Quantum Information and Computation

Instructor: Ira Rothstein `izr@.andrew.cmu.edu`

Office hours: 4 PM Wed.

Course content: This course is an introduction to the physics of quantum information and quantum computing. It is assumed that the students know the basics of quantum mechanics at the level of two state systems. Some knowledge of thermodynamics is helpful but not essential. The first part of the class will follow lecture notes provided by the instructor. We will then use the book "Quantum Processes Systems, and Information" by Schumacher and Westmoreland starting at chapter 4. We will develop quantum gates and algorithms ultimately writing simple code for the IBM quantum computer. The last part of the class will deal with quantum decoherence and information loss. For this part of the class we will follow lecture notes provided by the instructor.

Here is a list of lecture topics in the order they will be addressed. The last part of the course is subject to change depending upon how much progress we are making.

1. Introduction to the notion of classical information and Shannon Entropy. Thermodynamics Chaos and informations loss.

2. Maxwells Demon, Landuaers Principle. (Reading: Lecture notes).

3. Principles of classical computation and complexity (Reading: Lecture notes).

4. Review of Quantum Mechanics: Evolution of quantum systems and unitary operations. Reading chapter 5.

5. Introduction to Entanglement and Bells Inequalities. Reading chapter 6.

6. No Cloning theorem and quantum information. Reading chapter 7.

7. Density matrices and ensembles, Reading chapter 8.

8. Decoherence and why the world looks classical (Reading: Lecture notes).

9. Quantum circuits, and quantum supremacy. Reading Chapter 18.

10. Programming IBM-Q. see website.

11. Classical and Quantum chaos and information loss (lecture notes).

12. Entanglement and many body theory (lectures notes).

13. Topological Quantum computing (lecture notes)

Class web page: The class web page will be on CANVAS. It will have all of the assignments as well as solutions to the homework.

E-mail: I encourage students to make use of e-mail for quick correspondence with me regarding lecture material, homework problems, or whatever. I will also use e-mail to communicate with the class at large.

Homework: Assigned approximatelyweekly and due prior to next assignment. Late homework accepted with a penalty for tardiness. The homework is an essential part of the course. I believe most of what you learn will come from doing the homework.
Exams: The final grade will be based upon homework (%20,), mideterm (% 30) and final (%50).