FUNDAMENTALS OF DATA STRUCTURE & ALGORITHMS (INFO 2101)

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) Which one of the following is not an application of Stack Data Structure?
(a) String reversal
(b) Recursion
(c) Backtracking
(d) Asynchronous data transfer.

(ii) Let A be a square matrix of size n x n. Consider the following program. What is the expected output?

```
C = 100
for i = 1 to n do
   for j = 1 to n do
   {
      Temp = A[i][j] + C
      A[i][j] = A[j][i]
      A[j][i] = Temp - C
   }
for i = 1 to n do
   for j = 1 to n do
      Output(A[i][j]);
```

(a) The matrix A itself
(b) Transpose of matrix A
(c) Adding 100 to the upper diagonal elements and subtracting 100 from diagonal elements of A
(d) None of the above.

(iii) Which of the following is an advantage of adjacency list representation over adjacency matrix representation of a graph?
(a) In adjacency list representation, space is saved for sparse graphs
(b) DFS and BSF can be done in O(V + E) time for adjacency list representation. These operations take O(V^2) time in adjacency matrix representation. Here is V and E are number of vertices and edges respectively
(c) Adding a vertex in adjacency list representation is easier than adjacency matrix representation
(d) All of the above.

(iv) Let P be a singly linked list. Let Q be the pointer to an intermediate node x in the list. What is the worst-case time complexity of the best known algorithm to delete the node Q from the list?
(a) O(n) (b) $O(\log_2 n)$ (c) O(logn) (d) O(1).

(v) A program P reads in 500 integers in the range [0..100] representing the scores of 500 students. It then prints the frequency of each score above 50. What would be the best way for P to store the frequencies?
(a) An array of 50 numbers (b) An array of 100 numbers
(c) An array of 500 numbers (d) A dynamically allocated array of 550 numbers.

(vi) If the number of records to be sorted is small, then ______ sorting can be efficient.
(a) merge (b) heap (c) selection (d) bubble

(vii) Consider a complete binary tree where the left and the right sub trees of the root are max-heaps. The lower bound for the number of operations to convert the tree to a heap is
(a) Ω(logn) (b) Ω(n) (c) Ω(nlogn) (d) $\Omega(n^2)$.

(viii) Which of the following is not a stable sorting algorithm?
(a) Insertion sort (b) Selection sort
(c) Bubble sort (d) Merge sort.

(ix) Which of the following is not a limitation of binary search algorithm?
(a) must use a sorted array
(b) requirement of sorted array is expensive when a lot of insertion and deletions are needed
(c) there must be a mechanism to access middle element directly
(d) binary search algorithm is not efficient when the data elements more than 1500.

(x) The postorder traversal of a binary tree is 8, 9, 6, 7, 4, 5, 2, 3, 1. The inorder traversal of the same tree is 8, 6, 9, 4, 7, 2, 5, 1, 3. The height of a tree is the length of the longest path from the root to any leaf. The height of the binary tree above is –
(a) 2 (b) 3 (c) 4 (d) 5.

Group - B

2. (a) "Stack is an Abstract Data Type" – Justify this statement. [(CO1) (Evaluate/HOCQ)]
(b) Write an algorithm to reverse a singly linked list. [(CO2) (Apply/IOCQ)]
(c) Write an algorithm to transpose a matrix stored in sparse format.
[(CO2) (Remember/LOCQ)]
3 + 4 + 5 = 12

3. (a) "Big O notation is most efficient to represent time complexity of an algorithm" – Justify this statement. [(CO3) (Evaluate/HOCQ)]
(b) Design an algorithm to remove repetitive data from an array of integers.
[(CO2) (Apply/IOCQ)]

(c) Derive the addressing formula of an element A[i][j] for a 2D array of order m × n, where data elements are starred in the array in column major order, starting address is L_0 and each element requires c bytes of memory location. Using the formula find the address of A[3][2] where A is an 2-dimensional array of size 6 by 4 stored into the memory in column major order starting from memory location 2052. Consider that, the array is containing long integers. [(CO2)(Analyse/IOCQ)]

2 + 5 + (3 + 2) = 12

Group - C

4. (a) Write an algorithm to convert a given infix expression into corresponding postfix expression. [(CO2) (Remember/LOCQ)]

(b) Apply your algorithm to convert the given infix expression into postfix expression:
(e*(a+b)+f)-c-d*(g+h) [(CO2) (Apply/IOCQ)]

(c) Why do we need a stack to implement function calling instead of a queue? Justify your answer. [(CO2)(Evaluate/HOCQ)]

(d) Write a recursive algorithm to find out GCD of two numbers. Draw the recursion tree if this function is called to find out GCD of 18 and 30. [(CO2) (Analyze/IOCQ)]

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

5. (a) Write an algorithm to implement insertion and deletion of elements into a deque with input output restriction. [(CO2) (Remember/LOCQ)]

