

# Knight Foundation School of Computing and Information Sciences

**Course Title:** Quantum Algorithms

**Date:** 11/7/2022

**Course Number:** COT 5XXX

**Number of Credits:** 3

<b>Catalog Description:</b> Introduction to quantum theory and a survey of standard and advanced quantum algorithms; implementation of algorithms on a simulated or real quantum system.
<b>Textbook:</b> “Quantum Computation and Quantum Information” (10 <sup>th</sup> Ed) Nielsen and Chuang ISBN-13: <a href="#">978-1-107-00217-3</a>
<b>References:</b> Online reference materials
<b>Prerequisites:</b> <a href="#">COT 5407</a> or <a href="#">COT 6405</a>
<b>Corequisites:</b> None

Type: Elective

Prerequisites Topics:

- Linear algebra
- Data structures
- Algorithm analysis

Course Outcomes:

1. Describe fundamental concepts of quantum computing [Understanding]
2. Discuss quantum computer architecture [Understanding]
3. Analyze standard quantum algorithms [Analyzing]
4. Summarize advanced quantum algorithms [Understanding]
5. Design and evaluate implementation of quantum algorithms [Creating]

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**Outline**

<b>Topic</b>	<b>No. of Lecture Hours</b>	<b>Outcome</b>
<ul style="list-style-type: none"> <li>• Overview of Quantum Computing               <ul style="list-style-type: none"> <li>○ Basic quantum mechanics</li> <li>○ Classical vs Quantum systems</li> <li>○ Quantum computer architectures</li> <li>○ Complex Numbers</li> <li>○ Linear Algebra – vector and matrix operations</li> </ul> </li> </ul>	4	1
<ul style="list-style-type: none"> <li>• Quantum States and Quantum Gates               <ul style="list-style-type: none"> <li>○ Dirac notation, Bloch sphere, Hilbert space</li> <li>○ Quantum superposition</li> <li>○ Single qubit gates</li> <li>○ Multiple qubit gates</li> <li>○ Quantum entanglement, Bell state</li> </ul> </li> </ul>	4	2
<ul style="list-style-type: none"> <li>• Standard Quantum Algorithms               <ul style="list-style-type: none"> <li>○ Deutsch-Jozsa Algorithm</li> <li>○ Bernstein-Vazirani Algorithm</li> <li>○ Simon’s Algorithm</li> <li>○ Grover’s Algorithm</li> <li>○ Quantum Fourier Transform</li> <li>○ Shor’s Algorithm</li> </ul> </li> </ul>	12	3
<ul style="list-style-type: none"> <li>• Advanced Quantum Algorithms               <ul style="list-style-type: none"> <li>○ Quantum Counting</li> <li>○ Quantum Walk Search Algorithm</li> <li>○ Quantum Teleportation</li> <li>○ Quantum error correcting code</li> <li>○ Quantum Key Distribution</li> </ul> </li> </ul>	6	4, 5
<ul style="list-style-type: none"> <li>• Challenges in Quantum Technology               <ul style="list-style-type: none"> <li>○ Quantum measurement</li> <li>○ Cloning theorem</li> <li>○ Scalability in real quantum systems</li> </ul> </li> </ul>	4	

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**Course Outcomes Emphasized in Laboratory Projects / Assignments**

	<b>Outcome</b>	<b>Number of Weeks</b>
1	Quantum mechanics & linear algebra exercises Outcomes: 1	2
2	Quantum circuit design Outcomes: 2	2
3	Implementation of simple quantum algorithms Outcomes: 3	3
4	Implementation of an advanced quantum algorithm Outcomes: 4, 5	5