Current Errata for *Electromagnetic Waves*

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Preface Corrections

Page xiii: the section on **Recommended Course Content** should have no section number.

Chapter 2 Corrections

Page 56: In the second line, the text informs the reader that "in typical transmission lines (e.g. a coaxial line), electrical power propagates in the dielectric region between the conductors, typically at the velocity of light in free space." However, this discussion unfolds in Section 5.2 (NOT Section 2.3).

Page 94: Equation [2.55] should contain an attenuation term, as in equation [2.37]:

$$\mathbf{S_{av}} = \hat{\mathbf{z}}\frac{1}{2\,|\eta_c|}\left[C_{1x}^2 + C_{1y}^2\right]\cos\left(\phi_\eta\right)\mathbf{e^{-2\alpha z}} \quad (1)$$

Page 97: The final expression in equation [2.57] should read

$$\mathbf{E}(x,y,z) = \mathbf{E_0}e^{-j\beta_x x - j\beta_y y - j\beta_z z} = [\hat{\mathbf{x}}E_{0x} + \hat{\mathbf{y}}E_{0y} + \hat{\mathbf{z}}E_{0z}]e^{-j\beta_x x - j\beta_y y - j\beta_z z} \quad (2)$$

Page 101: Two paragraphs into 2.6.2 Nonuniform Plane Waves, the word *panes* should be spelled *planes*.

Page 101: In section 2.7, the first expression for the uniform plane wave should not have $\hat{\mathbf{k}}$ as its direction. The direction can be arbitrary $\mathbf{r}$, but is not necessarily $\hat{\mathbf{k}}$.

Chapter 3 Corrections

Page 163: In the sixth line from the bottom of the page, the expression for λ_{1z} should read:

$$\lambda_{1z} = \frac{\lambda_1}{\cos\,\theta_i} \quad (3)$$

Page 184: In part (b.) of the solution, the z-component of the electric field phasor should not be negative:

$$\mathbf{E_i}(y,z) = \eta_1 H_0\left(\hat{\mathbf{y}}\sin\,\theta_i + \hat{\mathbf{z}}\cos\,\theta_i\right)e^{-j\beta_1(\cos\,\theta_i y - \sin\,\theta_i z)} \quad (4)$$

The following expressions [3.32] and [3.33] in the textbook are correct, but we reprint for convenience:

$$\Gamma_{\perp} = \frac{\cos(\theta_i) - j\sqrt{\sin^2(\theta_i) - \epsilon_{21}}}{\cos(\theta_i) + j\sqrt{\sin^2(\theta_i) - \epsilon_{21}}} = 1e^{j\phi_{\perp}} \tag{5a}$$

$$\Gamma_{\parallel} = \frac{\epsilon_{21}\cos(\theta_i) - j\sqrt{\sin^2(\theta_i) - \epsilon_{21}}}{\epsilon_{21}\cos(\theta_i) + j\sqrt{\sin^2(\theta_i) - \epsilon_{21}}} = 1e^{j\phi_{\parallel}} \tag{5b}$$

Page 191: Note that the $\phi_{\perp}$ and $\phi_{\parallel}$ curves in Figure 3.33 should interchange in the region $\theta_i > \theta_{ic}$. The two curves $\phi_{\perp}$ and $\pi - \phi_{\parallel}$ in Figure 3.33 must be flipped around for incidence angles greater than the critical angle. The sign of the phase angle $\phi_{\perp}$ must be positive for an incidence angle greater than the critical angle, whereas $\left(\pi - \phi_{\parallel}\right)$ must be negative.

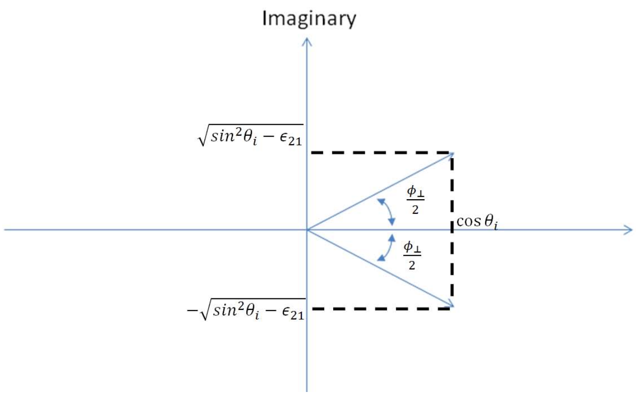
Page 192: However, the two half-tangent equations should read:

$$\tan\left(\frac{\phi_{\perp}}{2}\right) = -\frac{\sqrt{\sin^2(\theta_i) - \epsilon_{21}}}{\cos(\theta_i)} \tag{6a}$$

