Course Code : CAT 201 / CCT 201 **KQLR/RS – 24 / 1516**

Third Semester B. Tech. (Computer Science and Engineering / Artificial Intelligence and Machine Learning / Cyber Security) Examination

DATA STRUCTURES / DATA STRUCTURE AND ALGORITHMS

Time : 3 Hours] [Max. Marks : 60

Instructions to Candidates :—

(1) Assume suitable data wherever necessary.
(2) All questions carry marks as indicated.
(3) Draw suitable diagrams wherever necessary.

1. (a) Consider a zero-indexed array A with dimensions 5x6x7 that stores 4-byte integers is located at an address 6400. Calculate the address of A(4, 5, 6) using lexicographic order. Now, assume that A(4, 4, 4) is located at an address 6576 as per co-lexicographic ordering. Calculate the base address of A.
Note : Assume 1st dimension as the depth. 3(CO1)

(b) State and explain the time complexity for each of these scenarios in terms of Big O notation.

(i) You have a name and you want to find the person's phone number in the telephone directory.

(ii) You have a phone number and you want to find the person's name in the telephone directory.

(iii) You want to read the numbers of every person in the telephone directory. 3(CO1)

(c) Find the complexity of the program below.

(1)
```
void function(int n) {
    int i, j, k, count = 0 ;
    for (i = n/2 ; i <= n ; i++)
        for (j = 1 ; j <= n ; j = 2 * j)
            for (k = 1 ; k <= n ; k = k * 2)
                count++ ;
}
```

(2)
```
function(int n) {
        if (n == 1)  return ;
        for (int  i = 1 ;  i <= n ;  i++)  {
                for (int  j = 1 ;  j <= n ;  j = ++)  {
                        printf ("*") ;
                        break ;
                }
        }
}
```
4(CO1)

2. (a) Imagine three railroad cars positioned on the input side of the track in below mentioned diagram, numbered 1, 2 and 3, from left to right. Suppose we perform the following sequence of operation (which is compatible with the direction of the arrows in the diagram and does not require cars to "jump over" other cars) :

(i) Move car 1 into the stack ;

(ii) Move car 2 into the stack ;

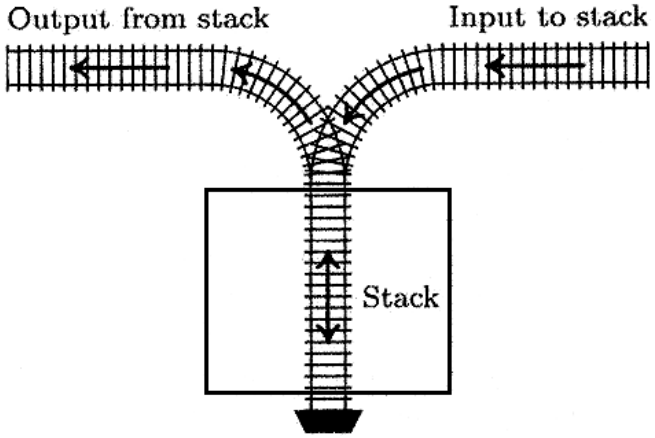
(iii) Move car 2 into the output ;

(iv) Move car 3 into the stack ;

(v) Move car 3 into the output ;

(vi) Move car 1 into the output.

As a result of these operations, the original order of the cars, 123, has been changed into 231. (This example is to understand the working of the track)



If there are six railroad cars numbered 123456,

(a) Check whether they can be permuted into the order 325641.

(b) Check whether they can be permuted into the order 154623.

Trace the stack step by step to justify your answer. 5(CO3,4)

(b) Let INITIALISE (Q) be an operation which initializes a linear queue Q to be empty. Let ENQUEUE (Q, ITEM) insert an ITEM into Q and DEQUEUE (Q, ITEM) delete an element from Q through ITEM. EMPTY_QUEUE (Q) is a Boolean function which is true if Q is empty and false otherwise, and PRINT (ITEM) is a function which displays the value of ITEM.
Execute the following set of operations on the linear queue Q in the given order :

(1) A = B = C = 0 ;

(2) INITIALISE (Q)

(3) ENQUEUE (Q, 15)

(4) ENQUEUE (Q, 87)

(5) ENQUEUE (Q, 29)

(6) DEQUEUE (Q, A)

(7) DEQUEUE (Q, C)

(8) ENQUEUE (Q, A)

(9) ENQUEUE (Q, B+33)

(10) DEQUEUE (Q, A)

(11) DEQUEUE (Q, B)

(12) while not EMPTY_QUEUE (Q) do

(13) DEQUEUE (Q, A)

(14) PRINT (A)

(15) PRINT (B)

(16) PRINT (C)

(17) end.

Trace the contents of the queue Q and the values of the variables A, B, C in tabulated format. Find the final output after execution of the above given set of operations on the linear queue Q. 5(CO3)

3. (a) Imagine you have a list representing participants in a race. Each participant is connected to the next participant, forming a loop (Assume that the last node is connected to the first node of the list). Your task is to split this list into two equal parts. If the number of participants is odd, the first list should have one extra participant than the second list.
Describe your approach and the steps taken to achieve an effective split for this problem. Also, identify and justify the type of data structure used to solve this real time scenario with the help of suitable graphical representation. 5(CO3,4)

(b) Assume you are developing the navigation history functionality for a web browser. The browser's navigation history is represented using a Doubly Linked List, with each node containing information about a visited web page. Each node has the following data related to web browser navigation history :

- PageID : A unique numeric page id of the Web page.
- URL : The Uniform Resource Locator of the web page.
- Timestamp : The time when the web page was visited.
- Previous : A pointer to go to the previous webpage.
- Next : A pointer to go to the next webpage.

