Errata
Instructor's Solutions Manual
Introduction to Electrodynamics, 3rd ed
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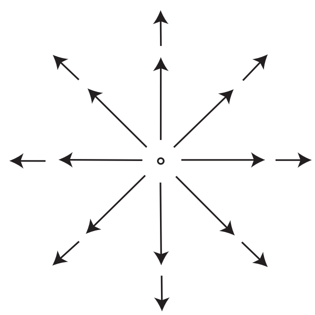
- Page 4, Prob. 1.15 (b): last expression should read $y + 2z + 3x$.
- Page 4, Prob.1.16: at the beginning, insert the following figure



- Page 8, Prob. 1.26: last line should read

  From Prob. 1.18: $\boldsymbol{\nabla} \times \mathbf{v}_a = -6xz\,\hat{\mathbf{x}} + 2z\,\hat{\mathbf{y}} + 3z^2\,\hat{\mathbf{z}} \Rightarrow$

  $\boldsymbol{\nabla} \cdot (\boldsymbol{\nabla} \times \mathbf{v}_a) = \frac{\partial}{\partial x}(-6xz) + \frac{\partial}{\partial y}(2z) + \frac{\partial}{\partial z}(3z^2) = -6z + 6z = 0.$ ✓

- Page 8, Prob. 1.27, in the determinant for $\nabla \times (\nabla f)$, 3rd row, 2nd column: change y^3 to y^2.
- Page 8, Prob. 1.29, line 2: the number in the box should be -12 (insert minus sign).
- Page 9, Prob. 1.31, line 2: change $2x^3$ to $2z^3$; first line of part (c): insert comma between dx and dz.
- Page 12, Probl 1.39, line 5: remove comma after $\cos\theta$.
- Page 13, Prob. 1.42(c), last line: insert $\hat{\mathbf{z}}$ after).
- Page 14, Prob. 1.46(b): change $\mathbf{r}'$ to $\mathbf{a}$.
- Page 14, Prob. 1.48, second line of J: change the upper limit on the r integral from ∞ to R. Fix the last line to read:

$$= \; 4\pi \left(-e^{-r}\right)\Big|_0^R + 4\pi e^{-R} = 4\pi\left(-e^{-R} + e^{-0}\right) + 4\pi e^{-R} = 4\pi. \checkmark$$

- Page 15, Prob. 1.49(a), line 3: in the box, change x^2 to x^3.

- Page 15, Prob. 1.49(b), last integration "constant" should be $l(x,z)$, not $l(x,y)$.
- Page 17, Prob. 1.53, first expression in (4): insert θ, so $d\mathbf{a} = r\sin\theta\, dr\, d\phi\, \hat{\boldsymbol{\theta}}$.
- Page 17, Prob. 1.55: Solution should read as follows:

  Problem 1.55

  (1) $x = z = 0;\ dx = dz = 0;\ y: 0 \to 1.\quad \mathbf{v}\cdot d\mathbf{l} = (yz^2)\,dy = 0; \int \mathbf{v}\cdot d\mathbf{l} = 0.$

  (2) $x = 0;\ z = 2 - 2y;\ dz = -2\,dy;\ y: 1 \to 0.$

  $\mathbf{v}\cdot d\mathbf{l} = (yz^2)\,dy + (3y+z)\,dz = y(2-2y)^2\,dy - (3y+2-2y)2\,dy;$

  $$\int \mathbf{v}\cdot d\mathbf{l} = 2\int_1^0 (2y^3 - 4y^2 + y - 2)\,dy = 2\left[\frac{y^4}{2} - \frac{4y^3}{3} + \frac{y^2}{2} - 2y\right]\Bigg|_1^0 = \frac{14}{3}.$$

  (3) $x = y = 0;\ dx = dy = 0;\ z: 2 \to 0.\quad \mathbf{v}\cdot d\mathbf{l} = (3y+z)\,dz = z\,dz.$

  $$\int \mathbf{v}\cdot d\mathbf{l} = \int_2^0 z\,dz = \frac{z^2}{2}\Bigg|_2^0 = -2.$$

  Total: $\oint \mathbf{v}\cdot d\mathbf{l} = 0 + \frac{14}{3} - 2 = \boxed{\frac{8}{3}}.$