(b) "If we try to delete a node (not the last one) from a linked queue then only rear pointer has to be updated" – justify this statement. What will happen if the last node has to be deleted? [(CO2) (Evaluate/HOCQ)]

(c) Write one application each for circular queue and deque. [(CO2)(Apply/IOCQ)]

6 + 2 + (2 + 2) = 12

Group - D

6. (a) Define AVL tree. [(CO4) (Remember/LOCQ)]

(b) Given the following Inorder and Postorder traversal of a binary tree, find the corresponding tree. Show each and every step you followed to generate your answer.
Inorder: BAPRQSZYMCNLD
Postorder: BRSQPZACLNMDY
Can you find the exact tree if preorder and postorder traversal is given?
[(CO2) (Apply/IOCQ)]

(c) Create a binary search tree for the following numbers start from an empty binary search tree.

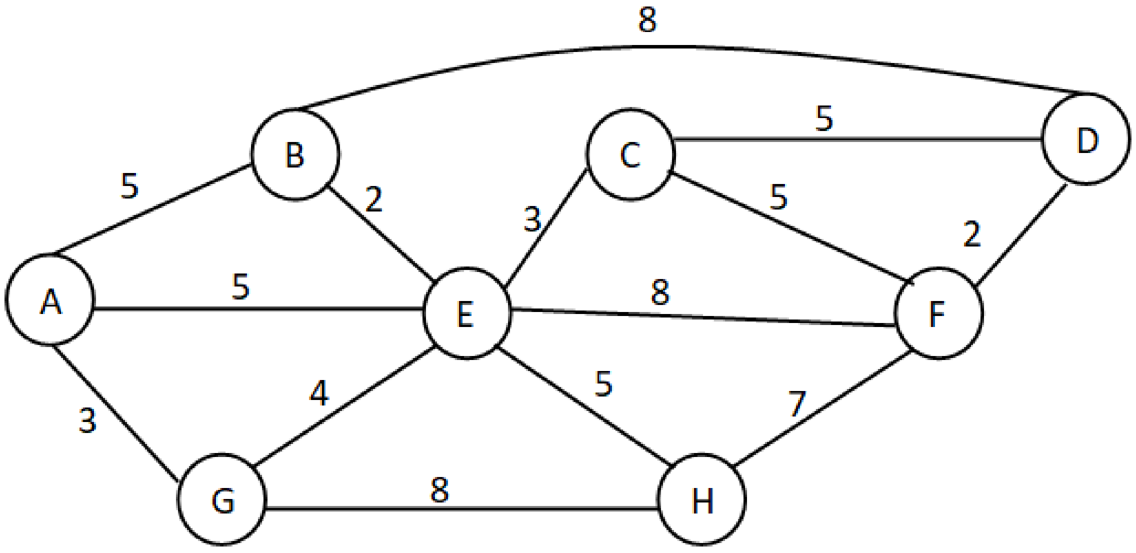
45, 26, 10, 60, 70, 30

Delete keys 10 and 45 one after the other and show the trees at each stage.
[(CO2)(Apply/IOCQ)]

2 + (4 + 1) + 5 = 12

7. (a) Compare and contrast the two representations adjacency matrics and adjacency hits of graph. To implement BFS which representation is more effective and how?
[(CO3)(Evaluate/IOCQ)]

(b) Compare the outputs of Prim's and Krushal's algorithms on the following graph. Show all steps you computed to achieve the results.



[(CO4) (Apply/IOCQ)]

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

Group - E

8. (a) Trace the action of radix sort on the following list of seven numbers considered as three-digit integers: 375, 447, 467, 395, 293, 235, 334. [(CO5) (Apply/IOCQ)]

(b) Apply merge sort to the list of seven numbers, 26, 33, 35, 29, 19, 12, 22. Find the complexity of merge sort algorithm. [(CO5) (Apply/IOCQ)]

6 + 6 = 12

9. (a) Apply interpolation search to search for the element 91 in the following list:

13 30 62 73 81 88 91 [(CO5)(Apply/IOCQ)]

(b) Describe any three ways to generate hash functions with suitable examples. What are the characteristics of a good hash function? [(CO6)(Remember/LOCQ)]

(c) When does a collision occur in hashing? Explain any two methods for collision resolution. [(CO6)(Understand/LOCQ)]

4 + (2 + 2) + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	26.04	64.58	9.38

Course Outcome (CO):

After the completion of the course students will be able to

1. Develop the knowledge of basic data structures for storage and retrieval of ordered or unordered data.
2. Design linear and non-linear data structures to be used for storing, accessing and manipulating data, and be able to choose the appropriate data structure to be used for different real-life applications.
3. Evaluate and compare the runtime and memory usage of algorithms with the help of mathematical background (Asymptotic Notation) of algorithm analysis.
4. Apply graph-based algorithms on shortest path problems.
5. Apply efficient algorithm for solving problems like sorting, searching, insertion and deletion of data.
6. Analyze hash functions and collision resolution techniques for storing and retrieving data efficiently into a hash table.

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