Date of submission: 07-September-2022

ID5841 - QUANTUM COMPUTING LAB
IIT MADRAS

Assignment 1 **Aug 2022**

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1. a) Using Quantum Circuits on IBM Q, show that the Fredkin gate is self-inverse.
   b) Verify the following Circuit identities

   (a) $CX_1C = X_1X_2$
   (b) $CZ_1C = Z_1$
   (c) $CY_2C = Z_1Y_2$
   (d) $CY_1C = Y_1X_2$

   Here "C' is the CNOT gate with qubit 1 being the control qubit and quabit 2 being the tanget qubit. X_1 implies Pauli X-gate on the first qubit.

2. A GHZ state is a multipartite state of the form $\frac{1}{\sqrt{2}}(|0\cdots0\rangle + |1\cdots1\rangle)$. Give the circuit diagram for the 3-qubit GHZ state, 4-qubit GHZ state and 5-qubit GHZ state. Show your results on the simulator as well as on any one of the IBMQ machine.

3. Draw the guantum circuit for the following states:

   (a) $\frac{1}{\sqrt{2}}(|001\rangle + |110\rangle)$
   (b) $\frac{1}{\sqrt{2}}(|101\rangle + |010\rangle)$
   (c) $\frac{1}{\sqrt{2}}(|100\rangle + |011\rangle)$

4. A W-state is an entangled bipartite state of the form $\frac{1}{\sqrt{3}}(|001\rangle + |010\rangle + |100\rangle)$. For a 4-qubit system the state reads

$$\frac{1}{\sqrt{4}}(|0001\rangle + |0010\rangle + |0100\rangle + |1000\rangle)$$

   . Construct the Circuit corresponding to these states and get their output using quantum state tomography on any IBMQ machine.

5. A N-qubit GHZ state will be of the form

   (a) $\frac{1}{\sqrt{2}}(|00\cdots0\rangle + |11\cdots1\rangle)$
   (b) $\frac{1}{\sqrt{N}}(|00\ldots01\rangle + |00\cdots10\rangle + \cdots + |01\ldots00\rangle + |100.00\rangle)$

   Can you guess the quantiun cincuit for these states.