

HW 09 CMSC 452
Morally Due TUES April 8 11:00AM
Dead-Cat Due THU April 10 11:00AM

1. (50 points) A Leo-Grammar is a grammar where each rule is of one of the following forms:

$$AB \rightarrow CDE$$

$$AB \rightarrow CD$$

$$A \rightarrow BC$$

$$A \rightarrow \sigma$$

$$A \rightarrow e$$

For example, the following is a Leo-Grammar

$$S \rightarrow AA$$

$$SS \rightarrow ABB$$

$$A \rightarrow BB$$

$$AA \rightarrow AAA$$

$$A \rightarrow a$$

$$B \rightarrow b$$

I have no idea what this grammar generates, nor do I care.

(Note that Leo-Grammars are NOT context free grammars.)

We assume $\Sigma = \{a, b\}$.

If G is a Leo-Grammar then $L(G)$ is the set of strings in $\{a, b\}^*$ that G generates.

- (a) (15 points) Find a function f such that the following is true:
A Leo-Grammar with t nonterminals has $O(f(t))$ rules.
- (b) (15 points) Find a function g such that the following is true:
The number of Leo-Grammars with t nonterminals is $O(g(t))$.
- (c) (20 points) Find a function h such that the following is true:
 $\exists w \in \{a, b\}^$ of length $O(h(t))$ such that there is NO Leo-Grammar G with t nonterminals such that $L(G) = \{w\}$.*

2. (50 points)

(a) (15 points) Let $\Sigma = \{a, b, c, d\}$.

Give a Context Sensitive Grammar for the language

$$\{w : \#_a(w) = \#_b(w) = \#_c(w) = \#_d(w)\}.$$

How many rules does it have?

(b) (15 points) Let $\Sigma = \{a_1, a_2, \dots, a_n\}$.

Give a Context Sensitive Grammar for the language

$$\{w : \#_{a_1}(w) = \#_{a_2}(w) = \dots = \#_{a_n}(w)\}.$$

(you may use DOT DOT DOT in your grammar)

(c) (20 points) Find a function r such that your Context Sensitive Grammar from the last part has $O(r(n))$ rules.