Course Number: COSC xxx

Course Title: Quantum Algorithms

Number of Credit Hours: 3

**Catalog Description**:

COSC xxx Quantum Algorithms – Three hours of lecture, 3 credits.

This course goes beyond the introductory level in order to more deeply quantify the implications of quantum computation. Applications such as machine learning, solutions to linear equations, search algorithms and cryptography will be discussed. Additionally, concepts involving quantum information will be

Prerequisite: Introduction to Quantum Computing

**Course Objectives**

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

• Describe quantum circuits for implementing various quantum algorithms.

• Analyze computational complexity of quantum algorithms

• Demonstrate skills by implementing and coding quantum algorithms.

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

Unit 0: Quantum computation and Qiskit review

Unit 1: Bernstein-Vazirani algorithm

Unit 2: Grover’s algorithm

Unit 3: Quantum Fourier transform

Unit 4: Addition using the QFT

Unit 5: Phase estimation

Unit 6: Shor’s algorithm

Unit 7: Maxcut algorithm

Unit 8: Subset sum algorithm

Unit 9: Solving linear systems of equations using HHL

Unit 10: Quantum machine learning

**Course Schedule**

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| --- | --- | --- | --- |
| **Week** | **Unit** | **Unit Name** | **Computer Lab/Project** |
|  |  |  |  |
| 1 | 0 | Quantum computation and Qiskit review | Subtractor design |
| 2 | 1 | Bernstein-Vazirani algorithm | Deutsch-Jozsa revisited |
| 3 | 2 | Grover’s algorithm | Database search |
| 4-5 | 3 | Quantum Fourier transform | Important QFT properties |
| 6 | 4 | Addition using the QFT | QFT adder |
| 7-8 | 5 | Phase estimation | Eigenvalue estimation |
| 9-10 | 6 | Shor’s algorithm | Factoring, discrete logarithms |
| 11 | 7 | Maxcut algorithm | Intro to optimization theory |
| 12 | 8 | Subset sum algorithm | NP complete problems |
| 13 | 9 | Solving linear systems of equations using HHL | Solutions of linear equations |
| 14-15 | 10 | Quantum machine learning | Quantum neural networks |
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**Bibliography:**

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

• Numerical Recipes in Quantum Information Theory and Quantum Computing. M.S. Ramkarthik. CRC Press. ISBN-13: 978-03677592852, 2021.