Corrections 1

Quantum Mechanics: Concepts and Applications
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Note: This list of corrections pertains to the first print that was produced in 2001.

Chapter 1

- Page 6, replace footnote # 3 by “Using a variable change $\beta = 1/(kT)$, we have $\langle E \rangle = -\frac{\partial}{\partial \beta} \ln \left( \int_0^\infty e^{-\beta E} dE \right) = -\frac{\partial}{\partial \beta} \ln(1/\beta) = 1/\beta \equiv kT$.”

- Page 9 right after Eq. (1.17), insert “is” after “This” in the statement “This an enormous...”.

- Page 15, in Eq. (1.37) replace $\Delta \lambda = \frac{4h}{m_e c^2}$ by $\Delta \lambda = \frac{4\pi h}{m_e c^2}$.

- Page 15, in Eq. (1.39) replace $E' = \frac{m_e c^2}{2} \left[ 1 + \frac{2m_e c^2}{E} \right]^{-1} \approx \frac{m_e c^2}{2} - \frac{(m_e c^2)^2}{4E} \approx ...$ by $E' = \frac{m_e c^2}{2} \left[ 1 + \frac{m_e c^2}{2E} \right]^{-1} \approx \frac{m_e c^2}{2} - \frac{(m_e c^2)^2}{4E} \approx ...$

- Page 31, inside footnote # 14, replace $F_G/F_e = \frac{Gm_e}{e^2} \approx 9.9 \times 10^{-30}$ by $F_G/F_e = \frac{(4\pi\epsilon_0)Gm_e m_p}{e^2} \approx 10^{-40}$.

- Page 54, in the paragraph before Problem 1.1, replace $1/(4\pi\epsilon_0) = 8.9 \times 10^9$ by $1/(4\pi\epsilon_0) = 8.99 \times 10^9$ N m$^2$ C$^{-2}$.

- Page 60, at the end of the line before Problem 1.10, replace $1/(4\pi\epsilon_0) = 8.9 \times 10^9$ by $1/(4\pi\epsilon_0) = 8.99 \times 10^9$ N m$^2$ C$^{-2}$.

- Page 71, Exercise 1.4, replace “...temperatures are 8500 K, 8500 K, and ...” by “...temperatures are 8500 K, 850 K, and ...”.

Chapter 2

- Page 92, last statement of Example 2.5, replace “In sum, the a state $|\psi >$ ...” by “In sum, if a state $|\psi >$ ...”.

- Page 106, Example 2.10, replace “Calculate inverse of the matrix $A =$ ...” by “Calculate the inverse of the matrix $A =$ ... ”.
• Page 111, replace \(|\psi_1\rangle, |\psi_2\rangle, \) and \(|\psi_3\rangle\) by \(|\phi_1\rangle, |\phi_2\rangle, \) and \(|\phi_3\rangle\) in equation (2.215); this equation should now read

\[
U = \begin{pmatrix}
\langle \phi'_1 | \phi_1 \rangle & \langle \phi'_1 | \phi_2 \rangle & \langle \phi'_1 | \phi_3 \rangle \\
\langle \phi'_2 | \phi_1 \rangle & \langle \phi'_2 | \phi_2 \rangle & \langle \phi'_2 | \phi_3 \rangle \\
\langle \phi'_3 | \phi_1 \rangle & \langle \phi'_3 | \phi_2 \rangle & \langle \phi'_3 | \phi_3 \rangle
\end{pmatrix}.
\]

• Page 116, replace the determinant in Eq. (2.248) by

\[
\begin{vmatrix}
7 - a & 0 & 0 \\
0 & 1 - a & -i \\
0 & i & -1 - a
\end{vmatrix}
\]

• Page 116, statement before Eq. (2.253), replace “corresponding to \(a_1 = 7 \ldots\)” by “corresponding to \(a_2 = \sqrt{2} \ldots\).”

• Page 116, inside Eq. (2.253), replace the last element of the vector \(-i(1 + \sqrt{2})\) by \(i(\sqrt{2} - 1)y\).

• Page 122, insert a “-” sign after the equal sign in equation (2.290): i.e., replace “\(= i\bar{h}\vec{\nabla}(\vec{r}' | \vec{r})\)” by “\(= -i\bar{h}\vec{\nabla}(\vec{r}' | \vec{r})\)”.

• Page 134, inside Eq. (2.372), replace \(B\pi\) by \(B^2\pi\).

• Page 150, part (b) of Exercise 2.18, replace “\(A^2 + B^2 + C^2 = 4I, \ldots\)” by “(b) Show that \(A^2 + B^2 + 2C^2 = 4I, \ldots\)”.

