# OLLSCOIL NA hÉIREANN MÁ NUAD

# THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

## AUTUMN 2013 EXAMINATION

# CS210

# Algorithms & Data Structures 1

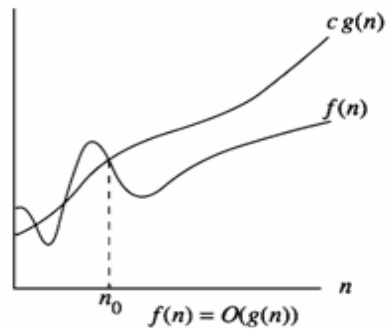Dr. S. Flynn, Dr. A. Winstanley, Dr. P. Maguire

Time allowed: 2 hours

Answer all three questions

**All questions** carry equal marks

**1** **(a)** Describe the concept of Big O Complexity in your own words, [5 marks] with reference to the diagram below. In your answer you should comment on the significance of the terms $c$, $n_0$, $g(n)$ and $f(n)$.



$$c\,g(n)$$
$$f(n)$$
$$n$$
$$n_0 \quad f(n) = O(g(n))$$

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

    i)   Insertion sort

    ii)  Selection sort

          63     38     12     53     89     26

**(c)** Complete the following method for deleting a value from an [6 marks] ordered array of `ints`. Assume the array is a class variable named `array`. Include comments which explain your code.

```
public void delete (int key){

// fill this in

    top--;
}
```

**(d)** Describe the binary search algorithm and show step by step how [6 marks] it would search for the number 23 in the following array.

    [12  23  37  39  42  51  57  62  81  87  93]

**[25 marks]**

**2** **(a)** Describe how the following data structures work, using diagrams [9 marks] as appropriate:

    i)   Queue
    ii)  Priority Queue

iii) Deque

(b) Design a Java method that uses a `Stack` object to check [6 marks] whether or not the brackets in a string of code match up or not (i.e. each opening bracket should be matched by a closing bracket of the same type). Your algorithm should be capable of dealing with three types of bracket, namely ( ), [ ] and { }. The method takes in a `String` to be verified and you can assume that a `Stack` class is available with push() and pop() methods.

Provide a Java implementation of your algorithm and explain how it works.

(c) Explain in detail how the method below works. Describe step-by- [5 marks] step how it would delete the number 29 from the following linked list, showing how the variables `current` and `previous` are updated:

```
┌─────┬─┐     ┌─────┬─┐     ┌─────┬─┐     ┌─────┬─┐
│ 18  │ ├──▶ │ 22  │ ├──▶ │ 29  │ ├──▶ │ 31  │ ├──▶
└─────┴─┘     └─────┴─┘     └─────┴─┘     └─────┴─┘
```
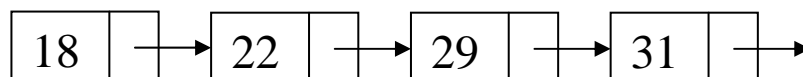
```java
public Link delete(int key){

    Link current = first;
    Link previous = first;
    while(current.data != key){
        if(current.next == null){
            return null;
        }else{
            previous = current;
            current = current.next;
        }
    }
    if(current == first){
        first = first.next;
    }else{
        previous.next = current.next;
    }
    return current;
}
```

(d) Describe the concept of recursion in your own words and show [5 marks] step-by-step how the following recursive method would compute an answer given an input of 20.

```
public int method(int number){
    if (number == 0){
        return 1;
    }
    return method((number % 7) - 1) * 2;
}
```

**[25 marks]**

**3** (a) Design an algorithm that takes in an array of `Strings`, sorts [8 marks] them by length and returns the sorted array.

Write a Java method that implements your algorithm with comments that explain the code clearly.

(b) Design an algorithm that takes in an `int` as a parameter and [8 marks] returns the closest prime to that number. For example, the algorithm would return 499 for an input of 500, because 499 is the closest prime to 500.

Write a Java method that implements your algorithm with comments that explain the code clearly.

(c) Design an algorithm that uses a Monte Carlo simulation to [9 marks] determine the probability that the six numbers drawn in the next Irish lottery will add up to 100 (e.g. 1, 6, 15, 16, 28, 34). The numbers in the Irish lottery range from 1 to 45.

Write a Java method that implements your algorithm with comments that explain the code clearly.