Errata

I regret that the following errors have come to my notice. The corrections are listed with the names of those who noticed them, to whom I am very grateful. Please send me a note at jdavies@elec.gla.ac.uk if you find others. I keep an up-to-date list of corrections on the web page www.elec.gla.ac.uk/~jdavies/ldsbook/.

1. Several figures contain lines that were drawn too thin and have not been printed clearly. (The problem was not visible on the proofs, and became apparent only when a high-resolution typesetter was used for the final production.) Figures 1.12, 1.13, 3.9, 3.12, 3.13, 3.18, 4.2, 7.8, and 9.9 were corrected in the 1999 reprint. Figures 3.4, 5.12, 7.5, and 9.3 were corrected in the 2000 reprint. There are still small problems with figures 3.15, 6.4, and 10.6.

2. Page 11, line 8 from bottom, ‘The dependence on time vanishes from both $\rho$ and $\Psi$’ should be replaced by ‘The dependence on time vanishes from both $\rho$ and $J$’. The density and current may be constant in time but the wavefunction cannot be. (Taizo Ohgi, 1999 May 5; corrected in the 2000 reprint.)

3. Page 25, equation (1.90), the wavefunction should be $\phi_{lmn}(\mathbf{R})$. (Uki Kabasawa, 2004 March 7)

4. Page 34, equation (1.117), the prefactor should be $1/4k_B T$; this means that $k_B T$ should be in the denominator, not the numerator. (Daisuke Fujita, 1999 May 31; corrected in the 2000 reprint.)

5. Page 41, exercise 1.1 refers to the ‘Clapham omnibus’, which will mean little to readers from outside Britain. Take it to be an object with a mass of 10 tonnes moving at a speed of 50 km h$^{-1}$ (about 30 mph). (2000 November 28)

6. Page 58, the coordinates of the four atoms in the FCC lattice are wrong. They should be $(0, 0, 0)$, $(\frac{1}{2}a, \frac{1}{2}a, 0)$, $(0, \frac{1}{2}a, \frac{1}{2}a)$, and $(\frac{1}{2}a, 0, \frac{1}{2}a)$. (Uki Kabasawa, 2004 March 7)
7. Page 62, first bullet point, the coordinates of \( K \) should be \((2\pi/a)(\frac{3}{4},\frac{3}{4}, 0)\).

(Joel Schulman, 2002 March 19)

8. Page 87, figure 3.5, the discontinuities \( \Delta E_c \) and \( \Delta E_v \) on both plots are not ‘transitive’. This means that the bands on the far right do not align perfectly with those on the far left, which they should because they are for the same material. For example, \( \Delta E_c \) in the upper plot should have 0.26 + 0.25 = 0.47, but this sum is incorrect. The error arose because I pasted together the alignments from Frensley (1994), which were the optimal values for each heterojunction separately. In fact Yu, McCaldin, and McGill (1992) show that the discontinuities are transitive within experimental error, and I should have used a consistent set of numbers. The lower plot is more problematic because of the quaternary nature of the interfaces, mentioned lower on the same page of the book, and I should look for newer data as growth is now better controlled.

(Jeremy Green, 2000 March 28; corrected in the 2000 reprint.)

9. Page 90, section 3.4.3, delete ‘inversely’ from ‘The width of this peak is inversely proportional to \( T_L + T_R \), …’. (Taizo Ohgi, 1999 June 30; corrected in the 2000 reprint.)

10. Page 93, figure 3.9, the two drawings should be labelled (a) and (b) to correspond with the citations in the text. (Md. Sujaul Haque Chowdhury, 1998 December 29; corrected in the 1999 reprint.)

11. Page 101, figure 3.14 from Rieger and Vogl (1993). There is a small error in the labelling of the contours in figure 3.14(a) for the offset in the conduction band. Near the top right-hand corner there is a contour labelled ‘−0.10’ that should be ‘0.05’ (positive and with half the magnitude). Unfortunately the labelling of this contour is essential for exercise 3.7! I am grateful to M. Rieger and P. Vogl for checking this. (1999 May 31; corrected in the 2000 reprint.)

12. Page 115, exercise 3.2, the radius of the mouth of the K-cell is given as \( A \approx 10 \text{ mm}^2 \) but should be \( A \approx 10 \text{ mm} \). (Sunida Awirothananon, 2002 November 27)

13. Page 120, before equation (4.7), it states that “The wavefunctions (4.3) and (4.6) must now be matched at \( z = \frac{1}{4}a \).” The wavefunctions should be (4.3) and (4.5). (Uki Kabasawa, 2004 March 7)

14. Page 120, equations (4.7) and (4.8), in both cases the exponent on the right-hand side should be negative: \( \exp(-\frac{1}{2}\kappa a) \). (1999 June 17; corrected in the 2000 reprint.)