• Page 152, part (e) of Exercise 2.23, replace “\(\hat{U}\) being the matrix of eigenvectors of \(\hat{B}\)” by “\(\hat{U}\) being the matrix of the normalized eigenvectors of \(\hat{B}\).”

• Page 152, part (f) of Exercise 2.23, replace “\(\hat{U}^{-1} = \hat{U}\)” by “(f) Verify that \(\hat{U}^{-1} = \hat{U}^\dagger\)”.

• Page 156, replace \([x, [\hat{A}, \hat{X}]]\) in part (c) of Exercise 2.48 by \([\hat{X}, [\hat{A}, \hat{X}]]\).

Chapter 3

• Page 161, inside Eq. (3.13), replace \(\left| \frac{\sqrt{2}}{3} \langle \phi_1 | \phi_2 \rangle \right|^2\) by \(\left| \frac{2}{3} \langle \phi_2 | \phi_2 \rangle \right|^2\).

• Page 186, replace Eq. (3.159) by

\[
\vec{J}(x, t) = \frac{i\hbar}{2m} \left( \psi(x, t)\frac{d\psi^*(x, t)}{dx} - \psi^*(x, t)\frac{d\psi(x, t)}{dx} \right) \hat{\vec{i}}.
\]

• Page 187, replace equations (3.168) and (3.169) respectively by

\[
P(E_1) = \left| \sqrt{\frac{2}{7}} \langle \phi_1 | \phi_1 \rangle \right|^2 = \frac{2}{7}, \quad P(E_2) = \left| \sqrt{\frac{3}{7}} \langle \phi_2 | \phi_2 \rangle \right|^2 = \frac{3}{7},
\]

\[
P(E_3) = \left| \frac{1}{\sqrt{7}} \langle \phi_3 | \phi_3 \rangle \right|^2 = \frac{1}{7}, \quad P(E_4) = \left| \frac{1}{\sqrt{7}} \langle \phi_4 | \phi_4 \rangle \right|^2 = \frac{1}{7}.
\]
Page 188, replace equations (3.171) and (3.172) respectively by

\[ P(a_1) = \left| \sqrt{\frac{2}{7}} \langle \phi_1| \phi_1 \rangle \right|^2 = \frac{2}{7}, \quad P(a_2) = \left| \sqrt{\frac{3}{7}} \langle \phi_2| \phi_2 \rangle \right|^2 = \frac{3}{7}, \]

\[ P(a_3) = \left| \frac{1}{\sqrt{7}} \langle \phi_3| \phi_3 \rangle \right|^2 = \frac{1}{7}, \quad P(a_4) = \left| \frac{1}{\sqrt{7}} \langle \phi_4| \phi_4 \rangle \right|^2 = \frac{1}{7}. \]

Page 200, replace \( \Psi(x, 0) \) in Exercise 3.3 by

\[ \Psi(x, 0) = \sqrt{\frac{4}{7a}} \sin \left( \frac{\pi x}{a} \right) + \sqrt{\frac{2}{7a}} \sin \left( \frac{2\pi x}{a} \right) + \sqrt{\frac{8}{7a}} \sin \left( \frac{3\pi x}{a} \right). \]

Page 204, cancel Exercise 3.26 and replace it with the following exercise:

Consider a system whose initial state at \( t = 0 \) is given in terms of a complete and orthonormal set of four vectors \( \langle \phi_1 \rangle, \langle \phi_2 \rangle, \langle \phi_3 \rangle, \langle \phi_4 \rangle \) as follows:

\[ |\psi(0)\rangle = A \sqrt{6} |\phi_1\rangle + \frac{1}{\sqrt{6}} |\phi_2\rangle + |\phi_3\rangle + \frac{1}{2} |\phi_4\rangle, \]

where \( A \) is a real constant.

(a) Find \( A \) so that \( |\psi(0)\rangle \) is normalized.

(b) If the energies corresponding to \( |\phi_1\rangle, |\phi_2\rangle, |\phi_3\rangle, |\phi_4\rangle \) are given by \( E_1, E_2, E_3, \) and \( E_4, \) respectively, write down the state of the system \( |\psi(t)\rangle \) at any later time \( t. \)

(c) Determine the probability of finding the system at a time \( t \) in the state \( |\phi_2\rangle. \)

Chapter 4

Page 212, replace \( 4K^2 \) by \( 4K \) in the numerator of the expression of the transmission coefficient \( T \) in Eq. (4.27).

