DATA STRUCTURES
(MCA1201)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Let A be a two-dimensional array declared as follows:
A: array [1…10] [1…15] of character;
Assuming that each character takes one memory locations the array is stored in row-major order and the first element of the array is stored in location 100, what is the address of the element A[i][j] ?
(a) 15i + j + 84 (b) 15j + i + 84 (c) 10i + j + 89 (d) 10j + i + 89

(ii) Linked Lists are not suitable for:
(a) Binary Search (b) Polynomial Manipulation
(c) Insertion Sort (d) Radix Sort

(iii) In the worst case, the number of comparisons needed to search for a key in a singly linked list of length n is:
(a) $\log_2 n$ (b) n/2 (c) $\log_2 n - 1$ (d) n

(iv) The equivalent Postfix notation for ((A + B) * C – (D – E) ^ (F + G)) is:
(a) AB + C * DE - - FG + ^ (b) ^ - * +ABC - DE + FG
(c) (AB)+CDE* -- FG+^ (d) AB*+DE—FG+^

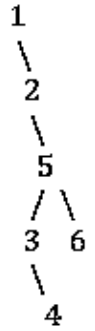
(v) What is the data structure used to implement the BFS traversal of a graph?
(a) Stack (b) Queue (c) Binary Tree (d) B-tree

(vi) Recursion uses the ____ data structure as it follows ____ ordering.
(a) Queue, LIFO (b) Queue, FIFO (c) Stack, LIFO (d) Stack, FIFO

(vii) Binary search can be applied to an array that is
(a) Not sorted (b) Already sorted
(c) Having random values (d) Of any ordering

(viii) The time complexity of running binary search on a linked list whose elements are already sorted is:
(a) O(1) (b) O(log n) (c) O(n) (d) O(n log n)

(ix) What will be the post order traversal of the given tree?



(a) 1, 2, 3, 4, 5, 6
(b) 5, 3, 4, 6, 2, 1
(c) 4, 3, 6, 5, 2, 1
(d) 3, 4, 6, 5, 2, 1

(x) An AVL tree is a tree
(a) Which is binary search tree and height balanced tree.
(b) Which is a binary search tree but unbalanced tree.
(c) With at most two children.
(d) With at most three children.

Fill in the blanks with the correct word

(xi) A linked list having n nodes (n >= 1) where no node stores a NULL pointer is a _____ linked list.

(xii) If front is equal to rear in a circular queue which is not empty, the queue has _____ element(s).

(xiii) The optimal data structure used to solve the Tower of Hanoi problem is _____.

(xiv) The minimum number of edges in a connected undirected graph, having n nodes is_____.

(xv) The time complexity of building a max-heap is _____.

Group - B

2. (a) Discuss the worst case running time of Insertion sort. *[(CO1,C04)(Analyze/IOCQ)]*
(b) Which one is asymptotically bigger, n or log n? Draw the graphs required. *[(CO2)(Analyze/IOCQ)]*
(c) Write the pseudo code to insert an element into a singly linked list at a given position. Take appropriate measure when the list is empty or if the given position does not exist in the list. *[(CO2)(Apply/IOCQ)]*

4 + 4 + 4 = 12

3. (a) Give an example of linear data structure. *[(CO2)(Understand/LOCQ)]*
(b) Given a 2D integer array of dimension 100 x 200 and also given that the base address of the 2D array is 2020. Assume that the array index of the matrix starts from [10, 20]. Find the address of the element with index [50,160] for column major ordering and row major ordering. *[(CO2)(Understand/IOCQ)]*
(c) Draw and explain the asymptotic curves for Θ, Ω and O. *[(CO1) (Remember/LOCQ)]*
(d) What is the time complexity to insert an element at the end of a singly linked list? *[(CO2) (Understand/LOCQ)]*

1 + 4 + 6 + 1 = 12

Group - C

4. (a) Evaluate the result of the given infix expression using proper data structure:

2*(5*(3+6))/15 - 2.
Show every step clearly. *[(CO2)(Apply/IOCQ)]*

(b) Discuss the key features of tail recursion. Explain with suitable example how it is different from a normal recursive function. *[(CO2,CO6)(Remember/LOCQ)]*

(c) Is Double Ended Queue a FIFO data structure? Explain. *[(CO2)(Remember/IOCQ)]*

5 + 4 + 3 = 12

5. (a) Implement a Double Ended Queue using a doubly linked list. *[(CO2)(Remember/LOCQ)]*

