CSE 599Q: Intro to Quantum Computation

Instructor (me): James R. Lee
TA: Kasper Lindberg
Course info: https://homes.cs.washington.edu/~jrl/cse599Q/
CSE 599Q: Intro to Quantum Computation

Autumn 2022
T Th 11:30am-12:50pm in ARC 160
Instructor: James R. Lee
Office hours TBA
Teaching assistant(s):
  - Kasper Lindberg (TBA)
Course email list [archived]
Class discussion: CSE 599Q EdX
Course evaluation: 100% Homework

Reference material:
- Quantum Computer Science: An Introduction (Mermin)
- Quantum Computation and Quantum Information (Nielsen and Chuang)

Related context:
- Quantum computing (Saxon, VM)
- Quantum computer and quantum information (Doroshkevich, CMU)
- A CS theory talk
- Qubits, quantum mechanics, and computers (Barkeley)
- More emphasis on the physics perspective
- Quantum computing for the determined (Nielsen, youtube)
- Basics of QC w disposable Alice quantum states
- Quantum algorithms (QCI, MIT)
- Quantum algorithms based on Shor and Grover
- Quantum complexity theory (Aaronson, MIT)
- Quantum information science (Carole, MIT)
- Has quantum error correcting codes
- Online Quantum video lectures
- Relevant notes on the universe (Sean Carroll)

Course description:
An introduction to the field of quantum computing from the perspective of computer science theory.

Quantum computing leverages the revolutionary potential of computers that exploit the parallels of the quantum mechanical laws of the universe. Topics covered include:
- The axioms of quantum mechanics
- Quantum cryptography (quantum money, quantum key distribution)
- Quantum algorithms (Shor’s algorithm)
- Quantum information theory (mixed states, measurements, and quantum channels)
- Quantum state tomography (encoding and distinguishing quantum states)
- Quantum complexity theory
- Quantum error correction
- Quantum “Supernature”

Prerequisites: A background in undergraduate-level linear algebra, probability theory, and CS theory.

Lectures
- Dec 29: Computing with parallel universes

This, Dec 29
Computing with parallel universes

- Course overview
- The experimental origins of quantum mechanics
- Black-body radiation
- The photoelectric effect
- Spectra of hydrogen and the Rydberg formula
- Quantum cryptography
- Computational efficiency and computational models (deterministic, nondeterministic, quantum) and contrasting behaviors for problems like integer multiplication, a matching problem, and factorization

Relevant notes lecture: “12OctParallel Universes”
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An introduction to the field of quantum computing from the perspective of computer science theory. Quantum computing leverages the revolutionary potential of computers that exploit the parallelism of the quantum mechanical laws of the universe. Topics covered include:

- The axioms of quantum mechanics
- Quantum cryptography (quantum money, quantum key distribution)
- Quantum algorithms (Grover search, Shor's algorithm)
- Quantum information theory (mixed states, measurements, and quantum channels)
- Quantum state tomography (learning and distinguishing quantum states)
- Quantum complexity theory
- Quantum error correction
- Quantum "supremacy"

Prerequisites: A background in undergraduate level linear algebra, probability theory, and CS theory.
"Quantum computing is... nothing less than a distinctively new way of harnessing nature... it will be the first technology that allows useful tasks to be performed in collaboration between parallel universes."

"When a quantum factorization engine is factorizing a 250-digit number, the number of interfering universes will be of the order of $10^{500}$. This staggeringly large number is the reason why Shor's algorithm makes factorization tractable. I said [earlier in the book] that the algorithm requires only a few thousand [or maybe a million] operations. I meant, of course, a few thousand parallel operations in each universe that contributes to the answer. All those computations are performed in parallel, in different universes, and share their results through interference."

Quotes from David Deutsch (cofounder of quantum computing)
quantum computation

Math ∩ CS ∩ Physics
quantum mechanics arose from observations

Blackbody radiation problem

Photoelectric effect

Spectral lines
Foundations of quantum mechanics: 1900–1925

Quantum computation: 1980+
(Benioff, Feynman, Manin, Deutsch, ...)

hacking the universe
all aboard the hype train