CS3311 Homework 8 Due date: Wednesday, November 1, 2017, by class time, 1:05pm
Submission: Typed, pdf on Canvas (scanned submissions are not allowed)

The answers must be the original work of the author. While discussion with others is permitted and encouraged, the final work should be done individually. You are not allowed to work in groups. You are allowed to build on the material supplied in the class. Any other source must be specified clearly.

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1. *(10+10 points)* Consider the following grammars G_1 and G_2:

G_1 :
$S \to xAx$
$A \to Aa \mid Ab \mid c \mid d$

G_2 :
$S \to xAx$
$A \to c \mid d \mid cB \mid dB$
$B \to aB \mid bB \mid a \mid b$

(a) Give a derivation sequence for string $xcabx$ in G_1. Give the derivation tree of the sequence.

(b) Give a derivation sequence for string $xcabx$ in G_2. Give the derivation tree of the sequence.

2. *(50 points)* Give a context-free grammar (CFG) for each of the following languages *(8 points each)*.
Explain how the grammar works *(2 points each)*.

(a) $L = \emptyset$

(b) $L = \{\lambda\}$

(c) $L = \{w \mid w \in \{a, b, c\}^*, w$ does not contain substring $bc\} = c^*(b \cup ac^*)^*$

(d) $L = \{a^n b^m c^{2n+m} \mid n, m \geq 0\}$

(e) $L = \{a^n b^m \mid n \neq m, n \geq 0, m \geq 0\}$
(Hint: "not equal to" means "less than or greater than".)

Please turn the page over for additional questions.

3. *(20 points, 8+2 points each)* Consider the language L which consists of all the strings with nested parentheses, braces, and brackets where the opening and closing symbols have to match ($\lambda \in L$). The alphabet is $\Sigma = \{ (,), \{, \}, [,] \}$.

Examples of strings in this language are:

$\{\}, \quad [], \quad (), \quad \{()\}, \quad [[[\{\}]]], \quad [[[\{()\}]]]$

Examples of strings that are not in the language are:

$\{)$	the opening and closing symbols don't match
$\{()$	missing $\}$
$\{(\})$	the openings and closings don't match

(a) Write a CFG for L. Explain the grammar.

(b) Write a recursive definition for L. You don't need to write the closure. Explain the recursive step.

4. *(5 + 5 points)* Consider the following grammar:

$$S \rightarrow aSA \,|\, \lambda$$
$$A \rightarrow bA \,|\, \lambda$$

(a) Prove the grammar is ambiguous by finding a string that has two distinct leftmost derivations. Show the two derivations.

(b) Build the derivation trees for the derivations in Part (a).