (b) see the solution; (c) $\dfrac{r\varepsilon}{r + R} e^{-t/rC}$

P29.2 (a) west; (b) no deflection; (c) up; (d) down

P29.4 (a) $86.7\ \text{fN}$; (b) $51.9\ \text{Tm/s}^2$

P29.6 (a) $7.90\ \text{pN}$; (b) 0

P29.8 Gravitational force: $8.93\times10^{-30}\ \text{N down}$;
Electric force: $16.0\ \text{aN up}$;
Magnetic force: $48.0\ \text{aN down}$

P29.10 $B_y = -2.62\ \text{mT}$; $B_z = 0$; B_x may have any value

P29.12 $\left(-2.88\hat{\mathbf{j}}\right)\ \text{N}$

P29.14 $109\ \text{mA}$ to the right

P29.16 $\left(\dfrac{4IdBL}{3m}\right)^{1/2}$

P29.18 $\mathbf{F}_{ab} = 0$; $\mathbf{F}_{bc} = 40.0\ \text{mN}\left(-\hat{\mathbf{i}}\right)$; $\mathbf{F}_{cd} = 40.0\ \text{mN}\left(-\hat{\mathbf{k}}\right)$; $\mathbf{F}_{da} = (40.0\ \text{mN})\left(\hat{\mathbf{i}}+\hat{\mathbf{k}}\right)$

P29.20 (a) $5.41\ \text{mA}\cdot\text{m}^2$; (b) $4.33\ \text{mN}\cdot\text{m}$

P29.22 (a) $3.97°$; (b) $3.39\ \text{mN}\cdot\text{m}$

P29.24 (a) $80.1\ \text{mN}\cdot\text{m}$; (b) $104\ \text{mN}\cdot\text{m}$;
(c) $132\ \text{mN}\cdot\text{m}$;
(d) The torque on the circle.

P29.26 (a) minimum: pointing north at 48.0° below the horizontal; maximum: pointing south at 48.0° above the horizontal;
(b) $1.07\ \mu\text{J}$

P29.28 (a) $640\ \mu\text{N}\cdot\text{m}$; (b) 241 mW; (c) 2.56 mJ;
(d) 154 mW

P29.30 1.98 cm

P29.32 65.6 mT

P29.34 (a) $5.00\ \text{cm}$; (b) $8.78\ \text{Mm/s}$

P29.36 $\dfrac{m'}{m} = 8$

P29.38 see the solution

P29.40 $244\ \text{kV/m}$

P29.42 278 mm

P29.44 162 mm

P29.46 3.00 T

P29.48 (a) $7.44\times10^{28}/\text{m}^3$; (b) $1.79\ \text{T}$

P29.50 (a) $37.7\ \text{mT}$; (b) $4.29\times10^{25}/\text{m}^3$

P29.52 (a) 17.9 ns; (b) 35.1 eV

P29.54 39.2 mT

P29.56 (a) B_x is indeterminate. $B_y = 0$; $B_z = \dfrac{-F_i}{ev_i}$;
(b) $-F_i\hat{\mathbf{j}}$; (c) $-F_i\hat{\mathbf{j}}$

P29.58 128 mT north at an angle of 78.7° below the horizontal

P29.60 $\dfrac{3R}{4}$

P29.62 $B\sim10^{-1}\ \text{T}$; $\tau\sim10^{-1}\ \text{N}\cdot\text{m}$; $I\sim1\ \text{A}$; $A\sim10^{-3}\ \text{m}^2$; $N\sim10^3$

P29.64 $\dfrac{\lambda g\tan\theta}{I}$

P29.66 (a) $0.104\ \text{mm}$; (b) $0.189\ \text{mm}$

P29.68 $3.82\times10^{-25}\ \text{kg}$

P29.70 (a) see the solution;
empirically, $\Delta V_H = (100\ \mu\text{V/T})B$;
(b) 0.125 mm

P29.72 (a) $v = \dfrac{qBh}{m}$; The particle moves in a semicircle of radius h and leaves the field with velocity $-v\hat{\mathbf{j}}$;
(b) The particle moves in a smaller semicircle of radius $\dfrac{mv}{qB}$, attaining final velocity $-v\hat{\mathbf{j}}$;
(c) The particle moves in a circular arc of radius $r = \dfrac{mv}{qB}$, leaving the field with velocity $v\sin\theta\,\hat{\mathbf{i}} + v\cos\theta\,\hat{\mathbf{j}}$ where $\theta = \sin^{-1}\left(\dfrac{h}{r}\right)$

P30.2 $20.0\ \mu\text{T}$

P30.4 $200\ \text{nT}$

P30.6 $\left(1+\frac{1}{\pi}\right)\frac{\mu_0 I}{2R}$ into the page

P30.8 see the solution

P30.10 $\left(\frac{1}{\pi}+\frac{1}{4}\right)\frac{\mu_0 I}{2r}$ into the page

P30.12 $\frac{\mu_0 I}{12}\left(\frac{1}{a}-\frac{1}{b}\right)$ out of the page

P30.14 $\frac{\mu_0 I\left(a^2+d^2-d\sqrt{a^2+d^2}\right)}{2\pi ad\sqrt{a^2+d^2}}$ into the page

