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
<u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> 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 best-case time complexity of modified bubble sort is
        (a) $O(n^2)$ (b) $O(\log n)$ (c) $O(n)$ (d) $O(n\log_2 n)$

    (ii)   What will be the infix expression corresponding the following prefix expression?
        /-*+52932
        (a) ((5+2)*9-3)/2   (b) (5+2)*9-3/2
        (c)5/2-9*3+2   (d) None of these

    (iii)   A Heap is a
        (a) Binary Search Tree   (b) Complete Binary Tree
        (c) Full Binary Tree   (d) All of the above

    (iv)   Given a hash table T with 40 slots that stores 2000elements, the load factor α for T is
        (a) 25   (b) 80   (c) 40   (d) 50

    (v)   Consider the following C program.

```
#include <stdio.h>
int main () {
    int a [4] [5] = {{1, 2, 3, 4, 5},
            {6, 7, 8, 9, 10},
            {16, 17, 18, 19, 20}};
printf ("%d\n", *(*(a+**a+2) +3));
    return (0);
}
```

        The output of the program is _____
        (a) 20   (b) 0   (c) 5   (d) 19

    (vi)   The data structure used to check balanced parenthesis of an infix expression is
        (a) Graph   (b) Queue   (c) Tree   (d) Stack

(vii) Inserting a new node after a given node in a doubly linked list requires
(a) Four pointer modification   (b) Two pointer modification
(c) One pointer modification   (d) No pointer modification

(viii) Let G be a graph with n vertices and m edges. What is the complexity of Depth First Search of G. Assume that the graph is represented using adjacency matrix.
(a) $O(n)$ (b) $O(m+n)$ (c) $O(mn)$ (d) $O(n^2)$

(ix) In a max heap tree with elements 9, 12, 56, 16, 32, 19, 3, 10 which element gets deleted when a single call to delete function is made
(a) 9   (b) 56   (c) 10   (d) 12

(x) The inorder and preorder traversal of a tree are (D,B,A,E,C) and (A,B,D,C,E) respectively. Then the leaf nodes of the tree are
(a) C, D, and E   (b) C and E   (c) D and E   (d) E.

Group- B

2. (a) What is the time complexity of the following progam:
```
void fun(int n) {
    int i,j;
     for(i=1; i<=n/3; i++)
        for (j=1; j<=n; j+=4)
            printf("Hello \n");
    }
```
[(CO3) (Evaluate/HOCQ)]

(b) Find out the address of a[2][3][1] of a three dimensional array a of size 3×4×3 where the data is stored in column major order and the starting address is 2000.
[(CO1, CO2) (Apply/IOCQ)]

(c) Write an algorithm to add two matrices in their sparse form and print the resultant matrix in sparse form as normal matrix. Do not use any auxiliary matrix to store the original form of the sparse form matrix in any step in your algorithm. [(CO1,CO2)(Apply/IOCQ)]

3 + 3 + 6 = 12

3. (a) Heritage Institute of Technology, has organized 3 summer training programs during the months of June and July, 2022. Each program is associated with its course-title, course-start-date and course-fees. Write a **function to create the listing** of courses along with its details in a **required data structure.**
[(CO1, CO2) (Apply/IOCQ)]

(b) Using the following prototype write a program to delete an intermediate node from a doubly linked list. Assume the list is already created. The value of the node to be deleted has to be taken from user within the function itself.
void DEL (struct st * *); [(CO2,CO5) (Apply/IOCQ)]

(c) (i) Discuss the advantage and disadvantage of linked list over array.

(ii) "Global declaration of variables should be avoided". Justify for or against the statement. [(CO1)(Understand/LOCQ)]

3 + 5 + (2 + 2) = 12

Group - C

4. (a)   How stack is essential for implementation of recursion? Explain with example. [(CO1,CO2) (Analyze/IOCQ)]
    (b)   Draw the recursion tree for the solution of Tower of Hanoi problemusing recursion while the number of disks to be shifted is 5. [(CO1,CO2) (Apply/IOCQ)]
    (c)   When it will be advantageous to use recursion over iteration? Explain your answer. [(CO1,CO2)Evaluate/HOCQ)]

