Answers to Selected Problems

CHAPTER 1

P1.1. **(a)** 1/3; **(b)** 0.75; **(c)** $1/\sqrt{3}$

P1.4. **(a)** -2; **(b)** -1; **(c)** $-1, -5$; **(d)** 1

P1.6. Yes

P1.8. **(a)** 25; **(b)** 16; **(c)** $12\sqrt{2}$

P1.10. **(a)** $x + y + z = 4$

P1.13. $\frac{1}{\sqrt{6}}(\mathbf{a}_x + \mathbf{a}_y + \mathbf{a}_z)$

P1.16. $\sqrt{10}$

P1.19. $2\mathbf{a}_\theta$

P1.21. $\pm(\cos 2\phi\ \mathbf{a}_r - \sin 2\phi\ \mathbf{a}_\phi)$; **(a)** $\pm\mathbf{a}_\phi$; **(b)** $\pm(\frac{\sqrt{3}}{2}\mathbf{a}_r - \frac{1}{2}\mathbf{a}_\phi)$

P1.24. **(a)** $-mMG\dfrac{(x\mathbf{a}_x + y\mathbf{a}_y + z\mathbf{a}_z)}{(x^2 + y^2 + z^2)^{3/2}}$; **(b)** $-mMG\dfrac{(r_c\mathbf{a}_{rc} + z\mathbf{a}_z)}{(r_c^2 + z^2)^{3/2}}$;

(c) $-\dfrac{mMG}{r_s^2}\mathbf{a}_{rs}$

P1.26. **(a)** $x^2 + 2y^2 = 9, z = 3$; **(b)** $6x = 3y = 2z$

P1.28. $r \sin^2\theta = 1, \phi = \pi/6$

P1.29. $\dfrac{0.1949Q^2}{\varepsilon_0 L^2}$ away from the center of the tetrahedron

P1.31. **(a)** No solutions; **(b)** $-108\pi\varepsilon_0$ C at $(3, 3, 2)$

P1.33. $\dfrac{d^2z}{dt^2} + \dfrac{3Qz}{4\pi\varepsilon_0 ma^3} = 0$; $\dfrac{1}{2\pi}\sqrt{\dfrac{3Q}{4\pi\varepsilon_0 ma^3}}$

P1.36. $\dfrac{2\pi a}{z\sqrt{a^2 + z^2}}\mathbf{a}_z$

P1.39. $0.046\mu_0(I\ dz)^2$ toward the origin

P1.42. **(a)** Same; **(b)** $\sqrt{\dfrac{\pi d^2 w}{4\mu_0 lL}}$

P1.45. **(a)** $0.45\mu_0\mathbf{a}_z$; **(b)** $-0.057\mu_0\mathbf{a}_z$

P1.47. **(a)** $-3B_0\mathbf{a}_x$; **(b)** $B_0(\mathbf{a}_x + 2\mathbf{a}_y)$; **(c)** $B_0(-3\mathbf{a}_x + 2\mathbf{a}_y + 2\mathbf{a}_z)$

P1.50. $\dfrac{E_0}{3B_0}(2\mathbf{a}_x - \mathbf{a}_y - 2\mathbf{a}_z)$

P1.53. **(a)** $-\dfrac{qE_0}{2}\mathbf{a}_z$; **(b)** $\dfrac{qE_0}{2}\mathbf{a}_z$; **(c)** 0

CHAPTER 2

P2.1. **(a)** 1/2; **(b)** 0

P2.4. 0.5708

P2.7. 0

P2.9. $2\pi/3$

P2.12. **(a)** $-2B_0v_0 \cos \pi(x - v_0t)$; **(b)** 0

P2.15. **(a)** $B_0hb\omega \sin \omega t$; **(b)** 0

P2.18. **(a)** 128 A; **(b)** 8π A

P2.21. **(a)** $16\rho_0$; **(b)** $\rho_0/48$

P2.23. $\dfrac{B_0\pi^2}{2}$ Wb

P2.25. $\frac{1}{3}I$

P2.27. **(a)** $\frac{8}{3}$ C; **(b)** $\frac{32}{81}$ C

P2.29. 0 for $r < a$, $\dfrac{\rho_0(r^3 - a^3)}{3r^2}\mathbf{a}_r$ for $a < r < 2a$; $\dfrac{7a^3\rho_0}{3r^2}\mathbf{a}_r$ for $r > 2a$