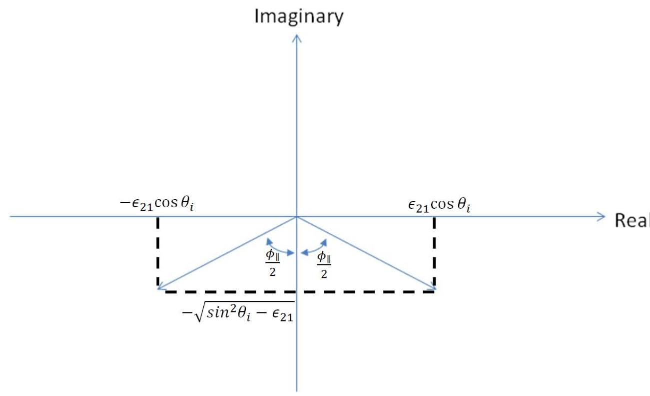
$$\tan\left(\frac{\phi_{\parallel}}{2}\right) = -\frac{\epsilon_{21}\cos(\theta_i)}{\sqrt{\sin^2(\theta_i) - \epsilon_{21}}} \tag{6b}$$

Page 192: Because of these altered half-tangent formulae, equation [3.34] becomes:

$$\Delta\phi = \phi_{\perp} - \phi_{\parallel} \quad \longrightarrow \quad \tan\left(\frac{\Delta\phi}{2}\right) = \frac{\tan(\frac{\phi_{\perp}}{2}) - \tan(\frac{\phi_{\parallel}}{2})}{1 + \tan(\frac{\phi_{\perp}}{2})\tan(\frac{\phi_{\parallel}}{2})} = \frac{\sin^2(\theta_i)}{\cos(\theta_i)\sqrt{\sin^2(\theta_i) - \epsilon_{21}}} \tag{7}$$



(a) Perpendicular polarization



(b) Parallel polarization

Assuming that equations [3.32] and [3.33] are veritable, we can derive the proper value of the phase change tangent:

$$\tan\left(\frac{\phi_\perp}{2}\right) = -\frac{\sqrt{\sin^2(\theta_i) - \epsilon_{21}}}{\cos(\theta_i)} = A \qquad \tan\left(\frac{\phi_\parallel}{2}\right) = -\frac{\epsilon_{21}\cos(\theta_i)}{\sqrt{\sin^2(\theta_i) - \epsilon_{21}}} = -\frac{\epsilon_{21}}{A}$$

$$\Delta\phi = \phi_\perp - \phi_\parallel$$

$$\tan\left(\frac{\Delta\phi}{2}\right) = \tan\left(\frac{\phi_\perp - \phi_\parallel}{2}\right) = \frac{A - \left(-\frac{\epsilon_{21}}{A}\right)}{1 + A\left(-\frac{\epsilon_{21}}{A}\right)} = \frac{A^2 + \epsilon_{21}}{A(1 - \epsilon_{21})}$$

$$\tan\left(\frac{\Delta\phi}{2}\right) = \frac{\frac{\sin^2(\theta_i) - \epsilon_{21}}{\cos^2(\theta_i)} + \epsilon_{21}}{\frac{\sqrt{\sin^2(\theta_i) - \epsilon_{21}}}{\cos(\theta_i)}(1 - \epsilon_{21})} = \frac{\sin^2(\theta_i) - \epsilon_{21}(1 - \cos^2(\theta_i))}{\cos(\theta_i)\sqrt{\sin^2(\theta_i) - \epsilon_{21}}(1 - \epsilon_{21})}$$

$$\tan\left(\frac{\Delta\phi}{2}\right) = \frac{\sin^2(\theta_i)(1 - \epsilon_{21})}{\cos(\theta_i)\sqrt{\sin^2(\theta_i) - \epsilon_{21}}(1 - \epsilon_{21})}$$

$$\tan\left(\frac{\Delta\phi}{2}\right) = \frac{\sin^2(\theta_i)}{\cos(\theta_i)\sqrt{\sin^2(\theta_i) - \epsilon_{21}}}$$

Page 192: Therefore, Figure 3.34 bears a different appearance.

