

**Due: Tuesday, Apr. 6**  
**30 points**

On homework, you may discuss with other students in the course about how to solve a problem, but the write-up should be your own. You **must include the names** of any students you consulted with. Give credit where credit is due.

1. (8 pts) Using the pumping lemma, prove the following language is not context-free. Show all steps of the proof!

$$L = \{a^n b^j c^k \mid n < j < k, k > 0\}. \text{ For example, } aabbbcccc \in L.$$

2. (8 pts) Using the pumping lemma, prove the following language is not context-free. Show all steps of the proof!

$$L = \{w \in \Sigma^* \mid n(a) > n(b), n(b) = n(c)\}, \Sigma = \{a, b, c\}, n(a) = \text{number of } a\text{'s in } w. \text{ For example, } abcacbaa \in L.$$

3. (8 pts) Prove the following

- (a) The family of context-free languages is NOT closed under difference.
- (b) The family of context-free languages is closed under regular difference. That is, if  $L_1$  is context-free and  $L_2$  is regular, then  $L_1 - L_2$  is context-free.

4. (6 pts) Consider the following grammar:

$$\begin{aligned} S &\rightarrow ABD \\ A &\rightarrow Bc \mid aa \\ B &\rightarrow bB \mid \lambda \\ D &\rightarrow dDA \mid \lambda \end{aligned}$$

- (a) Compute FIRST and FOLLOW for all the variables in the grammar.
- (b) Compute the LL(1) parse table.

5. (**EXTRA CREDIT** 4 pts) Consider the following grammar:

$$\begin{aligned} S &\rightarrow aAa \mid aBc \\ A &\rightarrow bBf \mid bbBa \mid be \\ B &\rightarrow bbbd \mid b \end{aligned}$$

- (a) The grammar is LL( $k$ ) for what value of  $k$ ?
- (b) Give an example of a string in which  $k$  lookaheads are needed to parse the string and explain why fewer than  $k$  lookaheads will not work (where  $k$  is the value you choose in part (a)).