Typos and Corrections for the 2013 printing of
Modern Electrodynamics

Inside Front Cover

First line of "CARTESIAN": Change

$$d\boldsymbol{\ell} = x\hat{\mathbf{x}} + y\hat{\mathbf{y}} + z\hat{\mathbf{z}} \quad \text{to} \quad d\boldsymbol{\ell} = dx\hat{\mathbf{x}} + dy\hat{\mathbf{y}} + dz\hat{\mathbf{z}}$$

p. vii, first line below "Contents": change "List of Applications" to "Table of Applications":

Table of Applications

p. xvi: the Section number for "Faraday's Disk Generator" should be 14.4.1.

p. xvi: remove the period after 20.2. in the column on the far left.

Preface

p. xx, 6th line of 2nd complete paragraph: change "into a issue" to "into an issue".

Chapter 1

p. 4, first line of text: change ``exactly twice in a'' to ``exactly twice in a single term of a''

p. 20: Change $\mathbf{r}$ to $\mathbf{r}'$ on the left hand side of Eq. (1.150), Eq. (1.151), and Eq. (1.154).

p. 25, Section 1.5, line 5: change *Frayn and Hnizdo* to *Frahm and Hnizdo*

p. 25, Section 1.5, line 6: Change "C.P. Frayn" to "C.P. Frahm"

p. 25, Problem 1.1(b): delete ``det'' in the middle term

p. 28, Problem 1.18(a): replace the text by

   (a)   Show that $\epsilon_{ijk} S_{ij} = 0$ if **S** is a symmetric matrix

Chapter 2

p. 30, Eq. (2.4): change q to Nq in front of the integral.

p. 38, Section 2.3, 2st line of 2nd paragraph: change "prove" to "establish".

p. 38, Section 2.3, 3rd line from the bottom: change "agrement" to "agreement".

p. 45, Section 2.4.2, Eq. (2.62): on the right hand side, change $E_z(\infty)$ to $\epsilon_0 E_z(\infty)$.

p. 49, Eq. (2.71), rightmost equation, 1st member of right side: change $c\rho$ to $c\rho_e$.

p. 50, Section 2.6, Eq. (2.75), rightmost member: change I_1 to I_2.

p. 50, Section 2.6, 1st and 2nd line immediately below Eq. (2.75): change I_2 to I_1.

p. 55, Section 2.7 at the top, 2nd line: change "Midgal" to "Migdal".

$$\frac{r_1 \Phi}{L^2} \quad \Rightarrow \quad r_1 \Phi.$$

p. 56, Prob. 2.8. 2nd line: Change $K(t) = K_0(t/\tau)$ to $K(t) = K_0(t/\tau)\hat{z}$

p. 56, Prob. 2.9. Replace all three sentences below the two equations by:

Show by explicit calculation that the net flux of charge into a volume element $dV = r^2 dr d\Omega$ through it bounding surfaces takes the expected value.

p. 56, Prob. 2.13, line 2: change "lenght" to "length".

p. 57, Problem 2.13, part (c): make the change

Chapter 3

p. 58: Change $\rho^\star(\mathbf{r})$ to $\tilde{\rho}(\mathbf{r})$ in Eq. (3.3) and Eq. (3.4) and in the lines immediately above and below these equations.

p. 59: Change $\rho^\star(\mathbf{r})$ to $\tilde{\rho}(\mathbf{r})$ in Eq. (3.9), in the line immediately above Eq. (3.9), and in footnote 1.

p. 59: Change $\rho^\star$ to $\tilde{\rho}$ in the two lines immediately below Eq. (3.9).

p. 59: Change $\mathbf{F}^\star$ to $\tilde{\mathbf{F}}$ in the line immediately below Eq. (3.9).

p. 78, replace the second sentence after Eq. (3.78) by:

U_E diverges for a single point charge, which is apparent from the $R \to 0$ limit of (3.77).

p. 78, 3rd line below Eq. (3.80): make the change

$$E = q\,\hat{\mathbf{r}}/4\pi\epsilon_0 r \quad \Rightarrow \quad E = q\,\hat{\mathbf{r}}/4\pi\epsilon_0 r^2$$

p. 81, Section 3.7. Replace the first two sentences by:

Let $\mathbf{E}(\mathbf{r})$ be the electric field produced by a charge density $\rho(\mathbf{r})$. The force exerted on the charge in a volume V (due to the charge that is not in V) is

p. 83, Figure 3.18: the labels for the `x' and `y' axes should be exchanged.

p. 85, Prob. 3.3, problem statement: "Example 2.1." should be "Example 3.l."

p. 86, Prob. 3.8: change $\theta(x)$ to $\Theta(x)$ and change $\theta(x-b)$ to $\Theta(x-b)$

p. 86, Problem 3.12, second line of problem statement: change "shell" to "infinitesimally thin shell".

Chapter 4

p. 93, Ninth line from the bottom:

  replace `can be a stable orbit' by `can be an orbit'

p. 93. Fifth line from the bottom:

 replace `an analysis—stable bound states' by `an analysis—bound states'

p. 102, Section 4.4: The second sentence should read:

All atomic nuclei produce a quadrupole potential[8], as do all homopolar diatomic molecules.

Footnote 8 should read:

Of course, the charge Q of a nucleus produces a potential $Q/4\pi\epsilon_0 r$.

p. 110, Fig. 4.15: the arrowhead labeled R should touch the dashed circle.

p.111, Example 4.4, last line of text before the figure: change "exterior expansion" to "interior expansion"

p. 121, Problem 4.2: Change the second part (d) to part (e).

p.121, Problem 4.6: The text should read:

Show that $dW = -\mathbf{E}(\mathbf{r}) \cdot d\mathbf{p}$ is the work needed to assemble charges $\pm dq$ into a dipole $d\mathbf{p}$ in an external field $\mathbf{E}(\mathbf{r})$. Ignore the dipole self-energy.

p.122, Problem 4.12, accompanying diagram: omit the portion of the x-axis that lies on the horizontal disk

p.123, Prob. 4.15, part (c): the unit vectors $\hat{\mathbf{r}}, \hat{\boldsymbol{\theta}}$, and $\hat{\boldsymbol{\phi}}$ should look as they do in part (d).

p.124, Problem 4.23, part (a): the factor farthest to the far right under the integral should be $Y_{\ell m}^*(\Omega')$. That is, change ℓ' to ℓ and m' to m

Chapter 5

p. 131, Eq. (5.16) and Eq. (5.17): change E to E_0 everywhere.

p. 147, Change $\Delta\tilde{U}_E$ to $\Delta\hat{U}_E$ in Eq. (5.78), Eq. (5.81), and Eq. (5.82).

p. 152, Problem 5.2: Replace EVERTHING after the first sentence by:

Calculate the 2×2 capacitance matrix for this geometry and show that C_{22} can be interpreted as the ordinary capacitance of two capacitors in parallel.

p. 153, Prob. 5.5, part (a): change the lower limit on the sum from $\ell = 0$ to $\ell = 1$

p. 184, Eq. (6.114): change $\mathbf{D}$ to $\mathbf{E}$ as the variable held constant in the middle partial derivative.

p. 189, first line: change "identify" to "identity".

Chapter 6

p.179, Eq. (6.86): left-most symbol should be δU_E rather than ΔU_E.

