University of Nevada, Las Vegas Computer Science 456/656 Spring 2022

Assignment 2: Due Monday February 14 2022

Name:_____

You are permitted to work in groups, get help from others, read books, and use the internet. You will receive a message from our graduate assistant telling you how to turn in the assignment.

1. If w is a string, then w^R is the reverse of w: for example, $abcac^R = cacba$. If L is any language, $L^R = \{w_R : w \in L\}$, the *reverse* of L.

   True of False:

   (a) _____ The reverse of any regular language is regular.

   (b) _____ The reverse of any context-free language is context-free..

2. A *palindrome* is a word that is its own reverse, such as "level" or "noon." Let L be the language of all palindromes over $\Sigma = \{a, b\}$, such as λ, a, bb, and $abbba$. L is a CF language. Give an unambiguous context-free grammar for L.

3. Let G be the following CF grammar, with start symbol S and variables S, X, Y
   $S \to XY$
   $X \to aXb|\lambda$
   $Y \to cYd|\lambda$
   Give a right-most derivation for $abcd$.

4. The *Dyck* language is the language over $\{(,)\}$ consisting of all strings of parentheses that are balanced, that is, every left parenthesis is paired with right parenthesis to its right. The following grammar, G_1, with start symbol S, generates the Dyck language:
   $S \to (S)$
   $S \to SS$
   $S \to \lambda$
   Prove that G_1 is ambiguous by giving two different leftmost derivations for the same string.

5. Give an unambiguous CF grammar, G_2, for the Dyck language.

6. Let L be the set of all palindromes of odd length over $\{a, b\}$, such as a, b, aaa, aba, $baabbbaab$. Give a Chomsky Normal Form grammar for L.

7. Illustrate a PDA which accepts the language of all strings over $\{a, b\}$ which have equal numbers of each symbol, such as λ, ab, ba, $aabaababbabb$.

8. Which of the following languages are **known** to be $\mathcal{NP}$-complete?

   (a) _____ The travelling salesman problem.

   (b) _____ Boolean satisfiability.

   (c) _____ Equivalence of context-free grammars.

   (d) _____ The knapsack problem.

   (e) _____ The independent set problem.

   (f) _____ Equivalence of left-regular (left-linear) grammars.

   (g) _____ The membership problem for a context-free language.

   (h) _____ 2-SAT

   (i) _____ 3-SAT.

   (j) _____ The set of all configurations of Rush Hour, with any size board, from which it is possible to get the red car out of the parking lot.