  Meanwhile, Stokes' thereom says $\oint \mathbf{v}\cdot d\mathbf{l} = \int (\boldsymbol{\nabla}\times\mathbf{v})\cdot d\mathbf{a}$. Here $d\mathbf{a} = dy\,dz\,\hat{\mathbf{x}}$, so all we need is
  $(\boldsymbol{\nabla}\times\mathbf{v})_x = \frac{\partial}{\partial y}(3y+z) - \frac{\partial}{\partial z}(yz^2) = 3 - 2yz.$ Therefore

  $$\begin{aligned}\int (\boldsymbol{\nabla}\times\mathbf{v})\cdot d\mathbf{a} &= \int\int (3-2yz)\,dy\,dz = \int_0^1 \left\{\int_0^{2-2y} (3-2yz)\,dz\right\}\,dy \\ &= \int_0^1 \left[3(2-2y) - 2y\tfrac{1}{2}(2-2y)^2\right]\,dy = \int_0^1 (-4y^3 + 8y^2 - 10y + 6)\,dy \\ &= \left[-y^4 + \tfrac{8}{3}y^3 - 5y^2 + 6y\right]\Big|_0^1 = -1 + \tfrac{8}{3} - 5 + 6 = \tfrac{8}{3}.\ \checkmark\end{aligned}$$

- Page 18, Prob. 1.56: change (3) and (4) to read as follows:

  (3) $\phi = \frac{\pi}{2};\ r\sin\theta = y = 1$, so $r = \frac{1}{\sin\theta},\ dr = \frac{-1}{\sin^2\theta}\cos\theta\,d\theta,\ \theta: \frac{\pi}{2} \to \theta_0 \equiv \tan^{-1}(\frac{1}{2})$.

  $$\begin{aligned}\mathbf{v}\cdot d\mathbf{l} &= \left(r\cos^2\theta\right)(dr) - (r\cos\theta\sin\theta)(r\,d\theta) = \frac{\cos^2\theta}{\sin\theta}\left(-\frac{\cos\theta}{\sin^2\theta}\right)d\theta - \frac{\cos\theta\sin\theta}{\sin^2\theta}\,d\theta \\ &= -\left(\frac{\cos^3\theta}{\sin^3\theta} + \frac{\cos\theta}{\sin\theta}\right)d\theta = -\frac{\cos\theta}{\sin\theta}\left(\frac{\cos^2\theta + \sin^2\theta}{\sin^2\theta}\right)d\theta = -\frac{\cos\theta}{\sin^3\theta}\,d\theta.\end{aligned}$$

  Therefore

  $$\int \mathbf{v}\cdot d\mathbf{l} = -\int_{\pi/2}^{\theta_0} \frac{\cos\theta}{\sin^3\theta}\,d\theta = \frac{1}{2\sin^2\theta}\Bigg|_{\pi/2}^{\theta_0} = \frac{1}{2\cdot(1/5)} - \frac{1}{2\cdot(1)} = \frac{5}{2} - \frac{1}{2} = 2.$$

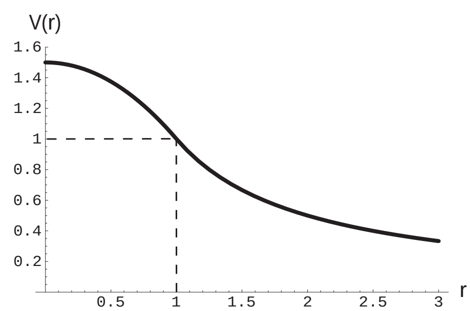
(4) $\theta = \theta_0, \; \phi = \frac{\pi}{2}; \; r : \sqrt{5} \to 0. \quad \mathbf{v} \cdot d\mathbf{l} = \left(r \cos^2\theta\right)(dr) = \frac{4}{5} r\, dr.$

$$\int \mathbf{v} \cdot d\mathbf{l} = \frac{4}{5} \int_{\sqrt{5}}^{0} r\, dr = \frac{4}{5} \frac{r^2}{2}\Bigg|_{\sqrt{5}}^{0} = -\frac{4}{5} \cdot \frac{5}{2} = -2.$$

Total:

$$\oint \mathbf{v} \cdot d\mathbf{l} = 0 + \frac{3\pi}{2} + 2 - 2 = \boxed{\frac{3\pi}{2}}.$$

- Page 21, Probl 1.61(e), line 2: change $= z\,\hat{\mathbf{z}}$ to $+z\,\hat{\mathbf{z}}$.
- Page 25, Prob. 2.12: last line should read
  Since $Q_{\text{tot}} = \frac{4}{3}\pi R^3 \rho$, $\mathbf{E} = \frac{1}{4\pi\epsilon_0}\frac{Q}{R^3}\mathbf{r}$ (as in Prob. 2.8).
- Page 26, Prob. 2.15: last expression in first line of (ii) should be $d\phi$, not *d phi*.
- Page 28, Prob. 2.21, at the end, insert the following figure