P30.16 (a) $10.0\ \mu\text{T}$; (b) $80.0\ \mu\text{N}$ toward wire 1;
(c) $16.0\ \mu\text{T}$; (d) $80.0\ \mu\text{N}$ toward wire 2

P30.18 Parallel to the wires and
0.167 m below the upper wire

P30.20 (a) opposite; (b) 67.8 A

P30.22 5.40 cm

P30.24 (a) 400 cm; (b) 7.50 nT; (c) 1.26 m; (d) zero

P30.26 (a) 3.60 T; (b) 1.94 T

P30.28 500 A

P30.30 (a) see the solution; (b) $d = a$

P30.32 (a) $\frac{\mu_0 IN}{2\ell}\left[\frac{a}{\sqrt{a^2+R^2}}-\frac{a-\ell}{\sqrt{(a-\ell)^2+R^2}}\right]$;
(b) see the solution

P30.34 (a) $-B\pi R^2\cos\theta$; (b) $B\pi R^2\cos\theta$

P30.36 (a) $7.40\ \mu\text{Wb}$; (b) $2.27\ \mu\text{Wb}$

P30.38 (a) $7.19\times10^{11}\ \text{V/m}\cdot\text{s}$; (b) 200 nT

P30.40 277 mA

P30.42 $2.97\times10^{4}\ \frac{\text{K}\cdot\text{J}}{\text{T}^2\cdot\text{m}^3}$

P30.44 2.02

P30.46 (a) $12.6\ \mu\text{T}$; (b) $56.0\ \mu\text{T}$

P30.48 2.01 GA west

P30.50 $\sim10^{-5}$ T, enough to affect the compass noticeably

P30.52 $12.0\ \text{mN}\left(-\hat{\mathbf{k}}\right)$

P30.54 $\frac{\mu_0 q\omega}{2.5\sqrt{5}\pi R}$

P30.56 1.80 mT

P30.58 (a) $\mu_0\sigma v$ horizontally away from you;
(b) 0; (c) $\frac{1}{2}\mu_0\sigma^2 v^2$ up; (d) $3.00\times10^{8}\ \text{m/s}$

P30.60 (a) see the solution; (b) 3.20×10^{-13} T;
(c) 1.02×10^{-24} N away from the first proton;
(d) 2.30×10^{-22} N away from the first proton

P30.62 $347\mu_0 I/\text{m}$ perpendicular to the coil

P30.64 (a) $\frac{1}{2}\mu_0\sigma v$; (b) out of the page,
parallel to the roller axes

P30.66 675 A downward

P30.68 (a) see the solution; (b) 59.2 nN

P30.70 see the solution

P30.72 $\frac{4}{15}\pi\omega\rho R^5$ upward

P31.2 0.800 mA

P31.4 (a) see the solution; (b) 3.79 mV ; (c) 28.0 mV

P31.6 78.5 μs

P31.8 (a) $\frac{\mu_0 n\pi r_2^2}{2R}\frac{\Delta I}{\Delta t}$ counterclockwise; (b) $\frac{\mu_0^2 n\pi r_2^2}{4r_1 R}\frac{\Delta I}{\Delta t}$; (c) upward

P31.10 $-14.2\ \text{mV}\cos(120t)$

P31.12 61.8 mV

P31.14 (a) see the solution; (b) 625 m/s

P31.16 see the solution

P31.18 13.3 mA counterclockwise in the lower loop and clockwise in the upper loop.

P31.20 1.00 m/s

P31.22 (a) 500 mA ; (b) 2.00 W ; (c) 2.00 W

P31.24 24.1 V with the outer contact positive

P31.26 121 mA clockwise

P31.28 (a) to the right; (b) to the right; (c) to the right; (d) into the paper

P31.30 negative; see the solution

P31.32 (a) 8.00×10^{-21} N downward perpendicular to r_1; (b) 1.33 s

P31.34 (a) $(9.87\ \text{mV/m})\cos(100\pi t)$; (b) clockwise

P31.36 (a) $(19.6\ \text{V})\sin(314t)$; (b) 19.6 V

P31.38 see the solution

P31.40 (a) 1.60 V ; (b) 0; (c) no change; (d) and (e) see the solution

P31.42 both are correct; see the solution

P31.44 $(-4.39\hat{\mathbf{i}} - 1.76\hat{\mathbf{j}})10^{11}\ \text{m/s}^2$

P31.46 $-(7.22\ \text{mV})\cos(2\pi 523\,t/\text{s})$

P31.48 (a) 43.8 A ; (b) 38.3 W

P31.50 (a) 3.50 A up in 2 Ω and 1.40 A up in 5 Ω; (b) 34.3 W ; (c) 4.29 N

P31.52 see the solution

P31.54 (a) $\frac{\pi B_{\max}^2 R^4 b\omega^2}{16\rho}$; (b) 4 times larger; (c) 4 times larger; (d) 16 times larger