Chapter 7

p. 206: Eq. (7.43): change to

$$a_m = \frac{\Omega_m(1 - e^{-m\pi})}{2\sinh(m\pi)} \quad \text{and} \quad b_m = \frac{\Omega_m(e^{m\pi} - 1)}{2\sinh(m\pi)}$$

p. 208, replace the 3$^{\text{rd}}$ line of text below Eq. (7.51) with:

When we add the two together, the first term in (7.51) is replaced by a position-independent *constant* when $0 < z < d$.

p. 213, Eq. (7.75): Exchange $A_{\ell m}$ and $B_{\ell m}$. In Eq. (7.76) and Eq. (7.77): delete the factor of $1/4\pi\epsilon_0$ in front of the double sum.

p. 217, first line of text after Eq. (7.91). $J_m(k_m n'\rho)$ should be $J_m(k_{mn'}\rho)$

p. 217, Delete ` $+$ *const.*' from the right side of Eq. (7.94)

p. 218, Remove the footnote reference from second line of text so

$$\text{gives}^{12} \rightarrow \text{gives}$$

p. 218, Eq. (7.96): remove the rightmost equals sign and everything that lies to the right of that equals sign.

p. 218, Change the line immediately after Eq. (7.96) to [note the insertion of the footnote reference]:

Regularizing the integrals and using the Plemelj formula (1.105) gives[12]

p. 218, Change Eq. (7.97) to

$$\varphi(\rho, z) = \frac{V_R + V_L}{2} + \frac{V_R - V_L}{2\pi i} \int\limits_{-\infty}^{\infty} \frac{d\kappa}{\kappa} \frac{I_0(|\kappa|\rho)}{I_0(|\kappa|R)} e^{i\kappa z}$$

p. 218, Delete the entire sentence after Eq. (7.98) which begins `The additive constant . . . .'

p. 230, Problem 7.6: For consistency with the Solution Manual, exchange the labels $\varphi = 1$ and $\varphi = -1$ in the diagram. Exchange also the labels $\varphi = 2$ and $\varphi = -2$ in the diagram.

Chapter 8

p. 252, Eq. (8.56): change the integrand from $d^3r\, \varphi(\mathbf{r})$ to $dS\, \varphi(\mathbf{r})$

p. 257, line immediately below Eq. (8.82): add this page to the Index under the entry "Wronskian, modified Bessel functions"

p. 266, Problem 8.4, left side of equation should read: $\varphi(z > b)$

Chapter 9

p. 284, Eq. (9.46) and Eq. (9.47): change $\varphi_1 - \varphi_2$ to $\varphi_2 - \varphi_1$

p. 286, change the entire paragraph immediately above Application 9.2 to:

It is worth emphasizing that the time-independent surface charge density $\sigma(\mathbf{r}_S) = \epsilon_0\, \hat{\mathbf{n}} \cdot \mathbf{E}_{\text{out}}(\mathbf{r}_S)$ is produced by a collection of immobile charge carriers which are fixed in space. These coexist with the charge carriers that constitute the steady current in the bulk of the wire. The latter move at the average drift velocity (9.16).

p. 290, Ex. 9.5, third equation: change "M =" to "$M_k =$".

Chapter 10

p. 301: Change $j^\star(r)$ to $\tilde{j}(r)$ in Eq. (10.3) and Eq. (10.4) and in the sentences immediately above and below these equations.

p. 307, Fig. 10.4: the point at the upper left where all the straight lines come together should be labeled P.

p. 308, Figure 10.5: the two lowest arrowheads in each of the three sets of concentric-circle field lines should be point in the opposite direction

p. 309, Eq. (10.32). Rightmost member should be:

$$-B_x\hat{x} + B_y\hat{y} - B_z\hat{z}.$$

p. 312, 1st line after the 1st equation in the gray box: make the change

$$K_{\pm} = \hat{\rho}I/2\pi\rho \qquad \Rightarrow \qquad K_{\pm} = \pm\hat{\rho}I/2\pi\rho$$

p. 331, Problem 10.9, part (c), last line: make the change

$$j(z) \quad \Rightarrow \quad K(z)$$

p. 333, Problem 10.20: Change the statement of the problem to:

Consider a vector potential $A = \frac{1}{2}C \ln(x^2 + y^2)\,\hat{z}$. Find a vector potential $A' = A'_x\,\hat{x} + A'_y\,\hat{y}$ which produces the same magnetic field.

p. 335, Prob. 10.25, line 1: change "which any vector" to "that any vector".

Chapter 11

p. 339, Eq. (11.18): change S_{kk} to S_{jj} both times it occurs.

p. 341, Eq. (11.27), far right side: change $A - m^2$ to $A \cdot m^2$

p. 350, Eq. (11.68): a minus sign is needed immediately after the equals sign.

p. 350, Eq. (11.70), after the first equals sign: change

$$\boldsymbol{r} \cdot (\nabla \times \boldsymbol{j}) = \epsilon_{ijk} r_j \partial_k j_i \quad \text{to} \quad \boldsymbol{r} \cdot (\nabla \times \boldsymbol{j}) = \epsilon_{ijk} r_i \partial_j j_k$$

p.361, Problem 11.1, change the last sentence to: ``Find the magnetic moment of this current distribution without performing any integrals.''

p. 363, Problem 11.13, add to the end of the problem:

Hint: Use (1.78) and $\nabla = \hat{\boldsymbol{r}} (\partial / \partial r) + \nabla_{\perp}$ to simplify the required integral to $\int d\Omega \nabla_{\perp} Y_{\ell m}$. Because $\nabla \left(r^{\ell} Y_{\ell m} \right)$ satisfies Laplace's equation, use Example 3.5 to prove that this integral is zero unless $\ell = 1$.

Chapter 12

p. 368, Section 12.3, two lines above Eq. (12.21): change

    magnetic field (9.11)   to   magnetic field (10.15)

p. 369, 2nd line of footnote 1: change the expression to

$$3 \boldsymbol{j}_2(\boldsymbol{r}) \cdot (\boldsymbol{r} - \boldsymbol{r}') \, \boldsymbol{j}_1(\boldsymbol{r}') \cdot (\boldsymbol{r} - \boldsymbol{r}') / |\boldsymbol{r} - \boldsymbol{r}'|^2 - 2 \boldsymbol{j}_2(\boldsymbol{r}) \cdot \boldsymbol{j}_1(\boldsymbol{r}')$$

p. 370-371. I am grateful to Prof. Thom Curtright of the University of Miami for suggesting this superior version of Example 12.2: Replace the text from the beginning to the paragraph on page 371 which begins "In light of . . ." by the following:

A negligibly thin and very long conducting ribbon has width w and carries a uniform surface current with density $K = I/w$ in the direction perpendicular to its width. Figure 12.3 shows a helical sheath solenoid made by wrapping this ribbon tightly around the surface of a long and non-conducting cylinder of radius R. Assume that the vector $\mathbf{K}$ makes an angle θ with respect to the $+\hat{\mathbf{z}}$ direction. Find the magnetic field inside and outside the solenoid (regarded as infinitely long) and the force per unit area $\mathbf{f}$ which acts on the ribbon. Show that there is a critical angle θ_c where $\mathbf{f}(\theta_c) = 0$ and discuss the cases $\theta < \theta_c$ and $\theta > \theta_c$ physically.
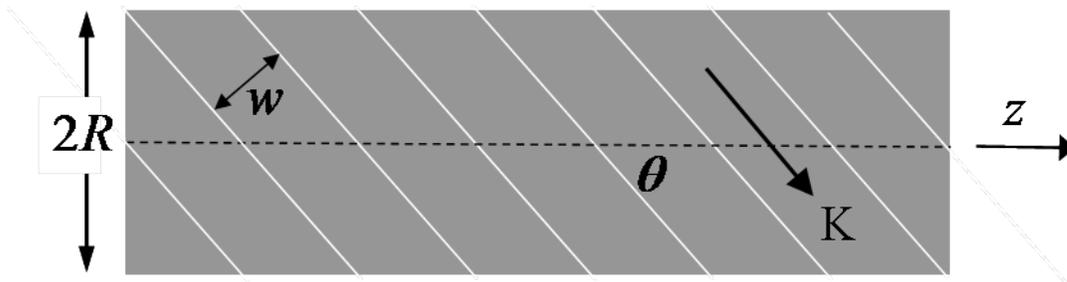
Figure 12.3: A helical sheath solenoid. The gaps (white) between adjacent turns of the tightly wrapped conducting ribbon (gray) should be regarded as infinitesimally narrow.

