

Assignment 1

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1 Solve the following questions:

1. Consider the following settings of sequential Stern-Gerlachs, tell what will be the final outputs with proper reasons
 - (a) $S_x \rightarrow S_y \rightarrow S_x \rightarrow S_y$ ($-, -, -$ rays are blocked sequentially).
 - (b) $S_z \rightarrow S_z \rightarrow S_x$ ($-, +$ rays are blocked sequentially)
 - (c) $S_x \rightarrow S_y \rightarrow S_z \rightarrow S_y$ ($+, +, +$ rays are blocked sequentially).

2. Describe an experiment to argue that quantum determinism is different from classical determinism.
3. Show that all the Pauli Matrices σ_i are Unitary and Hermitian. Find all $\sigma_i \otimes \sigma_j$. Find out whether $\sigma_i \otimes \sigma_j$ are Hermitian and Unitary or not?
4. Consider the four bipartite quantum states given below. Some of them are density matrices, while some of them are state vectors.

- (a) $\psi_1 = |00\rangle$
- (b) $\psi_3 = \frac{1}{\sqrt{2}}|00\rangle + \frac{1}{\sqrt{2}}|11\rangle$

For each of the state vectors above find the density matrices.

5. Find out which of the followings are pure states and mixed states?

- (a) $\rho_1 = \frac{1}{2}(|00\rangle\langle 00| + |01\rangle\langle 11| + |11\rangle\langle 00| + |11\rangle\langle 11|)$
- (b) $\rho_2 = \frac{1}{4}|00\rangle\langle 00| + \frac{1}{4}|01\rangle\langle 01| + \frac{1}{4}|10\rangle\langle 10| + \frac{1}{4}|11\rangle\langle 11|$
- (c) $\rho_3 = \frac{1}{2}(|00\rangle\langle 00| + |11\rangle\langle 11|)$
- (d) $\rho_4 = p \times I + (1 - p) \times \rho_1$

6. Show the following:

- (a) Find out whether projection operators are positive operators or not.
 - (b) Orthonormalize the following set of vectors $|0\rangle + 2|1\rangle, 8|0\rangle + 1|1\rangle - 6|2\rangle, |2\rangle$.
- (c) Find the tensor products of following matrices: (i) ρ_1 and ρ_3 , (ii) ρ_2 and ρ_4 and (iii) ρ_1, ρ_3 and ρ_4 (ρ_i are from Prob 5).