DATA STRUCTURES
(MCA 1201)

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) Running time of BUILD-MAX-HEAP function of heap sort is tightly bounded by which of the following?
(a) O(n) (b) O(n log n) (c) O(1) (d) None of these.

(ii) Let n be the number of nodes in a linked list, you may assume that n > 8. What are the time complexities of finding 8th element from the beginning and 8th element from the end in that singly linked list?
(a) O(1) and O(n) (b) O(1) and O(1)
(c) O(n) and O(1) (d) O(n) and O(n).

(iii) Suppose a binary tree is constructed with n nodes, such that each node has exactly either zero or two children. The maximum height of the tree will be?
(a) (n + 1) / 2 (b) (n - 1) /2
(c) n / 2 – 1 (d) (n + 1)/ 2 – 1.

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

(v) 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 utmost two children
(d) with utmost three children.

(vi) The leaves of an expression tree always contain
(a) operators (b) operands (c) null (d) expression.

(vii) A chained hash table has an array size of 100. What is the maximum number of entries that can be placed in the table?
(a) 100 (b) 200
(c) 10000 (d) There is no upper limit.

(viii) The array representation of a complete binary tree contains the data in sorted order. Which traversal of the tree will produce the data in sorted form?
(a) Preorder (b) Inorder
(c) Postorder (d) Level order.

(ix) Consider the following code snippet:

```
int fun(int n)
{
  int count = 0;
  for (int i = 0; i < n; i++)
     for (int j = i; j > 0; j--)
         count = count + 1;
  return count;
}
```

What is the time complexity of fun() in worst case?
(a) θ (n) (b) θ (n*logn) (c) θ (n^2) (d) θ (n*logn*logn).

(x) If a graph has 110 nodes and 98 edges, what would be the minimum number of components it may have?
(a) 10 (b) 96 (c) 12 (d) 95.

Fill in the blanks with the correct word

(xi) Searching is more efficient in _____ trees than in Binary Search Trees.

(xii) In the _____ the key is separated into different groups to generate the hash value.

(xiii) To traverse a _____, you begin at any node and follow the list in either direction until you return to the original node.

(xiv) In _____ algorithm the vertex is deleted from the queue when it is visited.

(xv) Traversing a binary expression trees in preorder yields ____ form of expression.

Group - B

2. (a) Write a program that creates a singly linked list. Use a function IsSort() that returns 1 if the list is sorted and 0 otherwise. *[(CO2)(Apply/IOCQ)]*

(b) Suggest an algorithm to find whether an array is a subset of another array. Note that these arrays contain distinct values.
Example: Input: arr1[] = {11, 1, 13, 21, 3, 7}, arr2[] = {11, 3, 7, 1}
Output: arr2[] is a subset of arr1[] *[(CO2,CO5)(Create/HOCQ)]*

5 + 7 = 12

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

$$T(n) = T(n-1) + qn \quad \text{if } n > 1,$$
$$= p, \quad \text{if } n = 1,$$

where p and q are constants. Find the time complexity of the algorithm in asymptotic notation. *[(CO1)(Analyse/IOCQ)]*

(b) Determine whether the statement is correct: $n! = O(n^n)$. *[(CO1) (Analyze/IOCQ)]*

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

```
for ( i=1; i < n; i *= 2 ) {
        for ( j = n; j > 0; j /= 2 ) {
                for ( k = j; k < n; k += 2 ) {
                        sum += (i + j * k );
                }
        }
}
```

[(CO1)(Analyze/IOCQ)]

4 + 3 + 5 = 12

Group - C

4. (a) 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. Show how this can be done in O(n) time using only a constant amount of additional storage. *[(CO2,CO6)(Create/HOCQ)]*

   (b) Write an algorithm to implement a queue using two stacks. *[(CO2)(Apply/IOCQ)]*

6 + 6 = 12

5. (a) Write a tail recursive function in C to calculate the sum of first n numbers (up to Fib(n)) in Fibonacci series. (Consider Fib(0) = 0) *[(CO2)(Apply/LOCQ)]*

   (b) Write a method to reverse a stack using recursion, without using any loop. [Consider the Stack class has push(),pop() methods]
   Input: elements present in stack from top to bottom 1 2 3 4
   Output: 4 3 2 1 *[(CO2)(Apply/IOCQ)]*

   (c) Consider the following recursive function that takes two arguments.

```
static int foo(int n, int r){
        if(n>0) return((n%r)+foo(n/r,r));
else return 0;
}
```

   What is the return value of the function foo when it is called as foo(345,10)?
   [(CO2)(Analyze/IOCQ)]

5 + 4 + 3 = 12

Group - D

6. (a) Write an algorithm to search an element in a binary search tree. Find its time complexity (best, worst and average case). *[(CO3,CO1)(Apply/IOCQ)]*

   (b) What are disadvantages of array representation of tree? Which of the trees could be processed more efficiently using array representation than linked structure? *[(CO3)(Understand/LOCQ)]*

   (c) Let h be the height of a binary tree. What is the maximum and minimum number of nodes possible? *[(CO3)(Analyze/IOCQ)]*

5 + 5 + 2 = 12

7. (a) Consider an AVL tree and insert 18, 81, 29, 15, 19, 25, 26, and 1 in it. Then delete nodes 39, 63, 15, and 1 from the AVL tree. Clearly mention each step. *[(CO3)(Create/IOCQ)]*

(b) The inorder and preorder traversal of a binary tree are given below:

Inorder: d b e a f c g

Preorder: a b d e c f g

Find the postorder traversal of the binary tree. *[(CO3)(Apply/IOCQ)]*

(c) How does the height of a binary search tree affect its performance like insertion, deletion, and searching? *[(CO3)(Understand/LOCQ)]*

6 + 4 + 2 = 12

Group - E

8. (a) When does a collision occur in hashing? Explain any two methods for collision resolution. *[(CO4)(Understand/LOCQ)]*

(b) Write an algorithm for heap sort. Derive its time complexity. *[(CO4,CO1)(Apply/IOCQ)]*

(c) Write BFS algorithm using greedy approach for traversing a graph. *[(CO5)(Apply/IOCQ)]*

4 + 4 + 4 = 12

9. (a) Consider a hash table of size 10. Using double hashing, insert keys 72, 27, 36, 24, 63, 81, 92, and 101 into the table. Write your own hash function. *[(CO4)(Apply/IOCQ)]*

(b) Suppose we are sorting an array of eight integers using heapsort, and we have just finished some heapify (either maxheapify() or minheapify()) operations. The array now looks like this: 16 14 15 10 12 27 28. How many heapify operations have been performed on root of heap? Explain. *[(CO4)(Analyze/IOCQ)]*

(c) Let (u, v) be a minimum weight edge in an undirected graph G. Show that (u, v) belongs to some minimum spanning tree of G. *[(CO5)(Analyze/IOCQ)]*

5 + 4 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	16.67	69.8	13.53

Course Outcome (CO):

After the completion of the course students will be able to

MCA1201.1 Analyze the asymptotic performance of algorithms.

MCA1201.2 Define basic linear data structure operation using array, linked list, stack, and queue.

MCA1201.3 Demonstrate Non linear data structure operations involving graphs, trees and heaps.

MCA1201.4 Apply algorithms for solving problems like sorting, searching, insertion and deletion of data, hashing.

MCA1201.5 Solve a problem using dynamic programming, greedy technique algorithms, brute force and divide-and-conquer technique algorithms.

MCA1201.6 Compare the performance of alternative approaches to problem solving using different data structures covered in this course, with respect to their efficiency.

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