

## Homework 7

1. Suppose the context-sensitive grammar

$$\begin{aligned} S &\rightarrow bSAA \mid \epsilon \\ A &\rightarrow a \\ bA &\rightarrow Ab \end{aligned}$$

where  $S$  is the starting symbol of the grammar. Give a derivation of the string "aaabaaabb". What can you say about the number of as and bs in the strings recognised by this grammar.

2. Consider the following grammar

$$\begin{aligned} S &\rightarrow N \cdot P \\ P &\rightarrow V \cdot N \\ N &\rightarrow N \cdot N \\ N &\rightarrow A \cdot N \\ N &\rightarrow \text{student} \mid \text{trainer} \mid \text{team} \mid \text{trains} \\ V &\rightarrow \text{trains} \mid \text{team} \\ A &\rightarrow \text{The} \mid \text{the} \end{aligned}$$

where  $S$  is the start symbol and  $S, P, N, V$  and  $A$  are non-terminals. Using the CYK-algorithm, check whether or not the following string can be parsed by the grammar:

The trainer trains the student team

3. Transform the grammar

$$\begin{aligned} A &\rightarrow 0A1 \mid BB \\ B &\rightarrow \epsilon \mid 2B \end{aligned}$$

into Chomsky normal form.

4. Consider the following grammar  $G$

$$\begin{aligned} S &\rightarrow \text{if}0 \cdot E \cdot \text{then} \cdot S \\ S &\rightarrow \text{print} \cdot S \\ S &\rightarrow \text{begin} \cdot B \cdot \text{end} \\ B &\rightarrow S \cdot ; \\ B &\rightarrow S \cdot ; \cdot B \\ E &\rightarrow \text{num} \end{aligned}$$

where  $S$  is the start symbol and  $S$ ,  $E$  and  $B$  are non-terminals.

Check each rule below and decide whether, when added to  $G$ , the combined grammar is ambiguous. If yes, give a string that has more than one parse tree.

- (i)  $S \rightarrow \text{if } 0 \cdot E \cdot \text{then} \cdot S \cdot \text{else} \cdot S$
- (ii)  $B \rightarrow B \cdot B$
- (iii)  $E \rightarrow (\cdot E \cdot)$
- (iv)  $E \rightarrow E \cdot + \cdot E$