P2.31. $\dfrac{J_0r^2}{3a}\mathbf{a}_\phi$ for $r < a$, $\dfrac{J_0a^2}{3r}\mathbf{a}_\phi$ for $r > a$

CHAPTER 3

P3.2. **(a)** $\dfrac{E_0}{3 \times 10^8} \sin 3\pi z \sin 9\pi \times 10^8 t\, \mathbf{a}_y$;

(b) $\dfrac{E_0(0.6\mathbf{a}_x - 0.8\mathbf{a}_z)}{3 \times 10^8} \cos [3\pi \times 10^8 t + 0.2\pi(4x + 3z)]$

P3.4. $\mathbf{B} = \dfrac{\alpha E_0}{\omega} e^{-\alpha z} \sin \omega t\, \mathbf{a}_z$; no

P3.6. $\pm\sqrt{5}/3$

P3.9. **(a)** $\dfrac{\rho_0}{2a}(x^2 - a^2)\mathbf{a}_x$ for $-a < x < a$, $\mathbf{0}$ otherwise;

(b) $\dfrac{\rho_0 r^2}{3a}\mathbf{a}_r$ for $0 < r < a$, $\dfrac{\rho_0 a^2}{3r}\mathbf{a}_r$ for $r > a$

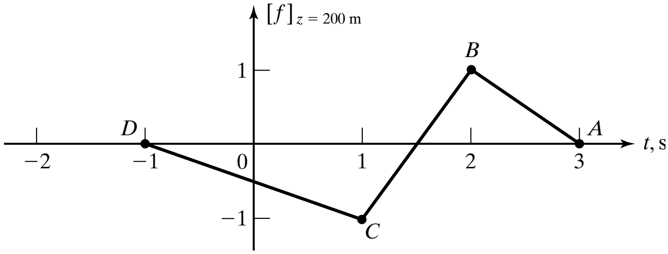
P3.11. **(a)** Yes; **(b)** yes; **(c)** no

P3.13. $\nabla \times \mathbf{v} = -2\omega\mathbf{a}_z$

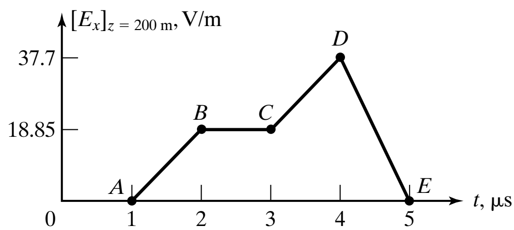
P3.16. **(a)** Both sides of divergence theorem are equal to $\frac{3}{2}$; **(b)** both sides of divergence theorem are equal to zero

P3.17. $\dfrac{\partial E_z}{\partial y} = -\dfrac{\partial B_x}{\partial t}, \dfrac{\partial H_x}{\partial y} = -J_z - \dfrac{\partial D_z}{\partial t}$

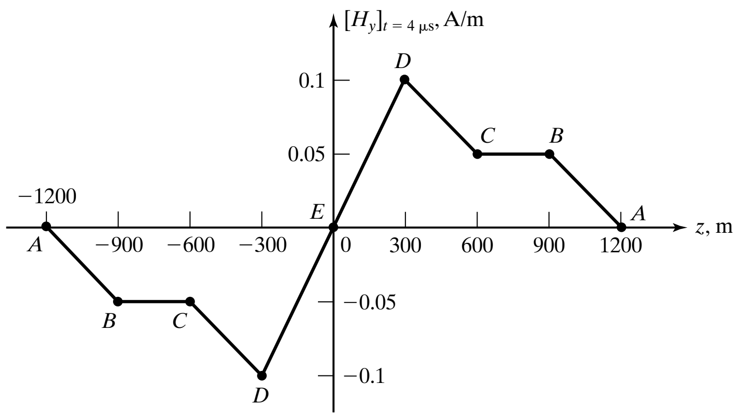
P3.20. **(c)**



P3.23. **(a)**



(d)



P3.25. **(a)** 45 MHz; **(b)** $6\frac{2}{3}$ m; **(c)** $-y$ direction;

(d) $0.1 \cos (9\pi \times 10^7 t + 0.3\pi y)\, \mathbf{a}_z$ A/m

P3.26. $\mathbf{E} = -37.7 \sin (15\pi \times 10^7 t \mp 0.5\pi x)\, \mathbf{a}_y$ V/m for $x \gtrless 0$