P31.56 (a) see the solution; (b) 0.250 T

P31.58 see the solution

P31.60 (a) $C\pi a^2 K$; (b) the upper plate; (c) see the solution

P31.62 (a) 97.4 nV ; (b) clockwise

P31.64 $\frac{\mu_0 I\ell v}{2\pi Rr}\frac{w}{(r+w)}$

P31.66 $\frac{MgR}{B^2\ell^2}\left[1-e^{-B^2\ell^2 t/R(M+m)}\right]$

P31.68 (a) 0.125 V to produce clockwise current; (b) 20.0 mA clockwise

P31.70 $\frac{1.18\times 10^{-4}}{0.800-4.90t^2}$; 98.3 μV

P31.72 see the solution

P32.2 1.36 μH

P32.4 240 nWb

P32.6 19.2 μWb

P32.8 (a) 360 mV ; (b) 180 mV ; (c) $t = 3.00$ s

P32.10 (a) 15.8 μH ; (b) 12.6 mH

P32.12 see the solution

P32.14 1.92 Ω

P32.16 see the solution

P32.18 92.8 V

P32.20 30.0 mH

P32.22 7.67 mH

P32.24 (a) 1.00 kΩ ; (b) 3.00 ms

P32.26 (a) 1.00 A ; (b) $\Delta V_{12} = 12.0$ V, $\Delta V_{1200} = 1.20$ kV, $\Delta V_L = 1.21$ kV ; (c) 7.62 ms

P32.28 (a), (b), and (c) see the solution; (d) yes; see the solution

P32.30 (a) 8.06 MJ/m^3 ; (b) 6.32 kJ

P32.32 (a) 27.8 J ; (b) 18.5 ms

P32.34 see the solution

P32.36 (a) 20.0 W ; (b) 20.0 W ; (c) 0;(d) 20.0 J

P32.38 $\dfrac{2\pi B_0^2 R^3}{\mu_0} = 2.70 \times 10^{18}$ J

P32.40 1.00 V

P32.42 781 pH

P32.44 $M = \dfrac{N_1 N_2 \pi \mu_0 R_1^2 R_2^2}{2\left(x^2 + R_1^2\right)^{3/2}}$

P32.46 400 mA

P32.48 281 mH

P32.50 220 mH

P32.52 (a) 503 Hz ; (b) 12.0 μC ; (c) 37.9 mA ; (d) 72.0 μJ

P32.54 (a) 2.51 kHz ; (b) 69.9 Ω

P32.56 see the solution

P32.58 (a) $0.693\left(\dfrac{2L}{R}\right)$; (b) $0.347\left(\dfrac{2L}{R}\right)$

P32.60 $\dfrac{9t^2}{\pi^2 C}$

P32.62 (a) $\varepsilon_L = -LK$; (b) $\Delta V_c = \dfrac{-Kt^2}{2C}$; (c) $t = 2\sqrt{LC}$

P32.64 (a) see the solution; (b) 91.2 μH ; (c) 90.9 μH, 0.3% smaller

P32.66 (a) 127 ; (b) 0.522 Ω ; (c) 76.8 mH

P32.68 (a) 20.0 ms; (b) 37.9 V; (c) 3.04 mV; (d) 104 mA

P32.70 95.6 mH

P32.72 (a) $I_L = 0,\ I_C = \dfrac{\varepsilon_0}{R},\ I_R = \dfrac{\varepsilon_0}{R}$, $\Delta V_L = \varepsilon_0,\ \Delta V_C = 0,\ \Delta V_R = \varepsilon_0$; (b) $I_L = 0,\ I_C = 0,\ I_R = 0$, $\Delta V_L = 0,\ \Delta V_C = \varepsilon_0,\ \Delta V_R = 0$

P32.74 (a) 251 μH ; (b) 25.1 μH ; (c) 25.1 nC

P32.76 3.97×10^{-25} Ω

P32.78 (a) 50.0 mT; (b) 20.0 mT; (c) 2.29 MJ;

(d) 318 Pa

P33.2 (a) 193 Ω ; (b) 144 Ω

P33.4 (a) 25.3 rad/s; (b) 0.114 s

P33.6 1.25 A and 96.0 Ω for bulbs 1 and 2; 0.833 A and 144 Ω for bulb 3

P33.8 7.03 H or more

P33.10 3.14 A

P33.12 3.80 J

P33.14 (a) greater than 41.3 Hz ; (b) less than 87.5 Ω

P33.16 $\sqrt{2}C(\Delta V_{\text{rms}})$

P33.18 –32.0 A

P33.20 2.79 kHz

P33.22 (a) 109 Ω ; (b) 0.367 A ; (c) $I_{\max} = 0.367$ A, $\omega = 100$ rad/s, $\phi = -0.896$ rad

