# CSE499A – Assignment on QISKIT

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Total marks: 30

Please open a Google Colab file and rename it as *CSE499A.16_Name&ID.ipynb*. Insert a text cell at the top of your notebook and include your name, NSU email address, and contact number. Download the Jupyter Notebook that underpins the expected output and submit it to my email mentioned above. The assignment needs to be submitted individually.
**Submission Deadline: November 22, 2024 (11:59 PM BD time)**

**Note: This is an individual assignment. For each problem, write your codes in a cell and provide your own explanations and understanding of each problem's solution in a text cell. Incorrect answers may receive partial marks, but any plagiarism or unauthorized collaboration will result in a zero grade for this assignment and can significantly impact your final grade in CSE499.**

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## Problem 1

(a) **3 points**: What are the main differences between classical information and quantum information? Give your own interpretation and example.

(b) **3 points**: What is the role of measurement in a superposition state? Explain with an example. Mathematically, represent a qubit in a superposition state using the symbols $|0\rangle$ and $|1\rangle$. Describe what this representation implies.

## Problem 2

(a) **2 points**: Define quantum entanglement. Why is it considered a unique feature of quantum mechanics? Give your own interpretation.

(b) **4 points**: Write a Qiskit code to create four Bell states(the entangled states between two qubits) and explain the outcome of the simulation.

# Problem 3

(a) **3 points**: Extend the two-qubit system to a three-qubit system by applying a CNOT gate and an additional H-gate. Show the Qiskit code, describe the resulting quantum state, and interpret the output.

(b) **3 points**: In QIskit, design an Ansatz(parameterized quantum circuit) circuit for a QNN. Give your own understanding.

# Problem 4:

(a) **3 points**: Consider the state $\psi = \frac{1}{\sqrt{2}}(|011\rangle - |100\rangle)$. Use Qiskit to generate this circuit and find the state vector. If possible, Run this circuit on a real quantum device provided by IBM.

(b) **3 points**: In Qiskit, construct quantum circuit of Bell $|\phi^-\rangle$ state using H-gate and Z-gate & Bell $|\psi^-\rangle$ state using H-gate, Z-gate and X-gate. Now apply measurements, simulate the circuits with 1000 shots, and plot a histogram to show the possible outcomes and corresponding probabilities.

# Problem 5:

**6 points**: Alice and Bob have qubits $A$ and $B$, initialized at states $|0\rangle$ and $|-\rangle$ respectively. Charlie has two qubits $A'$ and $B'$ at states $|+\rangle$ and $|1\rangle$ respectively. Charlie first goes to Alice and applies a CNOT gate at qubit $A'$, keeping qubit $A$ as control. Then, he goes to Bob and again applies another CNOT operation where $B$ is the control qubit, $B'$ is the target qubit. After the described operation, the quantum state is described as $|\psi\rangle_{AA'BB'}$. Now, using Qiskit, build the circuit and show the state $|\psi\rangle_{AA'BB'}$ as latex output.