University of Swaziland

Department of Computer Science

MAY 2014

Title of paper : *Data structures*

Course number : CS342

Time Allowed : Three(3) hours

Instructions :

- *Each question carries 25 marks*

- *Answer any four (4) questions from questions 1 to 6.*

This paper may not be opened until permission has been granted by the invigilator

Question 1

(a)   Explain the meaning of the following terms.

    (i) Abstract data type   *2 marks*

    (ii) Array mapping function   *2 marks*

    (iii) Offset of a filed in a record   *2 marks*

    (iv) Depth of a node in a tree   *2 marks*

    (v) Iterative algorithm.   *2 marks*

(b)   Draw a diagram showing a comparison of the typical big-oh time complexity of algorithms. Which class of algorithms is considered to be faster?   *2 marks*

(c)   State whether the following statements are true of false. If false, explain your answer.

    (i) The depth of the root node in a tree equals the height of the tree.   1 mark

    (ii) an array requires contiguous memory allocation.   *1 mark*

    (iii)A tree is a graph.   *1 mark*

    (iv)An $O(n \log n)$ algorithm is faster than an $O(n^2)$ algorithm.   *1 mark*

    (v) An array implementation of a list requires the same amount of space as a pointer-based implementation.   *1 mark*

(d)   Write the pseudocode for merge-sort algorithm, clearly stating the preconditions and post-conditions. With the aid of a sample array containing not less than 6 values, trace the execution of the algorithm. What is the running time of this algorithm?

                                                                  8 marks

Question 2

Let $A [lo_1..hi_1, lo_2..hi_2]$ be a 2D array

(a) Write a C++/C#/Java declaration of variable A as an 2D array of integers.　2 *marks*

(b) With the aid of an example, explain what is meant by row major order and column major order allocation for such a 2D array. Which one requires more memory?

5 *marks*

(c) Write a general array mapping function, *Address (A[i,j])*, assuming column major order. Explain or show how you obtained this expression.　4 *marks*

(d) What is the big-oh time complexity for accessing element A[i,j].　2 *marks*

(e) Assuming $A [lo_1..hi_1, lo_2..hi_2]$ is an array of employee records as defined below:

```
class Employee
{   string  TaxId[15];
    string name[30];
    int NumberofChildren;
};
```

(i)　Write a C++/C#/Java declaration of variable A as an 2D array of integers.

2 *marks*

(ii)　Write a C++/C#/Java function to perform the following displays all the records in array A, such that all records in the first column are displayed first, then the second column, up to the last column.　10 *marks*

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Question 3

Assuming a linked-list implementation of a queue,

(a) Draw a diagram of linked list implementation of a queue data structure with nodes containing the integer values 75, 10, 40, 45, 65, 300   *3 marks*

(b) How much memory would be required to store the elements in the queue in (a) above, and explain what would be the difference if the elements were stored in an array?   *3 marks*

(c) Using C++/C#/Java notation, define the structure of a **Node** in a queue.   *4 marks*

(d) Using C++/C#/Java notation, define class **Queue** as as defined in (b) above.

1 marks

(e) Write C++/C#/Java functions that implements the basic operations on the queue structure as defined above. (a)- (d)   *10 marks*

(f) Using the big-O notation, estimate the running times of the implementations given in (e) above.   *4 marks*

Question 4

(a) What is 2-3 tree?   *2 marks*

(b) Draw a picture of 2-3 search tree of height 3. How many leaf nodes are in this tree?   *3 marks*

(c) List and describe the operations of a stack data structure.   *3 marks*

(d) Write the pseudocode for an algorithm that uses a stack to evaluate post-fix expressions of the following form:

4 23 12 – 2 * +

Trace the execution of the algorithm on this example.   *8 marks*

(e) Using C++/C#/Java standard template library (STL)/Collection, write a C++/C#/Java a program that implements the pseudocode obtained in (d) above.

9 marks

Question 5

(a) What is a B+-Tree   *2 marks*

(b) Write the pseudocode for inserting into a B-tree of order b.   *4 marks*

(c) Following the pseudocode outlined in (b) above, construct a B-tree of order 5 containing the following string values. Show all intermediate trees leading to your final answer.

| Zipho, | Langa, | Khumalo, | Maseko, | Dlamini, | Dube, | Nkambule | Smith, | Jones, | Hlatsak‹ |

| Mthupha, | Zulu, | Simelane, | Johnson, | | Ginindza, | Shongwe, | Mavuso, | Gumbi, | Gina, |

Assume values are inserted in the given order.   *16 marks*

(d) List all node values in the B-tree constructed above assuming leve-order traversal. What is the running time of this traversal?   *3 marks*

Question 6

(a) Draw a picture of a sample directed graph G with 11 nodes and 19 edges. Each node must have at least 2 but not more than 3 neighbors.   *3 marks*

(b) Show the adjacency matric representation of the above graph G in (a) above. *3 marks*

(c) Using the C++/C#/Java STL/Collection, define a suitable structure that can be used to represent a graph using an adjacency matrix.   *6 marks*

(d) Based on your type definition in (c.) above, write C++/C#/Java code that would perform the following:

    (i)   Determine if any two given nodes are neighbors.   *4 marks*

    (ii)   Add an edge between two nodes.   *4 marks*

    (iii)   Display all neighbors of a given node.   *5 marks*