P33.24 19.3 mA

P33.26 (a) 146 V ; (b) 212 V ; (c) 179 V ; (d) 33.4 V

P33.28 $X_C = 3R$

P33.30 (a) 2.00 A ; (b) 160 W ; (c) see the solution

P33.32 353 W

P33.34 (a) 5.43 A ; (b) 0.905; (c) 281 μF ; (d) 109 V

P33.36 $\dfrac{11(\Delta V_{\text{rms}})^2}{14R}$

P33.38 46.5 pF to 419 pF

P33.40 (a) 3.56 kHz ; (b) 5.00 A ; (c) 22.4 ; (d) 2.24 kV

P33.42 $\dfrac{4\pi(\Delta V_{\text{rms}})^2 RC\sqrt{LC}}{4R^2C + 9L}$

P33.44 (a) 9.23 V ; (b) 4.55 A ; (c) 42.0 W

P33.46 (a) 1 600 turns ; (b) 30.0 A ; (c) 25.3 A

P33.48 (a) 83.3 ; (b) 54.0 mA ; (c) 185 kΩ

P33.50 (a) 0.34; (b) 5.3 W; (c) $4.8

P33.52 (a) see the solution; (b) 1; 0; (c) $\dfrac{\sqrt{3}}{2\pi RC}$

P33.54 (a) 1.00; (b) 0.346

P33.56 see the solution

P33.58 $R = 99.6\ \Omega$, $C = 24.9\ \mu\text{F}$, $L = 164$ mH or 402 mH

P33.60 $L = 0.200$ m and $T = 10.9$ N, or any values related by $T = (274\ \text{kg/ms}^2)L^2$

P33.62 (a) $i(t) = \dfrac{\Delta V_{\max}}{R}\cos\omega t$; (b) ;

(c) $i(t) = \dfrac{\Delta V_{\max}}{\sqrt{R^2 + \omega^2 L^2}}\cos\left[\omega t + \tan^{-1}\left(\dfrac{\omega L}{R}\right)\right]$;

(d) $C = \dfrac{1}{\omega_0^2 L}$; (e) $Z = R$; (f) $\dfrac{(\Delta V_{\max})^2 L}{2R^2}$;

(g) $\dfrac{(\Delta V_{\max})^2 L}{2R^2}$; (h) $\tan^{-1}\left(\dfrac{3}{2R}\sqrt{\dfrac{L}{C}}\right)$;

(i) $\dfrac{1}{\sqrt{2LC}}$

P33.64 $\sim 10^3$ A

P33.66 (a) 224 rad/s ; (b) 500 W ; (c) 221 rad/s and 226 rad/s

P33.68 either 58.7 Hz or 35.9 Hz

P33.70 (a) 919 Hz ; (b) $I_R = 1.50$ A, $I_L = 1.60$ A, $I_C = 6.73$ mA ; (c) 2.19 A ; (d) –46.7° ; current lagging

P33.72 see the solution

P16.2 see the solution

P16.4 (a) the P wave; (b) 665 s

P16.6 $0.800\ \text{m/s}$

P16.8 $2.40\ \text{m/s}$

P16.10 0.300 m in the positive x-direction

P16.12 $\pm 6.67\ \text{cm}$

P16.14 (a) see the solution; (b) 0.125 s; in agreement with the example

P16.16 (a) see the solution; (b) $18.0/\text{m}$; $83.3\ \text{ms}$; $75.4\ \text{rad/s}$; $4.20\ \text{m/s}$;
(c) $(0.2\ \text{m})\sin(18x + 75.4t - 0.151)$

P16.18 (a) $0.021\,5\ \text{m}$; (b) 1.95 rad; (c) $5.41\ \text{m/s}$;
(d) $y(x,\ t) = (0.021\,5\ \text{m})\sin(8.38x + 80.0\pi t + 1.95)$

P16.20 (a) see the solution; (b) $3.18\ \text{Hz}$

P16.22 $30.0\ \text{N}$

P16.24 (a) $y = (0.2\ \text{mm})\sin(16x - 3\,140t)$;
(b) $158\ \text{N}$

P16.26 $631\ \text{N}$

P16.28 $v = \dfrac{Tg}{2\pi}\sqrt{\dfrac{M}{m}}$

P16.30 (a) $v = \left(30.4\ \dfrac{\text{m}}{\text{s}\cdot\sqrt{\text{kg}}}\right)\sqrt{m}$; (b) $3.89\ \text{kg}$

P16.32 $\sqrt{\dfrac{mL\tan\theta}{4Mg}}$

P16.34 $1.07\ \text{kW}$

P16.36 (a), (b), (c) ;
(d)

P16.38 (a) $y = (0.075\,0)\sin(4.19x - 314t)$;
(b) $625\ \text{W}$

P16.40 (a) $15.1\ \text{W}$; (b) $3.02\ \text{J}$

P16.42 The amplitude increases by 5.00 times

P16.44 see the solution

P16.46 (a) see the solution;
(b) $\frac{1}{2}(x + vt)^2 + \frac{1}{2}(x - vt)^2$;
(c) $\frac{1}{2}\sin(x + vt) + \frac{1}{2}\sin(x - vt)$

P16.48 (a) $0.040\,0\ \text{m}$; (b) $0.031\,4\ \text{m}$;
(c) $0.477\ \text{Hz}$; (d) $2.09\ \text{s}$;
(e) positive x-direction

