**Date - 7/12**

**Quantum Computation using Qiskit**

**Chapter 1**

**Section 1: The Atoms of Computation**

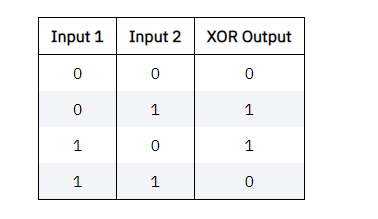
* To create the circuit following, following modules need to be imported:
  + from qiskit import QuantumCircuit, assemble, Aer
  + from qiskit.visualization import plot\_histogram
* QuantumCircuit – The function creates quantum circuit with the defined number of qubits. The output bits can also be defined which will be extracted from the circuit at the end.
  + Example:
    - qc = QuantumCircuit(n\_q, n\_b)
    - n\_q = number of qubits
    - n\_b = number of bits will be extracted
* assemble – The function used to turn the circuit to object
* Aer – Simulator used for the circuit
* measure – It adds a measurement and tell the qubit to write an output to a bit
* draw – raws the circuit
* plot\_histogram – User to plot histogram

**Creating an Adder Circuit**

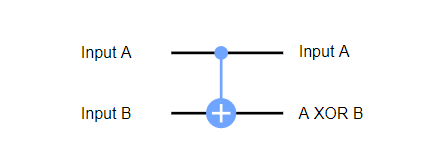
* NOT gate – It flips the bit values. 0 becomes 1 and 1 becomes 0. In qiskit, the NOT gate can be performed by using the ‘x’ operation
  + Example:
    - qc = QuantuamCircuit(n) # creating a circuit with n qubits
    - qc.x(5) # apply NOT gate/x operation on qubit 5

**Adding with Qiskit**

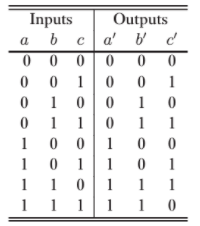
* A circuit is created that encodes the input, perform algorithmic operation and extract outputs.
* XOR gate – The operation refers to the inputs and if both the inputs are same, it will output 0 and if one of the inputs is different, then it will output 1.



* In Qiskit, the XOR operation can be performed using cx operation.
  + Example:
    - qc = QuantuamCircuit(2) # create a circuit with 2 qubits
    - qc.cx(0,1) # qubit 0 XOR qubit 1
    - Sample screenshot



* Toffoli Gate – The operation refers to the control inputs and if both the inputs are in 1 state, then it performed NOT operation on the third input
  + Example:



* The toffoli operation can be done using ccx operation in Qiskit
  + Example:
    - qc\_ccx = QuantumCircuit(4)
    - qc\_ccx.x(0) # apply NOT operation on 0 qubit
    - qc\_ccx.x(1) # apply NOT operation 1 qubit
    - qc\_ccx.ccx(0,1,3) # apply toffoli operation on 0,1 and 3 qubits

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**Section 2: Representing Qubit States:**

Classical bits for computation are either 0 or 1. But in Quantum, it can remain in many states (superposition) until extracted using measurement. When it is measures, it collapses to one of the states - |0> or |1>. Both these are states are mutually exclusive. The state can be mathematically represented in:

|0> =

and |1> =

The representation is known as Dirac notation. In Dirac notation, |0> or |1> is known as Ket and <0| or <1| is known as Bra. As part of the superposition, it can be in different states other than the above two states.

Ket = |x> =

Bra = <y| = [y1 y2]

**Bra-Ket notation:**

<x|y> = [x1 x2] = x1y1 + x2y2 = <y|x>

**Ket-Bra notation:**

|x><y| = [y1 y2] =

**The Rules of Measurement:**

|0> and |1> states are orthonormal, which means both the states are orthogonal (90 degrees) and normalized, which means to ensure the probability will be 1.

<Ψ|Ψ> = 1

|Ψ> = 1/ |0> + 1/ |1>

Probability of measuring a state |Ψ> in the |x> basis is:

P(|x>) =

**Example:**

