M.TECH/CSE/1ST SEM/CSEN 5101/2021

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) The maximum number of binary trees that can be formed with three unlabelled nodes is
(a) 1 (b) 5 (c) 4 (d) 3

(ii) Application of priority queue is
(a) Dijkstra's shortest path algorithm
(b) Prim's algorithm to find Minimum spanning tree of a given graph
(c) Heap sort
(d) All of the above

(iii) In open hashing, average case time complexity of search function for n keys and k slots on hash table, is
(a) O(1) (b) O(n) (c) O(k) (d) None of the above

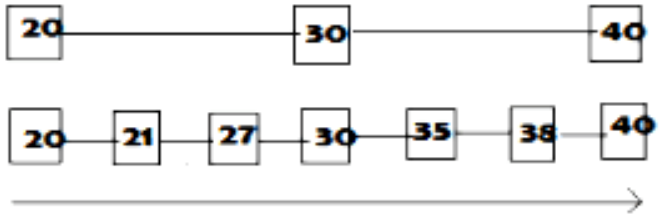
(iv) The maximum number of nodes possible in a Binary search tree of height h
(a) 2^{h-1} -1 (b) 2^{h+1} -1 (c) 2^{h} +1 (d) 2^{h-1} +1

(v) Suppose in a binary tree, every non-leaf node has non-empty left and right subtrees. If this tree contains 10 leaves, which among the following is true?
(a) cannot have more than 19 nodes (b) has exactly 19 nodes
(c) has exactly 17 nodes (d) cannot have more than 17 nodes

(vi) The number of internal nodes of a 2-3 tree having 9 leaves could be
(a) 4 (b) 5 (c) 6 (d) 7

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

(viii) Consider the 2-level skip list



How to access 38?

(a) travel 20-30-35-38 (b) travel 20-30-40-38

(c) travel 20-38 (d) travel 20-40-38

(ix) What is Π(2) of the pattern "aaa"? The prefix function of pattern matching is represented by Π.

(a) 0 (b) 1 (c) 2 (d) 3

(x) AVL tree is

(a) a tree which is balanced and is a height balanced tree

(b) a tree which is unbalanced and is a height balanced tree

(c) a tree with three children

(d) a tree with at most 3 children.

Group- B

2. (a) If we store a 4 × 5 matrix A in column-major ordering and base address is 3000, what will be the memory address of A[3,4]? If the matrix has 10 non-zero elements, will it be beneficial to store it in Triple format? [(CO2) (Understand/LOCQ), (CO1) (Remember/LOCQ)]

   (b) Write the pseudo code to insert an element at the end of a circular linked list. What is the time complexity of it? [(CO2) (Understand/LOCQ)]

   (c) Suppose you have a doubly linked list where the values are sorted in non-increasing order. However, you 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. [(CO4) Create/HOCQ]

(2 + 2) + (3 + 1) + 4 =12

3. (a) Using a stack, evaluate the value of the expression: ((2+7)*(5-3)). [(CO2) (Understand/LOCQ)]

   (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, identify the contents of the table when the sequence 1, 3, 8, 10 is inserted into the table using closed hashing. [(CO3) (Understand and Apply/IOCQ)]

   (c) Write all the subroutine to insert an element in a Max Priority Queue. What is the time complexity? [(CO2) (Understand/LOCQ)]

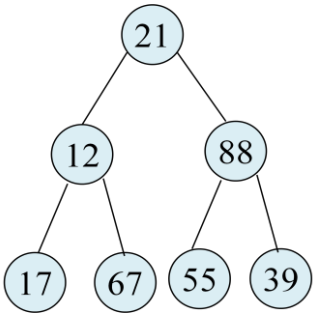
4 + 4 + (3 + 1) = 12

Group – C

4. (a) Please prove that "For any nonempty binary tree, T, if n_0 is the number of leaf nodes and n_2 the number of nodes with degree 2, then $n_0 = n_2+1$."
[(CO3) (Understand and Apply/IOCQ)]

(b) Suppose you have a binary search tree storing the marks of all the students in a class. Now, you want count the number of students who have scored between K1 and K2 (both inclusive). Write a C-function or pseudo-code to find this.
[(CO4, CO6) (Create/HOCQ),(Evaluate/HOCQ)]

(c) Is this a binary search tree? Give reason in one or two sentences.



