Introduction to Theory of Computing	Problem Set 6
CS 481 Fall 2004	Due Friday, October 15, 2004

Reading. To review the material for this week read Sections 19, 20 and 21 of Kozen.

We will have an in class prelim on Wednesday, October 20th. Review questions for the prelim, and sample questions from past prelims will be available on Friday, October 15th.

Please turn in Problem 1 and Problem 2 separately with your name and cornell.edu email written on both.

(1) Give a context free grammar generating the following languages over the alphabet $\Sigma = \{a, b, c\}$.

(a) $\{a^n b^n c^k | n, k \geq 0\}$

(b) $\{a^n b^k c^n | n, k \geq 0\}$

(c) set of words whose length is odd, and the middle character is an a.

(d) set of words $w \in (a+b)^*$ where $\#a(w) \geq \#b(w)$. **Hint:** consider the graph of differences $\#a(x) - \#b(x)$ over prefixes of x analogous to our graph for the language of balanced parentheses.

(e) Let A be the language in part (a). Give a grammar in Chomsky normal form for $A \setminus \{\varepsilon\}$.

(2) A *(strongly) right-linear grammar* is a CFG in which all productions are of the form $A \to aB$, $A \to a$, or $A \to \varepsilon$ where A, B are nonterminals and $a \in \Sigma$ is a word of terminals. We showed in class that all regular languages are context free. Here we claim that regular languages are exactly those that can be generated by a strongly right-linear grammar.

(a) Assume that you are given deterministic finite automata M. Show how to construct a strongly right-linear grammar that generates $L(M)$. You have to give the construction only, do not have to formally prove that it works.

(b) Consider a language a strongly right-linear grammar G. Show how to define a finite automata M (may be DFA or NFA) that accepts the language $L(G)$. You have to give the construction only, do not have to formally prove that your construction works.