CS164 Programming Language and Compilers **Fall 2015**

Written Assignment 2

Assigned: September 16 **Due:** September 28 at 1:15 PM

Instructions: This assignment asks you to prepare written answers to questions on context-free grammars. Each of the questions has a short answer. You may discuss this assignment with other students and work on the problems together. However, your write-up should be your own individual work.

Remember that written assignments are to be turned in at the start of lecture. Please write your name, your account name, your TA's name, and your section time on your homework! We need this information so that we can give you credit for the assignment and so that we can return it to you.

1. Let L be the language consisting of all properly balanced forms of brackets in the alphabet "{, [,], (,), }".For example (), {}[], and {[()]} are in in the language, but ()), [}, and {[}] are not.

   Write a context free grammar for the language L.

2. Consider the following grammar:

$$\begin{aligned} S &\rightarrow aSbS \\ S &\rightarrow bSaS \\ S &\rightarrow \epsilon \end{aligned}$$

   (a) Give a one-sentence description of the language generated by this grammar.

   (b) Show that this grammar is ambiguous by giving a string that can be parsed in two different ways. Draw both parse trees.

   (c) Give an unambiguous grammar that accepts the same language as the grammar above.

   (d) Give a grammar that accepts the same language as the grammar EXCEPT does not include the empty string. You are not allowed to use epsilon.

3. Using the context-free grammar for Cool given in Section 11 of the Cool manual, draw a parse tree for the following expression.

```
case a of
    x : Int => a + 5 * 4;
    y : String => "Hi".concat(a);
    z : Bool => true;
esac
```

   Note that the context-free grammar by itself is ambiguous, so you will need to use the precedence rules in Section 11.1 to get the correct tree.

4. What issues might a top down parser have with the grammar listed below? How would a bottom up parser avoid these issues? $\mathbb{Z}$ stands for all integers.

$$
\begin{aligned}
E &\rightarrow E + T \\
E &\rightarrow T \\
T &\rightarrow T * F \\
T &\rightarrow F \\
F &\rightarrow (E) \\
F &\rightarrow \mathbb{Z}
\end{aligned}
$$