QXR QUANTUM HACKATHON: Feb. 10th - Mar. 7th, 2025

Kickoff meeting (Zoom): Friday, Feb. 7th, 2:00 - 3:00 pm MST

WEEK 1 [Feb. 10th - 14th]: Intro to Quantum Computing with QISKIT (tutorial style)

- Hello Qiskit: simple puzzles and problems to get started with qubits and quantum gates (e.g. https://github.com/Qiskit/textbook/blob/main/notebooks/ch-demos/hello-qiskit.ipynb) with the possibility of creating one's own puzzles, incl. :
— Level 1 (Beginning with Bits)
— Level 2 (Basic single qubits gates)
— Level 3 (Two qubit gates)
— Level 4 (Beyond Clifford gates)
— Level 5 (Proving the uniqueness of quantum variables)

- Start in a fun way with the Quantum Coin Game! (e.g. https://github.com/Qiskit/textbook/blob/main/notebooks/ch-demos/coin-game.ipynb)

WEEK 2 [Feb. 17th - 21st]: Some standard Quantum Computing algorithms

- Ex. 1: Given two integers which can be positive or negative, generate a quantum algorithm that returns which is the larger number (e.g. https://github.com/qosf/monthly-challenges/blob/main/challenge-2023.02-feb/challenge-2023.02-feb.ipynb)

- Ex. 2: **Toffoli Gate**: Construct a Toffoli gate using the basis gate set (CX, RZ, SX and X gates) of IBM Quantum systems. (e.g. https://github.com/qiskit-community/ibm-quantum-challenge-2021/blob/main/content/ex1/ex1.ipynb)

- Ex. 3: **Quantum Phase Estimation Algorithm**: estimating Pi (e.g. https://github.com/Qiskit/textbook/blob/main/notebooks/ch-demos/piday-code.ipynb)

- Ex. 4: **Shor's Algorithm**: GOAL to factor 35 by doing quantum phase estimation on a circuit that implements *13y mod 35* (see https://github.com/qiskit-community/ibm-quantum-challenge-2021/blob/main/content/ex2/ex2.ipynb)

WEEK 3 [Feb. 24th - 28th]: Entanglement! and QEC!

- Ex. 1: **Quantum Error Correction (QEC)**: create circuits that can detect *x* & *z* errors on two qubits (e.g. https://github.com/qiskit-community/ibm-quantum-challenge-2021/blob/main/content/ex3/ex3.ipynb)

- Ex. 2: Construct a quantum circuit that implements the **Superdense Coding** protocol (e.g. https://github.com/Qiskit/textbook/blob/main/notebooks/ch-algorithms/superdense-coding.ipynb)

- Ex. 3: Construct a quantum circuit that implements the **Teleportation** protocol (e.g. https://github.com/Qiskit/textbook/blob/main/notebooks/ch-algorithms/teleportation.ipynb)

WEEK 4 [March 3rd - 7th]: Practical applications of QC!

- Ex. 1: **Transmon Qubit**: GOAL is to find the l1> -> l2> transition frequency f_{12} (see https://github.com/qiskit-community/ibm-quantum-challenge-2021/blob/main/content/ex4/ex4.ipynb)

- Ex. 2: **Variational Quantum Eigensolver (VQE)**: GOAL is to find the shortest ansatz circuits to accurately represent the ground state(s) of given problems. Be creative! (e.g. https://github.com/qiskit-community/ibm-quantum-challenge-2021/blob/main/content/ex5/ex5.ipynb)

- Ex. 3: **Quantum Approximate Optimization Algorithm (QAOA)**, a.k.a. The Knapsack Problem (see https://github.com/qosf/monthly-challenges/blob/main/challenge-2023.04-apr/terravenil/challenge-2023.04-apr.ipynb)

BONUS / ADDITIONAL PUZZLES (quantum games):

- Build a quantum battleship game with quantum CNOT gates (e.g. https://medium.com/qiskit/how-to-program-a-quantum-computer-982a9329ed02)
- Build a quantum battleship game with quantum measurements (e.g. https://decodoku.medium.com/how-to-program-a-quantum-computer-part-2-f0d3eee872fe)