

decoherence. We will also introduce the basics of computational complexity.

We then cover the basic concepts of quantum information processing, and some of the algorithms and protocols developed in the last few years. The topics covered will include: quantum bits and registers; quantum cryptography; quantum gates and circuits; universal sets of quantum gates; basic quantum algorithms, including Deutsch's algorithm, Shor's factoring algorithm, and the search algorithm of Grover; decoherence, quantum error correction, and the idea of fault-tolerant quantum computation; and a brief overview of some of the proposals to implement quantum computing, their advantages and disadvantages, and current experimental progress.

Course Outline

Week	Subjects	Text pages & Homeworks
1	General overview. The Stern-Gerlach experiment and spin-1/2 particles. Quantum bits.	1-17, 42-50
2	Review of linear algebra; Dirac notation; projectors; decompositions of the identity; tensor products. Postulates of quantum mechanics. Quantum registers.	60-90
3	Unitary transformations and time evolution. Schrödinger equation. No-cloning theorem. Entangling interactions.	17-28 HW #1 due
4	Examples of implementations using optical systems. Quantum gates. Quantum circuits. Entanglement. Quantum teleportation. Measurement and interference. Born rule. Complementarity and uncertainty.	171-185, 50-58, 90-98,
5	BB84 quantum cryptography. Quantum operations. Shannon entropy. Classical bits, circuits and Boolean functions. Reversible and irreversible gates.	185-188, 120-169 HW #2 due
6	Computational complexity classes. Quantum oracles and Deutsch's algorithm.	28-42
7	Universal sets of quantum gates. Circuits and general unitary transformations. Quantum Fourier transform and period finding.	188-204, 216-221 HW #3 due
8	Phase estimation and Shor's factoring algorithm. Computational complexity of Shor's algorithm. Comparison to best classical algorithm.	221-247

Week _____ Subjects _____ Text pages & Homeworks

9	Grover's search algorithm. Midterm Exam.	248-255
10	Mixed states and density matrices. Completely positive maps. Partial trace. Von Neumann entropy. Decoherence and effect of environment. Schmidt basis. Effective evolutions. Master equations.	98-118, 353-373, Choose projects, HW #4 due
11	Quantum trajectories. Random error model. Simple error correction. Quantum error correcting codes. Stabilizer codes.	373-398 425-474
12	Operations on encoded q-bits. Concatenated codes. Fault-tolerant quantum computation. Threshold theorem. Brief overview of other topics in quantum information.	474-497 HW #5 due,
13	Implementations. The DiVincenzo criteria. Linear ion trap. NMR. Achievements to date. Prospects of other techniques. Other potential applications.	277-349 Projects due

14-15 Presentation of student projects.

Academic Responsibilities:

Academic Integrity

“The University, as an instrument of learning, is predicated on the existence of an environment of integrity. As members of the academic community, faculty, students, and administrative officials share the responsibility for maintaining this environment. Faculties have the primary responsibility for establishing and maintaining an atmosphere and attitude of academic integrity such that the enterprise may flourish in an open and honest way. Students share this responsibility for maintaining standards of academic performance and classroom behavior conducive to the learning process. Administrative officials are responsible for the establishment and maintenance of procedures to support and enforce those academic standards. Thus, the entire University community bears the responsibility for maintaining an environment of integrity and for taking appropriate action to sanction individuals involved in any violation. When there is a clear indication that such individuals are unwilling or unable to support these standards, they should not be allowed to remain in the University.” (Faculty Handbook, 1994:20)

Academic dishonesty includes: (Faculty Handbook, 1994: 21-22)

Examination behavior – any use of external assistance during an examination shall be considered academically dishonest unless expressly permitted by the teacher.

Fabrication – any intentional falsification or invention of data or citation in an academic exercise will be considered a violation of academic integrity.

Plagiarism – the appropriation and subsequent passing off of another's ideas or words as one's own. If the words or ideas of another are used, acknowledgment of the original source must be made through recognized referencing practices.

Other Types of Academic Dishonesty – submitting a paper written by or obtained from another, using a paper or essay in more than one class without the teacher's express permission, obtaining a copy of an examination in advance without the knowledge and consent of the teacher, changing academic records outside of normal procedures and/or petitions, using another person to complete homework assignments or take-home exams without the knowledge or consent of the teacher.

The use of unauthorized material, communication with fellow students for course assignments, or during a mid-term examination, attempting to benefit from work of another student, past or present and similar behavior that defeats the intent of an assignment or mid-term examination, is unacceptable to the University. It is often difficult to distinguish between a culpable act and inadvertent behavior resulting from the nervous tensions accompanying examinations. Where a clear violation has occurred, however, the instructor may disqualify the student's work as unacceptable and assign a failing mark on the paper.

Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me as early in the semester as possible. Your letter must be specific as to the nature of any accommodations granted. DSP is located in STU 301 and is open 8:30 am to 5:30 pm, Monday through Friday. The telephone number for DSP is (213) 740-0776.