Course Number: COSC 386

Course Title: Introduction to Quantum Computing

Number of Credit Hours: 3

**Catalog Description**:

COSC xxx Introduction to Quantum Computing – Three hours of lecture, 3 credits.

Quantum computation involves highly parallel, quantum entangled systems devoted toward solving problems considered to be computationally difficult for classical computers. This course introduces basic mathematical and programming structures necessary for understanding and implementing basic quantum circuits. Key concepts such as quantum measurement, projections, reversible computation, unitary operators, entanglement, quantum gates, gate equivalences, density matrix and the no-cloning theorem will be emphasized within the course.

Prerequisite: COSC 241 or equivalent, Quantum Mechanics for Computing Scientists

**Course Objectives**

Upon completion of this course, students will be able to do the following:

• Describe the computational complexity of quantum circuits for implementing various quantum algorithms.

• Analyze quantum circuits employing quantum operators.

• Demonstrate skills by implementing and coding quantum algorithms

**Course Content (Statement of Subject Matter):**

Unit 0: Review of complex numbers and quantum concepts

Unit 1: Complex vector spaces and quantum operators

Unit 2: Introduction to Qiskit and single qubit circuits

Unit 3: Multiple qubit circuits and entanglement

Unit 4: Random number generation

Unit 5: Addition on a quantum computer

Unit 6: Deutsch-Jozsa algorithm

Unit 7: Quantum computation project

**Course Schedule**

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| --- | --- | --- | --- |
| **Week** | **Unit** | **Unit Name** | **Computer Lab/Project** |
|  |  |  |  |
| 1-2 | 0 | Review of complex numbers and quantum concepts | Roots of unity |
| 3-4 | 1 | Complex vector spaces and quantum operators | Unitarity, eigenvalues and eigenvectors |
| 5-6 | 2 | Introduction to Qiskit and single qubit circuits | Computations and measurements with single qubit operations |
| 7-9 | 3 | Multiple qubit circuits and entanglement | Reversible computation, multiple qubit computation, CNOT, Toffoli gates |
| 10 | 4 | Random number generation | QRNG |
| 11-12 | 5 | Addition on a quantum computer | Half adder and n-bit Full adder |
| 13 | 6 | Deutsch-Jozsa algorithm | Balanced binary sequences |
| 14-15 | 7 | Quantum computation project | Final project: Reversible computation |
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**Bibliography:**

• Introduction to Quantum Computing. Ray LaPierre. Springer. ISBN-13: 978-3030693176, 2021.

• Quantum Computation and Quantum Information, M.A. Nielsen and I.L.Chuang, 10th Anniversary Edition. Cambridge. ISBN-13 ‏ : ‎ 978-1107002173, 2011