

1. Transform the grammar

$$\begin{aligned} S &\rightarrow (S) \mid A \\ A &\rightarrow SS \mid \epsilon \end{aligned}$$

into Chomsky normal form. Show also the intermediate stages.

2. Simulate the CYK-algorithm when it solves whether the strings *aaaa* and *aaaaaaaa* are produced by the following grammar:

$$\begin{aligned} S &\rightarrow AB \mid BC \\ A &\rightarrow BA \mid a \\ B &\rightarrow CC \mid b \\ C &\rightarrow AB \mid a \end{aligned}$$

In positive cases show also a parse tree for the string.

3. Simulate the CYK-algorithm when it solves whether the strings *11001* and *00110* are produced by the following grammar:

$$\begin{aligned} S &\rightarrow AS \mid 1 \\ A &\rightarrow SA \mid 0 \end{aligned}$$

In positive cases show also a parse tree for the string.

4. Construct a push-down automaton for recognizing the following languages:

- (a)  $\{w c w^R \mid w \in \{a, b\}^*\}$
- (b)  $\{w \in \{a, b\}^* \mid w \text{ contains as many } a\text{'s and } b\text{'s}\}$

5. (a) Use the methods presented on the course to construct an  $\epsilon$ -automaton that corresponds to the regular expression  $(aa \cup bb)^*$ .
- (b) Construct a non-deterministic automaton (without  $\epsilon$ -transitions) that corresponds to the automaton in part (a).
- (c) Determinize the end result of part (b).
- (d) Minimize the end result of part (c).
6. Fill in the "Kurssikysely" question sheet that can be found at <http://ilmo.cs.helsinki.fi/kurssit/servlet/Valinta>. The questions are in Finnish. If you have trouble understanding them, ask a Finnish-speaking co-student or the lecturer at the exercise session.