$\mathbf{H} = \mp 0.1 \sin (15\pi \times 10^7 t \mp 0.5\pi x)\, \mathbf{a}_z$ A/m for $x \gtrless 0$

P3.29. $\dfrac{|1-k|}{|1-3k|}$; **(a)** $\dfrac{1}{2}$, **(b)** 1, **(c)** 0; **(a)** $\dfrac{2}{3}$, **(b)** $\dfrac{2}{5}$ or $\dfrac{1}{4}$

P3.31. **(a)** Elliptical; **(b)** −2

P3.33.
$$\mathbf{E} = 1.25E_0\left[\cos\left(2\pi \times 10^8 t - \frac{2\pi}{3}z + 0.2048\pi\right)\mathbf{a}_x + \sin\left(2\pi \times 10^8 t - \frac{2\pi}{3}z + 0.2048\pi\right)\mathbf{a}_y\right]$$
$$\mathbf{H} = \frac{E_0}{96\pi}\left[-\sin\left(2\pi \times 10^8 t - \frac{2\pi}{3}z + 0.2048\pi\right)\mathbf{a}_x + \cos\left(2\pi \times 10^8 t - \frac{2\pi}{3}z + 0.2048\pi\right)\mathbf{a}_y\right]$$

P3.34. **(a)** Right circular; **(b)** left circular; **(c)** left elliptical; **(d)** right elliptical

P3.37. **(a)** $\dfrac{V_0 I_0}{2\pi r^2 \ln (b/a)} \cos^2 \omega(t - \sqrt{\mu_0\varepsilon_0}z)\, \mathbf{a}_z, \dfrac{V_0 I_0}{4\pi r^2 \ln (b/a)}\mathbf{a}_z$; **(b)** $\dfrac{1}{2}V_0 I_0$

P3.39. **(a)** $0.0233\dfrac{\rho_0^2 a^5}{\varepsilon_0}$; **(b)** $1.08a$, $0.4763\rho_0$

CHAPTER 4

P4.2. **(b)** 0.431×10^{13} Hz; $1/\sqrt{2}$

P4.4. $\dfrac{\rho_{L0}}{2\pi\varepsilon_0}\left\{\dfrac{(x-d)\,\mathbf{a}_x + y\mathbf{a}_y}{(x-d)^2 + y^2} - \dfrac{(x+d)\,\mathbf{a}_x + y\mathbf{a}_y}{(x+d)^2 + y^2}\right\}$

P4.7. **(a)** $2\varepsilon_0 E_0(2\mathbf{a}_x + 2\mathbf{a}_y + \mathbf{a}_z)$; **(b)** $2\varepsilon_0\mathbf{E}$; **(c)** $\dfrac{\mathbf{D}}{2\varepsilon_0}$

P4.9. $\dfrac{\omega Q a^2}{4}\mathbf{a}_z$

P4.12. $3k\mu_0$

P4.14. **(a)** 21.224 m, 3.10;
(b) $91.82e^{-0.0533z} \cos (2\pi \times 10^6 t - 0.074z + 0.1988\pi)\, \mathbf{a}_x$ V/m

P4.17. **(a)** $1.5791 H_0^2 e^{-2z}$ W/m^2; **(b)** $1.3654 H_0^2$ W

P4.20. $2.25\mu_0$, $16\varepsilon_0$

P4.21. 1.0883×10^{-4} m^{-1}; 0.036276 rad/m; 1.732×10^8 m/s; 173.21 m; $(217.66 + j0.653)\ \Omega$; 9.189 km

P4.25. $2\varepsilon_0$

P4.27. $98\mu_0$

P4.30

$$\mathbf{E} = \begin{cases} 14.493 \cos\left(2\pi \times 10^6 t - \dfrac{\pi}{150}z + 0.163\pi\right)\mathbf{a}_x & \text{for } z > 0 \\ 14.493 e^{0.05334z} \cos(2\pi \times 10^6 t + 0.07401z + 0.163\pi)\,\mathbf{a}_x & \text{for } z < 0 \end{cases}$$

$$\mathbf{H} = \begin{cases} 0.0384 \cos\left(2\pi \times 10^6 t - \dfrac{\pi}{150}z + 0.163\pi\right)\mathbf{a}_y & \text{for } z > 0 \\ 0.1675 e^{0.05334z} \cos(2\pi \times 10^6 t + 0.07401z + 0.964\pi)\,\mathbf{a}_y & \text{for } z < 0 \end{cases}$$

P4.33.

