DATA STRUCTURES AND ALGORITHMS
(CSEN 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) Deleting a node at the end of a double linked list, where head & tail both are known would take time —
(a) O(1) (b) O(n)
(c) O(logn) (d) O(nlogn).

(ii) A drawback of linear probing is
(a) Primary clustering (b) Secondary clustering
(c) Folding (d) None of these.

(iii) $T(n) = O(\log n^{200})$, $F(n) = O(n^{0.999})$
(a) $T(n) = O(F(n))$ (b) $T(n) = \Omega(F(n))$
(c) $T(n) = \Theta(F(n))$ (d) None of the above.

(iv) DFS algorithm runs on a graph G(V, E) in time
(a) O(V+E) (b) O(V)
(c) O(ElogV) (d) O(VE).

(v) Worst-case time complexity of a comparison-based sort cannot be better than,
(a) O(nlogn) (b) $O(n^2)$
(c) O(n) (d) O(nlognlogn).

(vi) In a binary search tree with n nodes, searching a node may take time up to
(a) O(n) (b) O(logn)
(c) O(nlogn) (d) O(1).

(vii) A stack S has the entries a, b, c with a on the top. Another stack T is empty. An entry popped out of the stack S can be printed immediately or pushed in to the stack T. Finally all in the stack T are popped out and printed. Then which sequence can never be printed?
(a) b a c (b) b c a
(c) c a b (d) a b c

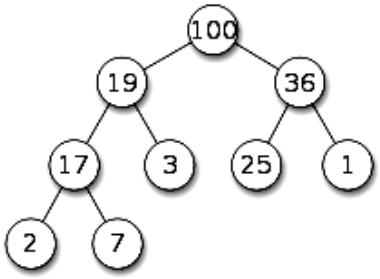
(viii) Suppose you place m items in a hash table with an array size of s. What is the correct formula for the load factor?

(a) s / m (b) m / s
(c) s + m (d) s - m

(ix) The number of leaf nodes in a full binary tree of n nodes

(a) (n + 1)/2 (b) (n - 1)/2
(c) n/2 (d) 2n - 1

(x) What will be the in-order traversal of the following binary tree?



(a) 2, 17, 7, 19, 3, 100, 25, 36, 1 (b) 2, 17, 7, 3, 19, 100, 25, 36, 1
(c) 2, 7, 17, 19, 3, 100, 25, 36, 1 (d) None of these

Fill in the blanks with the correct word

(xi) The exact (not asymptotic) height of an n-element heap is _____.

(xii) An array of n integers can be turned into a heap in _____ asymptotic time.

(xiii) The worst-case asymptotic time complexity of interpolation search is _____ than binary search (better/worse/same).

(xiv) Linked lists are not suitable to implement _____ search.

(xv) The number of leaves in a complete binary tree of height h is _____.

Group - B

2. (a) Write a function in C/pseudo-code to delete all the nodes that contains the certain value v, from a singly linked list in a single pass. If there are multiple occurrences, delete all occurrences. Discuss the time complexity of the algorithm. (Do not forget to look after the test cases when v will not exist in the list or list is empty). *[(CSEN2101.2, CSEN2101.3)(Apply, Analyse/IOCQ)]*

(b) Define Big-Oh, Big-Omega and Big-Theta with example.

[(CSEN2101.1)(Remember/LOCQ)]

6 + 6 = 12

3. (a) Prove: $n^2 + 100\,n = \theta(n^2)$. *[(CO1)(Understand and Remember/LOCQ)]*

(b) If the base address of an array Z with dimension 10X20 is 2023 and the array elements are stored in column-major ordering, what will be the address of the element Z[10][15]? In case Z is stored using row-major ordering, what will be the memory address of the same element? *[(CO1)(Understand & Remember/LOCQ)]*

(c) Write the pseudo-code of inserting an element after a given value in a doubly linked list. Your code should work for any position of the given value. Show proper error messages, if any. *[(CO1)(Understand and Remember/LOCQ)]*

4 + (2 + 2) + 4 = 12

Group - C

4. (a) Write a pseudo-code/C program to determine whether a singly linked list is a palindrome or not. Return 1 if it is a palindrome and 0 otherwise. Note that the expected solution run in linear time. *[(CSEN2101.4, CSEN2101.5)(Apply/IOCQ)]*

(b) What will be the postfix expression of the following infix expression?

