

Womanium Quantum Hackathon 2022

Quantum-Hardware-Education-Challenge---QWorld

TEAM: “Quantumania”

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Quantum Mechanics for Computer Scientists

Contents:

Unit 1: Classical vs Quantum

- i) Brief History
- ii) Classical Bits and Qubits
- iii) Classical Gates
 - a) NOT-Gate
 - b) OR- Gate
 - c) AND-Gate
- iv) Quantum Gates
 - a) X-Gate
 - b) Z-Gate
 - c) Hadamard Gate
 - d) CNOT- Gate
- v) Exercise
- vi) Problem Set

Unit 2: Flavour of Quantum Mechanics

- i) Wave Function/State Representation
- ii) Bra-Ket Notation
- iii) Eigenstates and Eigenvectors
- iv) Hermitian and Non-Hermitian Matrices
- v) Vector Space and Tensor Product
- vi) Exercise
- vii) Problem Set

Unit 3: Fundamentals of Quantum Computing

- i) Bloch Sphere
- ii) Bell States or Superposition State
- ii) Entanglement
- iii) Quantum Cryptography
- iv) Quantum Teleportation
- v) Exercise
- vi) Problem Set

Unit 4: Quantum Circuits

- i) Quantum Algorithms
- ii) Single Qubit Operations
- iii) Controlled Operations
- iv) Measurement
- v) Universal Quantum Gates
 - a. Two-level unitary gates are universal
 - b. Single qubit and CNOT gates are universal
 - c. A discrete set of universal operations
 - d. Approximating arbitrary unitary gates
 - e. Quantum computational complexity
- vi) Simulation of quantum systems
- vii) Exercise
- viii) Problem Set

Unit 5: Quantum Error Correction

- i) Types of Quantum Errors
- ii) Barriers to Quantum Error Correction
- iii) The three-bit flip code
- iv) Correcting Phase Errors
- v) Exercise
- vi) Problem Set

Unit 6: Applications

- i) Quantum Simulation of the Schrödinger Equation
 - a) Problem description
 - b) Algorithm Explanation
 - c) Algorithm Implementation
- ii) Quantum Random Walks
 - a) Problem description
 - b) Example
 - c) Algorithm Implementation
- iii) Quantum Tomography
 - a) Problem description
 - b) Example
 - c) Algorithm Implementation

PS: We have prepared few topics with explanation, codes, problem set and solution just to give the flavour of how we want to execute our idea. Since the time was short so it's not possible to develop all the units but what we have suggested is to introduce this as a separate course so that people may learn the basics and have a hand on experience of quantum mechanics, and it would be easy for them to understand the Q-bronze, silver and nickel easily without the hesitation of what these quantum notations mean and how they work.