CSCI3136
Assignment 4

Instructor: Alex Brodsky

Due: 9:00am, Friday, June 14, 2019

1. Consider the grammar in Figure 1:

   (a) **[5 marks]** Give a parse tree for the following program fragment.

   ```
   def fib( n ) {
     if ( less_than( n, 2 ) ) {
       return n
     }
     return add( fib( sub( n, 1 ) ), fib( sub( n, 2 ) ) )
   }
   ```

   (b) **[5 marks]** Is this grammar ambiguous? Give an intuitive justification.

   (c) **[10 marks]** Prove that this grammar is not LL(1). Hint: You can do this by constructing the FIRST, FOLLOW, and PREDICT sets.

   (d) **[10 marks]** Modify the grammar so that it is LL(1).

2. **[10 marks]** Give a context-free grammar that generates the language of properly nested brackets, such that if the last token is a right square bracket, it closes all remaining open left brackets. I.e., $\Sigma = \{\text{“}(\text{'}, \text{`})\text{'}, \text{`}]\text{'}\}$ and words such as `(()())` and `(()(]` are in the language, but words such as `(])`, `)(`, and `())` are not.

3. **[10 marks]** Give a context-free grammar that generates the language

$$L = \{\sigma \in \{a, b, c, d\}^* \mid (2|\sigma|_a = |\sigma|_b) \vee (|\sigma|_a = 2|\sigma|_b)\}$$

   Note: The notation $|\sigma|_a$ means the number of a's in σ.

$$
\begin{array}{rcl}
\mathit{MethodDecl} & \rightarrow & \texttt{'def'}\ \mathit{id}\ \texttt{'('}\ \mathit{ParamList}\ \texttt{')'}\ \mathit{Block} \\
\mathit{ParamList} & \rightarrow & \epsilon \\
\mathit{ParamList} & \rightarrow & \mathit{Param}\ \mathit{ParamListTail} \\
\mathit{ParamListTail} & \rightarrow & \epsilon \\
\mathit{ParamListTail} & \rightarrow & \texttt{','}\ \mathit{Param}\ \mathit{ParamListTail} \\
\mathit{Param} & \rightarrow & \mathit{id} \\
\mathit{Block} & \rightarrow & \texttt{'\{'}\ \mathit{Statements}\ \texttt{'\}'} \\
\mathit{Statements} & \rightarrow & \epsilon \\
\mathit{Statements} & \rightarrow & \mathit{Statement}\ \mathit{Statements} \\
\mathit{Statement} & \rightarrow & \mathit{IfStatement} \\
\mathit{Statement} & \rightarrow & \mathit{ReturnStatement} \\
\mathit{IfStatement} & \rightarrow & \texttt{'if'}\ \texttt{'('}\ \mathit{Expression}\ \texttt{')'}\ \mathit{Block}\ \mathit{Else} \\
\mathit{Else} & \rightarrow & \epsilon \\
\mathit{Else} & \rightarrow & \texttt{'else'}\ \mathit{Block} \\
\mathit{Else} & \rightarrow & \texttt{'else'}\ \mathit{IfStatement} \\
\mathit{ReturnStatement} & \rightarrow & \texttt{'return'}\ \mathit{Expression} \\
\mathit{Expression} & \rightarrow & \mathit{integer} \\
\mathit{Expression} & \rightarrow & \mathit{id} \\
\mathit{Expression} & \rightarrow & \mathit{id}\ \texttt{'('}\ \mathit{ArgList}\ \texttt{')'} \\
\mathit{ArgList} & \rightarrow & \epsilon \\
\mathit{ArgList} & \rightarrow & \mathit{Expression}\ \mathit{ArgListTail} \\
\mathit{ArgListTail} & \rightarrow & \epsilon \\
\mathit{ArgListTail} & \rightarrow & \texttt{','}\ \mathit{Arg}\ \mathit{ArgListTail} \\
\mathit{Arg} & \rightarrow & \mathit{Expression}
\end{array}
$$

Figure 1: A Grammar for function definitions.

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Summer 2019

Student Name	Login ID	Student Number	Student Signature

	Mark
Question 1a	/5
Question 1b	/5
Question 1c	/10
Question 1d	/10
Question 2	/10
Question 3	/10
Total	**/50**

Comments:

Assignments are due by 9:00am on the due date. Assignments *must* be submitted electronically via Brightspace. Please submit a PDF for the written work. You can do your work on paper and then scan in and submit the assignment.

Plagiarism in assignment answers will not be tolerated. By submitting their answers to this assignment, the authors named above declare that its content is their original work and that they did not use any sources for its preparation other than the class notes, the textbook, and ones explicitly acknowledged in the answers. Any suspected act of plagiarism will be reported to the Facultys Academic Integrity Officer and possibly to the Senate Discipline Committee. The penalty for academic dishonesty may range from failing the course to expulsion from the university, in accordance with Dalhousie Universitys regulations regarding academic integrity.