Theory of Computation (CS3102) Syllabus
University of Virginia
Professor Gabriel Robins

Course description (as listed in the undergraduate catalog): Introduces computation theory including grammars, finite state machines and Turing machines; and graph theory.

Special emphasis will be placed on basic models, unifying ideas, problem solving, the "scientific method", as well as elegance, insights, and generalizability in constructing mathematical proofs.

Prerequisites: Discrete mathematics (CS2102) or equivalent

Textbook: **Introduction to the Theory of Computation**, by Michael Sipser, 2005, Second Edition
Supplemental reading: **How to Solve It**, by George Polya, Princeton University Press
Selected papers at: http://www.cs.virginia.edu/~robins/CS_readings.html

Office hours: right after every class lecture, and other times by appointment (also Email Q&A and course blog)

Class structure: two exams (midterm and final), several problem sets, with problems taken from the textbook and other sources, and a term project (involving implementing and demoing some theory-related concepts, ideas, and/or algorithms). Extra credit will be given throughout the semester for solving challenging problems.

A brief history of computing:
- Aristotle, Euclid, and Eratosthenes
- Fibonacci, Descartes, Fermat, and Pascal
- Gauss, Euler, and Hamilton
- Boole, De Morgan, Babbage and Ada Agusta
- Venn, Bachmann, Carroll, Cantor and Russell
- Hardy, Ramanujan, and Ramsey
- Godel, Church, and Turing
- von Neumann, Shannon, Kleene and Chomsky

Fundamentals:
- Set theory
- Predicate logic
- Formalisms and notation
- Infinities and countability
- Dovetailing / diagonalization
- Proof techniques
- Problem solving
- Asymptotic growth
- Review of graph theory

Formal languages and machine models:
- The Chomsky hierarchy
- Regular languages / finite automata
- Context-free grammars / pushdown automata
- Unrestricted grammars / Turing machines
- Non-determinism
- Closure operators
- Pumping lemmas
- Non-closures
- Decidable properties

Computability and undecidability:
- Basic models
- Modifications and extensions to models
- Computational universality
- Decidability
- Recognizability
- Undecidability
- Rice's theorem

NP-completeness:
- Resource-constrained computation
- Complexity classes
- Intractability
- Boolean satisfiability
- Cook-Levin theorem
- Transformations
- Graph clique problem
- Independent sets
- Hamiltonian cycles
- Colorability problems
- Heuristics

Other topics (as time permits):
- Generalized number systems
- Oracles and relativization
- Zero-knowledge proofs
- Cryptography & mental poker
- The Busy Beaver problem
- Randomness and compressibility
- The Turing test
- AI and the Technological Singularity