COURSE OVERVIEW

Full Course Title: Quantum Computing for Beginners **Instructional Hours (Contact Hours):** 30

Course Description:

The 'Introduction to Quantum Computing' is designed to introduce the idea of quantum computing and algorithms whose fundamentals lie in the mechanics of the quantum world. The course involves rigorous derivation of the mathematical expressions from which quantum algorithms emerge. Furthermore, the course also covers practical implementation of various quantum algorithms using quantum SDK. The real-world application of quantum algorithms across different industries is also discussed in a detailed manner along with the implementation

Learning Outcomes:

- Understand the idea of quantum theory.
- Apply the idea of quantum theory to develop a new model computing and algorithms.
- Practically implement quantum algorithms from the basics to advanced level.

Learning Activities:

☒ Class Discussions/Discussion Boards
☒ Peer-to-Peer Work (pairs, small groups)
☒ Written Assignments (reports, essays)
☒ Case Study Analysis
☒ Student Projects
☒ Readings
☒ Textbook/Workbook Exercises
☒ Other: Click to enter

Methods of Assessment/Grading Criteria:

☒ Class/Discussion Boards Participation
☒ Written Assignments (reports, essays)
☒ Exams/Quizzes
☒ Individual Projects/Presentations
☒ Group Projects/Presentations
☒ Other: Click to enter

Course Topics:

- Unit 1 (Basics 1):

Theory: Idea of quantum computing, essential linear algebra, postulates of quantum mechanics, qubits, quantum gates, quantum circuit

Practical: IBM's Qiskit introduction, installation, composer, quantum state preparation quantum gates

- Unit 2 (Basics 2):

Theory: Multi partite system, entanglement, Bell's inequalities, Bell states, No cloning theorem, quantum teleportation and super dense coding

Practical: Multiple quantum states, two qubit gate, Bell state preparation, quantum teleportation and superdense coding

- Unit 3 (Quantum Algorithm 1):

Theory: Quantum oracle, phase oracle, quantum parallelism, Deutsch and Deutsch Jozsa algorithms, Bernstein Vazirani, Simon's algorithm, Grover's algorithm

Practical: Practical Implementation of Deutsch Jozsa algorithms, Bernstein Vazirani, Simon's algorithm, Grover's algorithm

Unit 4 (Quantum Algorithm 2):

Theory: Discrete Fourier Transform, Quantum Fourier Transform (QFT), quantum phase estimation (QPE), modular exponentiation, period finding, Shor's factorization algorithm, quantum key distribution (QKD), BB84 protocol

Practical: QFT, QPE, Shor's algorithm, BB84 protocol

Unit 5 (Quantum Computing, The Way Forward):

Theory: Quantum error correction. NISQ era, variational quantum algorithm (VQE), quantum adiabatic approximate optimization (QAOA), practical quantum computing, qubit modalities, challenges in QC research, Applications of quantum computing in finance, chemistry and material science, drug discovery.

Practical: VQE, QAOA, QC application in chemistry and finance.

Prerequisites:

Prior knowledge of quantum mechanics and linear algebra is desired. Basic understanding working of python is necessary.

Textbook:

1. Introduction to Classical and Quantum Computing by Tom Wong
2. Quantum computing explained by David McMahon
3. Quantum Computation and Quantum Information by Nielsen and Chuang

Other resources:

1. Introduction to Quantum Information Science by Scott Aaronson
2. Quantum Computation by John Watrous