Fill in the gaps:
Max element of the left sub-tree of a node is the _____ of the element contained in the b.
Min element of the right sub-tree of a node is the _____ of the element
[(CO3) (Understand and Apply/IOCQ), (CO1) (Remember/LOCQ)]

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

5. (a) What is the worst case time complexity of search function of a Binary Search Tree(BST)? When do you experience it? Write the two conditions a height-balanced BST satisfy. [(CO1) (Remember/LOCQ)]

(b) Write an algorithm to find the smallest element in a given binary search tree.
[(CO4) (Create/HOCQ)]

(c) If the pre order traversal of a binary tree is a recursive procedure, what kind of data structure do you think will be used in memory to execute it? Define predecessor, ancestor and siblings of a node in a binary tree.
[(CO3) (Understand and Apply/IOCQ), (CO1) (Remember/LOCQ)]

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

Group - D

6. (a) Obtain the AVL tree by the repeated insertions of data given below in their order of occurrence. Show all the intermediate trees. jan, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec. [(CO3)(Apply/IOCQ)]

(b) If n>=1 and t >=2, what will be the maximum height of the n-key B-Tree of minimum degree t? Is a B-tree balanced? Why do you think so?
[(CO1) (Remember/LOCQ)]

(c) Design an algorithm to delete a node in a skip list. [(CO4) (Design/IOCQ)]

5 + (1 + 2) + 4 = 12

7. (a) Please prove: "The expected number of coin tosses required in order to get tails is 2." Assume that the coin is unbiased and successive coin tosses are mutually independent of each other. [(CO3) (Understand and Apply/IOCQ)]

   (b) What is the worst-case time complexity of search in a 2-3 tree? Which do you prefer for searching, BST or 2-3 tree? Why? [(CO1) (Remember/LOCQ), (CO6) (Evaluate/HOCQ)]

   (c) What is the worst case running time to search for an element in a balanced binary search tree with $\mathbf{n2^n}$ elements? What is the maximum height of any AVL-tree with 7 nodes? Assume that the height of a tree with a single node is 0. [(CO3) (Understand and Apply/IOCQ)]

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

Group - E

8. (a) Construct the string matching automaton for the pattern "ababa". State its time complexity. [(CO5) (Understand and analyze/IOCQ)]
   State its time complexity. [(CO5) (Remember/LOCQ)]

   (b) Compute the prefix function for the pattern "abbabb". [(CO5) (Understand and analyze/IOCQ)]

   (c) 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? [(CO2,CO3) (Understand/LOCQ)]

(4 + 1) + 5 + 2 = 12

9. (a) How do you do one dimensional range searching? Analyse the time complexity. [(CO2) (Understand/LOCQ)]]

   (b) What is the time complexity to build a 2-D range tree?
   Fill in the blanks:
   The priority search tree is a hybrid of _____ and _____.
   Write the two kinds of queries in range searching. [(CO1) (Remember/LOCQ)]

   (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, d:3, e:5** and so on. Now, a Huffman code is used to represent the characters. What is the sequence of characters corresponding to the code: 110111100111010. [(CO3)(Apply/IOCQ)]

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

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	40.63%	42.71%	16.66%

Course Outcome (CO):

After the completion of the course students will be able to

CSEN5101.1. Remember definitions and notations of basic terminologies used in data structures.

CSEN5101.2. Learn and understand abstract data types and its significance; differentiate between linear and non-linear data structures for solving real world problems.

CSEN5101.3. Understand and apply some of the special trees, Tries data structure and various Hashing Techniques

CSEN5101.4. Design modular algorithms on linear and non linear data structures for solving engineering problems efficiently.

CSEN5101.5. Understand and analyze the basic principles of different string matching algorithms and identify their advantages and disadvantages.

CSEN5101.6. 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

Department & Section	Submission Link
CSE	https://classroom.google.com/c/NDA1NjExOTA2NzQz/a/MjI3ODg4ODY5NTU1/details