Intermediate-Level Problem Statements in Quantum Computing using IBM Qiskit

1. Implement the full Deutsch–Jozsa algorithm for a 3-qubit balanced oracle and verify the output.
2. Simulate Grover's Search Algorithm for a 3-qubit system (N=8) and visualize the amplitude amplification.
3. Implement Simon's Algorithm for a 2-bit hidden string and verify the measurement results.
4. Create and simulate a Quantum Fourier Transform (QFT) on 3 qubits and visualize its matrix representation.
5. Design and simulate the inverse QFT circuit to verify its correctness by applying QFT followed by inverse QFT.
6. Implement Bernstein–Vazirani Algorithm for a hidden bitstring of length 4 and confirm the results.
7. Simulate a 3-qubit GHZ state and verify its entanglement using state tomography tools in Qiskit.
8. Create a 3-qubit W state using basic quantum gates and verify it using statevector simulation.
9. Implement Quantum Phase Estimation (QPE) for a unitary operator and verify the estimated phase accuracy.
10. Simulate a Variational Quantum Eigensolver (VQE) for the ground state energy of H_2 molecule.
11. Use Qiskit Aer noise models to simulate decoherence and analyze its impact on Bell state fidelity.
12. Apply Quantum Error Correction using a 3-qubit bit-flip code and demonstrate recovery from a single error.
13. Build a parameterized quantum circuit (PQC) and use Qiskit Machine Learning module for classification of two points.
14. Implement Quantum Approximate Optimization Algorithm (QAOA) for a simple Max-Cut problem on a 4-node graph.
15. Design and simulate a hybrid quantum-classical workflow combining Qiskit with classical optimization using COBYLA.
16. Use transpiler passes to optimize a 4-qubit circuit and compare the circuit depth before and after optimization.
17. Implement Quantum Teleportation protocol and simulate it under realistic noise conditions using IBM backend.
18. Simulate a Quantum Random Walk on a line with 3 qubits and observe probability distribution evolution.
19. Develop a Quantum Neural Network (QNN) using Qiskit Machine Learning and train it on a binary dataset.
20. Execute Grover's algorithm and Deutsch–Jozsa algorithm on a real IBM Quantum backend, compare simulation vs hardware outputs.