$$\mathbf{E}_r = [0.4744E_0 \cos(3\pi \times 10^5 t + 10^{-3}\pi z + 0.8976\pi)\,\mathbf{a}_x + 0.1161E_0 \cos(9\pi \times 10^5 t + 3 \times 10^{-3}\pi z + 0.9043\pi)\,\mathbf{a}_x]\ \text{V/m}$$

$$\mathbf{E}_t = [0.3354E_0 e^{-6.283\times10^{-3}z} \cos(3\pi \times 10^5 t - 9.425 \times 10^{-3}\pi z + 0.1476\pi)\,\mathbf{a}_x + 0.1433E_0 e^{-7.894\times10^{-3}z} \cos(9\pi \times 10^5 t - 22.504 \times 10^{-3}\pi z + 0.0772\pi)\,\mathbf{a}_x]\ \text{V/m}$$

P4.36. $\mathbf{E}_r = -E_0 \cos(\omega t + \beta z)\,\mathbf{a}_x$; $\mathbf{E} = 2E_0 \sin\omega t \sin\beta z\,\mathbf{a}_x$

$\mathbf{H}_r = \dfrac{E_0}{\eta}\cos(\omega t + \beta z)\,\mathbf{a}_y$; $\mathbf{H} = \dfrac{2E_0}{\eta}\cos\omega t \cos\beta z\,\mathbf{a}_y$

$[\mathbf{J}_S]_{z=0} = \dfrac{2E_0}{\eta}\cos\omega t\,\mathbf{a}_x$

CHAPTER 5

P5.3. **(a)** $e^{-y}\sin x$; **(b)** $r\cos\phi$; **(c)** $-\dfrac{\cos\theta}{r^2}$

P5.5. $16x + 32y + z = 24$

P5.7. Direction lines are $(x^2 - y^2) = \text{constant}$

P5.9. $V = \dfrac{\rho_{L0}}{4\pi\varepsilon}\ln\dfrac{\sqrt{r^2 + (z+a)^2} + (z+a)}{\sqrt{r^2 + (z-a)^2} + (z-a)}$; equipotential surfaces are

$\dfrac{(c-1)^2}{4c}\left(\dfrac{r}{a}\right)^2 + \left(\dfrac{c-1}{c+1}\right)^2\left(\dfrac{z}{a}\right)^2 = 1$, where c is a constant

P5.15. $-\dfrac{\rho_0 d^2}{6\varepsilon}$ for $x < -d$; $\dfrac{\rho_0}{2\varepsilon}\left(dx + x^2 + \dfrac{x^3}{3d}\right)$ for $-d < x < 0$;

$\dfrac{\rho_0}{2\varepsilon}\left(dx - x^2 + \dfrac{x^3}{3d}\right)$ for $0 < x < d$; $\dfrac{\rho_0 d^2}{6\varepsilon}$ for $x > d$

P5.18.

(a) $\dfrac{\varepsilon_2 x}{\varepsilon_2 t + \varepsilon_1(d-t)}V_0$ for $0 < x < t$, $\dfrac{\varepsilon_2 t + \varepsilon_1(x-t)}{\varepsilon_2 t + \varepsilon_1(d-t)}V_0$ for $t < x < d$;

(b) $\dfrac{\varepsilon_1\varepsilon_2}{\varepsilon_2 t + \varepsilon_1(d-t)}$

P5.21. $\dfrac{V_0(r - b)}{a - b}; \dfrac{2\pi\varepsilon_0 b}{b - a}$

P5.22. 2.03365

P5.24. $2\pi\mu N^2 a^2 c \ln \dfrac{2a + b}{2a - b}$

P5.26. $\dfrac{\mu}{16\pi}$

P5.29. **(a)** $-0.0395 \sin 10^6\pi t$ V; **(b)** $-65.285 \sin 10^9\pi t$ V

P5.31. **(a)** $\sigma\sqrt{\dfrac{\mu}{\varepsilon}}l = 3$; **(b)** $\sigma\sqrt{\dfrac{\mu}{\varepsilon}}l \ll 1$; **(c)** $\sqrt{\omega\mu\sigma}l \ll 1$ and $\dfrac{\sigma}{\omega\varepsilon} \gg 1$

P5.33. Inductor of value $L = \mu dl/w$ in parallel with a series combination of $\frac{1}{5}L$ and $\frac{1}{3}C$, where $C = \varepsilon wL/d$

