Course Syllabus

ECE 398KF: Quantum Systems I

Description - This course provides a streamlined introduction to the physical and mathematical principles of quantum information processing. A variety of interdisciplinary topics will be covered from quantum mechanics, linear algebra, and computer science that collectively prepare the student for more advanced courses and research in quantum information science. Unlike traditional approaches to quantum mechanics, this course first introduces the concept of a qubit (or "quantum bit") and principles of finite-dimensional quantum systems before moving to the wave function and quantum particles in space.

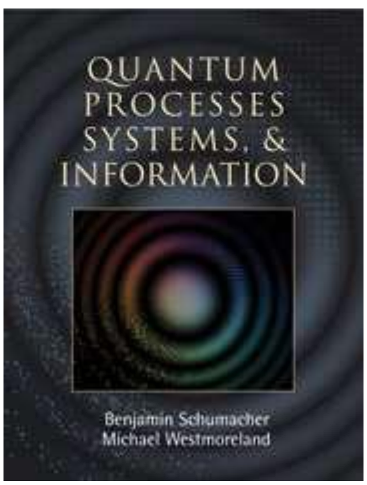
Prerequisites - PHYS 214

Instructor - **Prof. Kejie Fang (kfang3@illinois.edu)**

Office Hour - Mondays, 3-4PM

Textbook -

- Schumacher and Westmoreland, *Quantum Processes, Systems, and Information.*



A digital copy of this textbook can be obtained using the University's digital access to Cambridge University Press. Use this link

Homework, Exams, and Grading -

This course will have **homework assignments given every two weeks,** three midterm exams, and a final exam. Their relative contribution to the overall grade is as follows:

Homework	25%
Midterm Exams 1, 2, Final Exam	25% each

Course Outline -

Aug 22	Lecture 1	Bits and Information	S-W 1.1
Aug 24	Lecture 2	Quantum Systems and Wave-Particle Duality (complementarity, quantum probabilities)	S-W 1.2
Aug 29-31	Lecture 3	The Mach-Zehnder Interferometer (phase shifters, beam splitters, matrix representations, quantum sensing)	S-W 2.1
Sep 5-7	Lecture 4	Spin 1/2 particles (Stern-Gerlach experiment, bra-ket notation, measuring spin)	S-W 2.2
Sep 12	Lecture 5	Two-level atoms (time evolution, unitary operators and the Hamiltonian, transition probabilities)	S-W 2.3
Sep 14-19	Lecture 6	Schrodinger's equation (free particles, particles in a box)	S-W 11.1-2
Sep 21	Review		
Sep 26	Exam 1		
Sep 28 – Oct 3	Lecture 7	Hilbert Space (Eigenvalues/Eigenvectors, Spectral Decomposition)	S-W 3.1
Oct 5 – 10	Lecture 8	Operators and Observables (Pauli matrices, Trace, Expectation values, Adjoints)	S-W 3.2 -- 3.4
Oct 12	Lecture 9	Uncertainty principle	S-W 4.5
Oct 17-19	Lecture 10	Quantum Dynamics (Unitary evolution, Heisenberg picture)	S-W 5.1-5.2

Oct 24-26	Lecture 11	Ladder system (Quantum harmonic oscillators, coherent states)	S-W 13.1-3
Oct 31	Exam 2		
Nov 2 – 7	Lecture 12	Entanglement (Tensor products, interactions)	S-W 6.1-6.3
Nov 9	Lecture 13	EPR and Bell's Theorem	S-W 6.5-6.6
Nov 14 – 16	Lecture 14	Quantum Communication (Distinguishability, the Projection axiom, teleportation, entanglement swapping)	S-W 4.1-4.4
Nov 20-24	Thanksgiving break		
Nov 28 – 30	Lecture 15	Quantum computing	S-W 18.1-3
Dec 5		Review	