Albert-Ludwigs-Universität, Inst. für Informatik
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Theoretical Computer Science - Bridging Course
Winter Term 2020/21
Exercise Sheet 4

for getting feedback submit electronically by 12:15 p.m., Monday, November 30th, 2020

Exercise 1: Context-Free Grammar *(2+3 Points)*

For each of the following languages, give a context-free grammar to accept the language. The alphabet set is $\Sigma = \{0, 1\}$.

(a) $\{w \mid w \text{ contains at least three ones}\}$.

(b) $L_1 = \{w\#w' | w^R \text{ is a substring of } w', \text{ and } w, w' \in \{0,1\}^*\}$. [1]

Exercise 2: Chomsky Normal Form *(1+4 Points)*

Consider the following context-free grammar (CFG):

$$S \to aSb \mid D$$
$$D \to ccDc \mid \varepsilon$$

a) Which language does this grammar define?

b) Convert this CFG into an equivalent one in Chomsky Normal Form. Give the grammar you obtained after each step of the conversion algorithm.

Exercise 3: Constructing Pushdown Automata *(4 Points)*

Consider the language $L = \{a^n b^{2m} b a^n \mid m, n > 0\}$ over the alphabet $\Sigma = \{a, b\}$.
Construct a PDA $\mathcal{A}$ with $L(\mathcal{A}) = L$.

Exercise 4: Pumping Lemma for Context-Free Languages *(3+3 Points)*

Use the pumping lemma to show that the following languages over the alphabet $\Sigma = \{a, b\}$ are not context free:

(a) $\{ww \mid w \in \{a, b\}^*\}$

(b) $\{a^n b a^{2n} b a^{3n} \mid n \geq 0\}$

[1] w^R is achieved by reversing the order of the symbols in w.