DATA STRUCTURES AND ALGORITHMS
(MCAP 1201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) What is the outcome of the prefix expression + - * 3 2 / 8 4 1 ?
(a) 12 (b) 11
(c) 5 (d) 4.

(ii) Which type of linked list does not store NULL in next field of the last node?
(a) Singly linked list (b) Circular linked list
(c) Doubly linked list (d) All of these.

(iii) What is the minimum number of stacks needed to implement a queue? Consider the situation where no other data structure like arrays, linked list is available to you.
(a) 1 (b) 2
(c) 3 (d) 4

(iv) The time complexity of *enqueue* operation in Queue is _____.
(a) O(1) (b) O(n)
(c) O(log n) (d) O(n log n)

(v) Which rotation is done when a new node is inserted in the right sub-tree of the right sub-tree of the critical node?
(a) LL (b) LR
(c) RL (d) RR.

(vi) In a max-heap, element with the greatest key is always in which node?
(a) Leaf node (b) First node of left sub tree
(c) Root node (d) First node of right sub tree.

(vii) Leaves of which of the following trees are at the same level?
(a) Binary tree (b) B-tree
(c) AVL-tree (d) Expression tree.

(viii) What is the search complexity in direct addressing?
(a) O(n) (b) O(log n)
(c) O(n log n) (d) O(1).

(ix) What is the number of edges present in a complete graph having n vertices?
(a) (n*(n+1))/2 (b) (n*(n-1))/2
(c) n (d) Information given is insufficient.

(x) What is the number of moves required to solve Tower of Hanoi problem for k disks?
(a) 2k – 1 (b) 2k + 1
(c) $2^k + 1$ (d) $2^k - 1$.

Group- B

2. (a) Represent the following polynomial $5x^5 + 4x^2 - 25x + 10$ with array(s). Write an algorithm to read such a polynomial, take derivative of the polynomial and print the result. *[(CO4)(Apply/IOCQ)]*

(b) 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 location, 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]? *[(CO1)(Apply/IOCQ)]*

(c) What are header nodes or list headers? Why is it desirable sometimes to use header nodes? *[(CO4)(Understand/LOCQ)]*

6 + 3 + (1 + 2) = 12

3. (a) The running time of an algorithm T(n), where n is the input size is given by

$$T(n) = 8T(n/2) + qn, \text{ if } n > 1$$
$$= p, \text{ if } n = 1$$

where, p and q are constants. Find the time complexity of the algorithm in asymptotic notation. *[(CO2)(Analyze/IOCQ)]*

(b) Show that $4n^2 + 7 = O(n^3)$. *[(CO2)(Apply/IOCQ)]*

(c) Work out the computational complexity of the following piece of code:

```
for( count = 1; count<= n; count *= 2 ) {
                for( i = 0; i < count; i++ ) {
        for( j = 0; j < n; j += 2 ) {
                ... /* constant number of operations */}
    }
}
```

[(CO2)(Evaluate/HOCQ)]

4 + 3 + 5 = 12

Group - C

4. (a) What is a circular queue? What are the advantages of circular queue over linear queue? Write *append* and *serve* functions for a circular queue.
[(CO3)(Understand/LOCQ)]

(b) With the help of stack convert the following infix expression to corresponding postfix expression:
(assume ^ is the exponentiation operator) *[(CO4)(Apply/IOCQ)]*

((5 + 3) * 4) – 2 ^ 3 ^ 2

(1 + 2 + 3) + 6 = 12

5. (a) State the Towers of Hanoi problem. Devise a solution to the Towers of Hanoi problem clearly explaining the pre-condition and post-condition for any algorithm you write. Derive the time complexity of your algorithm in terms of O-notation. *[(CO2)(Apply/IOCQ)]*

(b) A queue Q containing n items and an empty stack S are given. It is required to transfer all the items from the queue to the stack, so that the item at the front of the queue is on the top of the stack, and the order of all the other items is preserved. How can this be done in O(n) time using only a constant amount of additional storage. *[(CO2)(Create/HOCQ)]*

(1 + 4 + 1) + 6 = 12

Group – D

6. (a) What are two ways of representing binary trees in the memory? Which one do you prefer and why? *[(CO4)(Evaluate/HOCQ)]*

(b) Given a binary tree whose inorder and preorder traversals are given by

Inorder: E I C F B G D J H K
Preorder: B C E I F D G H J K

Draw the tree. What will be the post order traversal of the binary tree? *[(CO1)(Apply/IOCQ)]*

(c) In a full binary tree of height k, how many internal nodes are present? *[(CO1)(Analyze/IOCQ)]*

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

7. (a) Construct a max heap with the following entries, in the order stated
26, 33, 35, 29, 42, 72. *[(CO5)(Apply/IOCQ)]*

(b) Insert the following keys in order to build them into an AVL tree:

A Z B Y C X D W E V F

Clearly mention the different rotations used and the balance factor of each node. *[(CO4)(Apply/IOCQ)]*

(c) Insert the following entries, in the order stated, into an initially empty B-tree of order 4.

A G F B K D H M J E S I R X C L N T U P

[(CO4)(Apply/IOCQ)]

4 + 4 + 4 = 12

Group - E

8. (a) Consider a hash table with size = 10. Using quadratic probing, insert the keys 27, 72, 63, 42, 36, 18, 29, and 101 into the table. Take c1 = 1 and c2 = 3. *[(CO4)(Apply/IOCQ)]*

(b) An article in a professional journal stated, "This recursive process [merge sort] takes time O(nlogn), and so runs 64 times faster than the previous method [insertion sort] when sorting 256 numbers." Criticize this statement.
[(CO3)(Analyze/IOCQ)]

(c) Write Dijkstra's algorithms using greedy approach for finding shortest path in a graph. *[(CO3)(Apply/IOCQ)]*

5 + 4 + 3 = 12

9. (a) How is the idea of sentinel used to increase the efficiency of linear search? What are the best and worst case complexities of linear search with sentinel?
[(CO6)(Analyze/IOCQ)]

(b) Trace the action of radix sort on the following list of seven numbers considered as three-digit integers:
265, 337, 357, 295, 193, 125, 224. *[(CO4) (Apply/IOCQ)]*

(c) Suppose that *L1* and *L2* are lists containing *n1* and *n2* integers, respectively, and both lists are already sorted into numerical order. Use the idea of binary search to describe how to find the median of the *n1* + *n2* integers in the combined lists.
[(CO6) (Create/HOCQ)]

(2 + 2) + 4 + 4 = 12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*9.38*	*69.79*	*20.83*

Course Outcome (CO):

After the completion of the course students will be able to
MCAP1201.1 Define the basic data structures and their operations.
MCAP1201.2 Evaluate algorithms in terms of time and memory complexity of basic operations.
MCAP1201.3 Understand the significance and context of application of different algorithm design techniques.
MCAP1201.4 Understand the significance and utility of different data structures and the context of their application.
MCAP1201.5 Evaluate solutions of a problem with different data structures and thereby understand how to select suitable data structures for a solution.
MCAP1201.6 Create or design an algorithm to aid in the solution of a real world problem.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*