DATA STRUCTURE AND BASIC ALGORITHMS
(CSEN 2004)

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 asymptotic running time of the following loop statement?
for (i = n; i >= 0; i = i/2);
(a) O(n) (b) O(log n) (c) O(n log n) (d) O(n^2).

(ii) A height balanced binary tree is a binary tree in which the height of two subtrees in every node differs by no more than
(a) 1 (b) 2 (c) 3 (d) none of these.

(iii) A connected graph with n vertices has
(a) At least n - 1 edges (b) At most n - 1 edges
(c) At least n^2 edges (d) At most n^2 edges

(iv) The time complexity of binary search algorithm is
(a) O(n log n) (b) O(n^2)
(c) O(n) (d) O(log n).

(v) Which sorting algorithm takes the least time to run if the input array is already sorted in the desired order?
(a) Selection sort (b) Insertion sort
(c) Quicksort (d) Merge sort.

(vi) The value in a BST can be sorted in ascending order by using which of the following traversals?
(a) Pre-Order traversal (b) Post-order traversal
(c) In-order traversal (d) Level order traversal.

(vii) The adjacency matrix of an undirected graph is a
(a) Unit matrix (b) Asymmetric matrix
(c) Symmetric matrix (d) Upper triangular matrix.

(viii) Which data structure is used to perform Depth First Search on a graph?
(a) Sorted array (b) Stack
(c) Queue (d) AVL tree

(ix) Assuming that an integer requires 4 bytes of storage, the address of the 100th element of an integer array having base address 5000 is
(a) 5395 (b) 5396 (c) 5399 (d) 5400.

(x) If a circular queue is implemented using an array having a maximum size of MAX_SIZE, overflow occurs when,
(a) rear == MAX_SIZE - 1 (b) front == MAX_SIZE - 1
(c) (rear + 1)%MAX_SIZE == front (d) (front + 1)%MAX_SIZE == rear.

Group- B

2. (a) Is the following statement correct? Justify your answer.
$7n^4 + 3n^2 + 2 = O(n^4)$ [(CO1)(Remember/LOCQ)]

(b) What is an abstract data type? Explain with an example.
[(CO1)(Remember/LOCQ)]

(c) Write a code snippet to delete the k^{th} node of a singly-linked list. Your code must handle all possible cases of errors. [(CO4)(Understand/IOCQ)]

(1 + 3) + 2 + 6 = 12

3. (a) What is the triplet array representation of the following 2D matrix?

0	7	0	0	4	0
8	0	0	0	0	0
2	0	6	0	0	0

Is it beneficial to store this matrix as a triplet array? Justify your answer.
[(CO3)(Understand/IOCQ)]

(b) Consider an 25X10 matrix A. Suppose Base(A)=400 and w=4 words per memory cell. What will be the address of A[10,8] in row major and column major order?
[(CO1)(Remember/LOCQ)]

(c) How is a circular linked list with a head pointer different from a circular linked list with a tail pointer? Which of the two would be better suited for implementing a queue and why? [(CO1)(Remember/LOCQ)]

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

Group - C

4. (a) What is tail recursion? How is it different from normal recursion? Explain with suitable example. [(CO3)(Understand/IOCQ)]

(b) Why is it beneficial to use a circular array to implement a queue? Explain with example. [(CO3)(Remember/LOCQ)]

(c) What value does the following function return when we pass the number 50 as argument? Give proper explanation.

```
int fun (int n)
{
```

```
if (n == 1)
        return n;
else
        return n + fun(n/2);
}
```

[(CO4)(Analyze/IOCQ)]

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

5. (a) Evaluate the result of the given postfix expression using appropriate data structure:

562^83*/+4-

Show the contents of your data structure as they get modified. [(CO5)(Understand/LOCQ)]

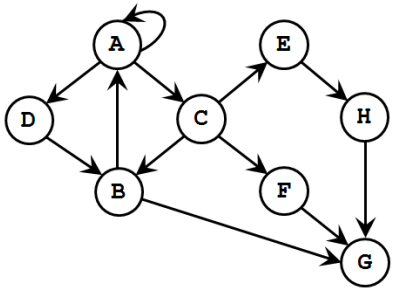
(b) Write an algorithm to pop an element from a stack. Your algorithm should handle overflow or underflow errors if applicable. [(CO4)(Analyze/IOCQ)]

(c) Write a recursive function to compute the n^{th} Fibonacci number. Draw the recursion tree for n = 5. [(CO4)(Analyze/IOCQ)]

5 + 3 + (2 + 2) = 12

Group - D

6. (a) Given the following directed graph, compute the in-degree and out-degree of each vertex. Now, perform DFS traversal of the graph to generate a DFS tree, taking A as the starting node. If more than one vertex can be visited at any given time, use alphabetical order to make the choice. At each stage of the DFS traversal, show the contents of the data structure that you are using.



[(CO2)(Understand/IOCQ)]

(b) What are the two ways of representing a graph? Explain their benefits and drawbacks. [(CO2)(Remember/LOCQ)]

(c) For a binary tree having n nodes, what is its height in an average case scenario? What is the maximum possible height that any binary tree can have? [(CO1)(Remember/LOCQ)]

(2 + 5) + (1 + 2) + (1 + 1) = 12

7. (a) Reconstruct a binary tree from its traversal sequences given below:
Inorder : A, B, D, E, C, G, I, H, K, J, F
Preorder : A, B, C, D, E, F, G, H, I, J, K
Write the postorder traversal sequence of the tree. [(CO1)(Understand/IOCQ)]

(b) Draw the different stages of an initially-empty AVL tree by inserting nodes in the following sequence (showing the balance factors of each node in each step):

50, 25, 70, 45, 65, 55, 85, 40, 95, 20, 42, 58
Write the inorder sequence of the final AVL tree. [(CO1)(Understand/IOCQ)]

(5 + 1) + (5 + 1) = 12

Group - E

8. (a) Define Hashing. What are the properties of the good hash function? [(CO1)(Remember/LOCQ)]

(b) Design an algorithm to perform binary search. Using the algorithm, search for elements 35 in the given set of elements [12 23 27 35 39 42 50]. [(CO6)(Design/HOCQ)]

(2 + 2) + (5 + 3) = 12

9. (a) Perform insertion sort on the given list to arrange the values in ascending order. Show all the different iterations that the algorithm goes through.

22, 29, 35, 42, 39, 25, 15, 32

[(CO2)(Understand/IOCQ)]

(b) Write the algorithm to implement quicksort algorithm. What are the time complexities of quicksort in the best case and average case scenarios? [(CO2)(Understand/LOCQ)]

6 + (4 + 2) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	39.58	52.09	8.33

Course Outcome (CO):

After the completion of the course students will be able to

1. Understand the data structures, their advantages and drawbacks
2. Identify the efficiency aspects of the graph and sorting algorithms covered in this course.
3. Learn about the data structures/methods/algorithms mentioned in the course with a comparative perspective
4. Describe problem statements and to design the solutions using programming language
5. Analyze and apply most appropriate data structure/method/algorithm in a program to enhance the efficiency
6. Develop and efficient program modifying an efficient one using the knowledge gathered from this course.

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