  In the figure, r is in units of R, and $V(r)$ is in units of $\frac{q}{4\pi\epsilon_0 R}$.
- Page 30, Prob. 2.28: remove right angle sign in the figure.
- Page 42, Prob. 3.5: subscript on V in last integral should be 3, not 2.
- Page 45, Prob. 3.10: after the first box, add:

$$\mathbf{F} = \frac{q^2}{4\pi\epsilon_0}\left\{-\frac{1}{(2a)^2}\,\hat{\mathbf{x}} - \frac{1}{(2b)^2}\,\hat{\mathbf{y}} + \frac{1}{(2\sqrt{a^2+b^2})^2}\left[\cos\theta\,\hat{\mathbf{x}} + \sin\theta\,\hat{\mathbf{y}}\right]\right\},$$

where $\cos\theta = a/\sqrt{a^2+b^2}, \quad \sin\theta = b/\sqrt{a^2+b^2}$.

$$\boxed{\mathbf{F} = \frac{q^2}{16\pi\epsilon_0}\left\{\left[\frac{a}{(a^2+b^2)^{3/2}} - \frac{1}{a^2}\right]\hat{\mathbf{x}} + \left[\frac{b}{(a^2+b^2)^{3/2}} - \frac{1}{b^2}\right]\hat{\mathbf{y}}\right\}.}$$

$$W = \frac{1}{4}\frac{1}{4\pi\epsilon_0}\left[\frac{-q^2}{(2a)} + \frac{-q^2}{(2b)} + \frac{q^2}{(2\sqrt{a^2+b^2})}\right] = \boxed{\frac{q^2}{32\pi\epsilon_0}\left[\frac{1}{\sqrt{a^2+b^2}} - \frac{1}{a} - \frac{1}{b}\right]}.$$

- Page 45, Prob. 3.10: in the second box, change "and" to "an".
- Page 46, Probl 3.13, at the end, insert the following: "[*Comment:* Technically, the series solution for σ is defective, since term-by-term differentiation has produced a (naively) non-convergent sum. More sophisticated definitions of convergence permit one to work with series of this form, but it is better to sum the series *first* and *then* differentiate (the second method).]"
- Page 51, Prob. 3.18, midpage: the reference to Eq. 3.71 should be 3.72.
- Page 53, Prob. 3.21(b), line 5: A_2 should be $\frac{\sigma}{4\epsilon_0 R}$; next line, insert r^2 after $\frac{1}{2R}$.
- Page 55, Prob. 3.23, third displayed equation: remove the first Φ.
- Page 58, Prob. 3.28(a), second line, first integral: R^3 should read R^2.
- Page 59, Prob. 3.31(c): change first V to W.
- Page 64, Prob. 3.41(a), lines 2 and 3: remove ϵ_0 in the *first* factor in the expressions for $\mathbf{E}_{\text{ave}}$; in the second expression change "ρ" to "q".
- Page 69, Prob. 3.47, at the end add the following:

  Alternatively, start with the separable solution

  $$V(x,y) = (C\sin kx + D\cos kx)\left(Ae^{ky} + Be^{-ky}\right).$$

  Note that the configuration is symmetric in x, so $C = 0$, and $V(x,0) = 0 \Rightarrow B = -A$, so (combining the constants)

  $$V(x,y) = A\cos kx \sinh ky.$$

  But $V(b,y) = 0$, so $\cos kb = 0$, which means that $kb = \pm\pi/2, \pm 3\pi/2, \cdots$, or $k = (2n-1)\pi/2b \equiv \alpha_n$, with $n = 1, 2, 3, \ldots$ (negative k does not yield a different solution—the sign can be absorbed into A). The general linear combination is

  $$V(x,y) = \sum_{n=1}^{\infty} A_n \cos\alpha_n x \sinh\alpha_n y,$$

  and it remains to fit the final boundary condition:

  $$V(x,a) = V_0 = \sum_{n=1}^{\infty} A_n \cos\alpha_n x \sinh\alpha_n a.$$

Use Fourier's trick, multiplying by $\cos\alpha_{n'}x$ and integrating:

$$V_0\int_{-b}^{b}\cos\alpha_{n'}x\,dx=\sum_{n=1}^{\infty}A_n\sinh\alpha_n a\int_{-b}^{b}\cos\alpha_{n'}x\,\cos\alpha_n x\,dx$$

$$V_0\frac{2\sin\alpha_{n'}b}{\alpha_{n'}}=\sum_{n=1}^{\infty}A_n\sinh\alpha_n a\,(b\delta_{n'n})=bA_{n'}\sinh\alpha_{n'}a;$$