3 + 5 + 4 = 12

5. (a)   Write an algorithm to implement priority queue where lower value of the priority represents higher priority.   [(CO1,CO2) (Understand/LOCQ)]
    (b)   State what are the usage of stack in the computer system. [(CO1,CO2) (Remember/IOCQ)]
    (c)   Write an algorithm to implement insert operation in a linked circular queue. [(CO1,CO2)(Analyze/HOCQ)]

6 + 3 + 3 = 12

Group - D

6. (a)   The inorder and preorder traversals of a binary tree T yield the following sequence of nodes:
    Inorder :   U K M E A L F J Z G
    Preorder : A K U E M Z F L J G
    Draw the tree T, explaining each step. What is the disadvantage of a binary search tree.   [(CO1,CO2) (Understand/LOCQ)]
    (b)   A student's 8 semester marks are maintained in a 1D array as follows [52, 86, 65, 41, 96,98,61,97].   Transform the array into a max heap with proper explanation of each transformations performed. What step you would perform to obtain the maximum marks obtained over all the semester. [(CO2,CO5) (Apply/IOCQ)]
    (c)   Write the function to create a binary search tree based on the details of 5 employees. Each node its information part maintains the following: emp-name, emp-salary and required pointers.   [(CO2)(Apply/IOCQ)]

(3 + 1) + 3 + 5 = 12

7. (a)   Insert the following keys in the order given below to build them into an AVL tree 3, 2, 1, 4, 5, 6, 7, 16, 15, 14. Clearly mention the different rotations used and balance factor of each node.   [(CO1) (Understand/LOCQ)]
    (b)   Design a balanced tree-based index structure, having order 3, on the id column for the following information.

Manager-name: 'Harry', 'Susan', 'Neena', 'Rosy', 'Gitz', 'Jkg', 'Mita'
ID: 2,   45,   56,   34,   23,   67,   25
[(CO3) (Apply/IOCQ)]

(c)   Compare the order of node visit starting from A using BFS and DFS for the following graph:
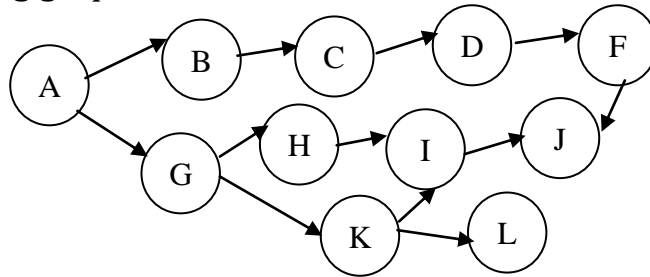
[(CO4)(Apply/IOCQ)]

3 + 3 + (3 + 3) = 12

Group - E

8. (a)   Deduce the average case time complexity of Binary Search.
          [(CO5) (Analyze/IOCQ)]
    (b)   "Radix Sort cannot be implemented on any kind of data." – Criticize on this statement.   [(CO5) (Evaluate/HOCQ)]
    (c)   Write an algorithm to implement quick sort without recursion. Implement this to sort the following dataset: Java, Python, C, Basic, Cobol.
          [(CO5)(Apply/IOCQ)]

2 + 3 + (4 + 3) = 12

9. (a)   (i) Explain with an example how double hashing works.
          (ii) $f(key) = key \bmod 7$ with linear probing to insert keys 37, 38, 72, 48, 98, 11, 96 into a table indexed from 0 to 6. What will be the location of key 11?
          [(CO6) (Understand/LOCQ)]
    (b)   A hash table can store a maximum of 10 records. Currently there are records in locations 1,3,4,7,8,9,10. What is the probability of a new record going into location 2 with a hash function resolving collisions by linear probing?
          [(CO6) (Analyse/HOCQ)]
    (c)   Discuss how using sentinel the performance of insertion sort can be improved.
          [(CO5) (Analyse/HOCQ)]
    (d)   Which sorting technique/techniques is/are called online sorting and why? Why the other sorting techniques are not called so? [(CO5)(Analyse/IOCQ)]

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

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	21.88%	59.38%	18.75%

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

Department & Section	Submission Link
IT	https://classroom.google.com/c/NDA1MjAyNTE0MjAy/a/NDY4MDAzNzc0MTEy/details