CP-414 Winter 2025 Assignment 3
Due: Monday, March 17

1. Consider the context-free grammar with the rules (**E is start variable**)

$E \to E + T \mid T$
$T \to T \times F \mid F$
$F \to (E) \mid a \mid b$

Give **parse tree** and **leftmost derivation** for each string

a) $a+b\times a+b$
b) $a\times a+b$
c) $(a+b) \times (b+a) + b$
d) $(((a)))$

2. Convert CFG from question 1 to an equivalent PDA using the procedure given in Theorem 2.20.

3. Consider the context free grammar with the rules (S is start variable, A and B are variables, 0 and 1 are terminals):

$S \to A \mid B \mid 1$
$A \to 0S1S$
$B \to 0S$

Show that this grammar is ambiguous, i.e., **give an example of a string in language** that has two **different leftmost** derivations, Show your work (in particular **show those derivations**). Try to find as short ambiguous string as possible.

4. Convert the following CFG (**A is start variable, 0 and 1 - terminals**) into an equivalent CFG in Chomsky normal form, using the procedure given in Theorem 9. **Show all intermediate steps**.

$A \to ABC \mid AC \mid B$
$C \to BC1 \mid B \mid \varepsilon$
$B \to 00 \mid \varepsilon$

5. Give a context-free grammar generating the language of all strings over alphabet **{0,1}** with the number of **0**s equal to the number of **1**s plus 2. For example, strings 010100, 110000, 0100, 1000, 010001 are in this language, while strings 0110, 1, 0, 0000000001 are not. **Justify correctness of your grammar.**

6. Consider two languages: $L_1=\{ x^n y^m x^m z^n \mid n>0, m>0\}$ and $L_2=\{ x^n y^n x^n z^m \mid n>0, m\geq 0\}$ over alphabet $\{x,y,z\}$. Show that one of them is context-free (by providing a context-free grammar that defines this language) and another is not context-free (by using Pumping Lemma for context free languages).

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