FUNDAMENTALS OF DATA STRUCTURES
(CSBS 2101)

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) Convert the infix to postfix for A-(B+C)*(D/E)
(a) ABC+DE/*- (b) ABCDE/*+-
(c) ABC-DE*/+ (d) None of the above.

(ii) A machine needs a minimum of 100 sec. to sort 1024 names by Merge sort. The minimum time needed to sort 512 names will be approximately
(a) 49.5 sec (b) 45 sec (c) 72.7 sec (d) 50 sec.

(iii) Given two sorted files of size of size 'm' and 'n' respectively. The number of comparisons needed in the worst case by the merge sort algorithm will be
(a) m x n (b) maximum of m, n (c) m+n (d) m+n-1.

(iv) The minimum number of edges required to create a cyclic graph of n vertices is
(a) 2n (b) n-1 (c) n+1 (d) n.

(v) The maximum number of comparisons necessary when performing a binary search of 1,00,000 item is
(a) 100 (b) 51 (c) 17 (d) 1000.

(vi) As a part of the maintenance work, you are entrusted with the work of rearranging the library books in a shelf in proper order, at the end of each day. The ideal choice will be
(a) Bubble sort (b) Insertion sort (c) Selection sort (d) Heap sort.

(vii) A hash table can store a maximum of ten records. Currently there are records in locations 1, 3, 4, 7, 8, 9, 10. The probability of a new record going into location 2, with a hash function resolving collisions by linear probing is
(a) 0.6 (b) 0.1 (c) 0.2 (d) 0.5.

(viii) In a modified Towers of Hanoi problem, you have to move 5 disks from peg 1 to peg 3! To do that first you need to move 4 disks from peg 1 to peg 2. How many legal moves will it take to move 4 disks from peg 1 to peg 2?
(a) 31 (b) 16 (c) 32 (d) 15.

(ix) One can convert a binary tree into its mirror image by traversing it in
(a) Inorder (b) Postorder (c) Preorder (d) None of the above.

(x) When in order traversal of a tree resulted E A C K F H D B G; the preorder traversal would return
(a) FAEKCDBHG (b) EAFKHDCBG (c) FAEKCDHGB (d) FEAKDCHBG.

Fill in the blanks with the correct word

(xi) The technique of linear probing for collision resolution can lead to _____.

(xii) A linear list of elements in which deletion can be done from one end (front) and insertion can take place only at the other end (rear) is known as _____ .

(xiii) In order to reverse a string of characters, a _____ data structure is used.

(xiv) A complete binary tree of level 5 has _____ many nodes.

(xv) If a node having two children is deleted from a binary tree, it is replaced by its _____.

Group - B

2. (a) Find the sparse representation (triple format) for the following matrix. Check whether it is useful to use the sparse representation instead of the original matrix.

$$\begin{bmatrix} 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

[(CO1)(Understand/LOCQ)]

(b) Determine the time complexity of the following program segments in term of Big-Oh.

```
void function (int n)
{   for (int i = 0; i < n; i++)
        for(j = i; j < i*i; j++)
                if (j % i == 0)
          {    for (int  k = 0; k <= j; k++)
                printf("India");
            }
        }
```

[(CO1)(Evaluate/HOCQ)]

(c) Algorithm RSum(a,n)

```
{  if  (n <= 0) then
        return 0;
        else
        return RSum(a, n-1) + a[n];
}
```

Deduce the space complexity of the above algorithm. *[(CO1)(Analyze/HOCQ)]*

4 + 4 + 4 = 12

3. (a) Explain with the help of diagram(do not write code), how the pop operation takes place in case of a linked list implementation of Stack. Write down the algorithm for pop operation in linked Stack. *[(CO2)(Understand/LOCQ)]*

(b) Write a C function only to count number of nodes in a singly linked list.
[(CO2)(Apply/IOCQ)]

(c) Explain with a diagram how the end node of a circular linked list is deleted. Write down the corresponding algorithm for the operation. *[(CO2)(Understand/LOCQ)]*

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

Group - C

4. (a) Stack A has the entries a, b, c (with a on the top and c at the bottom). Stack B is empty. An entry popped out of stack A can be printed immediately or pushed to stack B. An entry popped out of the stack B can only be printed. In this arrangement, which of the following permutations of a, b, c are not possible? Examine each option carefully with the help of proper diagram and justify the right permutation.
(i) b a c (ii) b c a (iii) c a b (iv) a b c *[(CO3)(Evaluate/HOCQ)]*

(b) Consider the following queue of characters, where QUEUE is a circular queue with a size of 6. At some point, FRONT = 2, REAR = 4 and QUEUE:__, A, C, D, __, __. Here "__" denotes an empty cell in the array. What will be the value of FRONT and REAR after every operation, also describe the QUEUE as the following operations takes place.