So $A_n=\frac{2V_0}{b}\frac{\sin\alpha_n b}{\alpha_n\sinh\alpha_n a}$. But $\sin\alpha_n b=\sin\left(\frac{2n-1}{2}\pi\right)=-(-1)^n$, so

$$V(x,y)=\boxed{-\frac{2V_0}{b}\sum_{n=1}^{\infty}(-1)^n\frac{\sinh\alpha_n y}{\alpha_n\sinh\alpha_n a}\cos\alpha_n x.}$$

- Page 74, Prob. 4.4: exponent on r in boxed equation should be 5, not 3.
- Page 75, Prob. 4.7: replace the (defective) solution with the following:

  If the potential is zero at infinity, the energy of a point charge Q is (Eq. 2.39) $W=QV(\mathbf{r})$. For a physical dipole, with $-q$ at $\mathbf{r}$ and $+q$ at $\mathbf{r}+\mathbf{d}$,

  $$U=qV(\mathbf{r}+\mathbf{d})-qV(\mathbf{r})=q\left[V(\mathbf{r}+\mathbf{d})-V(\mathbf{r})\right]=q\left[-\int_{\mathbf{r}}^{\mathbf{r}+\mathbf{d}}\mathbf{E}\cdot d\mathbf{l}\right].$$

  For an ideal dipole the integral reduces to $\mathbf{E}\cdot\mathbf{d}$, and

  $$U=-q\mathbf{E}\cdot\mathbf{d}=-\mathbf{p}\cdot\mathbf{E},\ \text{since}\ \mathbf{p}=q\mathbf{d}.$$

  If you do not (or cannot) use infinity as the reference point, the result still holds, as long as you bring the two charges in from the *same point*, $\mathbf{r}_0$ (or two points at the same potential). In that case $W=Q\left[V(\mathbf{r})-V(\mathbf{r}_0)\right]$, and

  $$U=q\left[V(\mathbf{r}+\mathbf{d})-V(\mathbf{r}_0)\right]-q\left[V(\mathbf{r})-V(\mathbf{r}_0)\right]=q\left[V(\mathbf{r}+\mathbf{d})-V(\mathbf{r})\right],$$

  as before.
- Page 75, Prob. 4.10(a): $\frac{1}{r^3}$ should be $\frac{1}{r^2}$.
- Page 79, Prob. 4.19: in the upper right box of the Table (σ_f for air) there is a missing factor of ϵ_0.
- Page 91, Problem 5.10(b): in the first line $\mu_0 I^2/2\pi$ should read $\mu_0 I^2 a/2\pi s$; in the final boxed equation the first "1" should be $\frac{a}{s}$.
- Page 92, Prob. 5.15: the signs are all wrong. The end of line 1 should read "right ($\hat{\mathbf{z}}$)," the middle of the next line should read "left ($-\hat{\mathbf{z}}$)." In the first box it should be "(n_2-n_1)", and in the second box the minus sign does not belong.

- Page 114, Prob. 6.4: last term in second expression for $\mathbf{F}$ should be $+\hat{\mathbf{z}}\frac{\partial B_x}{\partial z}$ (plus, not minus).
- Page 119, Prob. 6.21(a): replace with the following:

  The magnetic force on the dipole is given by Eq. 6.3; to move the dipole in from infinity *we* must exert an opposite force, so the work done is

  $$U = -\int_{\infty}^{\mathbf{r}} \mathbf{F}\cdot d\mathbf{l} = -\int_{\infty}^{\mathbf{r}} \nabla(\mathbf{m}\cdot\mathbf{B})\cdot d\mathbf{l} = -\mathbf{m}\cdot\mathbf{B}(\mathbf{r}) + \mathbf{m}\cdot\mathbf{B}(\infty)$$