P5.35. 534.881 A-t

P5.37. 8.4×10^4 Wb

P5.39. $\dfrac{V^2 w}{2d}(\varepsilon - \varepsilon_0)\mathbf{a}_x$

P5.42. **(a)** $\frac{1}{2}N^2I^2\pi a^2(\mu - \mu_0)\mathbf{a}_x$ for $0 < x < b$, $-\frac{1}{2}N^2I^2\pi a^2(\mu - \mu_0)\,\mathbf{a}_x$ for $l < x < (l + b)$, $\mathbf{0}$ otherwise;

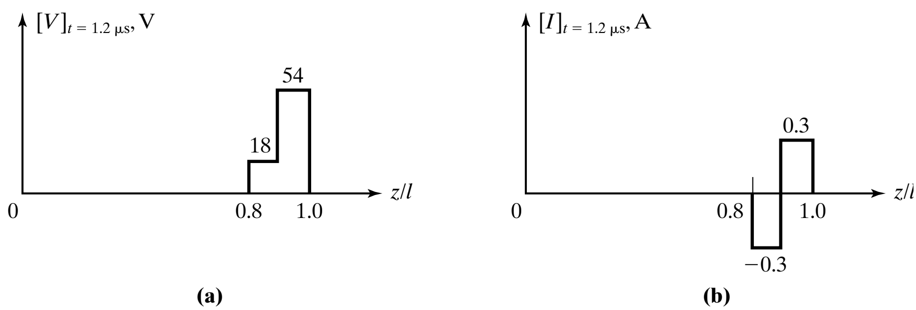
(b) $\frac{3}{4}N^2I_0^2\pi a^2 b(\mu - \mu_0)$ from mechanical to electrical form

CHAPTER 6

P6.2. $\frac{1}{15}\mu_0$ H/m, $60\varepsilon_0$ F/m; $4\pi\ \Omega$

P6.6. 125 V, 25 Ω, 60 Ω, 2μs

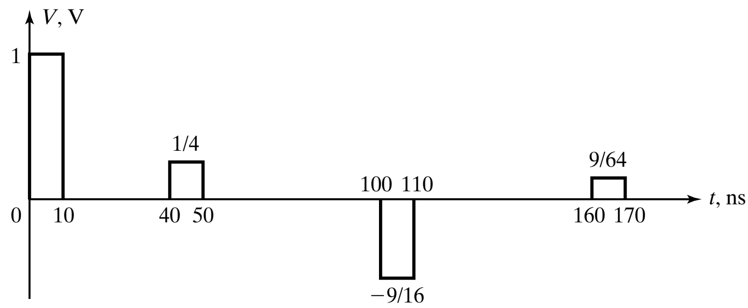
P6.10.



P6.13. $V^- = -0.2V^+$, $I^- = 0.002V^+$; $V^{++} = 0.2V^+$, $I^{++} = 0.004V^+$

P6.15. 150 m, $4\varepsilon_0$; $A = 8/15$

P6.17.

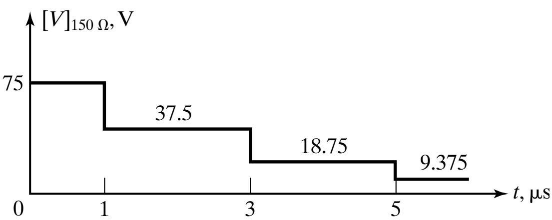


P6.19. **(a)** $\dfrac{dV^-}{dt} + \dfrac{1}{2CZ_0}V^- = \dfrac{V_0}{4CZ_0}$ for $t > T$;

