ADVANCED DATA STRUCTURES
(CSE5101)

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) Which of the following represents a binary min-heap?
(a) {25, 10, 12, 13, 14, 16, 8} (b) {25, 12, 16, 8, 10, 14, 13)
(c) {8, 13, 16, 25, 14, 10, 12} (d) {8, 10, 14, 12, 13, 25, 16)

(ii) Consider the following postfix expression with single digit operands, where the operators have their usual meaning:
8 2 3 ^ / 2 3 * + 5 1 * -
Which of the following correctly represents the top two elements of the stack just after the second * is evaluated?
(a) 6, 1 (b) 5, 7 (c) 1, 5 (d) 3, 2

(iii) A binary tree (T) has 10 internal (i.e. non-leaf) nodes and 6 leaf nodes. The total number of edges in T is
(a) 12 (b) 13 (c) 14 (d) 15

(iv) The inorder and preorder traversal of a binary tree results are given below.
Inorder: 42, 29, 51, 10, 37, 63
Preorder: 10, 29, 42, 51, 37, 63
The postorder traversal result is
(a) 29, 51, 10, 37, 63, 42 (b) 51, 10, 37, 63, 42, 29
(c) 42, 51, 29, 63, 37, 10 (d) 10, 37, 63, 42, 29, 51

(v) The number of all possible Binary Search Trees representing a set of 5 distinct elements is
(a) 2 (b) 5 (c) 14 (d) 42

(vi) The minimum possible number of nodes that can be present in an AVL tree of height 4 is
(a) 13 (b) 12 (c) 11 (d) 10

(vii) The maximum number of items in a B-tree of order 5 and height 3 is
(a) 124 (b) 126 (c) 624 (d) 626

(viii) Which of the following statements is false in case of a skip list?
(a) It is a randomized data structure
(b) Height of the sentinel always grows
(c) To decide whether a node grows its height, we flip a coin
(d) Bottom layer may or may not be fully connected

(ix) Which one of the following is true regarding Huffman code?
(a) Error detecting code (b) Reflective code
(c) Variable length code (d) Weighted code

(x) In 2-D space, p_0, p_1 and p_3 are three points. The cross product $(p_2- p_0)$ X $(p_1- p_0)$ is negative. This indicates:
(a) the line segment p_0p_2 is counter-clockwise w.r.t. the line segment p_0p_1 and there is a left turn at the point p_1
(b) the line segment p_0p_2 is counter-clockwise w.r.t. the line segment p_0p_1 and there is a right turn at the point p_1
(c) the line segment p_0p_2 is clockwise w.r.t. the line segment p_0p_1 and there is a left turn at the point p_1
(d) the line segment p_0p_2 is clockwise w.r.t. the line segment p_0p_1 and there is a right turn at the point p_1

Fill in the blanks with the correct word

(xi) The maximum number of nodes possible in a Binary Search Tree (BST) of height 5 is _____.

(xii) A balanced BST, storing n points can be built in O(_____) time, if the points are given in sorted order.

(xiii) The prefix pattern of pattern matching is represented by π. The value of π(2) for the pattern "aaa" is _____.

(xiv) For any nonempty binary tree (T), if N_{leaf} is the number of leaf nodes and N_2 is the number of nodes with degree 2, then the relation between N_{leaf} and N_2 is _____

(xv) When the value of k is 1, a k-D Tree is equivalent to a _____.

Group - B

2. (a) Show all the steps of building a max heap from the array containing the following 10 elements in sequence: 24, 21, 23, 22, 36, 29, 30, 34, 28, 27 *[(CO2)(Apply)/IOCQ)]*
(b) Write the pseudo codes of all the functions required to insert an element in a Max Priority Queue. *[(CO2)(Understand/LOCQ)]*
(c) 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. *[(CO3)(Apply/IOCQ)]*

4 + 4 + 4 = 12

3. (a) Consider a hash table with 7 slots. The hash function is h(k) = k mod 7. An experiment is carried out to resolve the collisions by open addressing with cubic

probing. The following 6 keys are inserted in the order: 5, 28, 19, 15, 17 and 33. Show the steps to fill up the hash table. *[(CO3)(Apply/IOCQ)]*

(b) An m × n matrix has x numbers of non-zero elements. Derive the relation between m, n and x so that it will be beneficial to store the matrix elements in Triplet format. *[(CO1)(Analyse/HOCQ)]*

(c) Show all the steps of building a max heap from the array containing the following 10 elements in sequence: 4, 1, 3, 2, 16, 9, 10, 14, 8 and 7. *[(CO2)(Apply/IOCQ)]*

5 + 3 + 4 = 12

Group - C

4. (a) What is meant by the balance factor of a node in a binary tree? When is a binary tree said to be balanced? Consider all binary trees that have five nodes. How many of these are balanced? *[(CO1)(Understand/LOCQ)]*

(b) For any nonempty binary tree (T), if N_{leaf} is the number of leaf nodes and N_2 is the number of nodes with degree 2, then prove that

$$N_{leaf} = N_2 + 1$$ *[(CO1)(Understand/LOCQ)]*

(c) Write the pseudo codes for both the (i) recursive and (ii) iterative procedures to search for a node with a given key in a Binary Search Tree. Which version is more efficient? Why? *[(CO4)(Create, Analyse/HOCQ)]*

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

5. (a) With an example of a binary search tree, show how to delete a node having
(i) no children (ii) only one child *[(CO3)(Understand/LOCQ)]*

(b) Describe briefly, with suitable examples, two methods for memory representation of a tree. Compare these two methods with four important points. *[(CO1)(Remember, Understand/LOCQ)]*

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

Group - D

6. (a) What is Red-Black Tree? *[(CO3)(Remember/LOCQ)]*

(b) What is the minimum and maximum number of keys that can be stored in a node of B-tree of order 4? *[(CO3)(Apply/IOCQ)]*

(c) Write a pseudo code for deleting an element in a skip list. *[(CO4)(Create/HOCQ)]*

4 + 2 + 6 = 12

7. (a) Write a pseudo code for inserting an element in a skip list. *[(CO4)(Create/HOCQ)]*

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

6 + 6 = 12

Group - E

8. (a) What role does the prefix function play in the KMP pattern matching algorithm? *[(CO6)(Analyse/IOCQ)]*

(b) Suppose that the procedure 'Compute-Prefix-Function (P)' is available to you. Write the pseudo-code for a KMP matcher (T, P) for text T and pattern P using the above procedure. *[(CO6)(Analyse/HOCQ)]*

(c) Determine the prefix function π for the pattern P = "bababacbba" *[(CO6)(Apply/IOCQ)]*

3 + 5 + 4 = 12

9. (a) This question relates to computational geometry. Let Q = {p1, p2, p3, p4} be a set of 4 points in the X-Y plane. We want to determine whether the line segment joining p1 and p2 intersects the line segment joining p3 and p4. Describe briefly a method that can be used to solve the problem. For illustration, use the points p1 = (10, 5), p2 = (5, 10), p3 = (6, 8), p4 = (15, 3). *[(CO6)(Apply/HOCQ)]*

(b) Showing each intermediate step, draw a k-D tree that results from inserting the following points:
P(10, 12), Q(13, 8), R(13, 18), S(12, 12), T(0, 4) *[(CO3)(Analyse/IOCQ)]*

(c) Compare Trie data structure and Hash Table for lexicographic search. *[(CO6)(Understand/LOCQ)]*

6 + 4 + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	29.17	37.5	33.33