NUI MAYNOOTH

Ollscoil na hÉireann Má Nuad

OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

JANUARY 2008 EXAMINATION

CS210

Algorithms & Data Structures 1

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Time allowed: 2 hours

Answer ***three*** questions

All questions carry equal marks

[25 marks]

1 (a) Explain Big-O notation in your own words and with the aid of an appropriate diagram. **[7 marks]**

A function involves the following number of steps where *n* is the size of the problem:

$$f(n) = \log(n) + n/2 + 5$$

State the Big-O complexity of the function and prove that this is the case using the mathematical definition.

(b) State the Big-O complexity of the following code and explain your reasoning clearly. **[4 marks]**

```
for(int i = 8; i< n/2; i++){
      for(int j = i; j < 2*i; j++){
           array[i]=array[i]+j;
       }
 }
```

(c) The following method deletes an element from an ordered array. Explain how the code works in your own words and state its Big-O complexity. **[5 marks]**

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

(d) Describe in your own words an efficient algorithm for searching an ordered array, using examples and diagrams as appropriate. Provide a Java or pseudocode implementation. **[6 marks]**

(e) Mention briefly the advantages and disadvantages of maintaining an ordered versus an unordered array. **[3 marks]**

[25 marks]

2 (a) Sort the following numbers using bubblesort, writing out every intermediate ordering that results: **[4 marks]**

4 8 2 6 3 1

(b) Describe the insertion sort algorithm in your own words and provide a Java or pseudocode implementation of the algorithm. **[7 marks]**

(b) Explain the concept of recursion in your own words. **[7 marks]**

Describe an algorithm for calculating the power of a number recursively.

(c) Describe the mergesort algorithm in your own words using suitable examples and diagrams. **[7 marks]**

[25 marks]

3 (a) Explain the concepts of a *stack*, *queue* and *priority queue*, using examples and diagrams as appropriate. **[6 marks]**

(b) With the aid of a suitable diagram, describe how a queue can be implemented using an array. **[6 marks]**

Provide a Java or pseudocode implementation of the *insert* method of an array-based queue data structure.

(c) With the aid of a suitable diagram, identify the steps involved in deleting the last link from a double-ended linked list. Should the list be singly-linked or doubly-linked? **[5 marks]**

(d) The following method adds a link to a linked list. Explain the code in your own words. **[5 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;
}
```

(e) Mention briefly the advantages of implementing a queue using a linked list instead of an array. **[3 marks]**

[25 marks]

4 (a) Show the binary tree that results after the following elements are inserted in the order given: **[6 marks]**

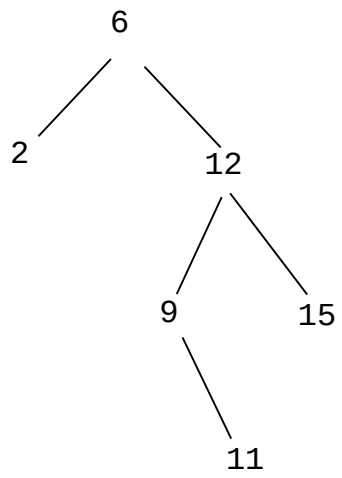
4 14 8 1 23 17 3

Show the order in which each of the following tree traversals visits the nodes in this tree:

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

(b) Explain using appropriate diagrams how a node is deleted from a binary tree when the node to be deleted has one child. **[7 marks]**

Draw the tree that results when 6 is deleted from the following tree:



(c) Complete the following method for returning the minimum node in a binary tree: **[4 marks]**

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

     …… fill this in

     return last;
}
```

(d) Design an algorithm for returning the node in a binary tree with the closest value to an input node. For example, if the algorithm takes in an input node with a value of 6 and the binary tree contains nodes with the values 2, 5, 8 and 9, then 5 is the closest and this node should be returned. Describe in your own **[4 marks]**

words how this could be achieved.

(e) Briefly compare the efficiency of binary trees with that of ordered arrays and linked lists, with reference to insertion, deletion and searching. **[4 marks]**