(b) $\dfrac{V_0}{2} - \dfrac{V_0}{2}e^{-(1/2CZ_0)(t-T)}$ for $t > T$

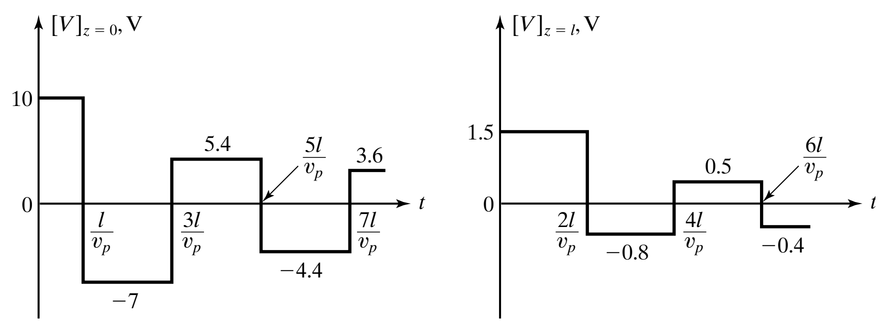
P6.21. **(a)** L; **(b)** $\frac{1}{3}$

P6.23. **(a)**



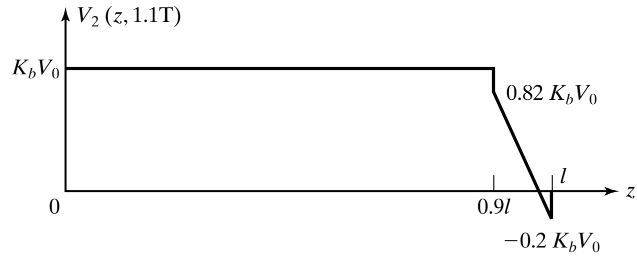
(b) 62.5×10^{-6} J

P6.27.



P6.29. **(a)** 38.4 Ω; **(b)** 48.4 Ω

P6.32. **(c)**



CHAPTER 7

P7.2.

d	V_{rms}, V	I_{rms}, A
0	$0.7906V_0$	0
$\frac{1}{3}l$	$0.6374V_0$	$0.0047V_0$
$\frac{1}{2}l$	$0.5V_0$	$0.0061V_0$
l	$0.3536V_0$	$0.0071V_0$

P7.5. $\dfrac{nv_p}{l}, n = 1, 2, 3, \ldots$

P7.7. 4.7746 cm

P7.9. 0.3229 GHz; 0.7920 GHz; 1.2698 GHz

P7.12. $(59.78 + j75.80)\ \Omega$

P7.14. 20 cm

P7.17. $(40 - j30)\ \Omega$; 30 W

P7.20. 30 Ω; 75 Ω

P7.22. 0.4119λ; 1.53

P7.26. **(a)** 1,562 MHz; **(b)** 4.0

P7.28. $(r - 2)^2 + x^2 = 1$

P7.30. **(a)** 2.0; **(b)** 1.56; **(c)** 2.24

P7.32. 0.126λ; 0.094λ

P7.34. 0.093λ to 0.159λ

P7.36. $(0.328\lambda, 0.458\lambda)$ or $(0.496\lambda, 0.042\lambda)$

P7.39. $(l_1 = 0.313\lambda, l_2 = 0.136\lambda)$ or $(l_1 = 0.168\lambda, l_2 = 0.364\lambda)$

P7.41. $(144.23 - j32.59)\ \Omega$; $(1.035 + j4.561) \times 10^{-4}\ \text{m}^{-1}$

P7.43. **(a)** 20.01 W; **(b)** 11.77 W; **(c)** 8.24 W

CHAPTER 8

P8.2. **(a)** Yes;

(b) $\dfrac{1}{12\pi}(-4\mathbf{a}_x + 5\mathbf{a}_y + 3\mathbf{a}_z) \cos [3\pi \times 10^7 t - 0.02\pi(3x + 4z)]$

P8.5. **(a)** 47.7465 MHz; **(b)** along $(-0.6\mathbf{a}_y + 0.8\mathbf{a}_z)$;
(c) $\frac{1}{12\pi}(-j0.5\mathbf{a}_x + 0.8\mathbf{a}_y + 0.6\mathbf{a}_z)e^{j(0.6y-0.8z)}$; **(d)** left-elliptical;
(e) 0.1658 W

P8.6. 1 cm

P8.9. $\frac{E_0}{8}\{3 \sin 20\pi x\,[\cos(10^{10}\pi t - 83.776z) + \cos(2 \times 10^{10}\pi t - 199.793z)]$
$- \sin 60\pi x \cos(2 \times 10^{10}\pi t - 91.293z)\}\mathbf{a}_y$

P8.11. **(a)** 0.25; **(b)** 0.4307; **(c)** 0.221

P8.15. **(a)** $\frac{0.866}{k}$; **(b)** $\frac{0.6378}{k}$; **(c)** $\frac{0.6495}{k}$

P8.17. **(a)** 1.7047×10^8 m/s; **(b)** 1.7321×10^8 m/s

P8.20. $\mathbf{E}_r = 0.0294E_0(\mathbf{a}_x + \mathbf{a}_z)\cos[6\pi \times 10^8 t + \sqrt{2}\pi(x - z)]$
$\mathbf{E}_t = 0.6863E_0(\mathbf{a}_x - \sqrt{2}\,\mathbf{a}_z)\cos[6\pi \times 10^8 t - \sqrt{2}\pi(\sqrt{2}x + z)]$

