Graduate Course in WINTER 2016
EECS598: Quantum Information, Quantum Probability and Quantum Computing

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Description: The failures of classical theories to explain important physical phenomena led to revolutionary and unprecedented changes in our thinking, and, in turn, to the development of quantum mechanics in the first half of the twentieth century. It turns out that the laws of quantum mechanics lead to a new theory of probability (quantum probability) which is a non-commutative generalization of classical theory of probability. It was long believed that information processing and computing were solely mathematical constructs and as such were independent of nature and the laws of quantum mechanics. In the 1980s this assumption was found to be untrue, and the consequences have been profound. The introduction of quantum mechanics into communications and computation has produced new paradigms (quantum information) and some unforeseen results in the fields of computation, communications and learning. For example, quantum algorithms have now been found for factoring composite numbers (Shor's algorithms 1994). In contrast, there are no known practical (i.e., polynomial time) classical solutions for the problem. Moreover, recently quantum probability models have been proposed for human cognition to explain question-order-effects in polling and violations of rational decision theory. This course is an introduction to this general area. A basic working knowledge of linear algebra is a prerequisite, but no prior knowledge of quantum mechanics, classical computing or information theory is assumed. Graduate students in all areas of engineering, computer science, system theory, the physical sciences and mathematics should find this material of interest.

Syllabus: Extended introduction and overview of the field; linear algebra fundamentals; postulates of quantum mechanics; quantum probability models, quantum circuits and gates; entanglement, teleportation and Bell's inequality; quantum computation and algorithms, introduction to quantum error-correcting codes; quantum data compression (Von Neumann entropy); quantum communications (as time-permits).

Text: Quantum computation and quantum information by Nielson and Chuang