**Lab Manual: Quantum Computer Experiment**

**Step 1: Theoretical Background**

Quantum computing leverages the principles of quantum mechanics to process information. Key concepts include:

* **Qubits:** The basic unit of quantum information, analogous to bits in classical computing.
* **Superposition:** A qubit can be in a state of 0, 1, or both simultaneously.
* **Entanglement:** Qubits can become entangled, such that the state of one qubit is dependent on the state of another.
* **Quantum Gates:** Operations that change the state of qubits (e.g., Hadamard gate).

In this experiment, we will use a single qubit and the Hadamard gate to create superposition.

**Step 2: Implementation**

1. **Set Up Your Environment**
   * Ensure you have Python installed.
   * Install Qiskit and Matplotlib:

bash

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pip install qiskit matplotlib

1. **Write the Code**
   * Use the following code to create and execute the quantum circuit:

python

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from qiskit import QuantumCircuit

from qiskit\_aer import AerSimulator

import matplotlib.pyplot as plt

# Create a Quantum Circuit with 1 qubit

qc = QuantumCircuit(1)

qc.h(0) # Apply Hadamard gate

qc.measure\_all() # Measure the qubit

# Visualize the circuit

print("Quantum Circuit:")

print(qc.draw())

# Execute the circuit using the AerSimulator

simulator = AerSimulator()

result = simulator.run(qc).result()

counts = result.get\_counts()

# Plotting the results

plt.bar(counts.keys(), counts.values())

plt.title('Measurement Results')

plt.xlabel('State')

plt.ylabel('Counts')

plt.show()

1. **Run the Code**
   * Execute the script in your Python environment.

**Step 3: Test Results**

* **View the Quantum Circuit Diagram**  
  The line print(qc.draw()) will output a visual representation of the quantum circuit.
* **Measurement Results**  
  After executing the circuit, you will see a bar plot displaying the measurement results. The expected outcome is that the qubit will be found in the |0⟩ and |1⟩ states with approximately equal probability due to the Hadamard gate.

**Step 4: Analyze the Results**

* **Interpreting the Bar Plot**
  + The x-axis represents the states (|0⟩ and |1⟩).
  + The y-axis represents the number of counts (how many times each state was measured).
  + If the Hadamard gate worked correctly, you should see roughly equal counts for both states.

**Conclusion**

This simple experiment illustrates the principles of superposition in quantum computing. By applying the Hadamard gate to a qubit, we can create a state where the qubit has equal probabilities of being measured as 0 or 1. This foundational concept is critical for understanding more complex quantum algorithms.