1 Other Topics

1.1 Other kinds of computation

These include:

1. Hypercomputation is computation that cannot be done on a Turing machine. There are actually conferences discussing this topic. A paper about this can be found here:

   http://arxiv.org/ftp/math/papers/0209/0209332.pdf . Also see the Wikipedia article at

   http://en.wikipedia.org/wiki/Hypercomputation .

2. Quantum computation. This involves randomness, but does not go beyond Turing computability.

3. DNA computation

Also Chaitin's Ω is a real, irrational, uncomputable number between zero and one that roughly tells the probability that a random Turing machine will halt. If this number were known exactly, we could solve the halting problem.

1.2 Historical Perspective

The *Chomsky hierarchy* was formerly taught, consisting of the following:

language	grammar	machine
regular languages	regular grammars	dfa
context-free languages	context-free grammars	pda
context-sensitive languages	context-sensitive grammars	linear bounded automata
recursive languages	?	Turing machines that always halt
r.e. languages	general grammars	Turing machines

Context-sensitive grammars have productions of the form $\alpha \to \beta$ where $|\alpha| \leq |\beta|$. Linear bounded automata are Turing machines restricted not to move beyond the tape on which the input is written. Regular grammars have productions of the form $A \to aB$ or $A \to a$. General grammars are also called type 0 grammars, phrase structure grammars, unrestricted grammars, or semi-Thue grammars.

1.3 NP Completeness

This area considers the time taken by deterministic and nondeterministic Turing machines as functions of the length of the input. In particular, which problems can be solved within polynomial time by a deterministic or a nondeterministic Turing machine. These are called P and NP, respectively. The big question is whether $P = NP$. Many problems of practical importance are in the class NP but are not known to be in P. These include the traveling salesman problem, graph coloring, Boolean satisfiability, and many, many others. Currently these problems require exponential time on a deterministic computer, so heuristics are often used to attempt to solve them.