OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

JANUARY 2014 EXAMINATION

CS210

Algorithms & Data Structures 1

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Time allowed: 2 hours

Answer all three questions

All questions carry equal marks

1 (a) A function *f*(*n*) is said to be $O(g(n))$ if there is a positive constant [4 marks] *c* such that for all $n > n_0$ $f(n) \leq c.g(n)$. Explain the significance of this big O notation in your own words, highlighting its relevance to the evaluation of algorithms.

(b) Describe an algorithm which takes in an array of `Card` objects, [6 marks] shuffles them in a random order, and returns the shuffled array. Complete the Java method below.

```
public Card[] shuffle (Card[] deck){

     …fill this in…
}
```

(c) Describe how the binary search algorithm works. Provide a Java [6 marks] implementation of the algorithm that searches an array of `ints` for a given value, returning the index of the array where that value is found.

```
public int binarySearch (int key){

     …fill this in…
}
```

(d) Show how the numbers below would be sorted by the following [9 marks] algorithms.

    i) Bubble sort
    ii) Insertion sort
    iii) Merge sort

```
33   18   47   59   12   56   80   22
```

[25 marks]

2 (a) Describe the following data structures, using examples and [9 marks] diagrams as appropriate

    i) Queue
    ii) Priority queue
    iii) Stack

(b) Complete the following method for deleting a link from the middle of a single-ended singly-linked list, where `key` is the value to be deleted and `first` is a pointer to the first link in the list. [7 marks]

```java
public void delete(int key, Link first){

    …fill this in…
}
```

(c) Describe briefly an idea for an algorithm that can find and return the 3rd last element in a single-ended singly-linked list following a single pass of the list. [3 marks]

(d) Explain the concept of recursion. Show what happens when the following method is run given an input of 17. What is the output? [6 marks]

```java
public int method(int number){
    if (number == 2){
        return 7;
    }
    return method((number % 5) + 1) + 2;
}
```

[25 marks]

3 (a) Write a Java method that takes in an `int` and calculates the percentage of the day that the digits on a digital clock exceed that `int` value when added together (e.g. three minutes to six is displayed as 5:57, which sums to 17). [8 marks]

(b) Player 1 and Player 2 are playing a game where Player 1 flips *x* coins and Player 2 flips *y* coins. The winner is the one who gets the most heads (if it's a draw they flip again). Write a Java method that takes in *x* and *y* and uses a Monte Carlo simulation to calculate the probability that Player 1 will win. [8 marks]

(c) Write a Java method that takes in an array of `ints` and returns the array in the same order with all duplicates removed. [9 marks]