Write the pseudocode for deleting any one visited webpage from the navigation history of the web browser. Your pseudocode must handle three cases : Deleting the history of –

(1) 1st page visited.

(2) Last page visited and

(3) Any intermediate visited if the page id is given (other than 1st and last webpage).

Ensure that the pointers previous and next are adjusted correctly after deletion of the webpages and the logic is clear and concise.

Support your pseudocode with suitable diagrams illustrating the Doubly Linked List before and after the deletion operation for each of the three cases. 5(CO3,4)

4. (a) Compare and contrast between linear search and binary search. State the scenarios when linear search is preferrable than Binary search. Write algorithm for implementing a binary search. Trace your algorithm (step-by-step) in locating the key 33 in the list, Keys [ ] = {44, 22, 11, 78, 33, 88, 33, 22, 55}. 5(CO1,2)

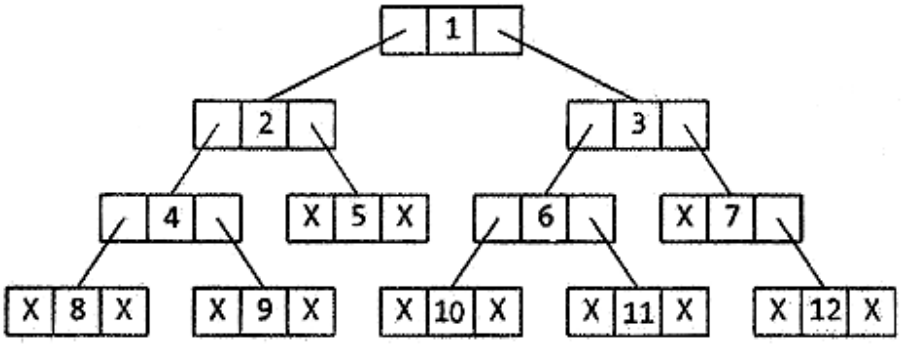
(b) Consider an array of integers : [6, 3, 8, 5, 2, 7, 4, 1].

(1) Implement the quick sort algorithm to sort the given array in ascending order. Provide the step-by-step process of how the quick sort algorithm works on this array. Clearly indicate the pivot element at each step and show how the array is divided and sorted into smaller subarrays.

(2) Explain how the quick sort algorithm utilizes the divide and conquer technique. Discuss the key steps where the arrays is divided into subarrays. How these subarrays are recursively sorted ? Highlight the divide and conquer approach used in quick sort. 5(CO1,2)

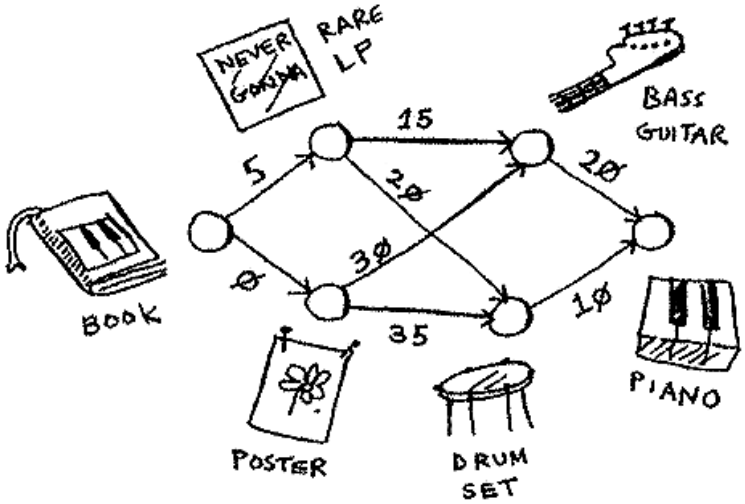
5. (a) Construct an AVL Tree by inserting the keys in a sequence – 40, 70, 50, 20, 30, 80, 10, 90, 35, 95.
Remove a key 50 from the constructed tree.
Sketch the specific steps during the removal. 5(CO3,4)

(b) Illustrate the concept of threaded binary tree. State and discuss its various types. Convert the following Binary Tree into One Way Threaded Tree.



Support your answer by stating the algorithm for converting Binary Tree into One Way Threaded Tree. 5(CO3)

6. (a) Mohit has a music book and he is trying to trade this book for a real piano. But while doing so, he is very confused about the items to trade and the amount of money to be paid. (Refer the graph attached below). In this graph, the nodes are all the items Mohit can trade for. The weights on the edges are the amount of money he would have to pay to make the trade. So, he can trade the poster for the guitar for $30, or trade the LP for the guitar for $15.



How is Mohit going to Figure out the path from the book to the paino where he spends the least amount of money ? So, design a best solution for Mohit using any suitable algorithm to solve this problem. Also, state the series of trades Mohit needs to make and the minimum amount of money he needs to pay to get the piano. 5(CO3,4)

(b) A hash table has 7 buckets, each with capacity to store 2 keys. Show step-by-step process of inserting following keys in the mentioned sequence into the hash table using —

(1) Linear probing, and

(2) Quadratic probing.

199, 67, 133, 89, 24, 54, 71, 45, 80, 25.

Indicate specific collisions encountered and resolved in the process. 5(CO3)