Quantum Computation for the Curious
Student Taught Course, Winter 2011

Student Instructor: Gabriel Mendoza (Senior, Independent Study in Physics and Computer Science)

Sponsoring Professor: John Preskill

Course Description: Quantum computers use quantum resources, resources present at the smallest physical scales, to process information. In some cases, this can lead to a significant speed advantage over classical computers. How significant is this speed advantage? For the problem of prime factorizing large integers, this may mean the difference between finding a solution in a day versus finding a solution in the age of the universe! In addition to potential practical applications, studying quantum computers has led to important insights in foundational physics and computer science.

This course introduces the basics of quantum computation and quantum information, with an emphasis on the ideas behind the subjects. Topics covered will include quantum physics, computational complexity theory, major quantum algorithms, quantum error-correction and fault-tolerance, and physical implementations of quantum computers. Advanced physics, computer science, and mathematics background is not required, and underclassmen are particularly encouraged to enroll.

Format: This class will meet once a week for an hour. Homework will consist of readings and one problem set per week, usually consisting of 2-3 problems. Problem sets will be graded on a 0/1 scale, with a 1 given if the majority of the set is correct or if reasonable effort is evident.

Topics by class:
Class 1: Overview, intro to quantum physics, double slit experiment, basics of complexity theory, qubits
Class 2: Logic gates, quantum circuits, Deutsch-Jozsa algorithm, Grover's algorithm
Class 3: Quantum teleportation, quantum entanglement, intro to quantum cryptography
Class 4: Shor's algorithm
Class 5: Decoherence, quantum error correction, fault-tolerance
Class 6: Measurement-based quantum computation, quantum games, quantum money, and other topics
Class 7: Physical implementations: photons, ions, superconducting qubits
Class 8: Other QIS technology: quantum cryptography, lithography, metrology, microscopy
Class 9: Advanced topics: topological QC, adiabatic QC, and quantum simulation

Books: The Temple of Quantum Computing by Riley Perry
(optional): Quantum Computation and Quantum Information by Michael Nielsen and Isaac Chuang

Instructor Qualifications: I have studied quantum computation and quantum information science for six years, and conducted research in the fields for four years that have resulted in publications and presentations. I have conducted theoretical research on quantum error correction and fault-tolerance at the Institute for Quantum Information at Caltech, experimental research in optical quantum computation at the Centre for Quantum Photonics at University of Bristol, research in noise in unconventional computers at Harvard University, and experimental research on superconducting approaches to quantum computation at UCSB. In addition, I have completed several courses related to the topic at Caltech.