15. Page 122–123, there are several factors of \( \frac{1}{2} \) missing from the limiting expressions for \( \theta \). They occur in the numbered paragraphs as follows.
Errata

(i) Correct.
(ii) Correct.
(iii) Should contain “…the intersections approach \( \theta = \frac{1}{2} n \pi \)."
(iv) Should contain “…the intersections approach \( \theta = \frac{1}{2}(n - 1) \pi \)."
(v) Should contain “When the state has only just become bound in the well and \( \theta \approx \frac{1}{2}(n - 1) \pi \). Also, "Increasing \( V_0 \) increases its kinetic energy to give \( \theta \approx \frac{1}{2} n \pi \)."

The expressions for \( k \) are correct. (1999 June 17; corrected in the 2000 reprint.)

16. Page 137, the substrate for the quantum corral shown in figure 4.10 is described as gold but should be copper. The caption to the figure is correct. (Uki Kabasawa, 2004 January 15)

17. Page 140, near end of section 4.7.4, should be ‘The spherical well requires \( \theta_0 > \pi/2 \) or \( a^2 V_0 > \pi^2 \hbar^2 / 8m \) to bind a state.’ The denominator should contain 8 rather than 2. (1999 July 17; corrected in the 2000 reprint.)

18. Page 145, a few lines before equation (4.87), it states that “The energy of the second state falls by 49 mV” but the units should be meV. (Uki Kabasawa, 2004 March 7)

19. Page 147, equation (E4.1), the three wavefunctions should be \( \phi \) rather than \( \psi \). (1999 September 14; corrected in the 2000 reprint.)

20. Page 159, equation (5.36) contains several errors; the lower left entry in the first matrix should be \( T_{21} \) rather than \( T_{12} \); the bottom row of the final matrix should contain \( A \) and \( B \) rather than \( C \) and \( D \). The corrected equation is as follows.

\[
\begin{pmatrix}
C \\
D
\end{pmatrix} = T 
\begin{pmatrix}
A \\
B
\end{pmatrix} = \begin{pmatrix}
T_{11} & T_{12} \\
T_{21} & T_{22}
\end{pmatrix} \begin{pmatrix}
A \\
B
\end{pmatrix} = \begin{pmatrix}
T_{11}A + T_{12}B \\
T_{21}A + T_{22}B
\end{pmatrix}.
\]

(5.36)

(Taizo Ohgi, 1999 September 16; corrected in the 2000 reprint.)

21. Page 166, the notation for the density of electrons could be confusing. Here I use \( n_{2D}(\mu) \) for the total density of electrons in a two-dimensional (sub)band. Unfortunately \( n_{2D}(E) \) is used for the density of states in most other places. The changes would be too extensive to correct – sorry.

22. Page 177, final paragraph of section 5.5, the description of the ‘third device’ in figure 5.15 is wrong. The text describes it as having GaSb barriers but the figure is labelled AlSb. This has a type II or staggered alignment with InAs, as shown in figure 3.5, not a type III or broken gap alignment as described in the text. (Anders Blom, 2004 June 2)

23. Page 179, equation (5.90), \( \cos k_1 a \) should be \( \cos k_1 w \). (2000 January 21; corrected in the 2000 reprint.)
24. Page 185, last sentence, it would be more accurate to say that “The broad regions of 2DEG on either side act as the ‘reservoirs.’” (Uki Kabasawa, 2004 March 7)

25. Page 190, equation (5.107) is nonsense and should be replaced with

\[
\sum_n T_{mn} = \sum_n T_{nm}.
\]

(2000 May 23; corrected in the 2000 reprint.)

26. Page 191, figure 5.25, the leads are muddled in the caption for part (a) of the figure. It should read “(a) A current \( I \) flows into lead 2 and out of lead 1; no current passes down lead 3, which is used purely to measure voltage.” (Uki Kabasawa, 2004 March 7)

27. Page 196, equation (5.127), both derivatives should be taken with respect to \( z \) rather than \( x \). (Taizo Ohgi, 1999 November 9; corrected in the 2000 reprint.)

