

# Theory of Computer Science

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## Exercise Sheet 6

**Due: Wednesday, April 10, 2019**

**Exercise 6.1** (Chomsky Normal Form; 2 Points)

Specify a grammar in Chomsky normal form that generates the same language as grammar  $G = \langle \Sigma, V, P, S \rangle$  with  $\Sigma = \{a, b, c\}$ ,  $V = \{S, X, Y\}$  and the following rules  $P$ :

$$\begin{aligned} S &\rightarrow XY \\ X &\rightarrow c \\ X &\rightarrow cS \\ Y &\rightarrow abb \\ Y &\rightarrow aYb \\ Y &\rightarrow \epsilon \end{aligned}$$

**Exercise 6.2** (Length of Derivations in Chomsky Normal Form; 2 Points)

Let  $G$  be a grammar in Chomsky normal form and  $w \in \mathcal{L}(G)$  a non-empty word ( $w \neq \epsilon$ ), which is generated by  $G$ . Show that every derivation of  $w$  from the start variable of  $G$  consists of exactly  $2|w| - 1$  steps.

**Exercise 6.3** (PDAs, 2 Points)

Specify a PDA that accepts that language

$$L = \{w_1\$w_2 \mid w_1, w_2 \in \{a, b\}^* \text{ and } w_1 \text{ and } w_2 \text{ contain the same number of } as\}$$

over  $\Sigma = \{a, b, \$\}$ .

**Exercise 6.4** (Nondeterministic Turing Machines; 4 Points)

Consider language  $L = \{w\$w \mid w \in \{0, 1\}^*\}$  over  $\{0, 1, \$\}$ . Specify the state/transition diagram of an NTM  $M$  with  $\mathcal{L}(M) = L$ . Also explain the behaviour of your TM in words.