ADVANCED DATA STRUCTURES
(CSEN 5101)

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)

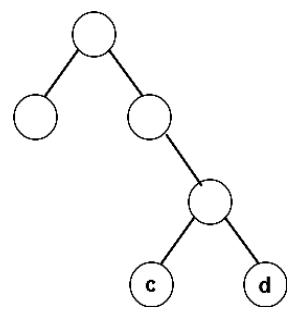
1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) A hash table contains 10 buckets and uses linear probing to resolve collisions. The key values are integers and the hash function used is **key % 10**. If the values 43, 165, 62, 123, 142 are inserted in the table, in what location would the key value 142 be inserted?
(a) 2 (b) 3 (c) 4 (d) 6.

(ii) The following postfix expression with single digit operands is evaluated using a stack: **8 2 3 ^ / 2 3 * + 5 1 * –** Note that ^ is the exponentiation operator. The top two elements of the stack after the first * is evaluated are
(a) 6, 1 (b) 5, 7 (c) 3, 2 (d) 1, 5.

(iii) Which of the following tree can be most effectively represented by an array?
(a) AVL Tree (b) Binary Search Tree
(c) Almost complete Binary Tree (d) B-tree

(iv) What is the computed code word for d from the following tree using Huffman coding?
(a) 111 (b) 001 (c) 110 (d) 011.



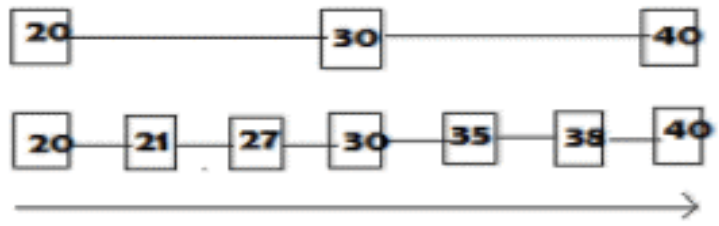
(v) Which of the following is true?
(a) Larger the order of B-tree, less frequently the split occurs
(b) Larger the order of B-tree, more frequently the split occurs
(c) Smaller the order of B-tree, more frequently the split occurs
(d) Smaller the order of B-tree, less frequently the split occurs.

(vi) Which of the following permutations can be obtained in the output (in the same order) using a stack assuming that the input is the sequence 1, 2, 3, 4, 5 in that order?
(a) 3, 4, 5, 1, 2 (b) 3, 4, 5, 2, 1 (c) 1, 5, 2, 3, 4 (d) 5, 4, 3, 1, 2.

(vii) What is the worst case search time of a hashing using separate chaining algorithm?
(a) O(N log N) (b) O(N) (c) $O(N^2)$ (d) $O(N^3)$.

(viii) 2-3 tree is a specific form of _____
(a) B – tree (b) B+ – tree (c) AVL tree (d) Heap.

(ix) How do you access 38 in the above skip list?
(a) travel 20-30-35-38 (b) travel 20-30-40-38
(c) travel 20-38 (d) travel 20-40-38.



(x) What is the run time of finding the nearest neighbour in a k-d tree?
(a) O(2+ log N) (b) O(log N) (c) O(2^d log N) (d) O(N log N).

Group – B

2. (a) Suppose you have a linked list containing some integers in ascending order. The linked list may have a number of duplicate entries. Now, you need to remove all the duplicates such that the resulting linked list contains only unique elements. You are not allowed to use a new linked list for this purpose. Write a pseudo code to accomplish this. [(CSEN5101.4)(Design/IOCQ)]

(b) Show the steps of inserting the following key elements into a maximum priority queue according to the given order of insertion as follows:
8, 12, 22, 25, 15, 16, 18, 100 [(CO3)(CO4)(CO6)(Apply/IOCQ)]

(c) Write the pseudo-code of max-Heapify function. [(CO3)(CO4)(CO6)(Analyze/IOCQ)]

4 + 5 + 3 = 12

3. (a) Consider a hash table with 9 slots. The hash function is h(k) = k mod 9. The collisions are resolved by chaining. The following 9 keys are inserted in the order: 5, 28, 19, 15, 20, 33, 12, 17, 10. Find the maximum, minimum, and average chain lengths in the hash table. [(CSEN5101.1, CSEN5101.3)(Apply/IOCQ)]

(b) Consider a hash table of size seven, with starting index zero, and a hash function **(3x + 4) mod 7**. Assuming the hash table is initially empty, show the contents of the table when the sequence 1, 3, 8, 10 is inserted into the table using closed hashing. [(CSEN5101.1, CSEN5101.3)(Apply/IOCQ)]

(c) Explain the insertion & deletion operations on a priority queue with an example. [(CSEN5101.1,CSEN5101.2)(Remember/LOCQ)]

4 + 4 + 4 = 12

Group – C

4. (a) (i) Show the necessary steps of constructing a binary search tree using the following key elements according to the given order of insertion:
25, 20, 36, 10, 22, 30, 40, 5, 12, 28, 38, 48
[(CO1)(CO2)(CO3)(CO4)(Apply/IOCQ)]

(ii) Show the necessary steps for deleting each of the following key elements from this BST (constructed earlier), as per the given order of deletion:
12, 25, 20, 40, 36, 10. [(CO1)(CO2)(CO3)(CO4)(Apply/IOCQ)]

(b) Suppose you have a binary search tree storing marks of the students in a class. Now, you want to identify how many students have scored X, such that K1 < X < K2. Write a function for this. Estimate the running time of your algorithm.
[(CSEN5101.4, CSEN5101.6)(Design/IOCQ)(Evaluate/HOCQ)]