The surface current density of this solenoid is

$$\mathbf{K} = \left(\hat{\mathbf{z}}\cos\theta + \hat{\boldsymbol{\phi}}\sin\theta\right)\frac{I}{w}.$$

Ampère's law in its most elementary form and superposition give the total magnetic field inside and just outside this solenoid as

$$\boldsymbol{B}_{\text{in}} = \frac{\mu_0 I}{w} \sin\theta \; \hat{\boldsymbol{z}} \qquad\qquad \boldsymbol{B}_{\text{out}} = \frac{\mu_0 I}{2R} \; \hat{\boldsymbol{\phi}}$$

From (12.4), the force density on the surface is $\frac{1}{2} \boldsymbol{K} \times (\boldsymbol{B}_{\text{in}} + \boldsymbol{B}_{\text{out}})$. Namely,

$$\boldsymbol{f} = \frac{\mu_0 I^2}{2w} \left[\frac{\sin^2\theta}{w} - \frac{\cos\theta}{2\pi R} \right] \hat{\boldsymbol{\rho}}.$$

We rewrite this expression by noting that the geometrical condition for a tight wrapping of the ribbon (no gaps or overlaps) is $w = 2\pi R \cos\theta$. Therefore,

$$\boldsymbol{f} = \frac{\mu_0 I^2}{2w^2} \left[\sin^2\theta - \cos^2\theta \right] \hat{\boldsymbol{\rho}} .$$

The critical angle where $\boldsymbol{f}$ vanishes is $\theta_c = \pi/4$.

p. 374, 1st line after Eq. (12.43): change "sufficient" to "sufficiently"

p. 374. Eq. (12.44). Change the sign of the 3rd term in the square bracket on the RHS from negative to positive so it reads:

$$+(\boldsymbol{m}_2 \cdot \hat{\boldsymbol{r}})\boldsymbol{m}_1$$

p. 378, Fig. 12.9, change the last sentence of the caption to: Arrows indicate that adjacent wires carry current in opposite directions.

p. 382, line immediately above Eq. (12.78): change

   it often preferable   to   it is often preferable

p. 384, third line after Eq. (12.90): change

   (see Section 10.8)   to   [see (10.8)]

p. 388, line immediately above Eq. (12.109): change

    [see (1.29)]   to   [see (14.42)]

p. 390, Eq. (12.116), change the subscript on the far right from Φ, R to I, R

p. 393, Section 12.7.4, second line of text: change ``Because two parallel current attract,'' to ``Because two parallel currents attract,''

p. 393, Eq. (12.126): change $\Delta \tilde{U}$ to $\Delta \hat{U}$ in the leftmost member.

p. 394, Eq. (12.129): change $\Delta \tilde{U}$ to $\Delta \hat{U}$ in the leftmost member.

p. 394, Eq. (12.130): change $\Delta \tilde{U}$ to $\Delta \hat{U}$ in the leftmost member.

Chapter 13

p.422, Sec. 13.6.1, Eq. (13.64) should be

$$\frac{1}{\mu} \nabla \times \boldsymbol{B} - \boldsymbol{B} \times \nabla \left(\frac{1}{\mu}\right) = \boldsymbol{j}_f$$

p. 430, Sec. 13.6.6, title of part (A): the parentheses in " $(\mu \to \infty)$" should not be boldface.

p. 433, Eq. (13.102): remove the factor of one-half in front of the first integral on the RHS.

p. 434, end of last sentence before Section 13.7.3: change ``Figure 13.12 and Figure 13.14.'' to ``Figure 13.13 and Figure 13.14.''

p. 448, Sec. 13.7, line 1: change "with *Landau*" to "*Landau*".

p. 450, Prof. 13.7, part (c): Under the integral, change $\cos^2 2\theta$ to $\cos^2 \theta$

p. 450, Prob. 13.8, line 5: change "Example 9.3" to "Example 10.2".

p. 450, Prob. 13.9, change last line of text to:

Let $R \ll t$ and find **B** at every point in space that lies very far from both ends of the cylindrical hole.

Chapter 14

p. 418, Eq. (13.47), topmost and rightmost expression: $nr < R \Rightarrow r < R$.

p. 461, second line of text: change

   Both merit our attention.   to   All of these merit our attention.

p. 467, Eq. (14.44), below the integral sign: change ``AEBA'' to ``ADEA''

p. 467, Section 14.5: Replace ALL the material beginning just after (14.47) and ending with (14.50) by :

We next use (14.46) and (14.47) to form the ratio,

$$\frac{E_F}{E_C} \sim \frac{\varepsilon_0 \omega B}{\rho}. \tag{14.48}$$

Now use (14.46) and (14.47) again to estimate the magnetic field in (14.48) using the Ampère-Maxwell law:

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{j} + \frac{1}{c^2}\frac{\partial \mathbf{E}}{\partial t} \quad \Rightarrow \quad \frac{B}{\ell} \sim \mu_0 j + \frac{\omega}{c^2}\left(\frac{\ell\rho}{\varepsilon_0} + \omega B\ell\right). \qquad (14.49)$$

A glance back at (14.45) shows that the first and second terms on the far right side of (14.49) are both of order $\mu_0 \omega \ell \rho$. Therefore, solving the rightmost equation in (14.49) for B and substituting into (14.48) gives

$$\frac{E_F}{E_C} \sim \frac{\omega^2 \ell^2 / c^2}{1 - \omega^2 \ell^2 / c^2}. \qquad (14.50)$$

p. 470, Section 14.6, third line: Replace ALL the material beginning with ``Rather than starting'' and ending at (14.62) with:

Using the Ampère-Maxwell law on the right side of (14.53), let $\mathbf{B}_A$ be the magnetic field produced by the Ampère current j and let $\mathbf{B}_d$ be the magnetic field produced by the displacement current

$$\mathbf{j}_d = \epsilon_0 \, \partial \mathbf{E}/\partial t. \qquad (14.59)$$

Writing $\nabla \sim 1/\ell$ and $\partial/\partial t \sim \omega$ as described in connection with Fig 14.9 gives the magnitude estimates

$$B_A \sim \mu_0 j \, \ell \qquad \text{and} \qquad B_d \sim \ell \omega E/c^2 \qquad (14.60)$$

However, according to Faraday's law,

$$\nabla \times \mathbf{E} = - \frac{\partial}{\partial t}[\mathbf{B}_A + \mathbf{B}_d] \quad \Rightarrow \quad E \sim \mu_0 \omega j \ell^2 + \ell^2 \omega^2 E/c^2. \qquad (14.61)$$

Solving (14.61) for E and using this to estimate the displacement current in (14.59) gives the ratio

$$\frac{j_d}{j} \sim \frac{\omega^2 \ell^2 / c^2}{1 - \omega^2 \ell^2 / c^2} \qquad (14.62)$$

p.478, Figure 14.13: replace the four appearances of κR by $|\kappa|R$.

p.478, 7$^{\text{th}}$ line of text, replace "As the magnitude of $\kappa = (1+i)/\delta$" by "As the magnitude $|\kappa|R = \sqrt{2}R/\delta$".

p. 478, Eq. (14.102). Replace by

$$J_0(|\kappa|\rho) = 1 - \frac{1}{4}|\kappa|^2\rho^2 + \frac{1}{64}|\kappa|^4\rho^4 + \cdots \qquad (|\kappa|\rho \ll 1)$$

p. 478, Eq. (14.103). Replace by

$$J_0(|\kappa|\rho) \sim \sqrt{\frac{1}{2\pi|\kappa|\rho}} \cos(|\kappa|\rho - \pi/4) \qquad (|\kappa|\rho \gg 1)$$

p. 479. Figure 14.14: reverse the directions of the arrows on the dashed loop.

p. 479. Replace Section 14.10.1 ENTIRELY (up to the box labelled `Young Rutherford') by:

The skin effect arises from an interplay between Ohm's law, Ampere's law, and Faraday's law. To gain some insight, it is instructive to derive and analyze an integral equation for the current density $\boldsymbol{j} = \sigma\boldsymbol{E}$ using the integral forms,

$$\oint_C d\boldsymbol{\ell} \cdot \boldsymbol{H} = \int_S d\boldsymbol{S} \cdot \boldsymbol{j} \quad \text{and} \quad \oint_{C'} d\boldsymbol{\ell} \cdot \boldsymbol{E} = -\int_{S'} d\boldsymbol{S} \cdot \frac{\partial \boldsymbol{B}}{\partial t} \qquad (14.106)$$

The circular loop C is coincident with, and traversed in the same direction as, a closed magnetic field line of radius ρ defined by the dotted and crossed symbols in Figure 14.14. The rectangular loop C' shown dashed in Figure 14.14 has length ℓ and width ρ. The long leg coincident with the wire's symmetry axis is traversed from left to right, which we define as the direction of positive j in the diagram.

