COMP3131/9102: Programming Languages and Compilers
Week 3 Tutorial Questions
Context-Free Grammars

1. Consider the grammar:

$$
\begin{array}{rlcl}
1 & bexpr & \rightarrow & bexpr \textbf{ or } bterm \\
2 & & | & bterm \\
3 & bterm & \rightarrow & bterm \textbf{ and } bfactor \\
4 & & | & bfactor \\
5 & bfactor & \rightarrow & \textbf{not } bfactor \\
6 & & | & (\ bexpr\ ) \\
7 & & | & \textbf{true} \\
8 & & | & \textbf{false}
\end{array}
$$

   (a) What are the terminals, nonterminals and start symbol?

   (b) Construct the leftmost derivation for **not** (**false and true or true**).

   (c) Construct the rightmost derivation for the same expression

   (d) Construct a parse tree for for the same expression

   (e) What are the precedence and associativity for the three operators **or**, **and** and **not** implied in the grammar?

2. Suppose Productions 1 – 4 in Question 1 are deleted and replaced with:

$$
\begin{array}{rlcl}
1 & bexpr & \rightarrow & bexpr \textbf{ and } bterm \\
2 & & | & bterm \\
3 & bterm & \rightarrow & bterm \textbf{ or } bfactor \\
4 & & | & bfactor
\end{array}
$$

   (a) Draw the parse tree for the same expression in Question 1.

   (b) How has the change in the grammar affected the precedence of the boolean operators **or** and **and**?

3. Suppose Productions 1 – 4 in Question 1 are deleted and replaced with:

$$
\begin{array}{lcl}
bexpr & \rightarrow & bexpr \textbf{ or } bfactor \\
& | & bexpr \textbf{ and } bfactor \\
& | & bfactor
\end{array}
$$

   (a) Draw the parse tree for the expression in Question 1.

   (b) Draw also the parse tree for for **not** (**false or true and true**).

   (c) How has the change in the grammar affected the precedence of the boolean operators **or** and **and**?

(d) Is this grammar ambiguous?

4. Assume that the grammar in Question 1 is replaced with:

$$
\begin{array}{lll}
1 & bexpr & \rightarrow & bexpr \ \textbf{or} \ bexpr \\
2 & & | & bexpr \ \textbf{and} \ bexpr \\
3 & & | & \textbf{not} \ bexpr \\
4 & & | & (\ bexpr \ ) \\
5 & & | & \textbf{true} \\
6 & & | & \textbf{false}
\end{array}
$$

(a) Show that this grammar is ambiguous by constructing two different parse trees (or two different leftmost derivations or two different rightmost derivations) for the expression in Question 1.

(b) What can you say about the precedence and associativity of **or**, **and** and **not** implied in the grammar?