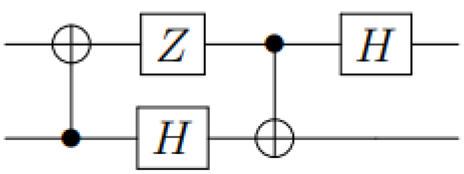
MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

II SEMESTER M. TECH (CSE/CSIS: Program Elective I)
END SEMESTER EXAMINATION, MAY 26, 2023
SUBJECT: FUNDAMENTALS OF QUANTUM COMPUTING (CSE 5025)
REVISED CREDIT SYSTEM

Time: 3 Hours (9.30 AM-12.30 AM) **MAX. MARKS: 50**
Note: Answer ALL the questions.

1A	Let $\lvert\psi\rangle=\left(\frac{1}{2}+\frac{i}{2}\right)\lvert 0\rangle+\left(\frac{1}{2}-\frac{i}{2}\right)\lvert 1\rangle$, compute $\langle\psi\rvert$ and $\langle\psi\mid\psi\rangle$.	05
1B	For $\lvert\psi\rangle$ defined Q1A, compute probabilities of getting 0 &1 (P(0) and P(1)).	03
1C	If $U=\begin{bmatrix}\frac{1}{\sqrt{2}} & \frac{i}{\sqrt{2}}\\ \frac{i}{\sqrt{2}} & \frac{1}{\sqrt{2}}\end{bmatrix}$, compute $U^{\dagger}$ (Conjugate transpose of U).	02
2A	Let $\lvert\phi\rangle=\frac{1}{2}\lvert 01\rangle+\frac{\sqrt{3}}{2}\lvert 10\rangle$ compute probabilities of getting 00, 01, 10 &11 (P(00), P(01), P(10) and P(11)).	02
2B	Compute outputs for all inputs $\lvert 00\rangle,\lvert 01\rangle,\lvert 10\rangle, and \lvert 11\rangle$ for the following 2 qubit quantum circuit and give its matrix representataion. 	05
2C	Test whether the following quantum state is entangled or not. Justify your answer. $\frac{1}{\sqrt{2}}\lvert 000\rangle+\frac{1}{\sqrt{2}}\lvert 111\rangle$	03
3A	In the quantum teleportation protocol, Alice and Bob are each in possession of one qubit of a pair in the joint state $\lvert\Phi^{+}\rangle=\frac{1}{\sqrt{2}}(\lvert 00\rangle+\lvert 11\rangle)$. In addition, Alice has a qubit in an arbitrary state $\lvert\phi\rangle=a\lvert 0\rangle+b\lvert 1\rangle$. Illusrate how the protocol works. In particular, show that it involves the transmission of exactly two classical bits of information from Alice to Bob and demonstrate how, at the end of the protocol, Bob is in possession of a qubit in state $\lvert\phi\rangle$.	05
3B	Design quantum circuit for quantum teleportation protocol.	02
3C	Encode the state $\lvert\psi\rangle=\alpha\lvert 0\rangle+\beta\lvert 1\rangle$ using Shor's 9 qubit code.	03

4A	Given the matrix of 2 qubit QFT_2 , compute the matrix of inverse QFT_2 (i.e. QFT_2^{-1}). $QFT_2 = \frac{1}{2}\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & i & -1 & -i \\ 1 & -1 & 1 & -1 \\ 1 & -i & -1 & i \end{bmatrix}$	02
4B	Let N= 15, and a =7, apply Shor's algorithm to find the period r and factors of *N*.	05
4C	Imagine we can define a unitary operator U that can copy the qubit states $\|\psi_1\rangle = \frac{1}{\sqrt{2}}(\|0\rangle + \|1\rangle)$ and $\|\psi_2\rangle = \frac{1}{\sqrt{2}}(\|0\rangle - \|1\rangle)$: $U\|\psi_1\rangle\|0\rangle = \|\psi_1\rangle\|\psi_1\rangle and U\|\psi_2\rangle\|0\rangle = \|\psi_2\rangle\|\psi_2\rangle$. Can U be used to copy $\|0\rangle$? Verify using an explicit calculation.	03
5A	Design Deutsch algorithm to test the function is constant or balanced.	05
5B	Construct quantum circuit for Deutsch algorithm.	02
5C	Design quantum circuit to encode the quantum state $\|\psi\rangle = a\|0\rangle + b\|1\rangle$ using 3 qubit bit flip code.	03