Page 193: In the solution to Example 3.14, equation [3.35] holds that $\phi_{max}/2 \approx 77.4°$. Note that it is NOT ϕ_{max} alone that equals 77.4°.

Page 196: The exponential for the transmission coefficient $\mathcal{T}_\perp$ should be $e^{-j\frac{\phi_\perp}{2}}$.

Chapter 4 Corrections

Page 260: Equation [4.12] lists $m = 0$ as a possible instantiation of the TE_m mode, but, in actuality, no wave exists, so the equation really should qualify $m = \pm 1, \pm 2, ...$

Page 266: In the solution to part (b.) of Example 4-1, the value of $\bar{v}_p$ should be $\frac{5c}{3}$, not $\frac{5c}{4}$.

Page 269: In the central paragraph, the expression for propagation direction should be

$$\hat{\mathbf{k}}_{\mathbf{1}} = \frac{-\beta_x \hat{\mathbf{x}} + \beta_z \hat{\mathbf{z}}}{\beta} = -\hat{\mathbf{x}} \cos(\theta_{i_m}) + \hat{\mathbf{z}} \sin(\theta_{i_m}) \tag{8}$$

Page 270: The incidence angles pictured in Figure 4.8 should be θ_{i_m} instead of θ_i.

Page 276: Equation [4.21] fails to sustain the factor of 2 in its denominator. Its correction:

$$\alpha_c = \frac{\text{Power lost per unit length}}{2 \times \text{Power transmitted}} = \frac{P_{loss}}{2P_{av}} \tag{9}$$

This alteration will not affect any of the subsequent equations for specific α_c because equations [4.22] and [4.24] already consider the dividend of 2.

Page 290: In equations [4.39] for "Free space below the slab," the exponentials should not be negatively signed. Each exponential should instead read, for $(x \leq -d/2)$: $...e^{+\alpha_x(x+d/2)}$

Page 290: Furthermore, several of the equations [4.39] lack a negative sign. We reprint correct renditions of all nine equations here for convenience:
For free space above the slab $(x \geq d/2)$:

$$E_z^0(x) = \left[C_0 \sin\left(\frac{\beta_x d}{2}\right)\right] e^{-\alpha_x(x-d/2)} \tag{10a}$$

$$E_x^0(x) = -\frac{j\bar{\beta}}{\alpha_x}\left[C_0 \sin\left(\frac{\beta_x d}{2}\right)\right] e^{-\alpha_x(x-d/2)} \tag{10b}$$

$$H_y^0(x) = -\frac{j\omega\epsilon_0}{\alpha_x}\left[C_0 \sin\left(\frac{\beta_x d}{2}\right)\right] e^{-\alpha_x(x-d/2)} \tag{10c}$$

For the dielectric region $(|x| \leq d/2)$:

$$E_z^0(x) = C_0 \sin(\beta_x x) \tag{11a}$$

$$E_x^0(x) = -\frac{j\bar{\beta}}{\beta_x} C_0 \cos(\beta_x x) \tag{11b}$$

$$H_y^0(x) = -\frac{j\omega\epsilon_d}{\beta_x} C_0 \cos(\beta_x x) \tag{11c}$$

For free space below the slab $(x \leq -d/2)$:

$$E_z^0(x) = -\left[C_0 \sin\left(\frac{\beta_x d}{2}\right)\right] e^{\alpha_x(x+d/2)} \tag{12a}$$

$$E_x^0(x) = -\frac{j\bar{\beta}}{\alpha_x}\left[C_0 \sin\left(\frac{\beta_x d}{2}\right)\right] e^{\alpha_x(x+d/2)} \tag{12b}$$

$$H_y^0(x) = -\frac{j\omega\epsilon_0}{\alpha_x}\left[C_0 \sin\left(\frac{\beta_x d}{2}\right)\right] e^{\alpha_x(x+d/2)} \tag{12c}$$