  (I used the gradient theorem, Eq. 1.55). As long as the magnetic field goes to zero at infinity, then, $U = -\mathbf{m}\cdot\mathbf{B}$. If the magnetic field does *not* go to zero at infinity, one must stipulate that the dipole starts out oriented perpendicular to the field.
- Page 125, Prob. 7.2(b): in the box, c should be C.
- Page 129, Prob. 7.18: change first two lines to read:

  $$\Phi = \int \mathbf{B}\cdot d\mathbf{a};\ \mathbf{B} = \frac{\mu_0 I}{2\pi s}\hat{\boldsymbol{\phi}};\ \Phi = \frac{\mu_0 I a}{2\pi}\int_s^{s+a}\frac{ds'}{s'} = \frac{\mu_0 I a}{2\pi}\ln\left(\frac{s+a}{s}\right);$$

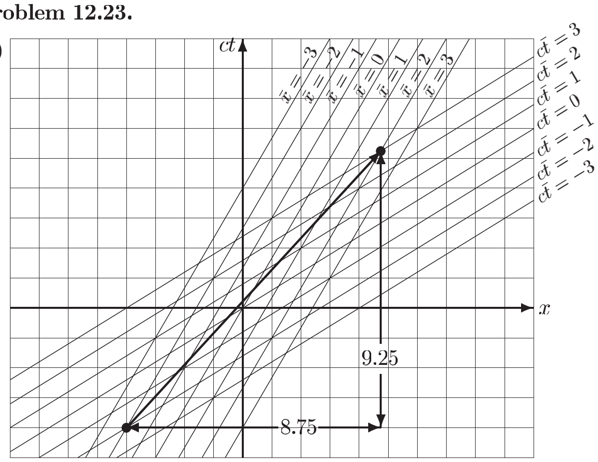
  $$\mathcal{E} = I_{\text{loop}}R = \frac{dQ}{dt}R = -\frac{d\Phi}{dt} = -\frac{\mu_0 a}{2\pi}\ln(1+a/s)\frac{dI}{dt}.$$

  $$dQ = -\frac{\mu_0 a}{2\pi R}\ln(1+a/s)\,dI \ \Rightarrow\ \boxed{Q = \frac{\mu_0 a I}{2\pi R}\ln(1+a/s).}$$
- Page 131, Prob. 7.27: in the second integral, r should be s.
- Page 132, Prob. 7.32(c), last line: in the final two equations, insert an I immediately after μ_0.
- Page 140, Prob. 7.47: in the box, the top equation should have a minus sign in front, and in the bottom equation the plus sign should be minus.
- Page 141, Prob. 7.50, final answer: R^2 should read R_2.
- Page 143, Prob. 7.55, penultimate displayed equation: tp should be $\cdot$.
- Page 147, Prob. 8.2, top line, penultimate expression: change a^2 to a^4; in (c), in the first box, change 16 to 8.
- Page 149, Prob. 8.5(c): there should be a minus sign in front of σ^2 in the box.
- Page 149, Prob. 8.7: almost all the r's here should be s's. In line 1 change "$a < r < R$" to "$s < R$"; in the same line change dr to ds; in the next line change dr to ds (twice), and change $\hat{\mathbf{r}}$ to $\hat{\mathbf{s}}$; in the last line change r to s, dr to ds, and $\hat{\mathbf{r}}$ to $\hat{\mathbf{s}}$ (but leave $\mathbf{r}$ as is).

- Page 153, Prob. 8.11, last line of equations: in the numerator of the expression for R change 2.01 to 2.10.
- Page 175, Prob. 9.34, penultimate line: $\alpha = n_3/n_2$ (not n_3/n_3).
- Page 177, Prob. 9.38: half-way down, remove minus sign in $k_x^2 + k_y^2 + k_z^2 = -(\omega/c)^2$.
- Page 181, Prob. 10.8: first line: remove ¿.
- Page 184, Prob. 10.14: in the first line, change (9.98) to (10.42).
- Page 203, Prob. 11.14: at beginning of second paragraph, remove ¿.
- Page 222, Prob. 12.15, end of first sentence: change comma to period.
- Page 225, Prob. 12.23. The figure contains two errors: the slopes are for $v/c = 1/2$ (not 3/2), and the intervals are incorrect. The correct solution is as follows:

Problem 12.23.

(a)



(b) $\frac{c}{v} = \text{slope} = \frac{9.25}{8.75}$

$\Rightarrow v = \frac{8.75}{9.25}c = \boxed{\frac{35}{37}c}$

(c) $v' = \frac{4}{5}c$, so $v = \frac{\frac{4}{5}c + \frac{3}{5}c}{1 + \frac{4}{5}\cdot\frac{3}{5}}$

$= \frac{(7/5)c}{(37/25)} = \boxed{\frac{35}{37}c}$ ✓

- Page 227, Prob. 12.33: first expression in third line, change c^2 to c.