If all quantities vary as $\exp(-i\omega t)$, the integrals in (14.106) simplify to

$$B(\rho) = \frac{\mu}{\rho} \int_0^\rho ds\, s\, j(s) \quad \text{and} \quad j(\rho) = j(0) - i\omega\sigma \int_0^\rho d\rho' B(\rho') \quad (14.107)$$

These expressions show that the current density in the wire become radially inhomogeneous because Faraday self-induction induces an electric field (and hence a contribution to the current density) which depends on the instant- aneous and radially inhomogeneous magnetic field produced by that current density. Inserting the left side of (14.107) into the right side and using (14.98) gives

$$j(\rho) = j(0) - \frac{2i}{\delta} \int_0^\rho d\rho' \frac{1}{\rho'} \int_0^{\rho'} ds\, s\, j(s). \quad (14.108)$$

This integral equation can be solved using the iterative method of successive approximations. Only elementary integrals appear and we find

$$\frac{j(\rho)}{j(0)} = 1 - \frac{i}{2}\left(\frac{\rho}{\delta}\right)^2 - \frac{1}{16}\left(\frac{\rho}{\delta}\right)^4 + \cdots \quad (14.109)$$

Because $\kappa = (1 + i)/\delta$, the series in (14.109) is identical to the series in (14.102) and the reader can check that the present method reproduces (14.100) exactly because (14.109) is the absolutely convergent series expansion of $J_0(\kappa\rho)$ for all values of ρ/δ.

p. 493, Section 14.4. The correct reference to the paper by Scanlon *et al.* is

American Journal of Physics **37**, 698 (1969).

p. 494, Section 14.10. Replace the reference to E.B. Moullin by:

G.S. Smith, ``A simple derivation for the skin depth in a round wire'', *European Journal of Physics* **35**, 025002 (2014).

p. 495, Problem 14.4, part (a): change "displacement current" to "displacement current density"

p. 499, Problem 14.25, second line: change

$$t \ll R \qquad \text{to} \qquad t \ll a$$

Chapter 15

p. 509, Example 15.2, fourth line of text from the bottom: $\rho \to \hat{\rho}$

p. 510, last complete paragraph, 4$^{\text{th}}$ line: change "White arrows" to "Gray arrows"; 6$^{\text{th}}$ line: change "white arrow" to "gray arrow".

p. 511, Figure 15.2, 2$^{\text{nd}}$ line of caption: change "white arrows" to "gray arrows".

p. 512, just after Eq. (15.39): change the beginning of the sentence from "The electric fields . . ." to ``Because $q_1 = q_2$ and $\nabla \varphi_1(\mathbf{r}_2, t) = -\nabla \varphi_2(\mathbf{r}_1, t)$, the electric fields . . . ."

p. 514, 2$^{\text{nd}}$ paragraph, 3$^{\text{rd}}$ line: change " jth " to " j$^{\text{th}}$ ". One line later: change " ith " to " i$^{\text{th}}$ ".

p. 520, Eq. (15.80), left side: change $\dfrac{\partial \mathbf{g}}{\partial t} + \nabla \cdot \mathbf{T}$ to $\dfrac{\partial \mathbf{g}}{\partial t} - \nabla \cdot \mathbf{T}$.

p. 520, 1$^{\text{st}}$ line after Eq. (15.80): change "add (15.79) to (15.80)" to "subtract (15.80) from (15.79)"

p. 520, 1$^{\text{st}}$ line after Eq. (15.81): change "These manipulations" to "Using (15.50), these manipulations"

p. 522: Replace the first full sentence and Eq. (15.94) by

The average current contributed by this particle is $I = q/T$, so the time-averaged linear momentum associated with its motion is not zero but

$$\mathbf{P}_{\text{mech}} = \frac{1}{T} \sum_{\alpha=1}^{N} \gamma_\alpha m \mathbf{v}_\alpha \, \delta t = \frac{1}{T} \sum_{\alpha=1}^{N} \gamma_\alpha m \boldsymbol{\delta \ell}_\alpha = \frac{I}{q} \oint \gamma m d\boldsymbol{\ell}$$

p. 524, Eq. (15.108), RHS: change $-\mathbf{j} \cdot \mathbf{E}.$ to $-\mathbf{j}_f \cdot \mathbf{E}.$

p. 530, Section 15.7, line 4: change "Application 15.5" to "Application 15.3"

p. 533, Change all the wording of Problem 15.11 to:

> **A Charged Particle in Static Fields** A particle with charge q and mass m produces fields $\mathbf{E_q}$ and $\mathbf{B_q}$ as it moves in static fields $\mathbf{E}_0(\mathbf{r})$ and $\mathbf{B}_0(\mathbf{r})$. Let $\mathbf{j}_0$ $(\mathbf{r})$ be the current density associated with the static fields and write out Poynting's theorem for the total fields assuming that no radiation is produced (all fields fall off more rapidly that $1/r$).
>
> (a) Argue that the div $\mathbf{S}$ term is absent from the theorem and that only cross terms like $\mathbf{E}_0 \cdot \mathbf{E}_q$, $\mathbf{B}_0 \cdot \mathbf{B}_q$, $\mathbf{j}_0 \cdot \mathbf{E}_q$, and $\mathbf{j}_q \cdot \mathbf{E}_0$ contribute.
>
> (b) Let $\mathbf{E}_0 = -\nabla \varphi_0$, use the work energy theorem, and rewrite the magnetic energy to show that the entire content of the Poynting theorem amounts to the statement, $\frac{1}{2}mv^2 + q\varphi_0(r_q) = const.$

Chapter 16

p. 539, Section 16.3, line just above Eq. (16.20): change `compute the derivatives" to

compute the derivatives $\partial_z = \partial_\xi + \partial_\eta$ and $\partial_{ct} = \partial_\xi - \partial_\eta$ so that

p. 539, 4th line after Eq. (16.21): replace "postive" by "positive".

p. 544, at the end of the footnote: change $\frac{1}{2}A^*B$ to $\frac{1}{2}\mathrm{Re}(A^*B)$.

p. 547, next-to-last sentence: change

``monochromatic LCP plane'' to ``monochromatic RCP plane''

p. 548, caption to Figure 16.8: change LCP to RCP.

p. 549, Example 16.2:

- line 3 of the problem statement: replace "left" by "right"

- line 4 of the problem statement: replace "right" by left"

- line 1 of the solution: change "LCP" to "RCP" and change "RCP" to "LCP"

- first equation of the Solution: change Re to $\frac{1}{2}\mathrm{Re}$

- second equation of the Solution: change " $\hat{\mathbf{z}} \times \mathrm{Re}$ " to "$-\hat{\mathbf{z}} \times \frac{1}{2}\mathrm{Re}$"

- second equation of the Solution: remove the minus sign just after the second equals sign

- first line of text after the second equation: change $= \tan z,$ to $= \tan kz,$

p. 560, end of the 3rd line below Eq. (16.120), make the change:

$$w_0 \text{ to } 2w_0 \quad \Rightarrow \quad \pi w_0^2 \text{ to } 2\pi w_0^2$$

p. 561, next-to-last line of Example 16.4: replace "Guoy" by "Gouy".