28. Page 199, the usage of the term ‘lead’ in sections 5.9.1 and 5.9.2 is inconsistent. Throughout most of this chapter I have implicitly used ‘lead’ to mean a ‘perfect lead’, in which no scattering or dissipation occurs. It would therefore be clearer if ‘leads’ were replaced by ‘reservoirs’ in the next-to-last sentence of section 5.9.1: “Processes within the reservoirs restore the distribution close to equilibrium.” The same replacement should be made in the second sentence of section 5.9.2: “It was argued in the preceding section that all energy is dissipated in the reservoirs, and the scattering processes could distort this distribution.” (Uki Kabasawa, 2004 January 15)

29. Page 203, exercise 5.14 makes little sense because the Fermi level lies well above the energy of the lowest resonance at equilibrium. Reduce the doping in the leads from \( 3 \times 10^{24} \text{ m}^{-3} \) to \( 5 \times 10^{23} \text{ m}^{-3} \) to avoid this. (2000 April 4; corrected in the 2000 reprint.)

30. Page 203, exercise 5.18 refers to figure 5.18 but it should be figure 5.19. (2000 January 24; corrected in the 2000 reprint.)

31. Page 207, about \( \frac{3}{4} \) down the page, there is a \( B \) missing from the inline equation for the vector potential in symmetric gauge; it should be \( \mathbf{A} = \frac{1}{2} B (-y, x, 0) = \frac{1}{2} \mathbf{B} \times \mathbf{R} \). (Md. Sujaul Haque Chowdhury, 1998 December 2; corrected in the 1999 reprint.)

32. Page 208, equation (6.3), the derivative with respect to \( t \) on the right-hand side should be a partial derivative. (2000 November 28)

33. Page 211, figure 6.2, the horizontal scale should be labelled \( \varepsilon \) rather than \( E \). (2000 November 28)
34. Page 218, equation (6.25), the signs of both off-diagonal entries in both matrices are wrong and should be reversed. (2000 November 28)

35. Page 218, figure 6.6, the caption should read ‘(a) in the absence of a magnetic field …’. (Debdeep Jena, 1999 March 3; corrected in the 1999 reprint.)

36. Page 222, after equation (6.35), the text should read ‘we can take the angular part of the wavefunction as \( \exp(i\theta) \)’. (2000 November 28)

37. Page 224, a minus sign is missed from the left-hand term of the second expression in equation (6.39), which should be \(-eBL_y/L_x/\hbar\). I should have said that the sample lies between \( x = 0 \) and \( x = L_x \) so that \( 0 < x_k < L_x \). Here is a clearer form of the equation.

\[
0 < -\frac{2\pi\hbar j}{eBL_y} < L_x, \quad -\frac{eB}{\hbar}L_xL_y < j < 0. \tag{6.39}
\]

(Carina Fasth, 2009 November 26)

38. Page 228, figure 6.10, the caption reads ‘…inset shows \( 1/R_{xx} \) …’ but it should be \( 1/R_{xy} \). (Debdeep Jena, 1999 March 3; corrected in the 1999 reprint.)

Also in this caption, the density is given as \( n_{2D} = 2.6 \times 10^{15} \text{ nm}^{-2} \); the units are wrong and it should instead be \( n_{2D} = 2.6 \times 10^{15} \text{ m}^{-2} \). (Md. Sujaul Haque Chowdhury, 1999 January 19; corrected in the 1999 reprint.)

39. Page 233, \( \hbar k \) should be removed from the sentence “Its energy and therefore its mechanical momentum \( \hbar k \) is not affected, …”. This is wrong because \( \hbar k = p \) which is the canonical momentum, not the mechanical momentum. (Uki Kabasawa, 2004 January 15)

40. Page 236, figure 6.15, the axis on the top of the graph has ticks in the wrong places. (2000 November 28)

41. Pages 239 and 240, there are three references to ‘figure 6.18(a)’ that should be simply ‘figure 6.18’. (2000 November 28)

42. Page 247, exercise 6.11 should be corrected to read ‘What would happen to the energies of Landau levels, including spin splitting, if electrons in a 2DEG had \( g = 2 \) and \( m = m_0 \) as if they were free?’ The mass was missing in the original form. (2000 November 28)

43. Page 247, exercise 6.12, the part given in the last sentence is impossible without further data and should be replaced by ‘Estimate also the mobility.’ (2000 November 28)

44. Page 252, the cross-reference on line 5 is to section 1.6 but should be section 1.5. (Uki Kabasawa, 2004 January 15)
45. Page 258, the coefficient in equation (7.37) is incorrect. The exact result in equation (7.36) is correct but the approximation that follows should be
\[
\frac{\text{decrease in energy}}{\text{difference in energy}} \approx \frac{1}{30} \left( \frac{\text{energy drop across well}}{\text{difference in energy}} \right)^2.
\]
Alternatively,
\[
\frac{\text{decrease in energy}}{\text{energy of ground state}} \approx \frac{1}{100} \left( \frac{\text{energy drop across well}}{\text{energy of ground state}} \right)^2.
\]
(Karen McIlvaney, 2004 October 1)