(b) Why is it beneficial to use a circular array to implement a queue? Explain with an example. *[(CO2)(Remember/LOCQ)]*

(c) What will the following function return if it is called from the main as fun(5, 0, 1)? Can you identify what the following function is calculating? It is something well-known.

```
int fun(int n, int a, int b)
{
    if (n == 0)
        return a;
    if (n == 1)
        return b;
    return fun(n - 1, b, a + b);
}
```

[(CO2)(Analyse/IOCQ)]

4 + (2 + 1) + (4 +1) = 12

Group - D

6. (a) Define m-way Search Tree.List down the properties of m-way Search Tree. Construct a B Tree of order 4 with the following elements
5,3,21,9,1,13,2,7,10,12,14,8. *[(CO3, CO6)(Apply/LOCQ)]*

(b) Distinguish between B Tree and B+ Tree. Construct a B+ tree with the following key values
1,4,7,10,17,21,31,25,19,20,28,42. Now delete 20,21, and 25 from this B+ Tree.
[(CO4)(Apply/IOCQ)]

(1 + 5) + 6 = 12

7. (a) Briefly explain the difference between a full binary tree and a complete binary tree with suitable examples. *[(C32)(Understand/LOCQ)]*

(b) Consider a binary search tree with **n** (i.e., **n >= 0**) nodes, which has been constructed using linked representation of tree, where the structure of each tree node has three components: key value/ data, pointer to left subtree and pointer to right subtree.
Suggest an algorithm (/ pseudo code/ Java-code) of a function (or procedure) which will delete a given key value from the binary search tree, provided it is found in the tree *[(CO3)(Apply/IOCQ)]*

(c) Consider the In-order and Post-order traversals of a tree as given below:

In-order: j e n k o p b f a c l g m d h i
Post-order: j n o p k e f b c l m g h i d a

Draw the tree. What will be the pre-order traversal of the tree? *[(CO3)(Apply/IOCQ)]*

3 + 5 + 4 = 12

Group - E

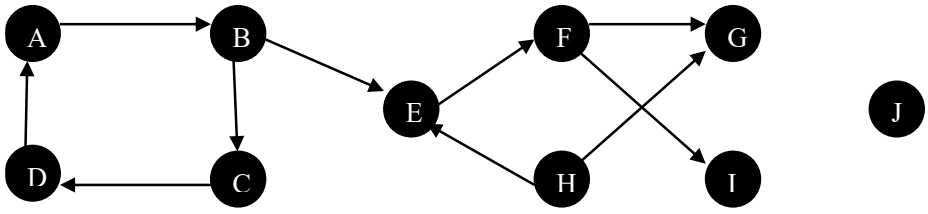
8. (a) When do you say that a certain sorting algorithm is stable?
The following pseudo-code works on an array of records indexed from 1 to n, where k_j is the key of the record of type integer present at index j. What job does it perform?

```
for i = n - 1 downto 1
    for j = 1 to i
        if kj > kj+1
            do exchange
        endif
    endfor
endfor
```

What changes occur (if any) if you change the ≤ operator in the above pseudo-code to
(i) < (ii) ≥ (iii) > *[(CO4)(Analyse/IOCQ)]*

(b) What is the greatest drawback of the naïve bubble sort algorithm that we cannot remove even if we use its improved version?
However, if we do a small modification in the algorithm, it gets removed. What is that modification?
What do we call the sorting algorithm after we perform that modification?
[(CO4)(Remember/LOCQ)]

(c) Please do a DFS traversal on the following graph starting from vertex H, i.e., d(H) = 1. Just write the discovery time d(u) and finishing times f(u) for each vertex u. You need not show any color change or intermediate versions of the graph. Also classify the edges into the four different types – tree, back, forward and cross edges. *[(CO2,CO3,CO6)(Apply/HOCQ)]*



(1 + 2 + 3) + (1 + 1 + 1) + 3 = 12

9. (a) Analyse the performance of Quick sort for best case and worst case with relevant example. *[(CO4)(Remember/IOCQ)]*

(b) For the elements 145,40,25,65,12,48,18,1,100,27,7,3,45,9,30 show that in "Heapify method" time complexity can be reduced to O(n). *[(CO4)(Analyse/IOCQ)]*

(c) Write down the Pseudocode for Merge-sort algorithm. Justify that the average case time complexity of Merge sort is $O(n\log_2 n)$. *[(CO4)(Apply/IOCQ)]*

(4 + 1) + (1 + 1) + (2 + 3) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	32.3	64.6	3.1