COP 3503 Spring 2024 Section 1 Final Exam

Date: 4/25/2024

Last Name: _____ First Name: _____

1) (10 pts) Write a method that takes in a TreeSet of Strings, which are all lowercase names and returns a TreeMap mapping each name to its 0-based sorted ranking. So for example, if the input set contained the names "Quan", "Alice", "Fred" and "Jamal", then the TreeMap should have the following mappings: Alice → 0, Fred → 1, Jamal → 2 and Quan → 3.

```
TreeMap<String,Integer> getMap(TreeSet<String> names) {

}
```

2) (5 pts) Draw the corresponding picture for the disjoint set stored by this array:

Index	0	1	2	3	4	5	6	7
Value	2	7	6	6	6	4	6	7

3) (20 pts) Let students, numbered 0, 1, 2, … in a class of n students, where n = rc, originally sit in a grid of seats with r rows and c columns as follows:

0	1	…	c-1
c	c+1	…	2c-1
…	…	…	…
n – c	n – c + 1	…	n - 1

Imagine that each student must get up and sit in a different seat that belongs to both a different row and different column than they originally were seated. Complete the program below so that it finds such an arrangement. (Specifically, it'll find the first lexicographical arrangement that is valid, if one exists.)

In the method, both the permutation array and used array are of size n, k represents the current slot of the permutation array to be filled in, and numC represents the number of columns in the classroom grid. Assume that n is divisible by numC and that the permutation array is storing the classroom with the first row in indexes 0 to c – 1, the second row in indexes c to 2c – 1, etc.

For example, calling the method with an empty permutation array for n = 12, numC = 4 returns true and fills the permutation array as follows:

5	4	7	6	9	8	11	10	1	0	3	2

This corresponds to a classroom arrangement of:

5	4	7	6
9	8	11	10
1	0	3	2

Fill in the necessary code in the go method to complete the solution:

```
import java.util.*;

public class q3 {
  public static void main(String[] args) {
    int n = 12, c = 4;
    int[] p = new int[n];
    boolean[] u = new boolean[n];
    boolean res = go(p, u, 0, c);
    if (res) {
      for (int i=0; i<n; i++) {
        System.out.print(p[i]+"\t");
        if (i%c == c-1) System.out.println();
      }
    }
  }
```

```
  public static boolean go(int[] perm, boolean[] used,
                           int k, int numC) {

    int n = perm.length;
    if (k == n) return true;

    for (int i=0; i<n; i++) {









    }

    return false;
  }
}
```

4) (6 pts) In the Divide and Conquer multiplication algorithm (Karatsuba's) when integers A and B are multiplied, three recursive multiplications are performed. When A = 178 and B = 117, assuming we split A and B into 8 bits, what are the three recursive multiplications that occur? Please express your answers in decimal. (Don't calculate the product, just give the two numbers that get multiplied. Credit is only given for the answers, 1 pt per slot.

Product #1: _____ x _____

Product #2: _____ x _____

Product #3: _____ x _____

5) (15 pts) Determine the fewest number of multiplications to calculate the product ABCDE, for matrices A, B, C, D, E with the following dimensions:

Matrix	Dimensions
A	2x7
B	7x3
C	3x4
D	4x1
E	1x5

In order to get full credit you must fill out the chart below appropriately, as shown in class. Please include your calculations below the chart.

	A	B	C	D	E
A	0				
B	X	0			
C	X	X	0		
D	X	X	X	0	
E	X	X	X	X	0

6) (9 pts) Consider counting the number of ways to make change for 15 cents using 1 cent, 2 cent, 5 cent and 9 cent coins. Fill in the table below showing the work that the dynamic programming algorithm to solve the problem would do to solve the problem. The first row has been filled out for you for convenience.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2															
5															
9															

7) (10 pts) Consider needing to schedule a single room for events. Each event gives a request with a start and end time. For this problem, we aim to maximize the amount of time the room is scheduled (not the number of events). Assume that all requests are ordered pairs of integers, (s, e), where $s > 0$ and $e < 10000$, and that there are no more than 1000 requests. Describe a solution to this problem that utilizes Dijkstra's algorithm to correctly solve it. (Hint: think of each event as a vertex in a graph.) Note: there is a dynamic programming solution to this problem. If you very, clearly describe that, you'll get full credit as well.

