National University of Computer and Emerging Sciences, Lahore Campus

	Course Name:	Quantum Computing	Course Code:	CS-4084
	Degree Program:	BS Computer Science	Semester:	Spring 2023
	Exam Duration:	60 Minutes	Total Marks:	44
	Paper Date:	14/11/2023	Weight	15%
	Sections:	ALL	No of Page(s):	10
	Exam Type:	Midterm II		

Student : Name:______________________________ Roll No.________________ Section:_______

Instruction/Notes: Please attempt all questions. Programmable calculators are not allowed.

You may bring an A4-sized cheat sheet, but your roll number should be clearly written on it. Sharing your cheat sheet will be considered a serious offense, punishable by an F grade.

Questions	Q1	Q2	Q3	Q4	Q5	Q6	**Total**
Marks	4	5	5	4	5	21	**44**
Marks Obtained							

Questions

1. What is $H^{\otimes 3}\frac{-|001\rangle+|011\rangle-|101\rangle-|111\rangle}{2}$? [**4 Marks**]

2. U_f is defined as $U_f |x\rangle |y\rangle = |x\rangle |f(x) \oplus y\rangle$. Given $f(01) = 11$, what is $U_f |01\rangle |--\rangle$? [**5 Marks**]

3. Given our data: $\frac{|00\rangle+|01\rangle+i|10\rangle-|11\rangle}{2}$, undergoes a linear shift of 2, what will be the corresponding phase-shift upon application of the Quantum Fourier Transformation (QFT)? Show both results before and after the phase shift. [**5 Marks**]

4. What is $QFT^{-1}\frac{|000\rangle-|010\rangle+|011\rangle}{\sqrt{3}}$ in simplified terms? Here QFT^{-1} refers to the inverse Quantum Fourier Transformation. Noted: You don't need to write the entire matrix, but you may use a more efficient (clever) approach. [**4 Marks**]

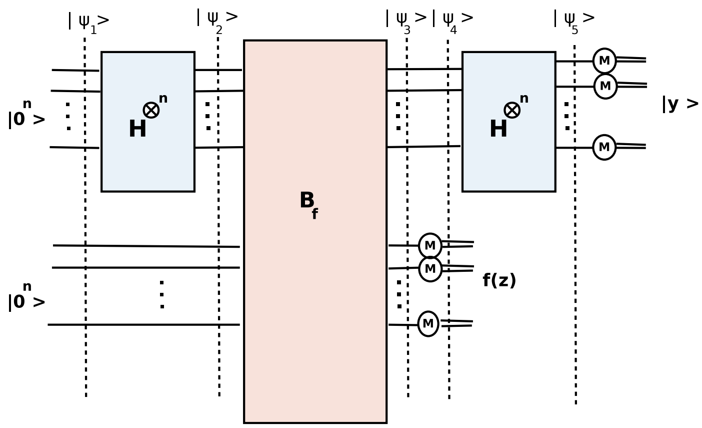

Figure 1: The circuit for the Simon's algorithm

5. We have applied Simon's algorithm to a 4-bit input. Given that we have $|\psi_5\rangle = \frac{|0101\rangle - |1001\rangle + |1100\rangle + |0000\rangle + |0010\rangle - |1110\rangle - |1011\rangle + |0111\rangle}{\sqrt{8}}$. Assuming that you have the same $|\psi_5\rangle$ repeatedly, what is the secret message s? [**5 Marks**]

6. Short questions [$3 \times 7 = 21$ Marks]:

   (a) Given $|\psi\rangle$ is a valid qubits register. What is the value of α

$$|\psi\rangle = \frac{1}{4}|000\rangle + \frac{1}{4}|010\rangle + \alpha|100\rangle$$

   (b) With what probability we will measure the last qubit as 1, given the following three qubits register?

$$|\phi\rangle = \frac{1}{\sqrt{7}}|000\rangle + \sqrt{\frac{2}{7}}|001\rangle + \sqrt{\frac{3}{7}}|101\rangle + \frac{1}{\sqrt{7}}|111\rangle$$

(c) What will be the resultant state after measuring the second qubit as 0, given the following three qubits register?

$$|\phi\rangle = \frac{1}{\sqrt{7}}|000\rangle + \sqrt{\frac{2}{7}}|001\rangle + \sqrt{\frac{3}{7}}|101\rangle + \frac{1}{\sqrt{7}}|111\rangle$$

(d) Calculate $A \otimes B$ given

$$A = \begin{pmatrix} 0 & 1 & -1 \\ 2 & 0 & 3 \end{pmatrix},$$

and

$$B = \begin{pmatrix} 1 & -1 \\ 0 & 2 \end{pmatrix}$$

(e) Write matrix $C = \begin{pmatrix} 1 & 2 & 0 \\ 4 & 0 & 1 \\ 0 & 0 & 99 \end{pmatrix}$ using Bra-Ket notation.

(f) In Period finding algorithm, if an output function period is 8 and size of your input function was 5-bits. What is the period of the input function?

(g) In Deutsch Jozsa algorithm what measurement at the end tells us if a given function is constant or balanced?

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