University of Nevada, Las Vegas Computer Science 456/656 Spring 2021

Assignment 4: Due Tuesday March 23, 2021

Name:_____

You are permitted to work in groups, get help from others, read books, and use the internet. Post your answers on Canvas as instructed by the graduate assistant, Mr. Singh, by 11:59 PM on the due date.

Some of the problems are to write proofs. Although you may simply copy a proof from my class presentation or from some other source, it would help if you try to undestand the proof. I will ask for proof(s) on the exam and on the final.

1. Which of these languages (problems) are **known** to be $\mathcal{NP}$-complete? If a language, or problem, is known to be $\mathcal{NP}$-complete, fill in the first circle. If it is either known not be be $\mathcal{NP}$-complete, or if whether it is $\mathcal{NP}$-complete is not known at this time, fill in the second circle.

   ◯ ◯ Boolean satisfiability.
   ◯ ◯ 2SAT.
   ◯ ◯ 3SAT.
   ◯ ◯ 4SAT.
   ◯ ◯ Subset sum problem.
   ◯ ◯ Generalized checkers, *i.e.* on a board of arbitrary size.
   ◯ ◯ Independent set problem.
   ◯ ◯ Traveling salesman problem.
   ◯ ◯ Regular expression equivalence.
   ◯ ◯ C++ program equivalence.
   ◯ ◯ Rush Hour: https://www.youtube.com/watch?v=HI0rlp7tiZ0
   ◯ ◯ Circuit value problem, CVP.
   ◯ ◯ Regular grammar equivalence.
   ◯ ◯ Dominating set problem.
   ◯ ◯ Partition.

2. State the pumping lemma for regular languages.

3. Use the pumping lemma to prove that the language generated by the grammar given below is not regular.
   $S \to iS$
   $S \to iSeS$
   $S \to wS$
   $S \to a$

4. Let L be the language over $\{a, b\}$ consisting of all strings which have the same number of a's as b's, such as aabb, abba, aaabbb, bbbaaa, ... Design a PDA which accepts L.

5. Give a context-sensitive grammar for $\left\{a^{2^n}\right\} : n \geq 0$

6. Give a polynomial time reduction of the subset sum problem to partition.

7. Give a polynomial time reduction of 3SAT to the independent set problem.

8. Prove that a language is recursively enumerable, $\mathcal{RE}$, if and only if it is accepted by some machine.