

University of Swaziland
Final Examination
MAY 2013

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) Justify the following statement without directly invoking the definition of big-oh notation : $N^2 + \log_2 N$ is $O(N^2)$. 3 marks
- (c) Using C++/Java notation, define a suitable structure that could be used to implement an ordered List. 3 marks
- (d) Write C++/Java functions that implement the *Create (constructor)*, *IsEmpty*, *Insert* and *Delete* operation on the structure described in (a) above. 12 marks
- (e) Using the big-O notation, estimate the running times of the implementations given in (d) above. 4 marks

Question 2

- (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 column-major order, show the array mapping function for a 2-D array. 3 marks
- (e) Using C++/Java notation, write a recursive function that takes an array of characters (a string) and determines if the array 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 3

- (a) List and describe the operations of a queue data structure. 6 marks
- (b) 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] , 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 queue. 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 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 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 function for class **TreeNode** and **BSTree** and defined in (a) above. 4 marks
- (c) Using C++/Java, and assuming your definition in (a) above, write a code for the following member functions that perform the followings tasks:
- a. Adding a new value to a binary search tree. 4 marks
 - b. post-order traversal of a 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 pre-order traversal algorithm on tree obtained in (d) above. 4 marks

Question 5

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

(b) Using your pseudocode in (a) above, and construct a B-tree of order 5 containing the following values.

20	98	10	200	40	150	25	315	70	75
65	100	15	30	17	800	50	80	100	400

Assume values are inserted in the given order. 15 marks

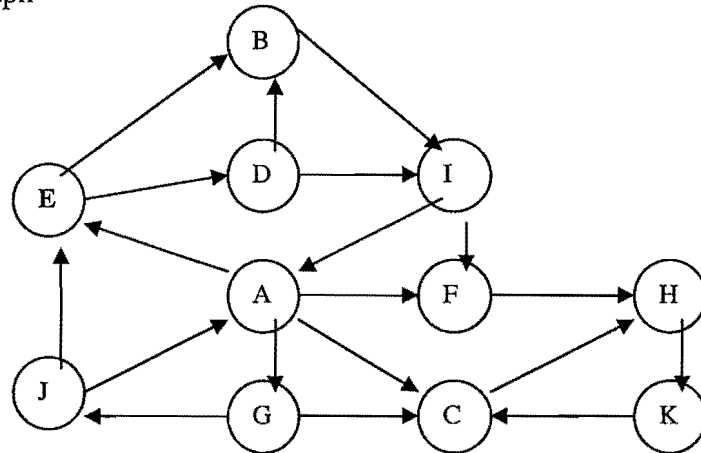
(c) List all node values in the B-tree constructed above assuming pre-order traversal.

What is the running time of this traversal? 3 marks

(d) What is the height of a B-tree of order 19 containing 130000 values. 3 Marks

Question 6

Consider the following graph



(a) Show the adjacency matrix representation of the above graph G. 4 marks

(b) Show the adjacency list representation of the above graph G. 4 marks

(c) 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. 7 marks

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