P8.22. **(a)** $3\varepsilon_0$;
(b) $\mathbf{E}_r = -0.5E_0\mathbf{a}_y \sin[6\pi \times 10^9 t + 10\pi(x - \sqrt{3}z)]$
$\mathbf{E}_t = E_0(0.2887\mathbf{a}_x - 0.5\mathbf{a}_z)\cos[6\pi \times 10^9 t - 10\pi(3x + \sqrt{3}z)]$
$+ 0.5E_0\mathbf{a}_y \sin[6\pi \times 10^9 t - 10\pi(3x + \sqrt{3}z)]$

P8.25. **(a)** 23; **(b)** $2/\sqrt{5}$

P8.28. 0.9152 (TE_0); 0.9130 (TE_1); 0.9090 (TE_2)

P8.30. $\tan\left(\frac{\pi d\sqrt{\varepsilon_{r1}}}{\lambda_0}\cos\theta_i\right) = -\frac{(\varepsilon_2/\varepsilon_1)\cos\theta_i}{\sqrt{\sin^2\theta_i - (\varepsilon_2/\varepsilon_1)}}$

P8.34. $z = \frac{1}{\alpha}\ln\frac{\alpha x - 1 + \sqrt{\alpha^2x^2 - 2\alpha x + \delta_0^2}}{\delta_0 - 1}; \frac{\delta_0^2}{2\alpha}, \frac{2\delta_0}{\alpha}$

P8.36. $x_a = \left[\frac{3(2m + 1)\lambda_0}{16n_0\sqrt{\alpha}}\right]^{2/3}, m = 0, 1, 2, \ldots$

CHAPTER 9

P9.2. 4.24 cm $\le a \le$ 4.47 cm

P9.4. **(a)** 1.70; **(b)** 0.366 cm, $4.9\varepsilon_0$

P9.7. 4472.1 MHz ($TE_{1,0,1}$); 5385.2 MHz ($TE_{0,1,1}$); 5656.9 MHz ($TE_{1,0,2}$); 6403.1 MHz ($TE_{0,1,2}$, $TM_{1,1,0}$); 6708.2 MHz ($TE_{1,1,1}$, $TM_{1,1,1}$)

P9.10. 6.096 GHz ($TE_{0,1}$); 6.685 GHz ($TE_{3,1}$)

P9.12. 0.4442 cm, 1.2726 cm

P9.14. **(a)** $\tan\frac{2\pi t}{\lambda_1}\sqrt{1 - \left(\frac{\lambda_1}{\lambda_c}\right)^2}\tan\frac{2\pi(d - t)}{\lambda_1}\sqrt{\frac{\varepsilon_2}{\varepsilon_1} - \left(\frac{\lambda_1}{\lambda_c}\right)^2}$
$= \frac{\sqrt{\varepsilon_1/\varepsilon_2}\sqrt{1 - (\lambda_1/\lambda_c)^2}}{\sqrt{(\varepsilon_2/\varepsilon_1) - (\lambda_1/\lambda_c)^2}}$;
(b) 3.479 GHz

P9.16. 0.882×10^{-3} Np/m
P9.17. **(c)** 9276
P9.24. 0.7108
P9.25. $T_0 = \sqrt{2\beta_z^{(2)} z}$; $\sqrt{2}T_0$
P9.27. **(a)** 4.89μs; **(b)** 106 ps
P9.32. 101.5°

P9.34.
$$\mathbf{E}_r = -\frac{E_0}{15}(7\mathbf{a}_x + \mathbf{a}_y)\cos(6\pi \times 10^9 t + 20\pi z)$$
$$\mathbf{E}_t = -\frac{E_0}{5}(2\mathbf{a}_x + \mathbf{a}_y)\cos(6\pi \times 10^9 t - 60\pi z) + \frac{2E_0}{15}(\mathbf{a}_x - 2\mathbf{a}_y)\cos(6\pi \times 10^9 t - 40\pi z)$$
$$\mathbf{H}_r = -\frac{E_0}{15\eta_0}(\mathbf{a}_x - 7\mathbf{a}_y)\cos(6\pi \times 10^9 t + 20\pi z)$$
$$\mathbf{H}_t = -\frac{3E_0}{5\eta_0}(\mathbf{a}_x - 2\mathbf{a}_y)\cos(6\pi \times 10^9 t - 60\pi z) + \frac{4E_0}{15\eta_0}(2\mathbf{a}_x + \mathbf{a}_y)\cos(6\pi \times 10^9 t - 40\pi z)$$