P16.50 (a) $21.0\ \text{ms}$; (b) $1.68\ \text{m}$

P16.52 $\Delta t = \sqrt{\dfrac{mL}{Mg\sin\theta}}$

P16.54 (a) $2Mg$; (b) $L_0 + \dfrac{2Mg}{k}$;
(c) $\sqrt{\dfrac{2Mg}{m}\left(L_0 + \dfrac{2Mg}{k}\right)}$

P16.56 $14.7\ \text{kg}$

P16.58 (a) $v = \sqrt{\dfrac{T}{\rho(10^{-7}x + 10^{-6})}}$ in SI units;
(b) $94.3\ \text{m/s}$; $66.7\ \text{m/s}$

P16.60 see the solution

P16.62 (a) $5.00\hat{\mathbf{i}}\ \text{m/s}$; (b) $-5.00\hat{\mathbf{i}}\ \text{m/s}$;
(c) $-7.50\hat{\mathbf{i}}\ \text{m/s}$; (d) $24.0\hat{\mathbf{i}}\ \text{m/s}$

P16.64 (a) μv_0^2; (b) v_0;
(c) One travels 2 rev and the other does not move around the loop.

P16.66 (a) $v = \left(\dfrac{2T_0}{\mu_0}\right)^{1/2} = v_0\sqrt{2}$;
$v' = \left(\dfrac{2T_0}{3\mu_0}\right)^{1/2} = v_0\sqrt{\dfrac{2}{3}}$; (b) $0.966\Delta t_0$

P16.68 $130\ \text{m/s}$; $1.73\ \text{km}$

P17.2 1.43 km/s

P17.4 (a) 27.2 s; (b) longer than 25.7 s, because the air is cooler

P17.6 (a) 153 m/s; (b) 614 m

P17.8 (a) 4.16 m; (b) 0.455 μs; (c) 0.157 mm

P17.10 1.55×10^{-10} m

P17.12 (a) 1.27 Pa; (b) 170 Hz; (c) 2.00 m; (d) 340 m/s

P17.14 $s = 22.5 \text{ nm} \cos\left(62.8x - 2.16 \times 10^4 t\right)$

P17.16 (a) 4.63 mm; (b) 14.5 m/s; (c) 4.73×10^9 W/m^2

P17.18 (a) 5.00×10^{-17} W; (b) 5.00×10^{-5} W

P17.20 (a) 1.00×10^{-5} W/m^2; (b) 90.7 mPa

P17.22 (a) $I_2 = \left(\frac{f'}{f}\right)^2 I_1$; (b) $I_2 = I_1$

P17.24 21.2 W

P17.26 (a) 4.51 times larger in water than in air and 18.0 times larger in iron;
(b) 5.60 times larger in water than in iron and 331 times larger in air;
(c) 59.1 times larger in water than in air and 331 times larger in iron;
(d) 0.331 m; 1.49 m; 5.95 m; 10.9 nm; 184 pm; 32.9 pm; 29.2 mPa; 1.73 Pa; 9.67 Pa

P17.28 see the solution

P17.30 10.0 m; 100 m

P17.32 86.6 m

P17.34 (a) 1.76 kJ; (b) 108 dB

P17.36 no

P17.38 (a) 2.17 cm/s; (b) 2 000 028.9 Hz; (c) 2 000 057.8 Hz

P17.40 (a) 441 Hz; 439 Hz; (b) 54.0 dB

P17.42 (a) 325 m/s; (b) 29.5 m/s

P17.44 48.2°

P17.46 46.4°

P17.48 (a) 7; (b) and (c) see the solution

P17.50 (a) 0.642 W; (b) 0.004 28 = 0.428%

P17.52 (a) 0.232 m; (b) 84.1 nm; (c) 13.8 mm

P17.54 (a) 0.515/min; (b) 0.614/min

P17.56 (a) 5.04 km/s; (b) 159 μs; (c) 1.90 mm; (d) 0.002 38; (e) 476 MPa; (f) see the solution

P17.58 (a) see the solution; (b) 85.9 Hz

P17.60 The gap between bat and insect is closing at 1.69 m/s.

P17.62 (a) see the solution; (b) 0.343 m; (c) 0.303 m; (d) 0.383 m; (e) 1.03 kHz

P17.64 80.0°

P17.66 67.0 dB

P17.68 $\Delta t = \frac{eE}{4\pi d^2 I_0 10^{\beta/10}}$

P17.70 see the solution

P17.72 $\sim 10^{11}$ Hz

P18.2 see the solution

P18.4 5.66 cm

P18.6 0.500 s

P18.8 (a) 3.33 rad; (b) 283 Hz

P18.10 (a) The number is the greatest integer $\le d\left(\frac{f}{v}\right)+\frac{1}{2}$;

(b) $L_n = \frac{d^2 - (n - 1/2)^2 (v/f)^2}{2(n-1/2)(v/f)}$ where $n = 1, 2, \ldots, n_{\max}$

