Maynooth University
National University of Ireland Maynooth

SEMESTER 1

January 2020 Examination

CS210
Algorithms & Data Structures 1

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Time allowed: 2 hours

Answer ALL Questions

All questions carry equal marks

Instructions

	Yes	No
Log Books Allowed	☐	☐
Formula Tables Allowed	☐	☐
Other Allowed (*calculator allowed)*	X	☐

General (*enter details)*

[25 marks]

1. Write a Java program that uses a Monte Carlo simulation to calculate the probability that two randomly selected numbers are coprime. [25 marks]

Two integers are said to be coprime if the only positive integer that divides both of them is 1. For example, 12 and 49 are coprime, because the only positive integer that divides evenly into both of them is 1. In contrast, 12 and 21 are not coprime, because 3 divides into both of them.

Include comments which explain your code clearly.

[25 marks]

2. Write a Java program that takes in a String array of 10,000 English words, and sorts them according to the number of unique letters they contain, before printing them out in order. The words containing the greatest number of unique letters should be printed out first, followed by those containing fewer unique letters. If two words use the same number of unique letters, then they should be sorted lexicographically (i.e. like a dictionary). [25 marks]

For example, the word "*fantastic*" uses 7 unique letters, so it should be printed out before "*banana*", which uses only 3 unique letters.

Include comments which explain your code clearly.

State the Big O complexity of your program and justify your reasoning.

[25 marks]

3. Write a Java program that manipulates a queue according to the given insert and remove commands, and then outputs the string that is in the middle of the queue. If there is an even number of strings in the queue, thus two middle strings, output the one which is nearest the front. If a remove command is issued for an empty queue then nothing should happen. [25 marks]

Input Format
A series of lines involving either INSERT or REMOVE commands. The command INSERT is followed by a space and then the string to insert (e.g. INSERT hello).

Output Format
Output the string that is in the middle of the queue following the given commands. If there are two middle strings, output the one nearest the front. If the queue is empty output "empty".

Sample Input

INSERT these
INSERT words
INSERT go
INSERT in
REMOVE
INSERT the
REMOVE
INSERT queue

Sample Output
in

Include comments which explain your code clearly.

Your answer should provide the full queue class.

[25 marks]

4. a) Analyse the Big O complexity of the following piece of Java code, and explain your reasoning. [4 marks]

```
for(int i = 3; i< n*20; i++){
    for(int j = 10; j >= 0; j--){
      for(int k = j; k < n; k++){
            counter++;
      }
    }
}
```

b) What does the following recursive method return given an input of 7? Explain your reasoning. Assume that `f[]` is a class variable initialized with zeroes. [4 marks]

```
public int f(int n) {
     if(n==0) return 1;
     if(n==1) return 1;
     if(f[n]!=0){
          return f[n];
     }else{
          f[n] = f(n-1) + f(n-2);
          return f[n];
     }
}
```

c) What does the following Java program output when run? Show clearly how the answer is derived. [4 marks]

```
public class BitManipulation{

   public static void main(String[] args){
      System.out.println(((32|13)>>2)&9);
   }
}
```

d) Describe in your own words the concept of a linked list, using examples and diagram as appropriate. Explain how you would design an algorithm to delete the tail of a double ended singly linked list. [4 marks]

e) Show step by step how the numbers below would be sorted by [9 marks]

i) Insertion sort
ii) Merge sort
iii) Selection sort

35 86 10 58 26 96 38 52