Quantum Computation Project Topics

Due: December 6th

Electronic submissions only (.pdf or .doc files of reasonable size)

We expect a 10-20 page paper for the undergraduate credit and a 15-30 page paper for the graduate credit (roughly 1.5 spaced with 12pt font). The length also depends on the nature of your topic. Please discuss your topic with at least one of the instructors. You can work in groups of size 2 to 3 if you wish, with proportionately longer projects. Your target audience should be your fellow classmates.

Write a paper on one of the following topics or any other topic that one of the instructors approves. We will try to add more suggestions to the following list, and can provide more information on request. A good reference for some of these topics is the book "The Physics of Quantum Information", edited by Bouwmeester, Ekert and Zeilinger.

1. Ensemble quantum computation.
2. Quantum cryptography. Chapter 2 of "The Physics of Quantum Information". Better yet, read http://www.cs.mcgill.ca/%7Ecrepeau/CRYPTO/Biblio-QC.html and go over some of the bibliography cited there.
3. Quantum Repeaters. See Chapter 8 of "The Physics of Quantum Information" and quant-ph/9808065, quant-ph/9803056 at xxx.lanl.gov.
4. Privacy Amplification. Classical and Quantum.
5. Quantum Computational Complexity and Communication Complexity. Start with quant-ph/9906111
6. Quantum Computer Algorithms. Start with quant-ph/9903061
7. Quantum Self Testing. Start with quant-ph/9904108 and look at some of the references to other work in self-testing.
8. Quantum Turing Machine. A great place to start is http://epubs.siam.org/sam-bin/dbq/toc/SICOMP/26/5
9. Lower Bounds for QC. Start with quant-ph/9802049
10. Approximate QFT.
11. Bell's Theorem
12. Quantum Teleportation.
13. Entanglement Purification.

14. The Polynomial Method for proving lower bounds. Start with quant-ph/9802049.

15. Geometrical Quantum Computing. Start with quant-ph/9910052v2 and quant-ph/0004015

16. Quantum Error Correction. Start with quant-ph/0207170 and chapter 7 of Preskill's notes available at http://www.theory.caltech.edu/people/preskill/ph229.

17. Fault-Tolerant quantum Computation. Start with quant-ph/9712048.

18. Simulation of quantum systems with quantum computers. Start with R.Feynman, "Simulating physics with computers", *Int. J. Theor. Phys,*, **21**, 467 (1982); S.Lloyd, "Unversal quantum simulators", *Science*, **273**, 1073 (1996); C.Zalka, "Simulating quantum systems on a quantum computer", *Proc. R. Soc. London A*, **454**, 313 (1998).

19. Experimental simulations of quantum systems with quantum computers, an example being NMR. Start with S. Somaroo *et al.*, "Quantum simulations on a quantum computer", *Phys. Rev. Lett.*, **82**, 5381(1999); C.H. Tseng *et al.*, "Quantum simulations with natural decoherence", *Phys. Rev. A*, **62**, 032309 (2000).

20. Physical Implementation of Quantum Computers. Start with D.P. DiVincenzo, "Quantum Computation", *Science*, **270**, 255 (1995) and quant-ph/0002077.

21. Ion trap for quantum computers. Look at J.I. Cirac and P.Zoller, "Quantum computations with cold trapped ions", *Phys. Rev. Lett.*, **74**, 4091 (1995); C. Monroe *et al.*, "Demonstration of a fundamental quantum logic gate", *Phys. Rev. Lett.*, **75**, 4714 (1995); B. Schwarzschild, "Labs demonstrate logic gates for quantum computation", *Physics Today*, March 1996, pp. 21; A. Steane, "The ion-trap quantum quantum information processor", *Appl. Phys. B-Lasers and Optics*, **64**, 623(1997).

22. Nuclear Magnetic Resonance QC. Check out quant-ph/0207172.

23. Cavity QED QC. To start look at Q. Turchette *et al.*, "Measurement of conditional phase shifts for quantum logic", *Phys. Rev. Lett.*, **75**, 4710 (1995) and T. Pellizzari, Decoherence, "Continuous Observation and Quantum Computing: A cavity QED Model", *Phys. Rev. Lett.*, **75**, 3788 (1995).

24. Optical Implementations of QC. Start with linear optics quantum computing: E. Knill *et al.*, "A scheme for efficient quantum computation with linear optics", *Nature*, **409**, 46 (2001).

25. Kane QC. Look at B.E. Kane, "A silicon-based nuclear spin quantum computer", *Nature*, **393**, 133 (1998) and quant-ph/9905096.

26. Quantum Dot QC. Check out D. Loss and D.P. DiVincenzo, "Quantum computation with quantum dots", *Phys. Rev. A*, **57**, 120 (1998); A. Imamoglu *et al.*, "Quantum information processing using quantum dot spins and cavity QED", *Phys. Rev. Lett.*, **83**, 4204 (1999).