Page 294: In the solutions to Example 4-6, certain numerical answers require revision:

$$TM_1 : \bar{\beta}_m \approx 8.23\, rad/cm, \quad \rightarrow \quad \frac{\bar{\beta}_m}{\beta_0} \approx 1.31$$

$$TM_2 : \bar{\beta}_m \approx 6.66\, rad/cm, \quad \rightarrow \quad \frac{\bar{\beta}_m}{\beta_0} \approx 1.06$$

Page 296: In Figure 4.18, the H-field lines are orthogonal to the propagation direction, so the mode is TM, as written. However, the E_z component, derived from equation [4.39], corrected above, indicates that the mode is, contrary to the caption, the odd **TM** mode.

Page 300: In equation [4.52], the permittivities in the last equality should be reciprocated:

$$\alpha_x \approx \frac{d}{2}\frac{\epsilon_0}{\epsilon_d}\left[\omega^2\mu_0\epsilon_0\left(\frac{\epsilon_d\mu_d}{\epsilon_0\mu_0} - 1\right)\right] = 2\pi\beta\left[\frac{\mu_d}{\mu_0} - \frac{\epsilon_\mathbf{0}}{\epsilon_\mathbf{d}}\right]\frac{d}{2\lambda} \tag{13}$$

Page 302: In the solution to part (b.) Example 4-8, the second line's β is missing an exponent:

$$\alpha_x^2 + \beta_x^2 = \beta^2\left(n_d^2 - n_c^2\right) \tag{14}$$

The answers also require slight revision:

$$\beta_x \approx 4.734 \;\; rad/\mu m$$

$$\alpha_x \approx 4.07 \;\; np/\mu m$$

$$\bar{\beta} \approx 12.703 \;\; rad/\mu m$$

Page 316: In the fifth line from the top, $\frac{d\bar{\beta}}{d\omega}$ should be $\frac{d\omega}{d\bar{\beta}}$.

Pages 324-325: Problem 4-24 is ill-defined. Because the transverse field E_y is cosinusoidal, we know that the field H_z is sinusoidal, evincing the **odd** TE mode. However, computing $\frac{\beta_x d}{2} = 5$, which lies between $\frac{3\pi}{2}$ and 2π, we begin to suspect that our wave does not propagate in the odd TE mode. According to Figure 4.19 on page 297, the intersections that occur between $\frac{3\pi}{2}$ and 2π belong to the **even** TE_4 mode. Similarly, when we compute $\alpha_x = \beta_x \tan\left(\frac{\beta_x d}{2}\right) = -16,902.575$, we obtain an inconsistent negative number. Thus, one of the parameters in the problem is inconsistent with the given odd TE field. The slab thickness d = 2 mm needs re-specification.

Chapter 5 Corrections

Page 346: The true upper bound for the dimension b is $b \leq 1.874\, cm$.

Page 350: The second mathematical expression, concerning $[P_{loss2}]_{y=0}$ leads to an erroneous rightmost expression, which should be

$$[P_{loss2}]_{y=0} = \ldots = C^2 R_s\left(\frac{a}{4} + \frac{\beta_{10}^2 a^3}{4\pi^2}\right) \tag{16}$$

Page 359: In equation [5.48], the expression for E_ϕ should not have a leading negative sign:

$$E_\phi = \frac{ja\omega\mu}{s_{nl}} C_n J_n'\left(\frac{s_{nl}}{a}r\right)\cos(n\phi)\, e^{-j\bar{\beta}_{nl}z} \tag{17}$$

Page 369: In the line after the expression for $f(r)$, the expression for h^2 is incorrect, since $h^2 = \bar{\gamma}^2 + \omega^2 \mu\epsilon$.

Page 380: In the unlabeled equation directly above equation [5.76], all instantiations of z should be d due to substitution.

Page 381: In the lower-right-hand diagram of Figure 5.20, b should be d.

Page 390: In the solution to part (a.) of Example 5-9, the TM_{111} mode has a lower resonance frequency than the TM_{210} mode, so $f_{111} \approx 1.257$ GHz should supplant $f_{210} \approx 1.45$ GHz.