P18.12 (a) $\Delta x = \frac{\lambda}{2}$;

(b) along the hyperbola $9x^2 - 16y^2 = 144$

P18.14 (a) $(2n+1)\pi$ m for $n = 0, 1, 2, 3, \ldots$;
(b) 0.029 4 m

P18.16 see the solution

P18.18 see the solution

P18.20 15.7 Hz

P18.22 (a) 257 Hz; (b) 6

P18.24 (a) 495 Hz; (b) 990 Hz

P18.26 19.976 kHz

P18.28 3.84%

P18.30 291 Hz

P18.32 0.352 Hz

P18.34 see the solution

P18.36 (a) 531 Hz; (b) 42.5 mm

P18.38 0.656 m; 1.64 m

P18.40 3 kHz; see the solution

P18.42 $\Delta t = \frac{\pi r^2 v}{2Rf}$

P18.44 $L = 0.252$ m, 0.504 m, 0.757 m, $\ldots$, $n(0.252)$ m for $n = 1, 2, 3, \ldots$

P18.46 0.502 m; 0.837 m

P18.48 (a) 0.195 m; (b) 841 m

P18.50 1.16 m

P18.52 (a) 521 Hz or 525 Hz; (b) 526 Hz;
(c) reduce by 1.14%

P18.54 4-foot and $2\frac{2}{3}$-foot ; $2\frac{2}{3}$ and 2-foot ; and all three together

P18.56 see the solution

P18.58 (a) and (b) 3.99 beats/s

P18.60 4.85 m

P18.62 31.1 N

P18.64 (a) $\frac{1}{2}Mg$; (b) $3h$; (c) $\frac{m}{3h}$; (d) $\sqrt{\frac{3Mgh}{2m}}$;
(e) $\sqrt{\frac{3Mg}{8mh}}$; (f) $\sqrt{\frac{2mh}{3Mg}}$; (g) h;
(h) $(2.00 \times 10^{-2})\sqrt{\frac{3Mg}{8mh}}$

P18.66 (a) 45.0 Hz or 55.0 Hz; (b) 162 N or 242 N

P18.68 see the solution

P18.70 262 kHz

P34.2 (a) 2.68×10^3 AD; (b) 8.31 min; (c) 2.56 s; (d) 0.133 s; (e) 33.3 μs

P34.4 733 nT

P34.6 $E = (300\ \text{V/m})\cos(62.8x - 1.88 \times 10^{10} t)$; $B = (1.00\ \mu\text{T})\cos(62.8x - 1.88 \times 10^{10} t)$

P34.8 see the solution

P34.10 2.9×10^8 m/s ± 5%

P34.12 49.5 mV

P34.14 (a) 13.3 nJ/m^3; (b) 13.3 nJ/m^3; (c) 7.96 W/m^2

P34.16 516 pT, $\sim 10^5$ times stronger than the Earth's field

P34.18 (a) 11.9 GW/m^2; (b) 234 kW

P34.20 33.4°C for the smaller container and 21.7°C for the larger

P34.22 (a) 50.0%; (b) 269 kW/m^2 toward the oven chamber; (c) 14.2 kV/m

P34.24 (a) 4.97 kW/m^2; (b) 16.6 μJ/m^3

P34.26 667 pN

P34.28 (a) 5.36 N; (b) 893 μm/s^2; (c) 10.7 days

P34.30 (a) 577 W/m^2; (b) 2.06×10^{16} W; (c) 68.7 MN; (d) The gravitational force is $\sim 10^{13}$ times stronger and in the opposite direction.

P34.32 4.09°

P34.34 (a) 93.3%; (b) 50.0%; (c) 0

P34.36 $\dfrac{2\pi m_p c}{eB}$

P34.38 see the solution

P34.40 (a) $\sim 10^8$ Hz radio wave; (b) $\sim 10^{13}$ Hz infrared light

P34.42 (a) 0.690 wavelengths; (b) 58.9 wavelengths

P34.44 The radio audience gets the news 8.41 ms sooner.

P34.46 (a) 187 m to 556 m; (b) 2.78 m to 3.41 m

P34.48 $\sim 10^6$ J

P34.50 (a) see the solution; (b) 378 nm

P34.52 (a) 31.4 MW; (b) 0.625 W/m^2; (c) 0.513%

P34.54 (a) 23.9 W/m^2; (b) 4.19 times the standard

P34.56 (a) 6.16 μPa; (b) 1.64×10^{10} times less than atmospheric pressure

P34.58 (a) 625 kW/m^2; (b) 21.7 kN/C and 72.4 μT; (c) 17.8 min

P34.60 (a) $\left(\dfrac{16m\rho^2}{9\pi}\right)^{1/3} gc$; (b) $\left(\dfrac{16\pi^2 m\rho^2}{9}\right)^{1/3} r^2 gc$

P34.62 (a) see the solution; (b) 17.6 Tm/s^2, 1.75×10^{-27} W; (c) 1.80×10^{-24} W

P34.64 3.00×10^{-2} deg

P34.66 (a) 3.33 m, 11.1 ns, 6.67 pT;

