Phys334/Phys534/Math493/Math689   Fall 2022

Introduction to Quantum Computation and Quantum Information

Course description:

This course is designed to enable students to start on quantum computing and related research. It is suitable to those with STEM background and working knowledge of linear algebra. This goal will be achieved by studying three components. The first is the basics of quantum information and computation such as qubit, quantum gates, quantum circuits, quantum state and measurement. Simple excise of these concepts and principles leads to entanglement, non-cloning theorem, the dense coding and quantum teleportation, which are foundationally different from classical information protocols. The second component is quantum algorithms including Deutsch-Josza, Bernstein-Varirani, Simon's, Shor's, and Grover's algorithms and quantum error correction. The third part is hand–on projects on implementing the quantum algorithms with a software package (qiskit) developed by IBM. Both online quantum computers and simulators will be used.

Prerequisites: Phys260 or Phys270, Math203 or Phys301 (C all better)

Previous exposure to quantum mechanics is a plus but not required. Physics, Electrical Engineering, Computer science, Math, and other STEM majors are welcome.

Location: Exploratory Hall 1004, Course materials/HW on Blackboard

Time: 9:00-10:15am, Tuesday and Thursday

Instructor: Ming Tian

Office hour: TBD, mtian1@gmu.edu,

Textbook: "An Introduction to Quantum Computing", Kaye, Laflamme, Mosca.

Grades: Weekly homework (40), projects (60)

Projects: Pick an algorithms from a list, design the circuit, write code in jupyter notebook using Qiskit, run it on the simulator, and show the circuit diagram and measurement results. Submit your code in jupyter notebook along with a project report in word or pdf. The report should introduce the problem, describe the algorithm, and explain the results.

For graduate-level credit: run your code on the simulator AND a quantum computer available online and compare results in the report.

Course content

1. Overview/intro: from history to current state-of-art, start on IBM Q experience, Qiskit
2. Math review: Vectors and Operators (Ch2)
3. QM review: State, transformation, and measurement. (Ch3)
4. Quantum gates/circuits (Ch4)
5. Programming with Qiskit
6. Toy applications (Ch5)
7. Intro. to Quantum Algorithms (Ch6)
8. Algorithms with superpolynomial speedup (Ch7)
9. Algorithms based on Amplitude amplification (Ch8)
10. Quantum computational complexity (Ch9)
11. Quantum error correction (Ch10)

Honor Code: [http://academicintegrity.gmu.edu/honorcode]

Discussion on homework questions and projects are encouraged. However, you should write you own answers to homework problems, programing codes, and project reports

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