OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

JANUARY 2013 EXAMINATION

CS210

Algorithms & Data Structures 1

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Time allowed: 2 hours

Answer all three questions

All questions carry equal marks

[25 marks]

1 (a) Consider the Java method below. How many lines will be printed out when *n* is 10? How about when *n* is 100? In light of this, derive an expression for how many lines will be printed out in terms of the input parameter *n*. State the Big O complexity of the method and prove that this is the case using the mathematical definition. [5 marks]

```
public void method (int n){
    for(int i = 0; i < (n - 5); i++){
        for(int j = 1000; j > n; j--){
            System.out.println("One step");
        }
    }
}
```

(b) Describe the following sorting algorithms and show step by step how they would sort the numbers below. [8 marks]

i) Bubble sort

ii) Merge sort

```
45    67    34    19    78    21
```

(c) Describe the binary search algorithm using appropriate examples. Complete the Java method below, which should return the index where the key is found. If the key is not in the array, then the method should return `-1`. [7 marks]

```
public int search (int[] array, int key){

    …fill this in…

}
```

(d) Discuss the advantages and disadvantages of storing information in an ordered array and describe an algorithm for inserting new information into an ordered array. What is the Big O complexity of this algorithm? [5 marks]

[25 marks]

2 (a) Describe the following data structures in detail and give examples of how they might be used. [8 marks]

i) Stack

ii) Queue

(b) Complete the following array-based Queue class by filling in the `insert()` and `remove()` methods. Include comments which explain your code. [6 marks]

```
public class Queue{

   private int maxSize;
   private long[] queArray;
   private int front;
   private int rear;
   private int nItems;

   public Queue(int s){
      maxSize = s;
      queArray = new long[maxSize];
      front = 0;
      rear = -1;
      nItems = 0;
   }

   public void insert(long j){

       //fill this in

   }

   public long remove(){

       //fill this in

   }
}
```

(c) Describe the concept of linked lists using example and diagrams as appropriate. What are the advantages and disadvantages of linked lists over arrays? [6 marks]

(d) Describe the concept of recursion and show how the binary search algorithm could be implemented recursively. [5 marks]

[25 marks]

3 (a) Design an algorithm that takes in a number in decimal and converts it to base 3. For example, the number 14 would be converted to 112 in base 3 (one 3^2, one 3 and 2 units). [8 marks]

Write your algorithm in Java with comments that explain it clearly.

(b) Design an algorithm that uses a Monte Carlo simulation to determine the odds of six lottery numbers being drawn in ascending order (e.g. 1, 6, 15, 28, 34, 42). The numbers in the Irish lottery range from 1 to 45. [8 marks]

Write your algorithm in Java with comments that explain it clearly.

(c) Design an algorithm that takes in an array of `ints` as a parameter and returns the mode of that array. The mode is the value that appears most often in a set of data. If there is more than one mode then it should return the lowest. [9 marks]

Write your algorithm in Java with comments that explain it clearly.