(b) $\mathbf{E} = (2.00\ \text{mV/m})\cos 2\pi\left(\dfrac{x}{3.33\ \text{m}} - \dfrac{t}{11.1\ \text{ns}}\right)\hat{\mathbf{j}}$;

$\mathbf{B} = (6.67\ \text{pT})\hat{\mathbf{k}}\cos 2\pi\left(\dfrac{x}{3.33\ \text{m}} - \dfrac{t}{11.1\ \text{ns}}\right)$;

(c) 5.31 nW/m^2; (d) 1.77×10^{-17} J/m^3;

(e) 3.54×10^{-17} Pa

P34.68 (a) 388 K; (b) 363 K

P35.2 227 Mm/s

P35.4 (a) see the solution; (b) 300 Mm/s

P35.6 (a) 1.94 m ; (b) 50.0° above the horizontal : antiparallel to the incident ray

P35.8 five times by the right-hand mirror and six times by the left-hand mirror

P35.10 25.5° ; 442 nm

P35.12 (a) 474 THz ; (b) 422 nm ; (c) 200 Mm/s

P35.14 22.5°

P35.16 (a) 181 Mm/s ; (b) 225 Mm/s ; (c) 136 Mm/s

P35.18 3.39 m

P35.20 $\theta_1 = \tan^{-1} n$

P35.22 106 ps

P35.24 23.1°

P35.26 (a) 58.9° ; (b) Only if $\theta_1 = \theta_2 = 0$

P35.28 see the solution

P35.30 (a) 41.5° ; (b) 18.5° ; (c) 27.6° ; (d) 42.6°

P35.32 (a) see the solution; (b) 37.2° ; (c) 37.3° ; (d) 37.3°

P35.34 $\sin^{-1}\left(\sqrt{n^2 - 1}\sin\Phi - \cos\Phi\right)$

P35.36 (a) 24.4° ; (b) 37.0° ; (c) 49.8°

P35.38 67.2

P35.40 (a) $\dfrac{nd}{n-1}$; (b) yes; (c) 350 μm

P35.42 (a) 10.7° ; (b) air; (c) Sound falling on the wall from most directions is 100% reflected.

P35.44 54.8° east of north

P35.46 (a) $\dfrac{h}{c}\left(\dfrac{n+1}{2}\right)$; (b) larger by $\dfrac{n+1}{2}$ times

P35.48 see the solution

P35.50 see the solution

P35.52 (a) 45.0° ; (b) yes; see the solution

P35.54 3.79 m

P35.56 (a) 0.042 6 ; (b) no difference

P35.58 0.706

P35.60 (a) $2\omega_m R$; (b) $2\omega_m \dfrac{x^2 + d^2}{d}$

P35.62 164 s

P35.64 36.5°

P35.66 $\theta = \sin^{-1}\left[\dfrac{L}{R^2}\left(\sqrt{n^2R^2 - L^2} - \sqrt{R^2 - L^2}\right)\right]$

P35.68 (a) nR_1; (b) R_2

P35.70 7.96°

P35.72 see the solution; $n = 1.328 \pm 0.8\%$

Chapter 36

P36.2 4.58 m

P36.4 see the solution

P36.6 (a) $p_1 + h$; (b) virtual; (c) upright; (d) +1; (e) No

P36.8 at $q = -0.267$ m virtual upright and diminished with $M = 0.026\,7$

P36.10 at 3.33 m from the deepest point of the niche

P36.12 30.0 cm

P36.14 (a) 160 mm; (b) $R = -267$ mm

P36.16 (a) convex; (b) At the 30.0 cm mark; (c) –20.0 cm

P36.18 (a) 15.0 cm; (b) 60.0 cm

P36.20 (a) see the solution;
(b) at 0.639 s and at 0.782 s

P36.22 4.82 cm

P36.24 see the solution; real, inverted, diminished

P36.26 2.00

P36.28 20.0 cm

P36.30 (a) $q = 40.0$ cm real, inverted, actual size $M = -1.00$;
(b) $q = \infty$, $M = \infty$, no image is formed;
(c) $q = -20.0$ cm upright, virtual, enlarged $M = +2.00$

P36.32 (a) 6.40 cm; (b) –0.250; (c) converging

P36.34 (a) 3.40, upright; (b) see the solution

P36.36 (a) 39.0 mm; (b) 39.5 mm

P36.38 1.16 mm/s toward the lens

P36.40 (a) 13.3 cm;
(b) see the solution; a trapezoid;
(c) 224 cm^2

P36.42 2.18 mm away from the film

P36.44 (a) at $q = -34.7$ cm virtual, upright and diminshed;
(b) at $q = -36.1$ cm virtual, upright and diminshed

P36.46 $\dfrac{f}{1.41}$

P36.48 23.2 cm

P36.50 (a) at 4.17 cm; (b) 6.00

P36.52 2.14 cm

P36.54 (a) see the solution; (b) $h' = -\dfrac{hf}{p}$;
(c) –1.07 mm

P36.56 3.38 min

P36.58 if $M < 1$, $f = \dfrac{-Md}{(1-M)^2}$,
if $M > 1$, $f = \dfrac{Md}{(M-1)^2}$

