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 = 1; i <= n; i = i*2);
(a) O(n) (b) O(log n) (c) O(n log n) (d) $O(n^2)$.

(ii) The postfix expression for the infix expression A + B * (C+D)/F + D * E is
(a) AB+CD+*F/D+E* (b) ABCD+*F/+DE*+
(c) A*B+CD/F*DE++ (d) A+*BCD/F*DE++.

(iii) 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.

(iv) Advantages of linked list representation of binary trees over arrays is
(a) dynamic size
(b) ease of insertion/deletion
(c) ease in randomly accessing a node
(d) both dynamic size and ease in insertion/deletion.

(v) Any binary tree can be accurately reconstructed from its
(a) Preorder & Postorder sequences (b) Inorder sequence only
(c) Inorder & Postorder sequences (d) None of the above are true.

(vi) If the values 5, 9, -1, 2, 0, 18, 8, -7 are inserted in the given sequence into an empty binary search tree, the inorder sequence of the final tree will be
(a) 5, 9, -1, 2, 0, 18, 8, -7 (b) -7, 8, 18, 0, 2, -1, 9, 5
(c) 5, -1, -7, 2, 0, 9, 18 (d) -7, -1, 0, 2, 5, 8, 9, 18.

(vii) The inorder successor of a node X, whose degree is 2, in a binary search tree is
(a) the smallest node in the left sub-tree of X
(b) the largest node in the left sub-tree of X
(c) the smallest node in the right sub-tree of X
(d) the largest node in the right sub-tree of X.

(viii) What is the best-case time complexity of the binary search algorithm?
(a) O(n) (b) O(log(n)) (c) O(1) (d) O(log(n^2)).

(ix) The minimum number of nodes required to connect all vertices of a graph having n nodes is
(a) n - 1 (b) n + 1 (c) n^2 (d) 2n.

(x) Which of the open-addressing technique is free from clustering problems?
(a) Linear probing (b) Quadratic probing
(c) Double hashing (d) Rehashing.

Group- B

2. (a) Is the following statement correct? Justify your answer.
$5n^4 + 2n^2 + 1 = O(n^4)$. [(CO3)(Understand/LOCQ)]
(b) Consider M[][] as a two-dimensional array of integers with starting address of 4000. The number of rows and columns are 5 and 6. Now calculate the address of M[2][4] using row-major and column-major addressing policy. [(CO3)(Learn/LOCQ)]
(1 + 3) + (4 + 4) = 12

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

8	0	0	0	0
0	0	4	0	0
0	1	9	0	0

Is it beneficial to store this matrix as a triplet array? Justify your answer.
[(CO1)(Remember/LOCQ)]
(b) What is the difference between best case and worst case time complexity of an algorithm? Explain with suitable example. [(CO3)(Remember/LOCQ)]
(c) Write a C function to search for a node in a singly linked list. Your function should handle all possible errors. [(CO3)(Analyse/IOCQ)]
(2 + 2) + (2 + 2) + 4 = 12

Group - C

4. (a) Create a data structure *twoStacks* that represents two stacks. Implementation of twoStacks should use only one array, i.e., both stacks should use the same array for storing elements.
Following functions must be supported by *twoStacks*.
- push1(int x) –> pushes x to first stack
- push2(int x) –> pushes x to second stack
- pop1() –> pops an element from first stack and return the popped element
- pop2() –> pops an element from second stack and return the popped element

Implementation of *twoStack* should be space efficient. [(CO5)(Analyze/HOCQ)]
(b) Write a recursive function to compute the n^{th} number of the Fibonacci series. Draw the recursion tree for n = 5. [(CO4)(Analyze/IOCQ)]
8 + (2 + 2) = 12

5. (a) Consider a single linked list with a head pointer and tail pointer. Implement the Queue ADT using a linked list. [(CO6) (Develop/IOCQ)]

(b) What are the time complexities of ENQUEUE and DEQUEUE operations for the above-mentioned Queue? [(CO6)(Develop/IOCQ)]

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

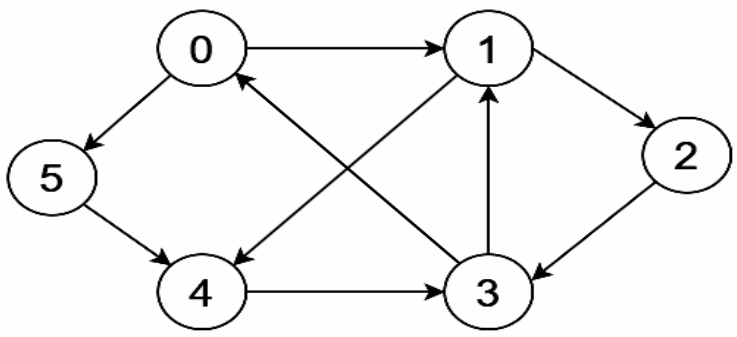
```
int fun (int n)
{
if (n == 1)
      return n;
else
      return n + fun(n/2);
}
```

[(CO4)(Analyze/IOCQ)]

6 + 2 + 4 = 12

Group - D

6. (a) Consider the following Graph.



Construct an adjacency list and adjacency matrix for the above mention Graph. [(CO5) (Analyze/IOCQ)]

(b) Apply Breadth First Search (BFS) algorithm to above mention Graph. Assume the start node as '1' and compute BFS. What is the time complexity of the BFS algorithm? [(CO4) (Describe/LOCQ)]

4 + (6 + 2) = 12

7. (a) What is the advantage of a Height Balanced Tree? [(CO3) (Learn/IOCQ)]

(b) Consider the following data sequence. Construct a Height Balanced tree with the given list of integers.

20, 21, 22, 14, 13, 17, 15, 18, 16, 19, 23, 25. [(CO6) (Develop/HOCQ)]

(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? [(CO3)(Remember/LOCQ)]

2 + 8 + (1 + 1) = 12

Group - E

8. (a) Given a hash table of 1000 locations (0 to 999), calculate the hash value using the mid-square method for keys 1234, 4567, and 5678. [(CO1) (Understand/LOCQ)]

(b) Explain the different types of collision resolution techniques in hashing. Using linear probing, insert the keys 34, 59, 88, 86, 55, 13, 84, 43 into a hash table having size 10. [(CO3) (Understand/LOCQ)]

(c) Is the following statement correct "Quicksort performs better than Insertion sort"? Justify your answer. [(CO2)(Remember/LOCQ)]

3 + (3 + 4) + 2 = 12

9. (a) Compare Merge short and Quick Sort with respect to space and time (Worst case, Average case). [(CO1)(Understand/IOCQ)]

(b) Consider the following sequence in the array and apply the Merge sort algorithm to sort the array. Discuss all the passes with relevant figures.

85, 45, 80, 65, 105, 100, 75, 70 [(CO1)(Understand/IOCQ)]

(c) Can you execute a binary search algorithm in a sorted Linked List? Justify your answer. [(CO5)(Analyze/IOCQ)]

2 + 8 + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	43.75	39.58	16.67

Course Outcome (CO):

After the completion of the course students will be able to

1. To understand the data structures, their advantages and drawbacks.
2. To identify the efficiency aspects of the graph and sorting algorithms covered in this course.
3. To learn about the data structures/ methods/ algorithms mentioned in the course with a comparative perspective.
4. To describe problem statements and to design the solutions using programming language.
5. To analyze and apply most appropriate data structure/ method/algorithm in a program to enhance the efficiency.
6. To develop an 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