Maynooth University
National University of Ireland Maynooth

OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

AUTUMN 2015 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

[25 marks]

1 (a) A function $f(n)$ is said to be $O(g(n))$ if there is a positive constant c such that for all $n > n_0$ $f(n) \leq c.g(n)$. Explain the significance of this definition in your own words, highlighting its relevance to algorithm efficiency. [5 marks]

(b) Describe how the binary search algorithm works. What is its Big O time complexity? Provide a Java 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. [6 marks]

```
public int binarySearch (int key){

     …fill this in…
}
```

(c) Show how the numbers below would be sorted by the following algorithms. [8 marks]

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

```
45   12   37   65   87   21   70   42
```

(d) Discuss the advantages and disadvantages of storing information in an ordered array versus an unordered array. Describe algorithms for inserting new information into both types of array. What is the Big O complexity of these algorithms? [6 marks]

[25 marks]

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

i) Queue
ii) Priority queue
iii) Stack

(b) Describe the concept of linked lists using example and diagrams as appropriate. What are the advantages and disadvantages of linked lists over arrays? [5 marks]

(c) Design an algorithm for reversing the contents of a single-ended [5 marks]

doubly-linked list, defining each step involved. Describe the algorithm in your own words, using diagrams as appropriate.

(d) Explain the concept of recursion. Show what happens when the following method is run given an input of 12. What is the output? [6 marks]

```
public int method(int number){
     if (number == 3){
          return 3;
     }
     return method((number % 4) + 1) + 2;
}
```

[25 marks]

3 (a) Write a Java program that prints out the integers from 1 to 100. For the multiples of three print “Fizz” instead of the number and for the multiples of five print “Buzz”. For numbers which are multiples of both three and five print “Fizzbuzz” [7 marks]

(b) Write a Java method that takes in a String as a parameter and returns the number of unique characters it contains. Provide comments which explain how your algorithm works. [8 marks]

(c) 2520 is the smallest number that can be divided by each of the numbers from 1 to 10 without any remainder. Write a Java program that computes the smallest positive number that is evenly divisible by all of the numbers from 1 to 20. Provide comments which explain how your algorithm works. [10 marks]