EECS4141

Quantum Computing

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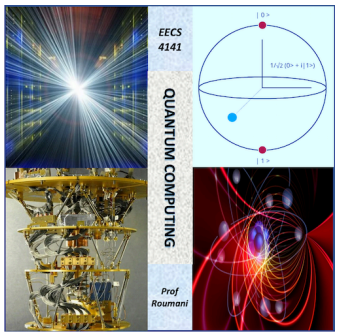

I. Calendar Description

This course presents an overview of the quantum computing field without assuming any prior exposure to quantum mechanics. Drawing parallels between quantum and classical computing, the course covers the physical layer briefly before moving to quantum gates, the circuit model, and quantum algorithms. Quantum information is covered through applications. *Prerequisites*: Math1025 or equivalent Linear Algebra course (plus for EECS students only: EECS2021, EECS3101).

II. Topics

1. **Foundational Concepts**
   - *Quantum vs Classical*
   - *The Qubit and its physical realizations*
   - *The Formalism: State representation, superposition and entanglement*
2. **Quantum Computation**
   - *The Quantum Circuit Model & Oracle Complexity*
   - *Quantum Fourier transform & Factoring*
   - *Quantum Search Algorithms*
3. **Quantum Information**
   - *Concepts and Communication Complexity*
   - *Super-dense Coding & Quantum Error Correction*
   - *Quantum Cryptography*

III. Expected Learning Outcomes

1. Employ linear algebra to represent, transform, and measure a quantum state.
2. Design a quantum circuit or determine the function of a given one.
3. Analyze a given quantum algorithm and run it using Qiskit or a similar platform.
4. Demonstrate the potential of and the challenges in building quantum computers.
5. Build a secure channel using quantum cryptography.

IV. Textbook

None Required.

Recommended resources:

- *Quantum Computing, A Gentle Introduction*
  By: Eleanor Rieffel and Wolfgang Polak,
  MIT Press Prentice Hall (2014), ISBN: 978-0-262-01506-6.
- *Quantum Computation and Quantum Information*
  By: Michael A. Nielsen and Isaac I. Chuang,
  Cambridge University Press (2010), ISBN: 978-1-107-00217-3.
- *Introduction to Quantum Computing*
  By: Philip Kaye, Raymond Laflamme, and Michele Mosca
  Oxford University Press (2007). ISBN 978-0-19-857049-3.

References:

- *Algorithms* (chapter 10)
  By: S. Dasgupta. C. H. Papadimitriou, and U. Vazirani, McGraw-Hill (2008).
- *Quantum Computing since Democritus*
  By: Scott Aaronson, Cambridge University Press (2013).
- *Bacon's notes, Dave Bacon, University of Washington,*
  https://courses.cs.washington.edu/courses/cse599d/06wi/
- *Preskill's notes, John Preskill, Caltech,*
  http://www.theory.caltech.edu/people/preskill/ph229/

V. Assessment & Weekly Schedule

See the course website.