Homework 7

1. Suppose the context-sensitive grammar

$$\begin{array}{lcl} S & ::= & bSAA \mid \epsilon \\ A & ::= & a \\ bA & ::= & Ab \end{array}$$

   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

$$\begin{array}{l} \boldsymbol{S} ::= \boldsymbol{N} \cdot \boldsymbol{P} \\ \boldsymbol{P} ::= \boldsymbol{V} \cdot \boldsymbol{N} \\ \boldsymbol{N} ::= \boldsymbol{N} \cdot \boldsymbol{N} \\ \boldsymbol{N} ::= \boldsymbol{A} \cdot \boldsymbol{N} \\ \boldsymbol{N} ::= \texttt{student} \mid \texttt{trainer} \mid \texttt{team} \mid \texttt{trains} \\ \boldsymbol{V} ::= \texttt{trains} \mid \texttt{team} \\ \boldsymbol{A} ::= \texttt{The} \mid \texttt{the} \end{array}$$

   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:

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The trainer trains the student team
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3. Transform the grammar

$$\begin{array}{lcl} A & ::= & 0A1 \mid BB \\ B & ::= & \epsilon \mid 2B \end{array}$$

   into Chomsky normal form.

4. Consider the following grammar G

$$\begin{array}{l} S ::= \texttt{if0} \cdot E \cdot \texttt{then} \cdot S \\ S ::= \texttt{print} \cdot S \\ S ::= \texttt{begin} \cdot B \cdot \texttt{end} \\ B ::= S \cdot \texttt{;} \\ B ::= S \cdot \texttt{;} \cdot B \\ S ::= num \\ E ::= num \\ B ::= num \end{array}$$

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) $S ::= \texttt{if0} \cdot E \cdot \texttt{then} \cdot S \cdot \texttt{else} \cdot S$
(ii) $B ::= B \cdot B$
(iii) $E ::= (\cdot E \cdot)$
(iv) $E ::= E \cdot + \cdot E$

5. Suppose the string "$9 - 5 + 2$". Give all ASTs that the following two grammars generate for this string.

   Grammar 1, where List is the starting symbol:

$$\begin{array}{lll} \mathit{List} & ::= & \mathit{List} + \mathit{Digit} \mid \mathit{List} - \mathit{Digit} \mid \mathit{Digit} \\ \mathit{Digit} & ::= & 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9 \end{array}$$

   Grammar 2, where String is the starting symbol:

$$\begin{array}{lll} \mathit{String} & ::= & \mathit{String} + \mathit{String} \mid \mathit{String} - \mathit{String} \mid \\ & & 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9 \end{array}$$