



NUI MAYNOOTH

Ollscoil na hÉireann Má Nuad

OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

AUTUMN 2007 EXAMINATION

CS210

Algorithms & Data Structures 1

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Time allowed: 2 hours

Answer *three* questions

All questions carry equal marks

- 1 (a) Explain the Order-of-Magnitude of an algorithm (Big-O notation) in your own words. Using the definition, show that the order of magnitude of the following function $f(n)$ is $O(n^3)$. [25 marks]
[6 marks]

$$f(n) = n^3 + 20n^2 + 1$$

- (b) The following method deletes an element from an ordered array. Describe how the code works and assess the algorithm's Order of Magnitude. [5 marks]

```
public void delete(long value){
    for (j=0;j<numberOfElements;j++){
        if(array[j]==value){
            break;
        }
    }
    for(int k=j; k<numberOfElements-1; k++){
        array[k]=array[k+1];
    }
    numberOfElements--;
}
```

- (c) Complete the following Java method for binary search of an ordered array and explain how the algorithm works. The method should search through the array between the lower and upper indices and return the index in which it finds searchKey (otherwise returning 0). [6 marks]

```
public int find(int searchKey, int array[], int lower, int upper)
{
    int check;
    while(true)
    {
        //fill this in
    }
}
```

- (d) Describe the stack and queue data structures, referring to how information is stored in each. Describe how a queue can be implemented using a circular 'wraparound' array and provide pseudocode insert() and remove() methods. [8 marks]

- 2 (a) Sort the following numbers using bubble sort, writing out the intermediate orderings that would result following each iteration: [25 marks]
[5 marks]

4 8 2 9 1 5

- (b) Complete the following Java code for the selection sort method and the swap method that it calls. Assume that the array of ints to be sorted is called 'array' and that the number of elements in the array is stored as an int called 'nElems'. [6 marks]

```
public void selectionsort(){.....}
```

```
public void swap(int one, int two){.....}
```

- (c) With the aid of suitable examples and diagrams, explain how the recursive mergesort algorithm works. [8 marks]

- (d) Compare the performance of the following sorting algorithms. Describe the circumstances to which each of the algorithms is best suited. [6 marks]

- i. Bubble Sort
- ii. Insertion Sort
- iii. Merge Sort

- 3 (a) Explain the idea of recursion in your own words. Complete the code below for a recursive power function that only uses multiplication and division.

[25 marks]
[7 marks]

```
int power (int k, int n) {  
    // raise k to power of n  
    if (n == 0)  
        return 1;  
    else{  
        //fill this in  
    }  
}
```

- (b) With the aid of a suitable diagram, describe the steps involved in deleting a link from the end of a double-ended singly-linked list. [6 marks]
- (c) The following method inserts a new link (data) after a specified link (key) in a doubly linked list. Explain the code in your own words. [6 marks]

```
public boolean insertAfter(long key, long data) {  
    Link current = first;  
    while(current.data != key) {  
        current = current.next;  
        if(current == null){  
            return false;  
        }  
        Link newLink = new Link(data);  
        if(current==last) {  
            newLink.next = null;  
            last = newLink;  
        } else {  
            newLink.next = current.next;  
        }  
        newLink.previous = current;  
        current.next = newLink;  
        return true;  
    }  
}
```

- (d) Explain how a linked list can be used to implement a stack and a queue, mentioning the type of linked list that would be required for each and the linked list methods that would be used. [6 marks]

- 4 (a) Show the resultant binary tree after the following elements are inserted in the order given: [25 marks]
[7 marks]

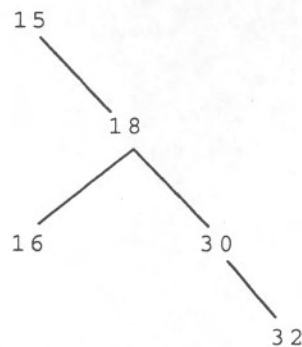
9 4 6 1 3 2 8

Write out the order in which each of the following tree traversals visit the nodes in this tree:

- (i) Pre-Order
- (ii) In-Order
- (iii) Post-Order

- (b) With the aid of suitable diagrams, explain how a node is deleted from a tree if the node to be deleted has one child or if it has no children. [8 marks]

Draw the tree that would result if 18 were deleted from the following tree and explain why this is the case:



- (c) Complete the Java code for the minimum() method below which finds the minimum node in the tree. Explain how the algorithm works. [5 marks]

```
public Node minimum(){
    Node current, last;
    current = root;

    //fill this in

}
```

- (d) Provide a pseudocode algorithm for finding the successor of a given node. [5 marks]