(4 + 2) + (5 + 1) = 12

5. (a) Suppose two of your friends have traversed a binary search tree in preorder and inorder manner. They have reported the traversal results as follows:
Inorder: 10, 12, 32, 34, 39, 45, 54, 56, 67, 78, 81, 89
Postorder: 10, 32, 34, 12, 39, 54, 67, 81. 89, 78, 56, 45
Derive the tree from the above mentioned data. Show each intermediate step.
[(CSEN5101.3)(Apply/IOCQ)]

(b) Write an algorithm to find the largest element in a given binary search tree.
[(CSEN5101.4)(Design/IOCQ)]

(c) Given the memory representation of a tree, construct the corresponding tree. -1 represents a null pointer. [(CSEN5101.2)(Understand/LOCQ)]

Root 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Left	10		7		17		1		-1	-1	5		-1		-1		-1	9
Nodes	A		B		C		D		E	F	G		H		I		J	K
Right	-1		11				-1		-1	-1	18		-1		-1		-1	13

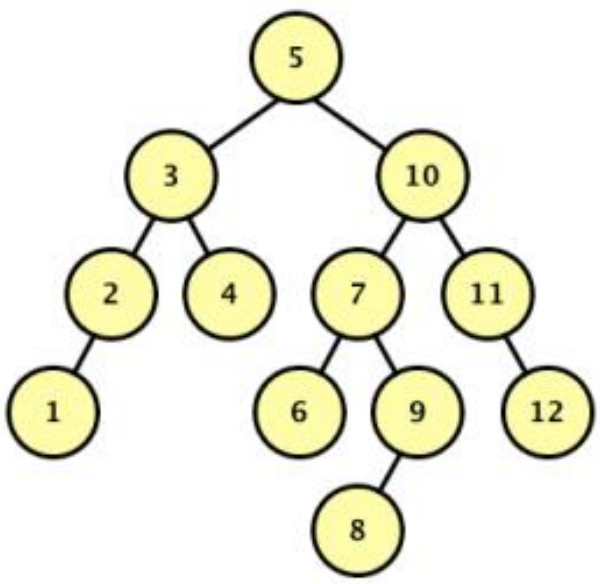
4 + 4 + 4 = 12

Group – D

6. (a) What is Red-Black Tree? [(CO1)(CO2)(CO3)(CO4)(Understand/LOCQ)]

(b) Show the necessary steps of constructing a Red-Black Tree using the following key elements according to the given order of insertion: 22, 10, 44, 56, 98, 32, 64,75
[(CO6)(CO2)(CO3)(CO4)(Apply/HOCQ)]

(c) Given the following AVL Tree:



(i) Draw the resulting BST after 5 is removed, but before any rebalancing takes place. Label each node in the resulting tree with its balance factor. Replace a node with both children using an appropriate value from the node's left child.

(ii) Now rebalance the tree that results from (i). Draw a new tree for each rotation that occurs when rebalancing the AVL Tree (you only need to draw one tree that results from an RL or LR rotation). You do not need to label these trees with balance factors. [(CSEN5101.3)(Apply/IOCQ)]

1 + 5 + (2 + 4) = 12

7. (a) Write a pseudo code for inserting an element in a skip list.
[(CO2)(CO3)(CO4)(CO6)(Evaluate/HOCQ)]

(b) Define B-Tree data structure. [(CO1)(CO2)(CO3)(CO4)(Understand/LOCQ)]

(c) Show the necessary steps of constructing a B-Tree of order 5, using the following key elements according to the given order of insertion as follows:
30,45,70,95,5,10,20,32,35,40,42,50,60,85,90,100,120,37
[(CO2)(CO3)(CO4)(CO6)(Apply/IOCQ)]

6 + 2 + 4 = 12

Group – E

8. (a) What is a k-D tree? If your search space has n number of points, what will be the height of the k-D tree? Draw the Kd-tree that results from inserting the following points:
[A(2, 3), B(4, 2), C(4, 5), D(3, 3), E(1, 5), F(4, 4), G(1, 1)]
Show each intermediate step.
[(CSEN5101.2,CSEN5101.3)(Understand/LOCQ),(Apply/IOCQ)]

   (b) Show the necessary steps and data of searching the pattern **P:**ATATCG in the following text **T:** GCATCCATATCCATATCGATCG, using Knuth Morris Pratt Algorithm.
[(CO1)(CO5)(CO6)(Apply/IOCQ)]

(2 + 4) + 6 = 12

9. (a) State the difference between a Trie data structure and a BST. Suppose you have two options: a Hash table and a Trie to keep your data, which one will you choose? Give explanation of your answers. [(CSEN5101.2)(Understand/LOCQ)]

   (b) Calculate the number of bits that may be required for encoding the message 'abccbccbaab' deploying Huffman encoding? [(CSEN5101.3)(Apply/IOCQ)]

   (c) The characters a to h have the set of frequencies based on the first 8 Fibonacci numbers as follows: a:1, b:1, c:2, and so on. Now, a Huffman code is used to represent the characters. What is the sequence of characters corresponding to the code: 110111100111010 [(CSEN5101.3)(Apply/IOCQ)]

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	15.63	66.67	17.7

Course Outcome (CO):

After the completion of the course students will be able to
1. **Remember** definitions and notations of basic terminologies used in data structures.
2. **Learn and understand** abstract data types and its significance; differentiate between linear and non-linear data structures for solving real world problems.
3. **Understand and apply** some of the special trees, Tries data structure and various Hashing Techniques
4. **Design** modular algorithms on linear and non linear data structures for solving engineering problems efficiently.
5. **Understand and analyze** the basic principles of different string matching algorithms and identify their advantages and disadvantages.
6. **Evaluate** the performance of different data structures with respect to various applications.

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