

Chapter One

1. $AC\{D, B\} = ACDB + ACBD$, $A\{C, B\}D = ACBD + ABCD$, $C\{D, A\}B = CDAB + CADB$, and $\{C, A\}DB = CADB + ACDB$. Therefore $-AC\{D, B\} + A\{C, B\}D - C\{D, A\}B + \{C, A\}DB = -ACDB + ABCD - CDAB + ACDB = ABCD - CDAB = [AB, CD]$

In preparing this solution manual, I have realized that problems 2 and 3 in are misplaced in this chapter. They belong in Chapter Three. The Pauli matrices are not even defined in Chapter One, nor is the math used in previous solution manual. - Jim Napolitano

2. (a) $\text{Tr}(X) = a_0 \text{Tr}(1) + \sum_{\ell} \text{Tr}(\sigma_{\ell}) a_{\ell} = 2a_0$ since $\text{Tr}(\sigma_{\ell}) = 0$. Also $\text{Tr}(\sigma_k X) = a_0 \text{Tr}(\sigma_k) + \sum_{\ell} \text{Tr}(\sigma_k \sigma_{\ell}) a_{\ell} = \frac{1}{2} \sum_{\ell} \text{Tr}(\sigma_k \sigma_{\ell} + \sigma_{\ell} \sigma_k) a_{\ell} = \sum_{\ell} \delta_{k\ell} \text{Tr}(1) a_{\ell} = 2a_k$. So, $a_0 = \frac{1}{2} \text{Tr}(X)$ and $a_k = \frac{1}{2} \text{Tr}(\sigma_k X)$. (b) Just do the algebra to find $a_0 = (X_{11} + X_{22})/2$, $a_1 = (X_{12} + X_{21})/2$, $a_2 = i(-X_{21} + X_{12})/2$, and $a_3 = (X_{11} - X_{22})/2$.

3. Since $\det(\boldsymbol{\sigma} \cdot \mathbf{a}) = -a_x^2 - (a_y^2 + a_z^2) = -|\mathbf{a}|^2$, the cognoscenti realize that this problem really has to do with rotation operators. From this result, and (3.2.44), we write

$$\det \left[\exp \left(\pm \frac{i\boldsymbol{\sigma} \cdot \hat{\mathbf{n}}\phi}{2} \right) \right] = \cos \left(\frac{\phi}{2} \right) \pm i \sin \left(\frac{\phi}{2} \right)$$

and multiplying out determinants makes it clear that $\det(\boldsymbol{\sigma} \cdot \mathbf{a}') = \det(\boldsymbol{\sigma} \cdot \mathbf{a})$. Similarly, use (3.2.44) to explicitly write out the matrix $\boldsymbol{\sigma} \cdot \mathbf{a}'$ and equate the elements to those of $\boldsymbol{\sigma} \cdot \mathbf{a}$. With $\hat{\mathbf{n}}$ in the z-direction, it is clear that we have just performed a rotation (of the spin vector) through the angle ϕ .

4. (a) $\text{Tr}(XY) \equiv \sum_a \langle a|XY|a \rangle = \sum_a \sum_b \langle a|X|b \rangle \langle b|Y|a \rangle$ by inserting the identity operator. Then commute and reverse, so $\text{Tr}(XY) = \sum_a \sum_b \langle b|Y|a \rangle \langle a|X|b \rangle = \sum_b \langle b|YX|b \rangle = \text{Tr}(YX)$. (b) $XY|\alpha \rangle = X|Y|\alpha \rangle$ is dual to $\langle \alpha|(XY)^\dagger$, but $Y|\alpha \rangle \equiv |\beta \rangle$ is dual to $\langle \alpha|Y^\dagger \equiv \langle \beta|$ and $X|\beta \rangle$ is dual to $\langle \beta|X^\dagger$ so that $X|Y|\alpha \rangle$ is dual to $\langle \alpha|Y^\dagger X^\dagger$. Therefore $(XY)^\dagger = Y^\dagger X^\dagger$. (c) $\exp[if(A)] = \sum_a \exp[if(A)]|a \rangle \langle a| = \sum_a \exp[if(a)]|a \rangle \langle a|$ (d) $\sum_a \psi_a^\dagger(\mathbf{x}') \psi_a(\mathbf{x}'') = \sum_a \langle \mathbf{x}'|a \rangle^* \langle \mathbf{x}''|a \rangle = \sum_a \langle \mathbf{x}''|a \rangle \langle a|\mathbf{x}' \rangle = \langle \mathbf{x}''|\mathbf{x}' \rangle = \delta(\mathbf{x}'' - \mathbf{x}')$

5. For basis kets $|a_i \rangle$, matrix elements of $X \equiv |\alpha \rangle \langle \beta|$ are $X_{ij} = \langle a_i|\alpha \rangle \langle \beta|a_j \rangle = \langle a_i|\alpha \rangle \langle a_j|\beta \rangle^*$. For spin-1/2 in the $|\pm z \rangle$ basis, $\langle +|S_z = \hbar/2 \rangle = 1$, $\langle -|S_z = \hbar/2 \rangle = 0$, and, using (1.4.17a), $\langle \pm|S_x = \hbar/2 \rangle = 1/\sqrt{2}$. Therefore

$$|S_x = \hbar/2 \rangle \langle S_x = \hbar/2| \doteq \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 1 \\ 0 & 0 \end{pmatrix}$$

6. $A[|i \rangle + |j \rangle] = a_i|i \rangle + a_j|j \rangle \neq [(i) + |j \rangle]$ so in general it is not an eigenvector, unless $a_i = a_j$. That is, $|i \rangle + |j \rangle$ is not an eigenvector of A unless the eigenvalues are degenerate.

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Sakurai Quantum Mechanics Solutions Problem Scattering Theory

Solution: Sakurai 5.9 (note in part (a) that my limits of integration on the θ integrals run from 0 to 2π , but the upper limit should actually just be π . Ultimately this is inconsequential as the integral simplifies to 0 regardless, so the solution still appears to be correct.

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Prénom Sakurai - La Signification du Prénom

The late J.J. Sakurai, noted theorist in particle physics, was born in Tokyo, Japan in

1933. He received his B.A. from Harvard University in 1955 and his PhD from Cornell University in 1958. He was appointed as an assistant professor at the University of Chicago, where he worked until he became a professor at the University of California, Los Angeles in 1970. Sakurai died in 1982 while he was visiting a professor at CERN in Geneva, Switzerland.

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