University of Swaziland

Department of Computer Science

Supplementary Examination

JULY 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)   With the aid of examples, explain the meaning of the following terms.

      (i) Abstraction   *2 marks*

      (ii) Record Mapping Function   *2 marks*

      (iii) Generic class   *2 marks*

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

      (v) Recursive algorithm.   *2 marks*

      (vi)Big-oh time complexity of algorithms   *2 marks*

(b)   State whether the following statements are true or 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*

(c)   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

Assuming an array based implementation of a list,

(a)   Using C#/Java notation, define a generic class for an ordered List.   *5 marks*

(b)   Write C++ functions that implement the *constructor, IsEmpty, Insert* and *Delete* operations on the structure described in (a) above.   *12 marks*

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

(d)   Write a recursive function that prints all the elements in a List.   *4 marks*

Question 3

(a) Compute the approximate amount of memory required to store N integer values in an array and in linked List. What can be concluded from this approximation about the relative memory usage in array and linked lists.   *5 marks*

(b) With the aid of an example, explain the difference between *row-major* and *column-major* allocation of a 2-dim array. Which allocation would you say is better in terms of the amount of memory used?   *5 marks*

(c) What is the running time of the operation that accesses an element at a specific index position in an array. (e.g. X[i]) . Explain your answer.   *4 marks*

(d) What is an array-mapping function? Assuming row-major order, show the array mapping function for a 2-D array. Show all workings.   *3 marks*

(e) Using C#/Java notation, write a recursive function that takes an array of characters (a string) and determines if the array of characters (string) contains a palindrome.
A palindrome is a word, phrase, number, or other sequence of symbols or elements, whose meaning may be interpreted the same way in either forward or reverse direction.   *8 marks*

Question 4

(a) List and describe the operations of a queue data structure.   *6 marks*

(b) With the aid of a diagram, compare a **Simple linked-list** *and* **Circular linked-list** implementation of a queue in terms of the memory requirements and the running times of the operations. In your opinion which one is a better implementation? Explain your answer.   *7 marks*

(c) Using C# Standard Template Library [or Java Collection] classes, write an algorithm that takes two queues of integer numbers [each sorted in ascending order] and constructs and returns a new queue [also sorted in ascending order] consisting of all members of the given queues. For example, if first queue is [1, 3, 3] with 1 in front and second queue is [-3, -2, 0, 4] with -3 in front, the new queue should be [-3, -2, 0, 1,1, 3,3,4] with -3 in front.   *12 marks*

Question 5

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

(b) Draw a diagram 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:

    7 20 4 2 - * +

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

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

                                                                                     9 *marks*

Question 6

Consider the following graph
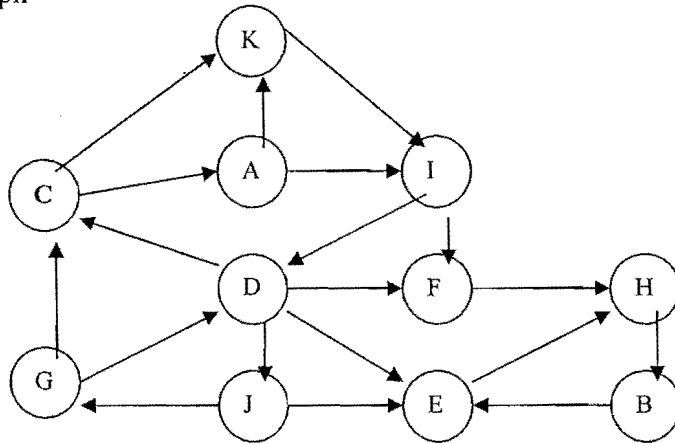
(a) Show the adjacency matrix representation of the above graph G.   2 *marks*

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

(c) Using C# or Java notation, define a suitable structure that can be used to represent a
    graph using an adjacency list.   7 *marks*

(d) List all the nodes of G, assuming Breadth-First Search (BFS) starting from node D.
    You may assume adjacent nodes are visited in alphabetical order.   3 *marks*

(e) Trace the execution of the Depth-First Search (DFS) algorithm on the above
    graph G starting from node D. Assume adjacent nodes are visited in alphabetic
    order.   10 *marks*