Computing and Quantum Computing RPI, 2022

A *theory* course on computing, starting with Turing Machines and Boolean circuits, and ending with Quantum Computing. Students must have a strong background in discrete mathematics, probability and linear algebra, but no background in quantum mechanics or physics is needed. The range of topics is from Turing Machines and solvability to the theory of Quantum Computing and new problems it can solve.

**1. Theory of Computing.**

(i) Quick review of Languages, DFA, PDA.
(ii) Turing Machines, P, NP.
(iii) NP hardness and Boolean Circuits.
(iv) Factoring and discrete logarithm.

**2. Theory of Quantum Computing (tentative outline).**

(i) Quantum computing basics.
(ii) Quantum circuits.
(iii) Feasible Quantum Computing.
(iv) Factoring and Discrete Logarithm.
(v) Why don't we have quantum computers yet?

**Texts (not required):**
Quantum Computing for Computer Scientists, Yanofsky and Mannucci, Cambridge.
Discrete Mathematics and Computing (DMC), Magdon-Ismail, dmc-book.com.

**Learning Outcomes.** Students entering this course should have a solid mathematical foundation in discrete mathematics, probability and linear algebra, in addition to a sound understanding of algorithms. This course will build from here to develop a a theoretical understanding of computing, quantum computing and the limits of computing, both theoretical and those implied by physics. The student will leave the course with an understanding of the basic paradigms of computing, the hard problems and the unsolveble problems. In addition the student will learn the potential that quantum computing has to offer and some of the hard problems it solves. The student should be able to identify problems which are classically solvable, and those not solvable. The student should be able to formulate quantum algorithms for basic problems and analyze their feasibility and performance. The student should gain familiarity with the basic mathematical techniques and be able to read and critique recent published literature in the field.

**Prerequisites.** CSCI 2200,2300; MATH2010. Linear algebra and probability (MATH4100 or PHYS4100).

**Grade.** The final grade is 100% based on homeworks. 4xxx and 6xxx levels are separately curved in the standard way.

**Collaboration and Academic Dishonesty.** Discussion is allowed. Copying (from **anywhere** is not. You should write and understand all solutions yourself. Treat your work with pride and respect the work of others. If you use 3rd party work, cite it. Plagiarizing is a **serious issue**. In cases of academic dishonesty, the minimum penalty will be an automatic grade of F, in addition to other institute mandated protocols.

**Late Assignments.** The late penalty is 20% per day (except in institute established illness or emergency).