

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics & Department of Applied Math

MIT 6.443J / 8.371J / 18.409 / MAS.865

Quantum Information Science

February 7, 2006

General Information & Syllabus

General Information:

Prereq.: 2.111 / 18.435J / ESD.79

Units: 3-0-9

Advanced graduate course on quantum computation and quantum information. Prior knowledge of quantum mechanics and basic information theory is required. The first semester of this two-course sequence (2.111 / 18.435J) was taught by Seth Lloyd in the Fall of 2005, and covered quantum algorithms, quantum error correction, cryptography, and introduced fault tolerance. This semester, we will cover models of quantum computation, advanced quantum error correction codes, fault tolerance, quantum algorithms beyond factoring, properties of quantum entanglement, and quantum protocols and communication complexity.

Lectures: Tuesday & Thursday 2:30-4pm, Room 36-153

Instructors: Prof. Isaac Chuang, 26-251 <ichuang@mit.edu>

Prof. Peter Shor, 2-284 <shor@math.mit.edu> ; office hours by appointment

TAs: TBA

Textbook: Quantum Computation and Quantum Information, by Nielsen and Chuang

Grading: Homework (4 problem sets) 40%, Project presentation 20% Project paper 40%

Schedule: Final project paper due on May 18, 2006

Web site: <http://www.media.mit.edu/quantum/8.371>

Syllabus:

[T 07-Feb] Lecture 1: Quantum operations ; operator sum representation ; system-environment model [PS#1 out]

[R 09-Feb] Lecture 2: Quantum error correction - criteria and examples

[T 14-Feb] Lecture 3: Calderbank Shor Steane codes

[R 16-Feb] Lecture 4: Stabilizers ; stabilizer quantum codes [PS#2 out, PS#1 due]

[T 21-Feb] No class (Monday schedule)

[R 23-Feb] Lecture 5: Topological quantum codes ; Kitaev's anyon model

[T 28-Feb] Lecture 6: Stabilizers II ; computing on quantum codes

[R 02-Mar] Lecture 7: concatenated codes ; the threshold theorem [PS#3 out, PS#2 due]

[T 07-Mar] Lecture 8: Cluster state quantum computation

[R 09-Mar] Lecture 9: Measurement and teleportation based quantum computation

[T 14-Mar] Lecture 10: Adiabatic quantum computation

[R 16-Mar] Lecture 11: Quantum algorithms on graphs; quantum random walks [PS#4 out, PS#3 due]

[T 21-Mar] Lecture 12: Quantum algorithms: the abelian hidden subgroup problem ; QFT over S_n

[R 23-Mar] Lecture 13: The nonabelian HSP ; hidden dihedral group ; positive and negative results

[T 28-Mar] Spring Break

[R 30-Mar] Spring Break

[T 04-Apr] Lecture 14: Channels I: Quantum data compression; entanglement concentration; typical subspaces

[R 06-Apr] Lecture 15: Channels II: Holevo's theorem ; HSW theorem ; entanglement assisted channel capacity
[Project forms out, PS#4 due]

[T 11-Apr] Lecture 16: Channels III: quantum-quantum channels, mother/father protocol ; distillable entanglement

[R 13-Apr] Lecture 17: Entanglement as a physical resource

[T 18-Apr] MIT Holiday: Patriot's day

[R 20-Apr] Lecture 18: Quantum protocols - quantum communication complexity ; distributed algorithms [Project forms due]

[T 25-Apr] Lecture 19: Quantum games

[R 27-Apr] Lecture 20: Quantum cryptography

[T 02-May] Project meetings

[R 04-May] Project meetings

[T 09-May] Project presentations

[R 11-May] Project presentations

[T 16-May] Project presentations

[R 18-May] Project presentations

[R 18-May] All final project papers due