46. Page 259, figure 7.2, the slope of the quantum well in part (b) has the wrong sign. It should be reversed to match figure 7.1 and the text. (Osamu Ishihara, 2000 October 5)

47. Page 269, the potential energy through a Schottky barrier is given as
\[
V(x) = V_b \left[ 1 - \frac{x}{d} \right]
\]
but should be
\[
V(x) = V_b \left[ 1 - \frac{(x/d)^2}{3} \right];
\]
the whole expression in brackets should be squared, not just \((x/d)\). The same error is repeated in equation (7.61), which should be
\[
T \approx \exp \left\{ -2 \int_0^d \left[ \frac{2mV_b}{\hbar^2} \left( 1 - \frac{x}{d} \right)^2 \right]^{1/2} \, dx \right\} = \exp \left\{ - \left( \frac{2mV_b}{\hbar^2} \right)^{1/2} \frac{d}{2} \right\}.
\]
(7.61)
The final expression in this equation was correct. (2001 April 16)

48. Page 274, equation (7.80), the numerical coefficient of \(K a^2\) should be squared. The equation should be as follows:
\[
\langle A | \hat{H}_0 + \hat{V} | B \rangle = \epsilon \langle A | B \rangle + \langle A | (-Kxy) | B \rangle = 0 - \left( \frac{16}{9\pi^2} \right)^2 K a^2 \equiv -\Delta.
\]
(7.80)
(2001 August 11)

49. Page 278, equation (7.90), the off-diagonal elements in the equation are garbled. The equation should be as follows:
\[
\det |E \mathbf{S} - \mathbf{H}| = \det \begin{vmatrix} (E - \epsilon) + c & (E - \epsilon)s + t \\ (E - \epsilon)s + t & (E - \epsilon) + c \end{vmatrix} = 0.
\]
(7.90)
(Igor Zozoulenko, 1999 August 16; corrected in the 2000 reprint.)

50. Page 283, there are several signs wrong. The bottom label in figure 7.11 should be \( 'k = -\frac{1}{2} G_n' \); the minus sign was missing from the figure but is stated correctly in the caption. Equation (7.113) should be
\[
E(k) \approx \frac{\epsilon_0(k) + \epsilon_0(k + G_n)}{2} \pm \left\{ |V_n| + \frac{[\epsilon_0(k) - \epsilon_0(k + G_n)]^2}{8|V_n|} \right\}.
\]
(7.113)
It had both signs wrong in the numerator of the last fraction. (2001 July 8)

51. Page 285, figure 7.12 shows two quantum wells for exercise 7.1. They have been drawn so that their lowest parts are at the same energy but it would have been more consistent with the exercise if the potential in the outer regions of the wells had been aligned. (2000 October 29)

52. Page 293, the second line should refer to state $f$ rather than state $j$. (Uki Kabasawa, 2004 March 7)

53. Page 313, equation (8.77) contains a spurious 0 in the matrix element. I have no idea how it got there! (2002 March 10)

54. Page 316, the treatment of the mass of the electron throughout section 8.7 is misleading. Although I have used a general mass $m$, it should be the ‘bare’ mass $m_0$ throughout. This is because the mass originates from the electron–photon interaction in equation (8.67), where it is clearly $m_0$. Unfortunately the expression (8.88) for the energy of a state in the quantum well would look strange if it contained only $m_0$. The issue is resolved later, in section 10.5, where it is explained that the effective mass should be used everywhere in the expressions to be consistent with the use of envelope functions for the wavefunctions. Thus the equations in section 8.7 are in fact correct, but you have to read section 10.5 for the explanation. (Anders Blom, 2004 March 17)

55. Page 324, exercise 8.1 is misleading. You are asked to perform the calculations using the golden rule, but this makes no sense because there is no continuum of states. Replace the instruction ‘Use the golden rule...’ with ‘Use time-dependent perturbation theory based on equation (8.12)...’. (2001 November 7)

56. Page 326, exercise 8.8, the value of $\rho v_s^2$ is too large by a factor of 10; the correct value is $\rho v_s^2 = 1.4 \times 10^{11}$ J m$^{-3}$. I am embarrassed to say that I converted the value incorrectly from data in CGS units! (2002 March 10)

57. Page 326, exercise 8.9, there is a factor of 4 missing from the denominator of equation (E8.7). The correct expression is

$$\frac{1}{\tau_{\text{LO}}} = \frac{e^2 K_{\text{LO}}}{4\pi \epsilon_0 \hbar} \left[ \frac{1}{\epsilon(\infty)} - \frac{1}{\epsilon(0)} \right] N_{\text{LO}}.$$  \hspace{1cm} (E8.7)

