Introduction to Quantum Computing

Fall 2024

Class Information

- **Instructor**: Hyosang Kang
- **Email**: hyosang@dgist.ac.kr
- **Office**: E7-G11
- **Office Hours**: make an appointment via email
- **Class Time**: Wed/Fri 13:00-14:30
- **Class Room**: E7-223

Grading

1. In-class participation: 30%

- There will be indivisual and group activities in class.
- Participation in these activities will be graded.

2. Project: 40%

- There are two projects in this course.
- Each project is worth 20%.
    - Project 1: Quantum Simulator
        - Based on what we cover in the first quarter of the class, we will construct a quantum simulator of our own.
        - There are no restrictions on the programming language or the platform.
        - The project will be done in groups.
        - There are Quantum Simulators such as Qiskit that you can refer to. (But you should not copy or reverse-engineer the code.)

- Project 2: Quantum Algorithm
  - Based on we cover in the second and third quarter of the class, you should device a quantum algorithm of your own.
  - The algorithm does not have to be new or original. It is ok to investigate and implement an existing algorithm.
  - You can use your abstract idea on Quanum Computing to develop the algorithm.
  - You can discover a real-life problem or a business item that could be solved by a quantum algorithm.

3. Report: 30%

- Each projects should be accompanied by a report.
- The report should follow the formal paper format, including an abstract, introduction, methodology, results, and conclusion.
- A template will be provided, but you can use your own format too.

Grade Scale

- The letter grade will be assigned based on the following scale:

Grade	Score								
A+	90-100	B+	65-74	C+	40-49	D+	15-24		
A0	80-89	B0	55-64	C0	30-39	D0	5-14		
A-	75-79	B-	50-54	C-	25-29	D-	1-4	F	0

- If you do not submit a project or a report, you will receive an F.
- Any act of plagiarism will result in an F.

Weekly Schedule

- **Week 1**: 1. Qubits
  - **Day 1**: 0. Orientation. 1-1. Vector Spaces
  - **Day 2**: 1-2. Qubits
- **Week 2**: 2. Quantum Gates
  - **Day 1**: 2-1. Matrices and multi-qubit systems
  - **Day 2**: 2-2. Operators and Quantum Gates
- **Week 3**: 3. Quantum Entanglement
  - **Day 1**: 3-1. Born's Rule
  - **Day 2**: 3-2. Quantum Entanglement and EPR Paradox

- **Week 4**: 4. Quantum Circuits
  - **Day 1**: Korea's Thanksgiving Day
  - **Day 2**: 4.1. Components of Quantum Circuits
- **Week 5**:
  - **Day 1**: 4.2. Computing Quantum Circuits
  - **Day 2**: TBA
- **Week 6**: 5. Early Quantum Algorithms
  - **Day 1**: 5.1. Deutsch-Jozsa Algorithm
  - **Day 2**: 5.2. Bernstein-Vazirani Algorithm, Simon Algorithm
- **Week 7**: 6. Quantum Fourier Transform
  - **Day 1**: 6.1. Discrete Fourier Transform
  - **Day 2**: 6.2. Quantum Fourier Transform
- **Week 8**: **Presentation Week**

- **Week 9**: Addendum
  - **Day 1**: Hangul Day
  - **Day 2**: BB84 Protocol
- **Week 10**: 7. Basic Number Theory
  - **Day 1**: 7.1. Continued fraction
  - **Day 2**: 7.2. Fermat's Little Theorem and
- **Week 11**: 8. Shor's Algorithm
  - **Day 1**: 8.1. Shor's Algorithm
  - **Day 2**: 8.2. Implementation of Shor's Algorithm
- **Week 12**: 9. Grover's Algorithm
  - **Day 1**: 9.1. Rotation and Projection Operators
  - **Day 2**: 9.2. Ideal Working of Grover's Algorithm

- **Week 13**: 10. Quantum Annealer
  - **Day 1**: 10.1. Quantum Annealer and QUBO
  - **Day 2**: 10.2. Max-Cut Problem, Graph Coloring Problems
- **Week 14**: 11. Quantum Error Correction
  - **Day 1**: 11.1. Quantum Decoherence and Syndrome Measurement
  - **Day 2**: 11.2. Quantum Error Correction Code
- **Week 15**: 12. Surface Code
  - **Day 1**: 12.1. Layout of Surface Code
  - **Day 2**: 12.2. Error Correction of Surface Code
- **Week 16**: **Presentation Week**