

Womanium Quantum Hackathon 2022

Quantum-Hardware-Education-Challenge---QWorld

Quantum Mechanics for Computer Scientists

Contents:

Unit 1: Classical vs Quantum

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

Unit 2: Flavour of Quantum Mechanics

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