

**COT 4210 Homework #4: Sections 2.1, 2.2**

**Assigned: 2/9/2021**

**Due Date/Time: On Webcourses**

1) Give parse trees and derivations for the following two strings

a)  $a + a + a$

b)  $((a))$

in the CFG  $G_4$  defined below:

$E \rightarrow E + T \mid T$

$T \rightarrow T \times F \mid F$

$F \rightarrow (E) \mid a$

2) Give context free grammars that generates the following languages with the alphabet  $\{0,1\}$ :

a)  $\{w \mid w = w^R, \text{ namely } w \text{ is a palindrome}\}$

b)  $\{w \mid w \text{ contains at least three 1s}\}$

c)  $\{w \mid \text{the length of } w \text{ is odd and its middle symbol is 0}\}$

d)  $\{w \mid w \text{ contains more 1s than 0s}\}$

For each grammar, briefly justify why it generates the desired language.

3) Give an informal description and state diagram of a PDA that accepts the language in question 2 part d.

4) Convert the following CFG into an equivalent CFG in Chomsky normal form, using the algorithm shown in class.

$A \rightarrow BAB \mid B \mid \epsilon$

$B \rightarrow 00 \mid \epsilon$

5) Show that context-free languages are closed under the following regular operations: union, concatenation and star.

6) Create a unambiguous context-free grammar over the alphabet  $\{a, b, c\}$  that generates the language  $L = \{a^i b^j c^k \mid i > j\}$ . Explain why your grammar is unambiguous.

7) Create a PDA for the language in question #6.