CSCI 480 - APS: Sample Final Exam

Duration: 100 minutes

Name:____

NetID:____

Student to your left: ________________________________

Student to your right: ________________________________

DO NOT OPEN THIS EXAM UNTIL INSTRUCTED

Instructions:

- **Write your full name and your NetID on the front of this exam.**
- Write the names of students sitting to your left and right.
- Make sure that your exam is not missing any sheets. There should be six (6) double sided pages in the exam.
- Write your answers in the space provided below each problem. If you make a mess, clearly indicate your final answer (or state that it is on the scrap paper).
- If you have any questions during the exam, raise your hand and we will get to you.
- At the end of the exam, there is one blank page. Use this as your scrap paper. If you need additional scrap paper, raise your hand and we will get it for you.
- This exam is closed books, closed notes, closed computers. You are allowed one double sided page of your own notes.
- **You need to stay in your seat until the exam is finished.** You should not leave the room even if you finish the exam. This distracts other students who are still working.

Good luck!

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Problem 1 (60 points).

Provide algorithms for three out of the following 5 problems. Write your answers on the page with the corresponding problem number! Cross out the other two pages for problems that should not be graded.

There will be no extra credit for answering more than three questions.

If you do not cross out any problems, the first three will be graded.

A. Alex is traveling for business with a given allowence of $1 <= M <= 500$ to spend. Since she is not allowed to keep the left over funds, she is trying to spend as much as possible without exceeding the allowence. She needs to pay for several categories of items: hotel, luch and dinner at a restaurant, transportation, etc. The number of categories is $1 <= C <= 20$. Each category has at most 10 options in it. If there are fewer than 10 options, the remaining ones have price of zero.

   Given the cost of different options in the different categories, determine what is the largest amount of money she can spend without exceeding her allowence. She must chose exactly one item in each category. If such a selection is not possible, your algorithm should indicate this in some way.

B. Given a two dimensional NxN integer matrix representing a grid that needs to be traversed, prodive an algorithm to go from the lower left corner to the upper right corner with the minimum cost. The only allowed moves are up and right. The value at each grid point is between 1 and 20. The value of N is between 1 and 100.

C. Potato sacks come in different weight capacities given by $10 <= C <= 30$ pounds. Potatoes come in different weights bwetween 1 and 3 pounds. You are given some number $1 <= K <= 10$ of potatoe weights and the size of the bag. Write an algorithm that determines if the bag can be filled exactly (i.e., not overflowing and no room left over).

D. You are given a bit string that consists of $1 <= n <= 32$ bits. You are also given a sequence of changes that invert some of the bits. Your task is to report, after each change, the length of the longest substring in which each bit is the same (it could be eiter a substring of zero bits or 1 bits).

   The original bit string is given as an actual binary string, for example, 001011. The sequence of changes specifies which bit position (counting starts at zero and goes from the least significant bit to the most significant bit) should be inverted. For example, if the change is listed as 3, then the above string will become 000011.

E. Calvin wants to give new names to all the constellations of stars in the sky. Two starts belong to the same constellation if the distance between in them (in 2D projection of their locations onto the sky plane) is less than $0 <= D <= 1000$. Given 2D coordinate of $0 <= N <= 1000$ stars, determine how many constellations there are. (You can assume that the coordinates are given as a pair of floating point numbers.)

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Problem 1.A

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Problem 1.B

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Problem 1.C

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Problem 1.D

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Problem 1.E

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Problem 2 (8 points).

Assume subsets of $S = 0, 1, 2, ..., 59$ are represented using 64-bit integers. Write a sequence of instructions (in C++ or Java) to accomplish the following tasks (in the order listed):

- create a set $A = 3, 7, 11, 28, 42$
- create a set $B = 2, 3, 7, 11, 13$
- create a set C that is the intersection of sets A and B, (restriction: you need to use the previously creates sets A and B to accomplish this)
- create a set D that is the differnce between sets A and B, i.e., contains all elements that are in A but not in B, (restriction: you need to use the previously creates sets A and B to accomplish this)

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Problem 3 (10 points) .

You are given a long array of final grades (range 0 to 100) in the Basic Algorithsm class. The array contains grades from the last 20 years during which the course was offered (so it is a large array).

Propose a way of sorting all the grades from smallest to largest in time proportional to O(N) where N is the size of the array.

Note: you do not need to outline the details of the algorith, just specify what kind of method and data structure could be used for this.

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Problem 4 (8 points).

Could one use a priority queue to calculate the median of N values initially stored in an int array? Briefly outline how this could be done and specify the time performance for this approach.

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Problem 5 (14 points).

The following solution has been proposed for the task of coming up with change for specified amount of money n using as few coins as possible from among the infinite supply of coins of K different denominations $C = c1, c2, ..., cK$.

`coins(n)` is a function that for a value of n returns the minimum number of coins that can be used or INF, if this is not possible

```
coins( n )
    if  n < 0   return INF   // solution is not possible
    if  n == 0  return 0     // all money used, we found a solution
    best = INF
    for all c in C
        best = min ( best ,  coins(n-c) + 1)
    return best
```

A. Revrite the above algorithm to make use of a dynamic programming table to improve the performance.

B. Show the content of the table when $n = 10$, $K = 4$, $C = 1, 2, 4, 5$

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SCRAP PAPER NAME ____________________

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