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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

M.Tech. (Computer Science and Engineering)

Mid Semester Exam

SUBJECT: CSE 5115 Quantum Computing

Time: 10.30 AM-12.30 PM Date:12-10-2023 MAX.MARKS: 30

Note: Answer All Questions

1A. A system containing two qubits is prepared in the following states:

$$|\Phi\rangle = \frac{1}{\sqrt{4}}|00\rangle + \frac{i}{\sqrt{4}}|01\rangle - \frac{1}{\sqrt{4}}|10\rangle + \frac{i}{\sqrt{4}}|11\rangle$$

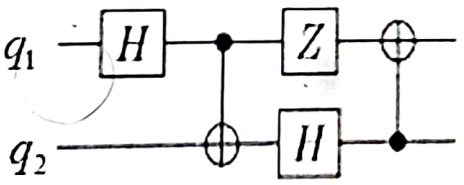
The first qubit is measured. What is the probability that the result is 0? What is the probability that the result is 1? For each possible result, write down the post-measurement state, and calculate the probability that a measurement of the second qubit will give 0 and 1. Write down the states after the second measurement. (5M)

1B. Determine whether the following quantum state is entangled or not. Justify your answer. (3M)

$$|g\rangle = \frac{1}{\sqrt{2}}(|01\rangle - |10\rangle)$$

1C. State 4 postulates of quantum mechanics. (2M)

2A. Consider the following two qubit quantum circuit. (H and Z are Hadamard and Z gates respectively)



Where q_1 and q_2 denote first and second qubit respectively. Compute outputs for the inputs $|00\rangle, |01\rangle, |10\rangle \text{ and } |11\rangle$. Hence compute the matrix representation of the above quantum circuit. (5M)

2B. Derive the Braket representation of X gate. (3 M)

2C. Let I and H are Identity and Hadamard gates. Compute $I \otimes H$ and $H \otimes I$. (2M)

3A. Alice wishes to send Bob a message via a secure protocol. She chooses to use a private key encryption technique and decides to use the BB84 protocol to generate a provably secure private encryption key. Alice's first step is to generate a random binary string. The string she generates is b = 1010100010010111. Alice then encodes this as a string of quantum qubits as per the BB84 protocol, using the encoding H H H I I H I H H I I I H I I H. What is the quantum string that she generates? Alice then sends the string to Bob, who decodes using I H H I H I H H I H I I I H I H. Alice and Bob announce their encodings publicly and retain the qubits for which they chose the same encoding. What is the string that they retain? (5M)

3B. Design the 2 qubit quantum circuit to implement the following Bell state. In the circuit for which input you will get following Bell state. Justify your answer. (3M)

$$|\Phi^-\rangle = \frac{1}{\sqrt{2}}(|00\rangle - |11\rangle)$$

3C. Compute 2 qubit QFT for the quantum state: $|f\rangle = \frac{1}{\sqrt{2}}(|01\rangle + |11\rangle)$. (2M)