CSE 105: Introduction to the Theory of Computation, Fall 1999
HW2 Due Thursday, Nov. 4, at the beginning of class

Context-free Grammars and PDA's

1. For the following languages, give a CFG that generates it.
   - (a) { w in {0,1}* | w contains twice as many **1**'s as **0**'s}
   - (b) the set of regular expressions over { **a, b** }, using the alphabet { **a, b,** $\cup$, *****, $\circ$, **(,)**, ϵ, ϕ }. (Use Definition 1.26 on p. 64 of our text)
   - (c) the set of strings described by the regular expression $(01^*) \cup (10)^*$.
2. Describe a PDA that accepts { $a^n b^m c^q \mid n, m, q \geq 0$ and $q \neq n + m$}
3. Problem 2.2 in text.
4. Show the steps to putting the following grammar in Chomsky normal form: (Here, the terminals of the grammar are { + , *, (,), a })

   $E \rightarrow E + T \mid T$
   $T \rightarrow T * F \mid F$
   $F \rightarrow (E) \mid a$

5. Consider the grammar over the alphabet { sub, sup, c, (,) }

   $E \rightarrow E\mathbf{sub}E\mathbf{sup}E \mid E\mathbf{sub}E \mid E\mathbf{sup}E$
   $E \rightarrow (E) \mid c$

   Is the grammar ambiguous? Support your answer.

6. Show the following language is *not* context-free:

   { www | w is in { a , b }*}