Theory of Computation (CS6160) Syllabus
University of Virginia
Professor Gabriel Robins

Course description (as listed in the graduate catalog): analyzes formal languages, the Chomsky hierarchy, formal computation and machine models, finite automata, pushdown automata, Turing machines, Church's thesis, reductions, decidability and undecidability, and NP-completeness.

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

Prerequisites: Discrete mathematics (CS2102) or equivalent

Textbook: **Introduction to the Theory of Computation**, by Michael Sipser, 2006
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: after every class lecture, and other times by appointment
Also Email Q&A and a running course-related 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.

Milestones in Computability and Logic:
- Axiomatic systems
- Principia Mathematica
- Godel's Incompleteness Theorem
- The Turing / Church thesis
- The infinity hierarchy
- Independence of the axioms
- Hilbert's Tenth Problem
- Information Theory
- Self-reproduction
- Formal languages
- Complexity theory
- Completeness
- Surreal numbers

Beyond the Chomsky hierarchy:
- Review of the Chomsky hierarchy
- Two-way finite automata
- Generalized finite automata
- State set minimization
- Left/right linear grammars
- Infinite automata
- Deterministic context-free languages
- Counter automata and languages
- Ambiguity in grammars and languages
- Grammar parsing
- Context-sensitive grammar
- The Turing test

Advanced undecidability:
- Context-free intersections
- Post correspondence problem
- Linear-bounded automata
- Turing reducibilities
- Computational universality
- Conway's Game of Life
- Busy beaver problem
- The recursion theorem
- Oracles and relativizations
- Non-recognizability
- Turing degrees
- Randomness, compressibility, and entropy

Advanced complexity theory:
- Time and space complexity classes
- Complexity hierarchies / separations
- NP-completeness reloaded
- Problem reductions
- Graph colorability
- Set cover problem
- Knapsacks and subset sums
- Savitch's Theorem
- PSPACE completeness
- NL completeness
- Approximation algorithms
- Zero-knowledge proofs
- Arthur-Merlin games