University of Swaziland

Department of Computer Science

Final Main Examination

MAY 2017

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) State precisely/formally the meaning of the statement: **f(n) is O(g(n))**

3 *marks*

(b) Draw a well-labeled graph showing a comparison of the typical running time functions. 2 *marks*

(c) Justify the following statement without directly invoking the definition of big-oh notation : $20\ N^2 + 10{,}0000\ \log_2 N$ is $O(N^{2)}$. 1 *marks*

(d) Using C#/Java notation, define the structure of a suitable generic(template) class that could be used to implement an ordered List of element of any type 3 *marks*

(e) Write C#/Java functions that implement the *Constructor, IsEmpty, Insert* and *Delete* operation on the structure described in (c) above. 12 *marks*

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

Question 2

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 100, 75, 10, 200, 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? State all your assumptions. 3 *marks*

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

(d) Using C# or Java notation, define class **Queue** using the node class defined in c above. 2 *marks*

(e) Write C# or Java function that implement each of the basic operations on the queue structure as defined in (d) above. 9 *marks*

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

Question 3

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

a) 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?

3 *marks*

b) Write a general array mapping function, *Address (A[i,j])*, assuming column major order. Explain or show how you obtained this expression. 3 *marks*

c) What is the big-oh time complexity for accessing element A[i,j]. Justify your answer.

2 *marks*

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

```
class Employee
{  string  pin[6];
   string firstname[10];
   string lastname[20];
   int NumberofChildren;
};
```

d) Write a C# or Java declaration of object A as a 2D array of employee records.

1 m*arks*

e) If array A has 1000 records how much memory is required to store the array? State all your assumptions. 2 m*arks*

f) Assuming array A has only 3 rows and the base address of array A is 100, what is the base address of record A[2,3] assuming column-major order, and what is the address the last name for this record. 4 *marks*

g) Using a C# or Java notation, define getters and setters for class Employee. What is the purpose of defining getters and setters? 4 *marks*

h) Using a C# or Java notation, override the **toString()** member function which returns a string representation of an employee record (first name, last name, pin number and number of children) 2 m*arks*

i) Using the **toString()** function defined in 3) above, write a C# or Java function that displays all the records in array A, such that all records in the first column are displayed first, then the second column, etc. up to the last column. 4 m*arks*

Question 4

(a) Using C#/Java notation, define the structure of a binary search tree. Your definition must contain two class definitions; **class TreeNode** - that models the structure of a node and **class BSTree** - that models the binary search tree. **Show all prototypes (function headers) of the required constructors and member functions, but not the actual code of the member functions.** *7 marks*

(b) Using C#/Java notation, write the constructor functions for classes TreeNode and BSTree defined in (a) above. *4 marks*

(c) Using C#/Java, and assuming your definition in (a) above, write code for the member functions:

a. Adding a new value to a binary search tree. 2 *marks*

b. Pre-order traversal of a binary search tree. 2 *marks*

c. Deleting a value from the binary search tree 3 *marks*

(d) Draw a binary search tree consisting of 13 nodes, and a height of 3. 3 *marks*

(e) Trace the execution of iterative post-order traversal algorithm on tree obtained in (d) above. 4 *marks*

Question 5

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

(b) Write the pseudocode for inserting an element 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.

Zondi, Shongwe, Khumalo, Maseko, Dlamini, Simelane, Nkambule, Smith, Jones, Mthupha, Zulu, Hlatshwaako, Johnson, Ginindza, Dube, Mavuso, Gumb, Gina, Langa

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

(d) List all node values in the B-tree constructed above assuming level-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 13 nodes and 21 edges. Each node must have at least 2 but not more than 3 neighbors. 3 *marks*

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

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

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

(i) Determine if any two given nodes are neighbors. 3 *marks*

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

(iii) Display all nodes 3 *marks*

(iv) Display all edges 3 *marks*