p. 562, Eq. (16.123), left member:

$$\exp[i\mathbf{k} \cdot \mathbf{r} - \omega(\mathbf{k})t] \quad \Rightarrow \quad \exp[i(\mathbf{k} \cdot \mathbf{r} - \omega(\mathbf{k})t)]$$

p. 563, footnote 20: replace "R, Beth," by "R. Beth,"

p. 570, beginning of the 1st line after Eq. (16.171):

$$\text{Equation (16.8)} \quad \Rightarrow \quad \text{Equation (16.9)}$$

p. 570, two lines above Eq. (16.174):

$$\boldsymbol{\pi}_e = -c\boldsymbol{\pi}_m. \qquad \Rightarrow \qquad \boldsymbol{\pi}_e = c\boldsymbol{\pi}_m.$$

p. 577, Problem 16.2, 1st line after the one-dimensional wave equation: change "localized, i.e., $f(\xi)$ can go to zero" to "*strictly* localized, i.e., $f(\xi)$ can be exactly zero".

p. 577, Problem 16.2, 1st line after the diagram: change "*cannot* be localized" to "*cannot* be strictly localized".

p. 578, Problem 16.5, part (d): change to read:

Show that the field in part (c) can be written as the sum of a standing wave with polarization $\hat{\boldsymbol{e}}_+$ and a standing wave with polarization $\hat{\boldsymbol{e}}_-$.

p. 582, Problem 16.22, part (a): change $\exp(i\mathbf{k}\cdot\mathbf{r}+\delta)$ to $\exp[i(kr+\delta)]$

p. 582, Problem 16.22, part (b), 2nd line: change $|\mathbf{k}_1|=\mathbf{k}_2|$ to $|\mathbf{k}_1|=|\mathbf{k}_2|$.

Chapter 17

p. 589, first line after Eq. (17.32): change $\boldsymbol{k}_R$ to $\boldsymbol{k}_T$

p. 594, Eq. (17.46): change $\cos\theta_1\cos\theta_1$ to $\cos\theta_1\cos\theta_2$ in the numerator of the fraction on the left hand side for the quantity T_{p}.

p. 596, add a square bracket to the rightmost member of Eq. (17.58):

$$\left(\frac{\omega}{c}\right)^2 [n_2^2 - n_1^2\sin^2\theta_1].$$

p. 596, Eq. (17.60), replace the exponential factor by

$$\exp[i(k_1 x\sin\theta_1 - \omega t)]$$

p. 596, LHS of Eq. (17.65): change $\dfrac{E_{Tz}}{E_{Tx}}$ to $\dfrac{E_{Tx}}{E_{Tz}}$.

p. 599, Example 17.3, final equation in the box, middle member: change

$$\frac{1}{2\omega\mu_2|} \qquad \text{to} \qquad \frac{1}{2\omega\mu_2}$$

p. 601, Example 17.4, end of 8th line of text: change

[see (17.38],   to   [see (17.38)],

p. 601, Example 17.4, next to last equation: replace $\frac{1}{2}\epsilon_0 c^2 E_I^2$ by $\frac{1}{2}\epsilon_0 c E_I^2$.

p. 602, Eq. (17.83): replace rr' in the denominator of the rightmost member by $r'r'$.

p. 607, Section 17.6. Add a footnote at the end of the text that precedes Eq. (17.98):

An Ohmic medium does not support a surface current density $\mathbf{K}$ because $\boldsymbol{j} = \sigma\boldsymbol{E}$ is valid at all points in and on the surface of such a medium.

p. 608, Eq. (17.111), change the beginning of the RHS from

$$\boldsymbol{E}e^{-(\omega/c)n''\hat{\boldsymbol{k}}\cdot\boldsymbol{r}} \qquad \text{to} \qquad \boldsymbol{E}\exp\!\left[-(\omega/c)n''\hat{\boldsymbol{k}}\cdot\boldsymbol{r}\right]$$

p. 617, Problem 17.3, last line of part (a), change "than" to "that"

p. 618, Prob. 17.5, last line: change the last line to: Find the fraction of the emitted rays which could (in principle) escape from the dielectric into the vacuum space above.

p. 619, Prob. 17.10, part (a): change ``Without appealing to the Fresnel equations," to ``Use a four plane-wave trial solution and"

p. 619, Prob. 17.10, part (b): change ``in term of the'' to ``in terms of the''

p. 619, Prob. 17.11: The parts of this problem should be labeled (a), (b), and (c) rather than (a), (b), and (b).

Chapter 18

p. 628, Eq. (18.26), make the change:

$$\frac{1}{16\pi^2} \quad \Rightarrow \quad \frac{1}{32\pi^2}$$

p. 631, Eq. (18.48), change this equation to

$$\frac{\hat{\epsilon}(\omega)}{\epsilon_0} \approx -\omega_p^2 \tau^2 + i\frac{\omega_p^2 \tau}{\omega} \qquad \omega\tau \ll 1$$

p. 632, 3rd line above Section 18.5.3: change "when is driven" to "when it is driven"

p. 632, last line of text: change (18.38) to (18.48).

p. 638, 1st line above Eq. (18.75): change "$n_+^2(\omega_+) =$ and" to "$n_+^2(\omega_+) = 0$ and"

p. 649, Section 18.7.1, section title: change Kramers-Krönig to Kramers-Kronig

p. 650, In the first line below Eq. (18.121), in the title line of Section 18.7.2 and in the immediately following line: change

Kramers-Krönig to Kramers-Kronig

p. 651, in the 1st, 4th, and 6th lines of the first full paragraph and in the 2nd lines of the following paragraph: change

Kramers-Krönig to Kramers-Kronig

p. 652, Example 18.4, in the 1st and 4th lines: change

Kramers-Krönig   to   Kramers-Kronig

p. 652, Section 18.7.3, in the 3rd line: change

Kramers-Krönig   to   Kramers-Kronig

p.653, in the 1st line and in the last line of Section 18.7.3: change

Kramers-Krönig   to   Kramers-Kronig

p. 654, in the 3rd line of the penultimate paragraph: change

Kramers-Krönig   to   Kramers-Kronig

p. 655, in the line immediately above Eq. (18.129): change

Kramers-Krönig   to   Kramers-Kronig

p. 658, Section 18.7, in the 1st and 2nd lines: change

Kramers-Krönig   to   Kramers-Kronig

p. 665, Problem 18.18, in the 2nd line of text: change

Kramers-Krönig   to   Kramers-Kronig

p. 659, Problem 18.2, part (a) :

1st equation: change left-most symbol from $J_i(r,t)$ to $J_i(\boldsymbol{r},t)$ and change right-most symbol from $E_j(r,t')$ to $E_j(\boldsymbol{r},t')$

2nd equation: change left-most symbol from $j_i(r,t)$ to $J_i(\boldsymbol{r},t)$ and change right-most symbols from

$dr'\sigma_{ij}(r - r', t - t')E_j(r', t').$ to

$$d^3r'\,\sigma_{ij}(\boldsymbol{r} - \boldsymbol{r}', t - t')E_j(\boldsymbol{r}', t').$$

p. 660, Problem 18.7: the stated electric field should be

$$\mathbf{E}(x, z) = [\hat{\mathbf{x}}\, E_x^{\text{in/out}} + \hat{\mathbf{z}}\, E_z^{\text{in/out}}]\exp[i(qx - \omega t)]\exp(-\kappa_{\text{in/out}}\,|z|)$$

p. 664, Problem 18.7, part (g): change $-4 < t < 50$ to $-40 < t < 50$

p. 665, Problem 18.18: Rearrange and change the text of this problem to:

Parseval's Relation Let the real and imaginary parts of $\hat{\chi}(\omega) = \chi'(\omega) + i\chi''(\omega)$ satisfy the Kramers-Kronig relation.