(a) F is added to the queue
(b) Two letters are deleted
(c) K, L and M are added to the queue
(d) Two letters are deleted
(e) R is added to the queue
(f) Two letters are deleted

[(CO3)(Understand/LOCQ)]

6 + 6 = 12

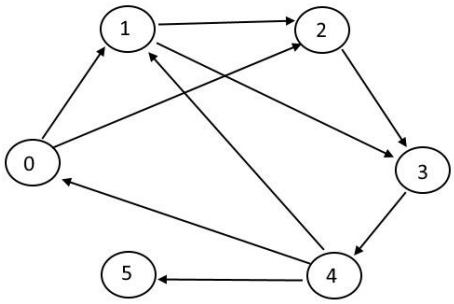
5. (a) Write a c function, in recursive method which implements Binary Search algorithm. *[(CO3)(Understand/LOCQ)]*

(b) Evaluate the following postfix expression by using Stack:7, 2, 3, -, +, 9, 6, -, /, 4, +. Draw stack and show what happens with proper explanations. *[(CO3)(Apply/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) Consider the following graph for BFS traversal. Starting from node 0, what will be the BFS traversal? Show every step. *[(CO4)(Apply/IOCQ)]*



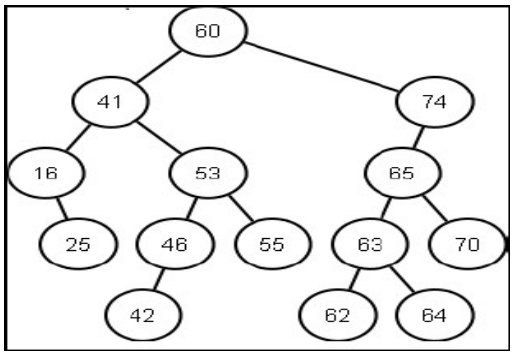
(b) Preorder traversal of a BST is this: 38, 14, 8, 23, 18, 20, 56, 45, 82, 70. What is the post order traversal of this BST? Step by step, show your work.

[(CO4)(Analyze/IOCQ)]

5 + 7 = 12

7. (a) Construct AVL tree for the following data: 21, 26, 30, 9, 4, 14, 28, 18. Show step by step, drawing the tree. In every step, show balance factor of every node and required rotation if any. *[(CO4)(Apply/IOCQ)]*

(b) Traverse the following tree using in-order and post-order tree traversal algorithm: *[(CO4) (Apply/IOCQ)]*



8 + 4 = 12

Group – E

8. (a) You are given a list of random numbers and asked to search for a particular number. Which searching algorithm you will use and why to find it in minimum time? Deduce the average time complexity of Linear Search. *[(CO5)(Analyze/IOCQ)]*

   (b) You are using Double Hashing for collision resolution. Your first hash function is h1(k) = k mod 13 and your second hash function is h2(k) = 8 – (k mod 8). You need to insert the following keys: 18, 41, 22, 44, 59, 32, 31, 73 in a table indexed from 0 to 6. How will you accomplish this task? Show step by step. *[(CO5)(Apply/IOCQ)]*

(3 + 2) + 7 = 12

9. (a) Suppose a company with 88 employees assigns a unique 4-digit employee no. to each employee which is used as primary key in the company emp- file. T is the hash table and L is the set of memory addresses in T. L consists of two-digit addresses: 00, 01, 02, ……,99.

   (i) Apply the division method to the following employee numbers: 3205, 7148, 2345. What will be the corresponding Hash addresses?

   (ii) If you apply folding method then what will be the corresponding hash addresses? *[(CO5)(Apply/IOCQ)]*

   (b) What is Double Hashing? When do we need it? Explain with an example. *[(CO5)(Understand/LOCQ)]*

   (c) (i) In insertion sort algorithm, how many times the outer for loop will iterate when n = 100?

   (ii) In insertion sort, at some point you are trying to insert k^{th} element where 0 < k < n. Assume also you started with a file which was sorted in reverse order. What will be the exact number of key comparisons? Explain. *[(CO5)(Analyze/IOCQ)]*

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

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	29.17	56.25	14.58

Course Outcome (CO):

After the completion of the course students will be able to

CSBS2101.1. Demonstrate the standard data structures covered in this course, in relevant applications.
CSBS2101.2. Identify the application of ordered and unordered lists in relevant problems of data structures.
CSBS2101.3. Apply stack and queue data structure to solve mathematical and real-life problems.
CSBS2101.4. Explore tree and graph approaches, mentioned in this course, to solve a given problem definition.
CSBS2101.5. Analyse algorithms related to sorting, searching and hashing covered in this course, in related applications.
CSBS2101.6. Compare the performance of alternative approaches built 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.*