P9.35. **(a)** 1.25 cm; **(b)** $-0.6E_0 \cos(6\pi \times 10^9 t + 20\pi z)\,\mathbf{a}_x$; **(c)** 2.5 cm

CHAPTER 10

P10.4. 3.2038 V/m; 2.2503 V/m; 4.133×10^{-3} A/m
P10.6. 0.2024λ
P10.8. 6.075
P10.10. 2.1932 W
P10.12. 0.0167 A, 0.01 W

P10.14. **(a)**
$$\mathbf{E} = -\frac{\eta\beta I_0 L \sin\theta}{8\pi r}\sin(\omega t - \beta r)\,\mathbf{a}_\theta$$
$$\mathbf{H} = -\frac{\beta I_0 L \sin\theta}{8\pi r}\sin(\omega t - \beta r)\,\mathbf{a}_\phi$$
(b) $20\pi^2\left(\frac{L}{\lambda}\right)^2$, 1.5

P10.16. $\frac{\pi\eta}{6}\left(\frac{2\pi a}{\lambda}\right)^4$, 1.5

P10.18. **(a)** $|\cos\psi|\left|\sin\left(\frac{\pi}{2}\cos\psi\right)\right|$; **(b)** $|\cos\psi|\cos\left(\frac{\pi}{4}\cos\psi - \frac{\pi}{4}\right)$

P10.22. Five elements spaced 2λ apart, current amplitudes in the ratio 1:2:3:2:1, and progressive phase shift of 180°
P10.25. $|\sin\theta \sin(\beta d_1 \sin\theta)\cos(\beta d_2 \cos\theta)|$
P10.27. **(a)** 0.8284; **(b)** 4; **(c)** 0

P10.29. $\left(\frac{j\beta E_0 abe^{-j\beta r}}{4\pi r}\right)\left[\frac{\pi^2}{\pi^2-\left(\frac{\beta a}{2}\sin\theta\cos\phi\right)^2}\right]$

$\times\left[\frac{\sin\left(\frac{\beta a}{2}\sin\theta\cos\phi\right)}{\frac{\beta a}{2}\sin\theta\cos\phi}\right]\left[\frac{\sin\left(\frac{\beta b}{2}\sin\theta\sin\phi\right)}{\frac{\beta b}{2}\sin\theta\sin\phi}\right];$

(a) $\frac{4\lambda}{a}$ **(b)** $\frac{2\lambda}{b}$ **(c)** $1.44\frac{\lambda}{a}$ **(d)** $\frac{8\pi}{3}\frac{ab}{\lambda^2}$

P10.33. 12.543°; 71.973°; 91.368°; 110.928°; 133.672°

CHAPTER 11

P11.2. **(a)** $\frac{3V_0}{4}\frac{\sinh(\pi x/b)}{\sinh(\pi a/b)}\sin\frac{\pi y}{b}-\frac{V_0}{4}\frac{\sinh(3\pi x/b)}{\sinh(3\pi a/b)}\sin\frac{3\pi y}{b}$ **(b)** $0.1517V_0$

P11.5. 0.4337, 0.7981, 1.0347, 1.1058; $\frac{\sin 2x}{\sin 2}$

P11.7. **(a)** $V_A = 12$ V, $V_B = 5.25$ V, $V_C = 2$ V, $V_D = 14.75$ V, $V_E = 7$ V, $V_F = 2.75$ V; **(b)** $|\mathbf{E}_B| = \frac{6.1033}{d}$ V/m; **(c)** $\pm 61.25\varepsilon_0$ C/m

P11.10. $0.9242\varepsilon_0$ C

P11.13. $12.536\varepsilon_0 a$

P11.15. $3.873\varepsilon_0 a$

P11.18. 160.55 Ω

P11.20. 227.8 pF/m; 38.2 pF/m; 35.7331 Ω; 1.2285×10^8 m/s

P11.22. $\frac{1}{9}\eta$

P11.24. 43.5 Ω

P11.27. $V_2 = 3.871$ V; $V_4 = 3.226$ V; $V_5 = 6.452$ V

P11.31. $V(4, 2) = V(4, 10) = 4.38$ V; $V(4, 4) = V(4, 8) = 3.245$ V; $V(4, 6) = 1.24$ V