P36.60 (a) inside the rod, 47.1 cm from the second surface;
(b) virtual, inverted, and enlarged

P36.62 25.3 cm to right of mirror, virtual, upright, enlarged 8.05 times

P36.64 place the lenses 9.00 cm apart and let light pass through the diverging lens first. 1.75 times

P36.66 (a) 1.40 kW/m^2; (b) 6.91 mW/m^2;
(c) 0.164 cm; (d) 58.1 W/m^2

P36.68 11.7 cm

P36.70 (a) 0.334 m or larger;
(b) $\dfrac{R_a}{R} = 0.025\,5$ or larger

P36.72 (a) 1.99;
(b) 10.0 cm to the left of the lens; –2.50;
(c) inverted

P36.74 (a) 13.3 cm; (b) –5.90; (c) inverted

P36.76 see the solution;
real, inverted, and actual size

P36.78 see the solution

Chapter 37

P37.2 515 nm

P37.4 (a) 36.2°; (b) 5.08 cm; (c) 508 THz

P37.6 maxima at 0°, 29.1°, 76.3°;
minima at 14.1° and 46.8°

P37.8 36.2 cm

P37.10 641

P37.12 6.33 mm/s

P37.14 see the solution

P37.16 (a) 1.29 rad; (b) 99.8 nm

P37.18 0.968

P37.20 (a) see the solution; (b) 9.00

P37.22 (a) $2.88E_0$ at 0.349 rad;
(b) $2.00E_0$ at $\frac{\pi}{3}$ rad; (c) 0;
(d) E_0 at $\frac{3\pi}{2}$ rad

P37.24 see the solution

P37.26 $x_1 - x_2 = \left(m - \frac{1}{48}\right)\lambda$ where $m = 0, 1, 2, 3, \ldots$

P37.28 see the solution

P37.30 612 nm

P37.32 512 nm

P37.34 96.2 nm

P37.36 (a) 238 nm; (b) λ increase; (c) 328 nm

P37.38 1.31

P37.40 1.20 mm

P37.42 449 nm; blue

P37.44 (a) see the solution; (b) 2.74 m

P37.46 number of antinodes = number of constructive interference zones
$= 1$ plus 2 times the greatest positive integer $\le \frac{d}{\lambda}$
number of nodes = number of destructive interference zones $= 2$ times the greatest positive integer $< \left(\frac{d}{\lambda} + \frac{1}{2}\right)$

P37.48 $\frac{\lambda}{2(n-1)}$

P37.50 5.00 km^2

P37.52 2.50 mm

P37.54 113

P37.56 115 nm

P37.58 (a) see the solution; (b) 266 nm

P37.60 see the solution

P37.62 see the solution

P37.64 (a) 14.7 μm; (b) 1.53 cm; (c) −16.0 m

P37.66 $7.99 \sin(\omega t + 4.44 \text{ rad})$

P37.68 130 nm

P37.70 0.498 mm

P38.2 547 nm

P38.4 91.2 cm

P38.6 (a) 1.09 m ; (b) 1.70 mm

P38.8 see the solution

P38.10 (a) 0°, 10.3°, 21.0°, 32.5°, 45.8°, 63.6°;
(b) nine bright fringes at 0° and on either side at 10.3°, 21.0°, 32.5°, and 63.6°;
(c) 1.00, 0.811, 0.405, 0.090 1, 0.032 4

P38.12 2.61 μm

P38.14 869 m

P38.16 0.512 m

P38.18 6.10 cm

P38.20 105 m

P38.22 (a) 2.40 μ rad ; (b) 213 km

P38.24 514 nm

P38.26 1.81 μm

P38.28 see the solution

P38.30 74.2 grooves/mm

P38.32 2

P38.34 (a) 0.738 mm ; (b) see the solution

P38.36 0.455 nm

P38.38 3

P38.40 $\frac{3}{8}$

P38.42 (a) 6.89 units ; (b) 5.63 units

P38.44 (a) see the solution; (b) For light confined to a plane, yes. $\left|\tan^{-1}\left(\frac{n_3}{n_2}\right) - \tan^{-1}\left(\frac{n_1}{n_2}\right)\right|$

P38.46 see the solution

P38.48 see the solution

P38.50 see the solution

P38.52 30.5 m

P38.54 (a) 1.50 sec; (b) 0.189 ly; (c) 10.5 sec;
(d) 1.52 mm

P38.56 see the solution

P38.58 11.5°

P38.60 (a) see the solution; (b) 428 μm

P38.62 see the solution

P38.64 $\frac{1}{8}$

P38.66 (a) see the solution; (b) 0.109°

P38.68 see the solution

P38.70 (a) see the solution; (b) $\phi = 1.39$ rad ;
(c) see the solution

P38.72 (a) $a\sin\theta = 1.430\,3\lambda$; (b) $a\sin\theta = 2.459\,0\lambda$