(a) $\Delta(x)$ is an acceptable representation of the delta function $\delta(x)$ if (i) $\Delta(0)$ diverges and (ii) $\Delta(x)$ exhibits the filtering property:

$$f(0) = \int_{-\infty}^{\infty} dx\, f(x)\Delta(x).$$

Show that these two properties are satisfied if

$$\Delta = \frac{1}{\pi^2} \int_{-\infty}^{\infty} \frac{dy}{y(y-x)}.$$

Hint: Substitute $\chi'(\omega)$ into $\chi''(\omega)$ or vice versa.

(b) Use $\Delta(x)$ in part (a) to prove Parseval's relation,

$$\int_{-\infty}^{\infty} d\omega\,|\chi'(\omega)|^2 = \int_{-\infty}^{\infty} d\omega\,|\chi''(\omega)|^2.$$

Chapter 19

p. 668, 2nd complete paragraph, 2nd line: change [see (5.15] to [see (5.15)]

p. 671, 6th line of the box labeled *Telegraphy and the Law of Squares* :delete the comma after the name "Thomson".

p. 673, Section 19.3.2, line 2: change $x = 2\pi m k_0 \cos\theta$ to $x_m = m\pi/k_0 \cos\theta$

p.674, Eq. (19.29): Change $\mathbf{E}_m = -2E_0 \sin(\cdots)$ to $\mathbf{E}_m = -2iE_0 \sin(\cdots)$ in the first line.

p. 681, Eq. (19.61), lower equation labeled `TE': replace $++$ by $+$ inside the square bracket.

p. 689, Eq. (19.96), rightmost member: exchange n_1 and n_2 so the factor in parenthesis reads

$$\left(1 - \frac{n_2^2}{n_1^2}\right)$$

p. 694, Example 19.3, 1st line of Solution: change $E_x(z, y)e^{-i\omega t}$ to
$$E_x(y, z)e^{-i\omega t}$$

p.696, upper equation of Eq. (19.122) for $\mathbf{E}_{\text{TM}}$: insert a minus sign in front of the first term inside the large square bracket

p. 709, Problem 19.8(a), 2nd line: change $\exp(ihz - \omega t)$ to $\exp[i(hz - \omega t)]$

p. 710, Problem 19.12 (b), next to last line: change

"part (b), now including" to "part (a), now including"

p. 712, replace the equation above Problem 19.19 by

$$\psi(x, y, t) = \sum_{m=0}^{5}(-1)^m \sin(\mathbf{k}_m \cdot \mathbf{r} - ckt)$$

Chapter 20

p. 714, last line of 1st paragraph: change ``name give to'' to ``name given to''

p. 717, Eq. (20.22), change $y\mathbf{y}$ to $y\hat{\mathbf{y}}$ on the right side .

p. 718, Example 20.1, in the sentence near the bottom that begins "The matching conditions": change $\hat{\mathbf{n}}\cdot[\mathbf{A}_1-\mathbf{A}_2]=0$ to $\hat{\mathbf{n}}_2\cdot[\mathbf{A}_1-\mathbf{A}_2]=0$

p. 723, Eq. (20.46): change right-most symbol from $f(\mathbf{r}',t).$ to $f(\mathbf{r}'|\omega).$

p. 725, Eq. (20.59): remove the factor 4π from inside the integral and insert the factor $1/4\pi\epsilon_0$ in front of the integral.

p. 725, Eq. (20.60): remove the factor 4π from inside the integral and insert the factor $\mu_0/4\pi$ in front of the integral.

p. 727, Eq. (20.70), delete the rightmost member so this equation reads:

$$\rho(\mathbf{r},t) = -\mathbf{p}(t)\cdot\nabla\delta(\mathbf{r}).$$

p.733, Eq. (20.94): the final term in the expansion on the right side, the term with $(r'/r)^2$, has the wrong sign. It should be plus (+) instead of minus (-).

p. 734, change the beginning of the second sentence after Eq. (20.104) to:

The integral of $\nabla'\cdot\mathbf{j}(\mathbf{r}',t^\star)$ vanishes (after an integration by parts)

p. 734, last sentence: change `four consequences' to `three consequences'.

p. 735: delete the sentence after Eq. (20.109) which begins ``Third, at a''

p. 735, 4$^{\text{th}}$ line above Eq. (20.112): change $\mathbf{j}\propto\hat{\mathbf{r}},$ to $\mathbf{j}=j\hat{\mathbf{r}},$

p. 738, all three labels for Figure 20.10 and three times in the first sentence of the caption: Change d to $2d$ on the left side of an equals sign (see the correction immediately below).

p. 738, first sentence after Eq. (20.124):

Change $d = \lambda/2$ to $2d = \lambda/2$
Change $d = 3\lambda/2$ to $2d = 3\lambda/2$
Change $d = 5\lambda/2$ to $2d = 5\lambda/2$

p. 738, second sentence after Eq. (20.124): change ``number of  lobes'' to ``number of distinct lobes''

p. 741, sentence just above Eq. (20.131): change ``moving charge and the launch times, launch points, and absorption points''  to ``moving charge, the launch times, the launch points, and the absorption points''

p. 747, Eq. (20.163): change the leftmost term from $\ddot{\boldsymbol{r}}$ to $\ddot{\boldsymbol{s}}$

p. 748, middle member of the last equation in the shaded box: change

$$\frac{\mu_0}{4\pi}\frac{2}{3c^3}|\ddot{\boldsymbol{p}}|^2 \qquad \text{to} \qquad \frac{\mu_0}{6\pi c}|\ddot{\boldsymbol{p}}|^2$$

p. 748, next-to-last line in the shaded box: change

$$\boldsymbol{p}_{\text{ret}} = \boldsymbol{p}(t) \qquad \text{to} \qquad \boldsymbol{p}_{\text{ret}} \approx \boldsymbol{p}(t)$$

p. 750, 3rd line after Eq. (20.185): change

(see Example 5.1 of Section 5.2)   to   (see Example 5.1 of Section 5.2.1)

p. 750, 4th line after Eq. (20.185): add bold face to change

$$\boldsymbol{m} = -2\pi a^3 B_0/\mu_0 \qquad \text{to} \qquad \boldsymbol{m} = -2\pi a^3 \boldsymbol{B_0}/\mu_0$$

p. 752, Example 20.5: replace the star by an asterix in the middle member of the next-to-last equation so this term reads

$$\frac{\mu_0}{6\pi c^3}\frac{1}{2}\text{Re}[\dot{\mathbf{m}}_\perp \times \ddot{\mathbf{m}}^*_\perp]$$

p. 752, Eq. (20.191): change c^2 to c^3 in the denominator on the RHS.

p. 752, Everywhere in Section 20.7.3, a double dot over the symbol for a Cartesian or traceless quadrupole moment should be replaced by a triple dot:

1. right side of Eq. (20.188): $\ddot{\mathbf{Q}} \to \dddot{\mathbf{Q}}$
2. right side of Eq. (20.189): $\ddot{\mathbf{Q}}_{\text{ret}} \to \dddot{\mathbf{Q}}_{\text{ret}}$
3. right side of Eq. (20.190): $\ddot{\mathbf{Q}}_{\text{ret}} \to \dddot{\mathbf{Q}}_{\text{ret}}$ (two occurrences)
4. right side of Eq. (20.191): $\ddot{\mathbf{Q}}_{\text{ret}} \to \dddot{\mathbf{Q}}_{\text{ret}}$
5. left side of Eq. (20.196): $\ddot{\mathbf{Q}} \to \dddot{\mathbf{Q}}$
6. right side of Eq. (20.196): $\ddot{Q}_{lm} \to \dddot{Q}_{lm}$, $\ddot{Q}_{ij} \to \dddot{Q}_{ij}$, $\ddot{Q}_{km} \to \dddot{Q}_{km}$, $\ddot{Q}_{tp} \to \dddot{Q}_{tp}$
7. right side of Eq. (20.198): $\ddot{Q}_{im}\ddot{Q}_{im} - \ddot{Q}_{ii}\ddot{Q}_{mm} \to \dddot{Q}_{im}\dddot{Q}_{im} - \dddot{Q}_{ii}\dddot{Q}_{mm}$
8. text line below Eq. (20.198): $\ddot{\mathbf{Q}} \to \dddot{\mathbf{Q}}$
9. right side of Eq. (20.200): $\ddot{\Theta}_{im}\ddot{\Theta}_{im} \to \dddot{\Theta}_{im}\dddot{\Theta}_{im}$