Page 392: "The other nonzero field components" listed in equation [5.90] can be derived through substitution into equations [5.3] (NOT equations [5.6]).

Page 396: The solution for Example 5-11 assumes that $d = 2a$, but this assumption is spurious since the equation for Q holds only for $d = \bar{\lambda}_{TE_{nl}}$. The problem statement should either specify $d = 2a$, or the solution should compute $d = \bar{\lambda}_{TE_{nl}}$.

Chapter 6 Corrections

Page 418: The label above equation [6.4] should be *Centrifugal* rather than *Centrifigal*.

Page 431: The first integrated equation lacks constant C_2:

$$x = \frac{E_0}{B_0}t + \frac{1}{\omega_c}\left(v_0 - \frac{E_0}{B_0}\right)\cos(\omega_c t) + C_2 \tag{18}$$

The value of C_2 is zero, but its representation should still appear in the equation.

Page 431: At the bottom right corner of the page, the solution to Example 6-5 refers to expressions [6.6], but the equations officially numbered [6.6] have not yet been introduced. The equations employed actually originate from unnumbered expressions for $\tilde{v}_x(t)$ and $\tilde{v}_y(t)$ on page 430.

Pages 433-434: The derivation for maximal magnetic field has some flaws. The correct derivation follows:

$$\hat{\mathbf{r}} = \cos\theta\,\hat{\mathbf{x}} + \sin\theta\,\hat{\mathbf{y}} \qquad \hat{\theta} = -\sin\theta\,\hat{\mathbf{x}} + \cos\theta\,\hat{\mathbf{y}}$$

$$\frac{\partial\hat{\mathbf{r}}}{\partial t} = -\frac{\partial\theta}{\partial t}\sin\theta\,\hat{\mathbf{x}} + \frac{\partial\theta}{\partial t}\cos\theta\,\hat{\mathbf{y}} \qquad \frac{\partial\hat{\theta}}{\partial t} = -\frac{\partial\theta}{\partial t}\cos\theta\hat{\mathbf{x}} - \frac{\partial\theta}{\partial t}\sin\theta\hat{\mathbf{y}}$$

$$\frac{\partial\hat{\mathbf{r}}}{\partial t} = \omega\hat{\theta} \qquad \frac{\partial\hat{\theta}}{\partial t} = -\omega\hat{\mathbf{r}}$$

$$\vec{v} = v_r\hat{\mathbf{r}} + v_\theta\hat{\mathbf{r}}$$

$$\frac{\partial \vec{v}}{\partial t} = \left(\frac{\partial v_r}{\partial t} - \omega v_\theta\right)\hat{\mathbf{r}} + \left(\frac{\partial v_\theta}{\partial t} + \omega v_r\right)\hat{\theta}$$

$$\frac{\partial \vec{v}}{\partial t} = \left(\frac{\partial v_r}{\partial t} - \frac{v_\theta^2}{r}\right)\hat{\mathbf{r}} + \left(\frac{\partial v_\theta}{\partial t} + \frac{v_\theta v_r}{r}\right)\hat{\theta}$$

Letting $\vec{a}$ represent the particle acceleration...

$$\vec{a} = \frac{\partial \vec{v}}{\partial t} = \frac{\vec{F}}{m} = \left(-\omega_c v_\theta + \frac{A}{r}\right)\hat{\mathbf{r}} + \omega_c v_r \hat{\theta}$$

Juxtaposing coefficients of $\frac{\partial \vec{v}}{\partial t}$ and $\frac{\vec{F}}{m}$ in $\hat{\theta}$, we obtain the equation:

$$\left(\frac{\partial v_\theta}{\partial t} + \frac{v_\theta v_r}{r}\right) = \omega_c v_r$$

$$\frac{\partial v_\theta}{\partial t} = v_r\left(\omega_c - \frac{v_\theta}{r}\right)$$

$$\frac{\partial v_\theta}{\partial t} = v_r\left(\omega_c - \frac{v_\theta}{r}\right)$$

$$\frac{\partial v_\theta}{\partial r}\frac{\partial r}{\partial t} = v_r\left(\omega_c - \frac{v_\theta}{r}\right)$$

$$\frac{\partial v_\theta}{\partial r} v_r = v_r\left(\omega_c - \frac{v_\theta}{r}\right)$$

