

1. Convert the grammars in question 1 of Problem set 5 to Chomsky Normal Form.
 2. Use the pumping lemma to show that the following languages are not context free.
 - a) $\{0^n 1^n 0^n 1^n \mid n > 0\}$
 - b) $\{0^n \# 0^{2n} \# 0^{3n} \mid n > 0\}$
 - c) $\{w \# t \mid w \text{ is a substring of } t, \text{ where } w, t \in \{a, b\}^*\}$
 - d) $\{t_1 \# t_2 \# \cdots \# t_k \mid k > 2, \text{ each } t_i \in \{a, b\}^*, \text{ and } t_i = t_j \text{ for some } i \neq j\}$
 3. Show that, if G is a CFG in Chomsky normal form, then for any string $w \in L(G)$ of length $n > 1$, exactly $2n - 1$ steps are required for any derivation of w .
 4. Let G be a CFG in Chomsky normal form that contains b variables. Show that, if G generates some string with a derivation having at least $2b$ steps, $L(G)$ is infinite.
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