Page 234, replace the matric of \( \hat{N} \) in Eq. (4.158) by

\[ \hat{N} = \begin{pmatrix} 0 & 0 & 0 & \cdots \\ 0 & 1 & 0 & \cdots \\ 0 & 0 & 2 & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}, \quad (2) \]

Page 236, replace Eq. (4.178) by

\[ \psi''_n = \left. \frac{d^2}{dx^2}(-k^2\psi) \right|_{x=x_n} = \frac{(k^2\psi)_{n+1} - 2(k^2\psi)_n + (k^2\psi)_{n-1}}{h_0^2}. \]

Page 237, replace the first line and Eq. (4.179) by: Using \( \psi''_n = -k_n^2\psi_n \) and substituting (4.178) into (4.177) we can show that

\[ \psi_{n+1} = \frac{2 \left( 1 - \frac{5}{12} h_0^2 k_n^2 \right) \psi_n - \left( 1 + \frac{1}{12} h_0^2 k_n^2 \right) \psi_{n-1}}{1 + \frac{1}{12} h_0^2 k_{n+1}^2}. \]
• Page 238, remove the clause “; plot the corresponding wave functions” from the statement of part (b) of Example 4.3.

• Page 242, in the statement before Eq. (4.198), replace “(c) Equation (4.197) shows ...” by “(c) Equation (4.196) shows ...”.

• Page 243, replace Eq. (4.201) by

\[ P(E'_1) = |\langle \psi_1 | \phi_1 \rangle|^2 = \frac{1}{a^2} \left| \int_0^a \psi^*_1(x) \phi_1(x) \, dx \right|^2; \]

• Page 243, in the statement before Eq. (4.202), replace “Using the relation \( \sin a \sin b = \frac{1}{2} \cos(a + b) \) by “Using the relation \( \sin a \sin b = \frac{1}{2} \cos(a - b) \)- \( \frac{1}{2} \cos(a + b) \), we have \( \sin(\pi x/4a) \sin(\pi x/a) = \frac{1}{2} \cos(3\pi x/4a) - \frac{1}{2} \cos(5\pi x/4a), \) hence”

• Page 243, replace Eq. (4.202) by

\[ P(E'_2) = |\langle \psi_2 | \phi_1 \rangle|^2 = \frac{1}{a^2} \left| \int_0^a \psi^*_2(x) \phi_1(x) \, dx \right|^2 = \frac{128}{15^2\pi^2} = 0.058 = 5.8\% \]

• Page 244, add “dx” inside the integral sign in the last line of Eq. (4.213).

• Page 252, replace Eq. (4.261) by

\[ \tan \left( \frac{\alpha}{2} \right) = \frac{\hbar k}{mV_0} \quad \Rightarrow \quad \tan \left( \sqrt{\frac{ma^2|E|}{2\hbar^2}} \right) = \sqrt{\frac{2\hbar^2|E|}{ma^2}}. \]

• Page 263, replace \( E_0, \, E_1, \) and \( E_2 \) in part (b) of Exercise 4.1 by \( E_1, \, E_2, \) and \( E_3. \)

• Page 263, replace \( P_1(x,t) \) and \( P_2(x,t) \) in part (c) of Exercise 4.1 by \( P_2(x,t) \) and \( P_3(x,t). \)

• Page 263, replace \( \langle X \rangle_1, \, \langle X \rangle_2, \, < P >_1, \) and \( < P >_2 \) in part (d) of Exercise 4.1 by \( < X >_2, \, < X >_3, \, < P >_2, \) and \( < P >_3. \)

• Page 263, replace \( \psi_1(x,t) \) and \( \psi_2(x,t) \) in part (e) of Exercise 4.1 by \( \psi_2(x,t) \) and \( \psi_3(x,t). \)

• Page 263, replace \( E_n = \pi^2n^2/(2ma^2\hbar^2) \) in Exercise 4.2 by \( E_n = \pi^2\hbar^2n^2/(2ma^2). \)
• Page 265, Exercise 4.9, the statement before (a), replace “a harmonic oscillator of width $a$ and energy $E_n = n\hbar(n + 1/2).$” by “a harmonic oscillator of energy $E_n = \hbar\omega(n + 1/2).$”

• Page 266, Exercise 4.17, replace the wave function by

$$\psi(x) = \begin{cases} 
Ax(a^2 - x^2) & 0 < x < a \\
0 & \text{elsewhere}
\end{cases}$$

Chapter 5

• Page 285, replace twice the ket “$|j, m_s >$” by “$|s, m_s >$” in the statement before Eq. (5.105).

• Page 288, inside Eq. (5.135), replace “$Y_{lm}(\theta, \psi) =$” by “$Y_{lm}(\theta, \varphi) =$”.

Chapter 6

• Page 368, remove the factor $c^4$ from Eq. (6.323).

Chapter 9

• Page 516, replace the ratios $\frac{8}{L^3}$ by $\sqrt{\frac{8}{L^3}}$ in equations (9.285) through (9.287).