(a + b) ^ d ^ e * f

[(CSEN2101.2, CSEN2101.3)(Understand/LOCQ)]

(c) Show the different passes of the stack (Value Stack) while evaluating the following expression: 3 * 4 + 14 / 7 * -3. *[(CSEN2101.2, CSEN2101.3)(Understand/LOCQ)]*

6 + 3 + 3 = 12

5. (a) Represent the following equation in post-fix form and evaluate the value. Use a stack data structure and show each step.

10 – (5*2) + 7 / 3.5 * 2 *[(CO2)(Understand/IOCQ)]*

(b) Write the pseudo-code of insertion and deletion of an element from an input-restricted doubly-ended queue. The deque is implemented using circular array. *[(CO1)(Understand & Remember/LOCQ)]*

6 + 6 = 12

Group - D

6. (a) Write a linear time algorithm to find whether a graph is cyclic or acyclic (*give proper justification of your answer*). What is the data structure used to implement your algorithm? *[(CSEN2101.5, CSEN2101.6)(Analyse/IOCQ)]*

(b) Is it possible to create a binary tree, whose pre-order and post-order traversal sequences are given? Justify your answer. *[(CSEN2101.3)(Evaluate/HOCQ)]*

(c) Suppose you have implemented a Binary Search Tree using linked list, where every node contains the addresses of left child and right child only. Write a pseudo-code/C program to insert an element into that Binary Search tree. *[(CSEN2101.4)(Remember/LOCQ)]*

(3 + 1) + 2 + 6 = 12

7. (a) Add the following list of numbers to an initially empty min-binary heap: 12, 5, 15, 9, 13, 7, 15, 10, 3, 20, 4. *[(CSEN2101.2)(Understand/LOCQ)]*

(b) Draw an AVL tree by inserting nodes in the following sequence –

15, 10, 25, 12, 65, 45, 75, 55, 70, 90, 105

[(CSEN2101.2)(Understand/LOCQ)]

(c) Write a pseudo-code/C program to find the maximum element of a Binary Search Tree. *[(CSEN2101.4)(Understand/LOCQ)]*

2 + 6 + 4 = 12

Group - E

8. (a) If an array starts from 0, what will be the indices of the left child and right child for a node in a binary heap whose index is i? What will be the index of the parent node if the index of the node is j? *[(CO6)(Remember/LOCQ)]*

   (b) Prove that $\sum_{h=0}^{\infty} \frac{h}{2^h} = 2$. *[(CO1)(Analyze/IOCQ)]*

   (c) Using the above result, justify that a max-heap can be generated in O(n) time from a set of n elements. You may assume that the number of elements at height h in a heap is at most $\lceil n/2^{(h+1)} \rceil$. *[(CO4)(Justify/HOCQ)]*

3 + 4 + 5 = 12

9. (a) Show that the expected number of comparisons required to find an element from an array of n elements if the element occurs twice in the array is (n + 1) / 3. *[(CO4)(Analyze/IOCQ)]*

   (b) The keys 12, 18, 13, 2, 3, 23, 5 and 15 are inserted into an initially empty hash table of length 10 using open addressing with hash function h(k) = k mod 10 and linear probing. What is the resultant hash table? *[(CO5)(Evaluate/IOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	53.13	39.58	7.29

Course Outcome (CO):

After the completion of the course students will be able to

CSEN2101.1 Understand and remember the basics of data structures and how time complexity analysis is applicable to different types of algorithms.

CSEN2101.2 Understand the significance and utility of different data structures and the context of their application. (For example, the queue in front of ticket counters uses first-in-first-out paradigm in a linear data structure)

CSEN2101.3 Apply different types of data structures in algorithms and understand how the data structures can be useful in those algorithms.

CSEN2101.4 Analyse the behaviour of different data structures in algorithms. (For example, given an algorithm that uses a particular data structure, how to calculate its space and time complexity.)

CSEN2101.5 Evaluate solutions of a problem with different data structures and thereby understand how to select suitable data structures for a solution. (For example, what are the different ways to find the second largest number from a list of integers and which solution is the best.)

CSEN2101.6 Evaluate different types of solutions (e.g. sorting) to the same problem.

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