p. 752, Line just above Eq. (20.195): change $Q_{xy} = Q_{yz}$ to $Q_{xy} = Q_{yx}$

p. 754, 1st line: change "left side of 20.197)" to "left side of (20.197)"

p. 754, Equation (20.199), the rightmost member should be

$$3Q_{ij} - Q_{kk}\delta_{ij}.$$

p. 754, Example 20.6: change m to m_k in the 3rd member of the last isolated equation so that equation reads

$$\mathbf{m} = \frac{1}{2}\sum_{k=1}^{N} q_k(\mathbf{r}_k \times \mathbf{v}_k) = \frac{q}{2m}\sum_{k=1}^{N} q_k(\mathbf{r}_k \times m_k\mathbf{v}_k) = \frac{q}{2m}\sum_{k=1}^{N}\mathbf{L}_k$$

p. 757, footnote 22 at the bottom of the page. Change $\nabla\times(\nabla\times\mathbf{L}) = -\mathbf{L}\nabla^2$. to $\nabla\times(\nabla\times\mathbf{L}) = -\nabla^2\mathbf{L}$.

p. 770, Problem 20.15, part (b), next to last line: change

$$\omega c/a = 2\pi \text{ and } \omega c/a \ll 1 \quad \text{to} \quad \omega a/c = 2\pi \text{ and } \omega a/c \ll 1$$

p. 772, Problem 20.23: replace the entire first paragraph (seven lines including an equation) by the following text:

A compact source of radiation is characterized by an electric dipole moment $\mathbf{p}(t) = \mathbf{p}_0 \cos \omega t$ and a magnetic dipole moment $\mathbf{m}(t) = \mathbf{m}_0 \cos \omega t$. Assume that the vectors $\mathbf{p}_0$ and $\mathbf{m}_0$ are real.

Chapter 21

p. 777, footnote 1 at the bottom of the page. In the middle member of the equation, change $(\epsilon_k^* \cdot \mathbf{E_{rad}})\epsilon$ to $(\epsilon_k^* \cdot \mathbf{E_{rad}})\epsilon_k$

p. 781, grey box at the top of the page, first line of text: the subscript "0" should not be bold and the embedded equation should read $\mathbf{q} = \mathbf{k}_0 - \mathbf{k}$

p. 781, grey box at the top of the page

second line of text after the equation: Change `x-ray' to `X-ray'
fourth line of text after the equation: Change `X-ray' to `x-ray'
p. 781: Application 21.1, next-to-last line of the caption to Fig. 21.5, first word: change `anisotopic.' to : `anisotropic in the rest frame of the Universe.'

p. 781: Application 21.1: change the third sentence of text after Figure 21.5 to:

The radiation seen from the $+z$-axis is unpolarized because the equal (unequal) intensity waves incident from the $\pm y$ ($\pm x$) axes scatter into the $+z$ direction preserving both intensity and polarization to give the mean intensity.

p. 782, first line of text above Eq. (21.23): change "smaller that" to "smaller than"

p. 782, 3rd line of 1st paragraph below Eq. (21.23): change (21.20) to (21.17).

p. 785, last line: Change `geometricvalue' to `geometric value'.

p. 788, Figure 21.9, caption: change final equation to

$$\sigma_{\text{geom}} = \pi R^2$$

p.791, first sentence: change $\alpha = \epsilon_0 V \chi$ to $\alpha = V \chi$.

p. 791, Example 21.3, end of 2nd line after 2nd equation: change (21.20) to (21.17)

Chapter 22

p. 823, Figure 22.1: The vectors labelled r and r' should NOT meet at a point as labelled. That is true for Galilean relativity only. The text immediately above Eq. (22.2) must be changed accordingly.

p. 832, Eq. (22.31): change the rightmost term to

$$\gamma^2(1 - \beta^2)[\Delta z^2 - c^2 \Delta t^2]$$

p. 832, Eq. (22.32): change the middle term to

$$(\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - (c\Delta t)^2$$

p. 834, Section 22.5, first sentence of second paragraph: change

    three vectors   to   three-vectors

p. 838, first line of text: change "is own" to "its own"

p.838, last sentence of the paragraph that contains Eq. (22.68). Replace "Photons and neutrinos have no rest frame." by "Photons have no rest frame."

p. 841, Example 22.2, final equation: delete a right parenthesis symbol so the square bracketed quantity on the left hand side reads $[\vec{r} - \vec{r}_k(\tau)]$

p. 849, Equation (22.133) change the RHS of the rightmost equation from $\dot{j}_\nu$ to $-\mu_0 \dot{j}_\nu$

p. 864, Section 22.6, line 4: change *Weinberg, Fisher,* and *Becker* to *Weinberg, Fisher* and *Hnizdo*, and *Becker*

p. 864, Section 22.6, between the 8th and 9th lines, i.e., between the reference to G.P. Fisher and the reference to R. Becker, insert:

V. Hnizdo, ``Magnetic dipole moment of a moving electric dipole'', *American Journal of Physics* **80**, 645 (2012).

p. 866, Problem 22.9: Remove the symbols $\rho(\mathbf{r})$ and $\mathbf{E}(\mathbf{r})$ from the first sentence.

p. 866, Problem 22.9(b): add a phrase at the end so the end of the sentence reads:

but that $\nabla \cdot \mathbf{S} = \nabla \cdot \mathbf{S}_0$ at points in space that do not lie on the moving charge distribution.

p. 866, Problem 22.12, part (b):   change S to K at the end of the sentence.

p. 866, Problem 22.12, part (c): change S to K at the end of the first sentence.

p. 868, Problem 22.26, part (b): replace the entire text by

(b) Suppose that a Lorentz boost from A_ν to A'_ν destroys the transverse property of the polarization, *i.e.,* $\mathbf{k}' \cdot \mathbf{A}' \neq 0$. Show that a plane wave as a gauge function is permissible and sufficient to ensure that $\tilde{A}_\nu = A'_\nu + \partial_\nu \Lambda$ is transverse and satisfies the Lorentz gauge constraint.

Chapter 23

p. 872, In the denominators of both Eq. (23.11) and Eq. (23.12):

$$R(t)g(t) \quad \Rightarrow \quad |R(t)g(t)|$$

$$R - \boldsymbol{\beta} \cdot \boldsymbol{R} \quad \Rightarrow \quad |R - \boldsymbol{\beta} \cdot \boldsymbol{R}|$$

p. 878, Figure 23.5: in the label $\Delta \mathbf{s} = \boldsymbol{\beta} R_{\text{ret}}$ near the bottom, only the symbols $\mathbf{s}$ and $\boldsymbol{\beta}$ should be bold.

p. 878, First line of text below Figure 23.5: replace $\overline{AB} = \boldsymbol{\beta} \mathbf{R}_{\text{ret}} \cdot \hat{\mathbf{n}}_{\text{ret}}$ by $\overline{AB} = \beta(\mathbf{R}_{\text{ret}} \cdot \hat{\mathbf{n}}_{\text{ret}})$ where the symbol "beta" in not bold. Six words later in the same sentence, the symbol "beta" should not be bold in $\beta \mathbf{R}_{\text{ret}}$

p. 880, Eq. (23.52), right side: replace the factor $\dfrac{(t - t_{\text{ret}})}{c}$ by $t - t_{\text{ret}}$

p. 880, Eq. (23.53), far right side: replace the factor $\dfrac{(t - t_{\text{ret}})}{c}$ by $t - t_{\text{ret}}$

p. 881, Section 23.3.2, third line after Eq. (23.59): change

decleration   to   deceleration

p. 888, Eq. (23.90): Replace $|\hat{\boldsymbol{v}}(\omega)|^2$ by $|\hat{\boldsymbol{r}} \times \hat{\boldsymbol{v}}(\omega)|^2$ and replace $|\hat{\boldsymbol{a}}(\omega)|^2$ by $|\hat{\boldsymbol{r}} \times \hat{\boldsymbol{a}}(\omega)|^2$.

