

Course Title: Quantum Algorithms

Credit Hrs: 3

Prerequisites: Programming experience and basic quantum mechanics knowledge

Course Objectives:

1. Design and implement quantum algorithms for computational problems
2. Master quantum programming languages and development environments
3. Optimize quantum circuits for practical applications

Course Learning Outcomes: Students will be able to:

1. Implement fundamental quantum algorithms (Shor's, Grover's, etc.)
2. Design quantum circuits using quantum gates and operations
3. Program quantum computers using Qiskit, Cirq, or similar frameworks
4. Optimize quantum algorithms for NISQ-era devices

Course Contents:

| Week | Contents |
|-------------|---|
| 1-2 | Quantum gates, circuits, and computational models |
| 3-4 | Quantum Fourier Transform and phase estimation |
| 5-6 | Shor's algorithm for integer factorization |
| 7-8 | Grover's search algorithm and amplitude amplification |
| 9-10 | Variational quantum algorithms (VQE, QAOA) |
| 11-12 | Quantum machine learning algorithms |
| 13-14 | Quantum error mitigation techniques |
| 15-16 | Algorithm implementation on real quantum hardware |

Textbooks / References:

1. Nielsen, M.A. & Chuang, I.L. "Quantum Computation and Quantum Information" (2016)
2. Johnston, E.R. "Programming Quantum Computers" (2019)

Assessments

3. Assignments: 10%

4. Quizzes: 10%
5. Midterm Exam: 30%
6. Final Exam: 50%

Course Title: Research Project

Credit Hrs: 6

Prerequisites: Completion of at least 16 credit hours in the program

Objectives:

1. Conduct independent research in quantum information sciences
2. Develop research methodology and project management skills
3. Contribute to advancing knowledge in chosen specialization area

Learning Outcomes: Students will be able to:

1. Design and execute independent research projects
2. Apply quantum theories to solve real-world problems
3. Present research findings effectively
4. Collaborate with faculty on cutting-edge research

Research Areas:

1. Quantum algorithms for defense applications
2. Quantum sensor development and optimization
3. Novel quantum communication protocols
4. Post-quantum cryptography implementation
5. Quantum machine learning for cyber security
6. Quantum error correction improvements

Course Contents:

| Week | Contents |
|-------------|---|
| 1-2 | Research proposal development and methodology |
| 3-4 | Literature review and background study |
| 5-6 | Experimental design and planning |
| 7-8 | Data collection and initial analysis |
| 9-10 | Algorithm/system development and testing |

- 11-12 Results analysis and interpretation
- 13-14 Report writing and documentation
- 15-16 Presentation preparation and defense