$$\frac{\partial v_\theta}{\partial r} = \omega_c - \frac{v_\theta}{r}$$

$$\frac{\partial v_\theta}{\partial r} + \frac{v_\theta}{r} = \omega_c$$

$$v_\theta = \frac{\int e^{\int \frac{1}{r}\,dr}\omega_c\,dr + C}{e^{\int \frac{1}{r}\,dr}}$$

$$v_\theta = \frac{\int r\omega_c\,dr + C}{r}$$

$$v_\theta(r) = \frac{\frac{r^2\omega_c}{2} + C}{r}$$

$$v_\theta(r) = \frac{r\omega_c}{2} + \frac{C}{r}$$

We know that $v_\theta(r = a) = 0$, so...

$$v_\theta(r = a) = \frac{a\omega_c}{2} + \frac{C}{a} = 0$$

$$C = -\frac{a^2\omega_c}{2}$$

$$v_\theta(r) = \frac{r\omega_c}{2} - \frac{a^2\omega_c}{2r}$$

At the outer conductor edge, $\vec{v}(b,\theta) = v_\theta\hat{\theta}$:

$$v_\theta(r=b) = \frac{b\omega_c}{2} - \frac{a^2\omega_c}{2b}$$

$$\frac{1}{2}m_e v^2 = \frac{1}{2}m_e\omega_c^2\left[\frac{b^2}{4} - \frac{a^2}{2} + \frac{a^4}{4b^2}\right]$$

$$\frac{1}{2}m_e v^2 = \frac{1}{2}m_e\omega_c^2\frac{1}{4b^2}\left[b^4 - 2a^2b^2 + a^4\right]$$

$$\frac{1}{2}m_e v^2 = \frac{1}{2}m_e\omega_c^2\frac{1}{4b^2}\left[\left(b^2 - a^2\right)^2\right]$$

$$q_e V_0 = \frac{1}{2}m_e\omega_c^2\frac{1}{4b^2}\left(b^2 - a^2\right)^2$$

Substituting $\omega_c = -\frac{q_e B_0}{m_e}$ into the expression above,

$$\frac{2q_e V_0}{m_e} = \left(-\frac{q_e B_0}{m_e}\right)^2\frac{1}{4b^2}\left(b^2 - a^2\right)^2$$

$$\frac{q_e^2 B_0^2}{m_e^2}\frac{1}{4b^2}\left(b^2 - a^2\right)^2 = \frac{2q_e V_0}{m_e}$$

$$B_0^2\frac{1}{4b^2}\left(b^2 - a^2\right)^2 = \frac{2m_e V_0}{q_e}$$

$$B_0^2 = \frac{8b^2 m_e V_0}{q_e\left(b^2 - a^2\right)^2}$$

$$\boxed{B_0 = \frac{b\sqrt{8m_e V_0/q_e}}{b^2 - a^2}} \qquad (19)$$

This equation supplants the boxed equation on page 434.

Page 443: In the seventh line of text below the timeline, the sentence should read: "Most applications of plasma physics **are** concerned with ionized gases."

Page 471: Equation [6.55b] is mislabeled as [11.55b].

Page 490: The second β in equation [6.76b] should be β^3:

$$S_r = \left(\frac{I dl \sin\theta}{4\pi}\right)^2 \eta\beta^2\left[\frac{1}{r^2} - \frac{j}{\beta^3 r^5}\right] \qquad (20)$$

Page 494: The problem statement for Example 6-7 should aver that $\lambda = 10$ m.

Page 498: The last line in equation [6.86] fails to eradicate the 2 multiplier and the square exponent in the denominator sine:

$$E_\theta = \frac{j60I_0}{r} e^{-j\beta r} \left[\frac{\cos(\beta L \cos\theta) - \cos(\beta L)}{\sin\theta} \right] \tag{21}$$

It appears that equation [6.87] correctly omits these superfluous factors.

Appendix Corrections

Page App-37: The answers to Problem 4.33(a.) should comprise multiples of 666 MHz because, for a dielectric on a ground plane, the thickness of the dielectric should be $d/2$, making $d = 11.25$ cm in this problem. Substitute into equation [4.50].