Ref. No.: Ex/IT/PC/B/T/211/2024

B.E. Information Technology Second Year First Semester 2024

Sub: Data Structures and Algorithms

Time: 3 Hours Full Marks: 100

Answer all Questions

1. Answer either (a) or (b)

a. (3+ 3 + 10 + 7 + 2)

i. Define the following terms:

Algorithm, ADT, Data structure

ii. Derive the time complexity of the following code in big-Oh notation?

```
int i, j, k = 0;
    for (i = n / 2; i <= n; i++)
    {
      for (j = 2; j <= n; j = j * 2)
      {
        k = k + n / 2;
      }
    }
```

iii. You are given an integer array of size n. Assume a sliding window of size k starting from index 0. In each iteration the sliding window moves to the right by one position till n-k. Write an algorithm to return an array containing the maximum number in all sliding windows. What is the time complexity of your algorithm?

iv. There are two singly linked lists in a system. By some programming error, the end node of one of the linked lists got linked to the second list, forming an inverted Y-shaped list. Write an algorithm to get the point where two linked lists merge.

v. What are the advantages and disadvantages of doubly linked list over circular linked list?

b. (3 + 6 + 4 + 8 + 4)

i. Write an algorithm to cyclically rotate an array clockwise by one position.

ii. Write an O(N) algorithm to find the count of elements before which all the elements are smaller from a given integer array. The first element is always counted as there is no other element before it.

iii. Let A be a four dimensional array declared as follows:

A: array [1...10][1...20][1...10][1...20] of integers;

Assuming that each integer takes one memory location, array is stored in **column-major** order, and the first element of the array is stored at location 1000, what is the address of the element A[3][4][3][4]?

iv. Given a linked list of size **N**. Write an O(N) algorithm to reverse every **k** nodes in the linked list. If the number of nodes is not a multiple of k then left-out nodes, in the end, should be considered as a group and must be reversed.

v. Write an O(1) algorithm to connect two circular linked lists.

2. (5 + 12 + 3)

a. Given two queues with their standard operations (enqueue, dequeue, size etc.) implement a stack with its standard operations (push, pop, size etc.).

b. Write an algorithm to sort a stack of integers (use recustion).

c. Consider the following operation along with standard Enqueue and Dequeue operations on queues, where k is a global parameter.

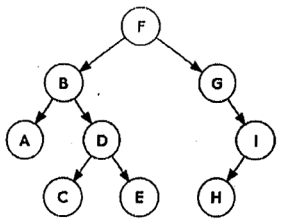
```
MultiDequeue (Q)
{
        m=k;
        while (Q is not empty and m>0)
        {
                Dequeue (Q);
                m=m-1;
        }
}
```

What is the worst case time complexity of a sequence of n MultiQequeue () operations on an initially empty queue.

3. Answer either (a) or (b)

a. (8 + 5 + 6 + 3)

i. In spiral order traversal of binary tree, nodes at different level are printed in alternating order. For example for the given binary tree, output should be F, B, G, I, D, A, C, E, H. Write an algorithm for spiral order traversal of binary tree.



ii. Construct the full binary tree corresponding to following preorder sequence with leaf node information.

Preorder sequence : {10 8 11 5 12 6 3 7 20 15 4 18 25 16 30}

Boolean array : {0 0 0 1 1 0 1 1 0 0 1 1 0 1 1}

iii. Derive an expression to compute minimum h_{min} and maximum height h_{max} of a B tree of order m and n number of keys.

iv. Given two max heaps of size n each, what is the minimum possible time complexity to make a one max-heap of size from elements of two max heaps?

b. (6 + 6 + 5 + 5)

i. In an implementation of AVL tree each node v has an extra field BF, the balance factor of node BF of a node is typically declared as integer. The BF can be used to balance the tree and to compute the height of the tree.

A. How can we reduce the number of extra bits necessary for balancing the AVL tree?

B. Suggest a recursive algorithm for computing the height of a given AVL tree using the representation you suggested above.

ii. Write an algorithm to convert a binary search tree into a sorted singly connected linked list.

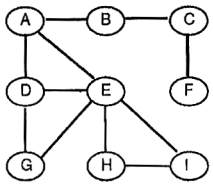
iii. A B-tree of order 4 is built from scratch by 10 successive insertions. What is the maximum number of node splitting operations that may take place?

iv. Consider a max heap, represented by the array: 40, 30, 20, 10, 15, 16, 17, 8, 4. Now consider that a value 35 is inserted into this heap. Show the resultant heap after this insertion.

4. (3 + 6 + 3 +3)

a. Discuss the characteristics of the adjacency matrix and adjacency list implementations for a graph. Include storage requirements and worst case performance of all graph operations.

b. State the order in which the vertices of the graph in the figure below will be traversed when the edges incident on a vertex are traversed by the alphabetic order of the adjacent vertices using depth first and breadth first traversal algorithms. Start at node A.



c. Let G be connected undirected graph of 100 vertices and 300 edges. The weight of a minimum spanning tree of G is 500. If the weight of each edge of G is increased by five, what will be the weight of a minimum spanning tree?

d. Difference between Prim's and Kruskal's algorithm for MST

5. Answer either (a) or (b)

a. (8 + 6 + 4)

i. Given an integer array, sort its element by their frequency and index. i.e., if two elements have different frequencies, then the one which has more frequency should come first; otherwise, the one which has less index should come first.

ii. A priority queue is implemented as a Max-Heap. Initially, it has 5 elements. The BFS traversal of the heap is: 10, 8, 5, 3, 2. Three new elements 1, 7, and 9 are inserted into the heap in that order. Give the BFS traversal of the heap after the insertion of the elements.

iii. A hash table of length 10 uses open addressing with hash function h(k)=k mod 10, and linear probing. After inserting 6 values into an empty hash table, the table is shown below:

0	
1	
2	42
3	23
4	34
5	52
6	46
7	33
8	
9	

1. Give a possible order in which the key values could have been inserted in the table.
2. How many different insertion sequences of the key values using the same hash function and linear probing will result in the hash table shown above?

b. (8 + 6 + 4)

i. Given a schedule containing the arrival and departure time of trains in a station, find the minimum number of platforms needed to avoid delay in any train's arrival.

ii. Insert the following elements on-by-one into an initially empty Max-Heap.

1, 2, 3, 4, 5, 6, 7, 8, 9, 10

iii. Consider a hash table with 9 slots. The hash function is h(k) = k mod 9. The collisions are resolved by chaining. The following 9 keys are inserted in the order: 5, 28, 19, 15, 20, 33, 12, 17, 10. What are the maximum, minimum, and average chain lengths in the hash table?