8) (10 pts) In the game of 301, a player throws darts at a dart board. Each throw is worth in between 1 and 20 points and gets subtracted from the player's score. The goal of the game is to get to zero. We will make several simplifications to the real game to make the mathematics required for this question easier. Define t(n) to be the expected number of throws it will take a player to complete the game when they start with n points, to a score of 0, assuming that the probability the player scores x points on a single throw is $\frac{1}{20}$, for each integer x in between 1 and 20, inclusive. If a player overshoots their score, so for example, if their current score is 7 but they get 12 points on the dart they throw, then their score reverts back to 7. (In short, a throw that's too big gets ignored.)

(a) Prove that t(1) = 20.

(b) Under the assumption that t(1) = t(2) = t(3) … = t(x) = 20, where x is an arbitrarily chosen integer in between 1 and 19, prove that t(x + 1) = 20 as well.

9) (15 pts) Gerald is buying books from "Buy One Get One Free Emporium Book Store." As the title of the store suggests, if a customer buys one book, he receives a book of equal or lesser value for free (if one is in stock.) Gerald has a fixed amount of money, ***money***, and he'd like to purchase the maximum number of books possible. Complete the method below, so that it takes in an array, ***bookprices***, of the prices of all the books in the store and the fixed amount of money he's willing to spend, ***money***, and returns the maximum number of books he could buy from the store without spending more than ***money***. (Note: There are some corner cases to consider. Namely, it's possible that the total number of books purchased could be an odd number.) Your code should run in expected O(nlgn) time, where n is the size of the array ***bookprices***.

```
public static int (long[] bookprices, long money) {




}
```

10) (7 pts) A graph has vertices labeled 'A' through 'N'. The edges in the graph (via adjacency list) are given below. Show the order that vertices get visited in a breadth first search starting at A. Whenever choosing between multiple options to enqueue, select the one that comes first alphabetically. Note: for ease, edges are provided in both directions.

Adjacency List of Graph

A → M	H → B, N
B → F, H, M	I → E, L
C → D, E, F, J, K	J → C, F, N
D → C, E, M	K → C, M
E → C, D, I	L → I
F → B, C, J, N	M → A, B, D, K
G → N	N → F, H, J, G

BFS: ___ , ___ , ___ , ___ , ___ , ___ , ___ , ___ , ___ , ___ , ___ , ___ , ___ , ___

11) (4 pts) In Program 4, you stored the position of several drones in a single integer. If drone #1 (least significant bits) is in row 3, column 2, and done #2 is in row 0 column 5, what single integer would store this set of drone locations, if you used the implementation requirement given?

_____

12) (5 pts) In class we looked at an algorithm to determine the rank of a permutation in lexicographical order.

Using this algorithm, determine the lexicographical rank of the permutation [3, 1, 0, 5, 2, 4]. Your answer must be in between 0 and 719, inclusive.

_____

13) (8 pts) In Program 5, you had to match drug names with corresponding codes. A drug could only match a code if the code appeared as a substring in the name of the drug. A greedy algorithm would simply go through the drugs in order and match them to the first code they match to, then repeat the process. Give an example with 4 drugs and 4 codes, where this algorithm fails to find a matching, but a matching exists. To get full credit, you must clearly order your drugs and codes, show the incomplete matching the algorithm would provide AND give a valid matching of all four drugs. (Your examples can use any alphabetic strings; they don't have to be names of real drugs.)

Drugs	Codes
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____

Greedy Algorithm produces the following matching:

1. _____ → _____
2. _____ → _____
3. _____ → _____
4. _____ → _____

(Note: At least one of these slots on the Right hand side must be blank.)

Here is a valid matching for the example:

1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____

14) (1 pt) The dining hall '63 South is a nod to the year UCF was founded. In what year was UCF founded?

_____

Java API Methods

Tree Set

```
// Retrieves and removes the first element.
E pollFirst();

// Returns the size of this TreeSet.
int size();
```

Tree Map

```
// Associates the specified value with the specified key.
V put(K key, V value);
```

Arrays

```
// Sorts the specified array into ascending numerical order.
static void sort(int[] a)
```

Scratch Page: Please clearly mark any work you would like graded.