

1. Explain the key features of a Stern-Gerlach experiment
 - Relate the magnetic moment to spin angular momentum
 - Explain the classical prediction and how it is different from experimental results.
2. Express a quantum state as a linear combination of eigenstates and interpret the expansion coefficients as probability amplitudes
 - a) for Spin-1/2, Spin-1, a particle in a box, and a general quantum system
 - b) Distinguish values that are measured, states after a measurement, and probabilities of measuring values
 - c) Relate the eigenstates for different spin components $\hat{S}_x$, $\hat{S}_y$, $\hat{S}_z$, $\hat{S}_n$
 - d) Normalize the state
 - e) Determine a quantum spin-1/2 state from the results of experiments.
 - f) Calculate measurement probabilities given a quantum state
 - g) Describe the role of relative and overall phase in distinguishing quantum states
3. Express quantum states and perform quantum calculations in matrix, Dirac, or wavefunction notation, as appropriate
 - a) Translate between matrix, Dirac, wavefunction, and histogram representations correctly
 - b) Change bases in Dirac notation using a completeness relation
 - c) Calculate matrix elements of operators
 - d) Calculate expectation values and uncertainty
 - e) Calculate the probability of finding a quantum particle to be in some region of space
 - f) Calculate the probability of measuring a particular value of an observable.
 - g) Determine if two complex valued vectors are orthogonal to each other
4. Interpret and predict the probabilistic outcomes of sequential Stern-Gerlach experiments, including a quantum interferometer
 - a) Distinguish mixed vs. superposition states and explain how you can experimentally distinguish them
 - b) Mathematically model the collapse of the quantum state using projection operators
 - c) Mathematically model the coherent superposition of quantum states in a quantum interferometer
5. Describe the relationship between operators and observables

- a) Relate possible measurement values and possible states after a measurement to the eigenvalues & eigenvectors of Hermitian operators
 - b) Determine energy eigenvalues and eigenstates from a Hamiltonian
 - c) Determine spin components/total spin and spin eigenstates from spin operators
 - d) Determine possible measurement values and possible states after a measurement from an operator that represents an observable
 - e) Describe the relationship between the eigenstates of observables that commute
6. Determine the time evolution of a spin quantum system or particles in an infinite or finite 1D potential well given a time-independent Hamiltonian and the initial state of the system
- a) Write down the Hamiltonian for a spin system in a uniform magnetic field
 - b) Write down the Hamiltonian for a particle in an infinite square well
 - c) Identify stationary states and when probabilities will not change with time.
 - d) Use time-evolved states in calculations (e.g., expectation value)