p. 902, just above Eq. (23.150), the embedded equation $\nabla |\mathbf{r} - \mathbf{r}'|^2 = 2(\mathbf{r} - \mathbf{r}')$ should not be split across two lines.

p. 907, Eq. (23.172): left hand side should be $t - t_{\text{ret}}$.

p. 908: Insert a period at the end of Eq. (23.178). In the line of text just above this equation, replace the word "Using" by the phrase,

"Now, if the black dot in Figure 23.18 is the origin of polar coordinates,"

p. 908: Replace the comma at the end of Eq. (23.179) by a period. In the line of text just <u>above</u> this equation, replace the word "and" by the phrase,

"Also, if $R_\parallel = \mathbf{R} \cdot \hat{\mathbf{v}}$, we have $d(\cos\theta)/dt = (\sin^2\theta/R)\dot{R}_\parallel = -(\upsilon\sin^2\theta)/R$, so"

p. 908, first line of text after Eq. (23.179): replace "the electromagnetic" by "Therefore, the electromagnetic"

p. 908, Eq. (23.180), second line: a vector $\hat{\mathbf{R}}$ is missing from the numerator of the fraction. In other words, replace the factor $\sqrt{\beta_n^2 - 1}$ by $\sqrt{\beta_n^2 - 1}\,\hat{\mathbf{R}}$.

p. 908, Eq. (23.180), last term:

$$\frac{q}{2\pi\epsilon_0} \quad \Rightarrow \quad \frac{q}{2\pi\epsilon}$$

p. 908, Eq. (23.181), right hand side: replace the factor $\dfrac{\mathbf{v}}{c_n^2}$ by $\dfrac{\upsilon}{c_n^2}$.

p. 909, last line: change "This the energy" to "This is the energy"

p. 913, Problem 23.9, part (a) : Change the sentence to: Find the total amount of energy radiated if the particle accelerates at a constant rate for the first half of its journey and decelerates at a constant rate for the second half of its journey.

p. 913, Problem 23.5, part (c): change the denominator of the fraction on the RHS so it reads:
$$4\pi\epsilon_0 c^2 B^2 - (q/c)\mathbf{B}\cdot(\hat{\mathbf{n}}\times\ddot{\mathbf{n}})_{\text{ret}}$$

p. 913, Problem 23.10: Change the first sentence to:

A non-relativistic particle with charge e and mass m begins at infinity with initial speed υ_0 and collides head-on with a fixed field of force.

Chapter 24

p. 922, part (a) of the Solution: replace lines 7 - 17 with

$$\mathbf{j}=\frac{\partial \mathbf{P}}{\partial t}+\nabla \times \mathbf{M}=\frac{\partial}{\partial t}\big[\mathbf{p}\delta(\mathbf{r}-\mathbf{r}_0)\big]+\nabla \times \big[\mathbf{m}\delta(\mathbf{r}-\mathbf{r}_0)+\mathbf{p}\delta(\mathbf{r}-\mathbf{r}_0)\times \mathbf{v}\big].$$

Because $\mathbf{v}(t)=\dot{\mathbf{r}}_0(t)$, writing out the divergence and curl operations gives

$$\rho=-\mathbf{p}\cdot\nabla\delta(\mathbf{r}-\mathbf{r}_0)$$

and

$$\mathbf{j}=\dot{\mathbf{p}}\delta(\mathbf{r}-\mathbf{r}_0)-\mathbf{m}\times\nabla\delta(\mathbf{r}-\mathbf{r}_0)-\mathbf{v}(\mathbf{p}\cdot\nabla)\delta(\mathbf{r}-\mathbf{r}_0).$$

Now, substitute ρ and $\mathbf{j}$ into the Lagrangian L_{pf} and integrate by parts to eliminate terms like $\nabla\delta(\mathbf{r}-\mathbf{r}_0)$. This localizes every function of position at $\mathbf{r}=\mathbf{r}_0$. Because $\mathbf{B}=\nabla\times\mathbf{A}$ and $\mathbf{p}\cdot(\mathbf{v}\times\mathbf{B})=(\mathbf{p}\cdot\nabla)(\mathbf{v}\cdot\mathbf{A})-(\mathbf{v}\cdot\nabla)(\mathbf{p}\cdot\mathbf{A})$, we find

$$L_{pf}=\dot{\mathbf{p}}\cdot\mathbf{A}+\mathbf{m}\cdot\mathbf{B}+\mathbf{p}\cdot(\mathbf{v}\times\mathbf{B})-\mathbf{p}\cdot\nabla\varphi+(\mathbf{v}\cdot\nabla)(\mathbf{p}\cdot\mathbf{A}).$$

Finally, using $\mathbf{E}=-\nabla\varphi-\partial\mathbf{A}/\partial t$, $\dot{\mathbf{A}}=\partial\mathbf{A}/\partial t+(\mathbf{v}\cdot\nabla)\mathbf{A}$, and the low-velocity Lagrangian $L_p=\frac{1}{2}mv^2$, the sum $L=L_p+L_{pf}$ takes the form,

p. 926, Eq. (24.49): the subscript of ε_0 should not be boldface.

p. 927, box at the top, last paragraph. The name "Schwarzchild" appears twice. Change both to "Schwarzschild".

Appendix B

p. 951: Eq. (B.1) should be

$$\nabla \times \boldsymbol{B}_{SI} = \frac{1}{c}\sqrt{\frac{\mu_0}{c}}\, \boldsymbol{j}_{SI} + \frac{1}{c}\sqrt{\mu_0 \epsilon_0}\, \frac{\partial \boldsymbol{E}_{SI}}{\partial t}$$

Appendix C

p. 952-953: Eq. (C.2) and Eq. (C.11): The coefficient of $dP(x)/dx$ should be $-2x$ rather than $-2xy$.

p. 954, Eq. (C.14): delete the minus sign on the right hand side.

p. 956, line of text below Eq. (C.31): replace (C.42) by (C.31).

p. 956, Eq. (C.33). Change the summation index from m to n so it reads

$$\sum_{n=1}^{\infty}$$

p. 957, second line of Eq. (C.37): lower limit of the integral for $H_0^{(1)}(x)$ should be " $-\infty$ " instead of " ∞ "

Index

p. 974: change "Schwarzchild" to "Schwarzschild".

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3$^{\text{rd}}$ equation:

Change last term of $\dfrac{\partial}{\partial r_k}\dfrac{\partial}{\partial r_m}\left(\dfrac{1}{r}\right)=\dfrac{3r_k r_m - r^2 \delta_{km}}{r^5}-\dfrac{4\pi}{r^2}r_k r_m \delta(\mathbf{r})$ so the entire

expression reads $\dfrac{\partial}{\partial r_k}\dfrac{\partial}{\partial r_m}\left(\dfrac{1}{r}\right)=\dfrac{3r_k r_m - r^2 \delta_{km}}{r^5}-\dfrac{4\pi}{3}\delta_{km}\delta(\mathbf{r})$

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"Maxwell Equations", 1$^{\text{st}}$ line, left column: change $\nabla \times \mathbf{E} = \rho/\epsilon_0$ to $\nabla \cdot \mathbf{E} = \rho/\epsilon_0$

"Maxwell Equations" 2$^{\text{nd}}$ line, right column: change $\nabla \times \mathbf{E} = \dfrac{\partial \mathbf{B}}{\partial t}$ to

$\nabla \times \mathbf{E} = -\dfrac{\partial \mathbf{B}}{\partial t}$.