(2002 March 10)

58. Page 352, equation (9.45), the Thomas–Fermi wavevector is labelled $Q_{\text{FT}}$ but should be $Q_{\text{TF}}$. (Uki Kabasawa, 2004 January 15)

59. Page 361, two lines above the bottom, there is a reference to figure 9.12(b) that should be figure 9.12(c). (Uki Kabasawa, 2004 January 15)
60. Pages 366 and 423, the URL for Greg Snider’s modelling program is slightly wrong: his home page is at www.nd.edu/~gsnider (there was a ‘g’ missing before ‘snider’). Versions for the Macintosh and PC can be downloaded from this page. (Corrected in the 2000 reprint.)

61. Page 372, equation (10.3), the variable of integration should be shown as $dt'$ rather than $dt$. (2003 May 21)

62. Page 379, equation (10.27), the heavy holes should start from $E_v$ rather than zero. The correct line of the equation is

$$\varepsilon_{hh}(K) = E_v + \varepsilon_0(K) \quad \text{(twice).} \quad (10.27)$$

(2003 April 23)

63. Page 383, equation (10.33), the sign in front of the first $\Delta$ is wrong and the wavevector should be $K$ rather than $k$. The correct equation is

$$(E' - E_v)(E' - E_v + \Delta) - P^2 K^2 (E' - E_v + 2\Delta) = 0. \quad (10.33)$$

(Andrew Hunter, 2002 May 16)

64. Page 384, the subject of equation (10.35) on the left hand side should be $\varepsilon(K)$ rather than $\varepsilon(K)$. (2003 April 24)

65. page 385, equation (10.36), the equation for $C$ should be for $C^2$. The correct set of equations is

$$A = \gamma_1, \quad B = 2\gamma_2, \quad C^2 = 12(\gamma_3^2 - \gamma_2^2). \quad (10.36)$$

(2003 April 24)

66. Page 385, figure 10.3, the end of the caption refers to a ‘dashed line’ but should refer to a ‘grey line’. (2000 November 28)

67. Page 409, Table of Physical Constants, there should be a minus sign in the exponent for the quantum of magnetic flux, $\Phi_0$; the correct value is $4.136 \times 10^{-15}$ Wb. (Frank Herman, 2000 May 23; corrected in the 2000 reprint.)

68. Page 410, there is a line missing from the table of notation between the rows for $\chi$ and $m_{hh}$: $E_P$ should be defined as ‘$S$–$P$ hybridization energy (section 7.3)’. (Uki Kabasawa, 2004 January 15)

69. Page 419, equation (A6.11), the variable of integration is missing; it should be shown as $t'$. The correct equation is

$$J(t) = \int_0^\infty \sigma(t') E_0 \delta(t - t') \, dt' = E_0 \sigma(t). \quad (A6.11)$$

(2003 May 21)
Errata

70. Page 421, section A6.2.2, the discussion that leads up to equation (A6.18) is misleading. First, the expression for $\sigma(t)$ is only approximate: the phase is incorrect and the frequency of free oscillations is slightly different from the natural resonant frequency $\omega_0$ in a damped system. This in turn means that the expressions for $\tilde{\sigma}(\omega)$ and $\tilde{\epsilon}_r(\omega)$ that follow are also approximations. They are reasonably accurate near the resonance but are seriously wrong near $\omega = 0$. However, the final expression for $\tilde{\epsilon}_r(\omega)$ in equation (A6.18) is correct. The ‘approximate’ sign gives the impression that equation (A6.17) is the exact result and that equation (A6.18) is an approximation, but the opposite is true.

It is sometimes useful to split the dielectric function into the contributions from its two poles and the correct expression is

$$\tilde{\epsilon}_r(\omega) = 1 - \frac{\omega_0^2}{2\omega_\ell} \left[ \frac{1}{(\omega - \omega_\ell) + \frac{1}{2}i\gamma} - \frac{1}{(\omega + \omega_\ell) + \frac{1}{2}i\gamma} \right].$$

This replaces equation (A6.17). The frequency $\omega_\ell$ is that for free oscillations in the damped system, given by $\omega_\ell^2 = \omega_0^2 - \frac{1}{4}\gamma^2$. (The same frequency should appear in equation (A6.15) instead of $\omega_0$.)

My aim in writing this section was to derive the Lorentz model directly from the physical picture of bound charges, rather than writing down the usual differential equation, but I cut too many corners! (2003 May 05)

2004 October 15