University of Nevada, Las Vegas Computer Science 456/656 Spring 2020

Assignment 5: Due Thursday April 9, 2020

Name:_____

You are permitted to work in groups, get help from others, read books, and use the internet. ~~But the handwriting on this document must be your own. Print out the document, staple, and fill in the answers. You may attach extra sheets. Turn in the pages to the graduate assistant at the beginning of class, March 24.~~

Email your homework paper, in pdf format, to the TA, Pradip Maharjan.

Before working these problems, watch my videos. For some problems, you may need to search the world-wide web..

1. True or False. T = true, F = false, and O = open, meaning that the answer is not known to science at this time.

   (a) _____ The regular language membership problem is known to be in Nick's class.

   (b) _____ The context-free language membership problem is known to be in Nick's class.

   (c) _____ The set of all recursively enumerable languages is countable.

   (d) _____ Every context-sensitive language in in $\mathcal{P}$-SPACE.

   (e) _____ $\mathcal{NC} = \mathcal{P}$-SPACE.

   (f) _____ If the integer factoring problem is in $\mathcal{P}$, there can be no secure one-way coding system.

   (g) _____ The decidability problem is decidable.

   The decidability problem is: given an encoding of Turing machine, $\langle M \rangle$, is $L(M)$ decidable?

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

   This problem is a replacement for Problem 3, which is much more difficult.

   The subset sum problem is to determine whether a given set of weighted items has a subset whose total weight is a given amount. For example, given a pocket of coins, can you select exactly one dollar's worth of those coins?

   The partition problem is a special case of the subset sum problem, where the desired sum is half the total of the items. For example, if you have a dollars worth of coins in your pocket, can you find a subset of those coins worth exactly fifty cents?

3. Give a polynomial time reduction of the knapsack problem to the subset sum problem.

   The knapsack problem is to determine whether a given set of items, each of which has both a value and a size, has a subset whose total size is at most a given amount and whose total value is at least a given amount. For example, can a burglar find a set of items which fit into his knapsack whose total value is at least five hundred dollars?

   I now believe this problem is rather difficult. I won't remove it, since someone may already have started working on it. Otherwise, simply work Problem 2 instead.

4. Prove that the context-free grammar equivalence problem is in the class co-R.E. (Hint: CYK)

5. Classify each of these languages/problems, by giving one of these answers.
   1. Known to be $\mathcal{NC}$
   2. Known to be $\mathcal{P}$-TIME, but not known to be in $\mathcal{NC}$ and not known to be $\mathcal{NP}$-complete.
   3. $\mathcal{NP}$, but not known to be $\mathcal{P}$-TIME, and not known to be $\mathcal{NP}$-complete.
   4. Known to be $\mathcal{NP}$-complete.
   5. Known to be $\mathcal{P}$-SPACE, but not known to be $\mathcal{NP}$.
   6. Not known to be $\mathcal{P}$-SPACE

   (a) _____ The Boolean circuit problem.

   (b) _____ The puzzle Rush Hour described at `http://www.mathsonline.org/game/jam.html` The decision problem is, given a configuration, is there a way to win?

   (c) _____ The integer factoring problem, using binary notation.

   (d) _____ Boolean satisfiability.

   (e) _____ The context-free grammar membership problem.

   (f) _____ Generalized chess. The decision problem is, given a position, can White force a win?