Computer Science 456/656 Spring 2019 Study Guide for the Second Examination
March 11, 2019

Name:____

No books, notes, scratch paper, or calculators. Use pen or pencil, any color. Use the rest of this page and the backs of the pages for scratch paper. If you need more scratch paper, it will be provided.

1. There could be a few questions on regular languages, regular expressions, and finite automata.

2. Review all the material of Assignments 3 and 4.

3. True or False. [5 points each]

   (a) ________ Every subset of a regular language is regular.

   (b) ________ The concatenation of any two context-free languages is context-free.

   (c) ________ The intersection of any two context-free languages is context-free..

   (d) ________ $\mathcal{P}$-TIME= $\mathcal{EXP}$-SPACE

   (e) ________ $\mathcal{P}$ =CO-$\mathcal{P}$

   (f) ________ $\mathcal{NP}$ =CO-$\mathcal{NP}$

   (g) ________ The complement of any recursive language is recursive.

   (h) ________ The *grader's problem* is decidable. We say programs P_1 and P_2 are *equivalent* if they give the same output if given the same input. The problem is to decide whether two programs (in C++, Pascal, Java, or some other modern programming language) are equivalent.

   (i) ________ Given any CF language L, there is always an unambiguous CF grammar which generates L.

   (j) ________ Given any CF language L, there is always an ambiguous CF grammar which generates L.

   (k) ________ If G is a CF grammar and $w \in L(G)$, then the leftmost derivation of w must be unique.

   (l) ________ If a language is accepted by some machine, then it must be decidable.

   (m) The Knapsack problem ("Given a finite set of items of various weights, and given a knapsack that has a given capacity, does there exist a set of items which exactly fills the knapsack?") is known to be in the class $\mathcal{P}$.

4. Fill in the blanks.

   (a) In a ________________ grammar, the right hand side of a rule cannot have more than two symbols.

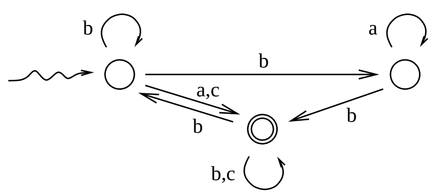
   (b) The ________________ algorithm can be used to prove that the class of context-free languages is a subclass of $\mathcal{P}$.

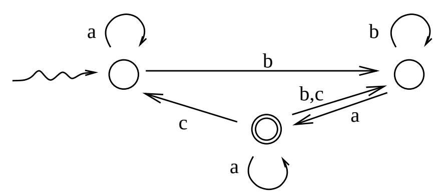
   (c) The class of *sliding block* puzzles includes a number well-known puzzles avaiable at toy stores, including Sam Lloyd's 15 puzzle, Rush Hour, and Rubik's Cube. The smallest complexity class which contains all sliding block puzzles is known to be ________________________________

5. You can prove that the knapsack problem is in the class $\mathcal{NP}$ by using the certificate/verifier method. What would a certificate be for the knapsack problem?

6. Let L be the language consisting of all regular expressions over the alphabet $\{a, b\}$. Write a CF grammar G for L. It is acceptable for G to be ambiguous.

7. [25 points] Write a regular expression for the language accepted by each of the following non-deterministic finite automata.





8. Draw a minimal DFA equivalent to each of the non-deterministic finite automata given in Problem 7.

9. Consider the following CF grammar G, where the start symbol is E:

   1. $E \to E + E$
   2. $E \to E - E$
   3. $E \to E * E$
   4. $E \to -E$
   5. $E \to (E)$
   6. $E \to x$
   7. $E \to y$
   8. $E \to z$

   This grammar can be parsed by an LALR parser which respects the usual precedence of operators. If the input string is $x - y$, the output of tha parser is 672. What is the output of the parser if the input string is $-(x + y) + x * (z - x)$?