UNIVERSITY OF WESTMINSTER

ELECTRONICS AND COMPUTER SCIENCE

2011-2012

Code: ECSE502

Title: Algorithms and Data Structures

Date: 03 May 2012

Time: 10:00

Duration: 2 Hours

INSTRUCTIONS TO CANDIDATES

YOU NEED TO ANSWER ALL QUESTIONS FROM ALL THREE SECTIONS.

Exam Paper 2011/12

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Section 1 [30 marks]

1. What is the time complexity when one inserts an item into an unordered array? Justify your answer.

[4 marks]

2. How is complexity of the *search* operation affected, in terms of the Big-O notation, in an unordered array which allows duplicates?

[5 marks]

3. What is the maximum number of elements that must be examined to complete a binary search in an array of 200 elements? Justify your answer.

[3 marks]

4. Assuming that the underpinning data structure for the implementation of queues is an array, explain how will you guarantee that an empty queue (array) is not taken mistakenly for a full one.

[4 marks]

5. Which link in a doubly linked list grants access to the whole list? Justify your answer.

[5 marks]

6. Given a search key, what kind of comparison is involved when we are interested in finding a particular node on a binary tree?

[4 marks]

7. What kind of rotations apply when balance needs to be restored in an unbalanced tree?

[5 marks]

Section 2 [35 marks]

8. Let us assume that you came along the following code:

```
Node reverse(Node head) {
Node previous = null;
Node current = head;
Node forward;

while (current != null) {
   forward = current.next;
   current.next = previous;
   previous = current;
   current = forward;
}
```

Describe in pseudo-code the main operation and underlying algorithm implemented by the code.

[7 Marks]

9. Let us assume the following cargo train specification:

- Train cars are linked in a specific order so that they may be loaded, unloaded, transferred, dropped off, and picked up in the most efficient manner possible.
- For instance, the Jiffy Mix plant needs sugar, flour, cornmeal, etc. Just around the bend might be a paper processing plant that needs chlorine, sulfuric acid, and hydrogen.
- Now, we can stop the train, unload each car of its contents, then let the train go on, but then everything else on the train has to sit while flour is sucked out of the caisson, then the sugar, etc.
- Instead, the cars are loaded on the train in order so that a whole chunk of it can be detached, and the remainder of the train moves on.
- The end of the train is easier to detach than a portion in the middle, and vastly easier than detaching a few cars in one spot, and a few cars in another spot.
- If needed, however, you can insert and remove items at any point in the train.

Describe in pseudo-code the underpinning data structure and the algorithm to run the train.

[13 marks]

10. Describe an algorithm in pseudo-code, which allows you to mark all those natural numbers that are prime numbers, i.e., natural numbers which can be divided only by themselves and one (1) in a set of k natural numbers {1, k}. You need to put all natural numbers from 1 to k into an array and keep only those numbers, which are

primes and delete those which are not. In your solution, it is sufficient to work with one array only.

[10 marks]

11. Let us assume that you came along the following lines of code, which initialise a 2-3-4 tree:

```
Tree234  theTree = new Tree234();

    theTree.insert(50);
    theTree.insert(40);
    theTree.insert(60);
    theTree.insert(30);
    theTree.insert(70);
```

Describe the structure of the 2-3-4 as of its exemplified initialisation above. Your description should refer only to nodes and their contents in terms of values and pointers to any children possible.

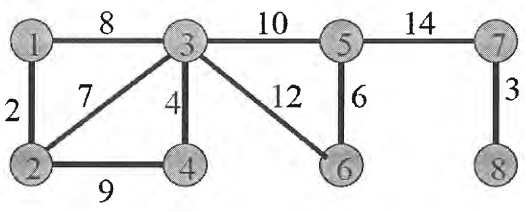
[5 marks]

Section 3 [35 marks]

12. If a graph with vertices {A, B, C, D} is represented by the adjacency lists of vertices , A:{B}, B:{A, C, D}, C:{B}, D:{B}, where is holds vertex:{set of adjacent vertices}, what is the corresponding adjacency matrix in terms of {0,1} elements? Justify whether the feature of symmetry for the matrix holds or not.

[10 marks]

13. Given the following graph, describe and apply Kruskal's method in order to derive the minimum spanning tree (MST) from this graph. What will be the MST derived from the graph? **[15 marks]**



14. Let us assume that you are given an unsorted list [8, 3, 13, 6, 2, 14, 5, 9, 10, 1, 7, 12, 4], which needs to be sorted into the list [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14] by applying the merge-sort algorithm. Assuming that you have two ways to resolve this problem, a) *recursively* and b) *non-recursively, i.e., iteratively*, you decided to implement it **iteratively**. Describe in pseudo-code the non-recursive solution, i.e., iterative implementation for the merge-sort algorithm. Give representative examples for each step of your algorithm.

[10 marks]