Homework 7

1. Suppose the context-sensitive grammar

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

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

   $S ::= N \cdot P$

   $P ::= V \cdot N$

   $N ::= N \cdot N$

   $N ::= A \cdot N$

   $N ::=$ student $\mid$ trainer $\mid$ team $\mid$ trains

   $V ::=$ trains $\mid$ team

   $A ::=$ The $\mid$ the

   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

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

   into Chomsky normal form.

4. Consider the following grammar G

$$
\begin{aligned}
S &::= \text{if0} \cdot E \cdot \text{then} \cdot S \\
S &::= \text{print} \cdot S \\
S &::= \text{begin} \cdot B \cdot \text{end} \\
B &::= S \cdot ; \\
B &::= S \cdot ; \cdot B \\
S &::= num \\
E &::= num \\
B &::= num
\end{aligned}
$$

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) $S ::= \mathtt{if0} \cdot E \cdot \mathtt{then} \cdot S \cdot \mathtt{else} \cdot S$
(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:

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

Grammar 2, where String is the starting symbol:

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