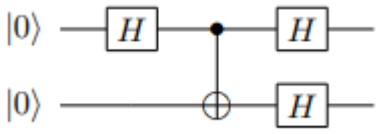
MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

I SEMESTER M. TECH (Computer Science & Engineering)
END SEMESTER EXAMINATION, December 5, 2023
SUBJECT: QUANTUM COMPUTING (CSE 5115)
REVISED CREDIT SYSTEM

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

1A	A qubit is prepared in state $\|\psi\rangle = \frac{1}{\sqrt{3}}\|0\rangle - \sqrt{\frac{2}{3}}\|1\rangle$. It is then measured. Compute P(1)? The qubit is measured a second time. Calculate P(0) and P(1) for the second measurement, given that the first measurement gave result 1?	**3**
1B	Define "braket" of two vectors $\|v\rangle and \|w\rangle$. If $\|v\rangle = \frac{1}{\sqrt{2}}\begin{bmatrix}1\\ i\end{bmatrix} and \|w\rangle = \frac{i}{\sqrt{2}}\begin{bmatrix}1\\ 1\end{bmatrix}$, compute $\langle v\|w\rangle$.	**3**
1C	Determine whether the following two qubit state is entangled or not. Justify your answer. $\frac{\|00\rangle + \|01\rangle}{\sqrt{2}}$	**4**
2A	Suppose you are given a system with a two qubit function $\|\psi\rangle = \frac{1}{2}\left(\|00\rangle + \|01\rangle + \|10\rangle + \|11\rangle\right)$. Can this state be expressed as a separable state? That is, can you find single qubit functions $\|\varphi_1\rangle$ and $\|\varphi_2\rangle$ such that $\|\psi\rangle = \|\varphi_1\rangle \otimes \|\varphi_2\rangle$? If yes, please find an expression for $\|\varphi_1\rangle$ and $\|\varphi_1\rangle$. If no, explain why not.	**4**
2B	Let H and I are Hadamard and Identity gates respectively and $\|\psi\rangle$ is as defined in Q2A. Compute $\|\psi_1\rangle = (H \otimes I)\|\psi\rangle$	**3**
2C	Define CNOT gate. Design CNOT circuit and compute CNOT matrix.	**3**
3A	Define I Gate. Derive the Braket representation of I gate.	**3**
3B	Show that SWAP can be implemented using CNOT gates. Design the corresponding SWAP circuit. Compute SWAP matrix.	**3**
3C	Explain No Cloning Principle. Illustrate No cloning principle using CNOT Gate.	**4**
4A	Compute the output of the following quantum circuit. 	**4**
4B	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* = 0101011101101000. 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	**4**

	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. Compute the string that they retain?	
4C	Suppose that charlie intercepts the qubit transmitted by Alice in the superdense coding protocol. Can she infer which of the four pairs of bits 00; 01; 10, or 11 Alice was trying to transmit? If so, how? If not, why not?	**2**
5A	Apply Grover's quantum search algorithm on a system with N= 4 and solution is indexed by x = 0.	**5**
5B	Let H is Hadamard gate, compute $H^{\otimes n}\left\|0\right\rangle^{\otimes n}$ and express result in summation form.	**3**
5C	Let $\left\|\psi\right\rangle = a\left\|0\right\rangle + b\left\|1\right\rangle$ be a quantum state, Alice wants to send to Bob. To reduce channel errors, Alice encode 0 by 000 and 1 by 111. Design quantum circuit to implement this encoding.	**2**