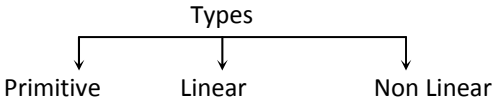
S.E. Sem. III [INFT]

Data Structures & Analysis

Time : 3 Hrs.] Prelim Paper Solution **[Marks : 80**

Q.1(a) Explain different types of data structures with examples. **[5]**

Ans.: Types of Data Structure : Data Structures can be categories as follows :



- **Primitive :** They are in build datatypes provided by the programming language. For example : int, fcoat, char etc.
- **Linear Data Structure :** In this all the elements would be at same level. Hence there is hierarchy between elements, for example : Stack, Queues, Array, linked list.
- **Non–Linear Data Structure :** In these the element would be at different levels. Hence there would be hierarchy between the elements. For example : Trees, Graph.

Operation on Data Structure :

1)	Create	2)	Insert	3)	Delete	4)	Modify/Edit/update
5)	Sort	6)	Search	7)	Merge	8)	Traverse

Q.1(b) Write a C program to implement Quick sort. **[5]**

Ans.: Quick Sort (Recursive)

```
Void quicksort (int x[], int lb, int ub)
{
    int p;
    if (lb < ub)
    {
        p = partition (x, lb, ub);
        quicksort (x, lb, p – 1);
        quicksort (x, p + 1, ub);
    }
}

int partition (int x[], int lb, int ub)
{
    int val = x [ ℓ b], down = lb+1, up = ub, t;
    while (down < = up)
    {
        while (down < = up && x [down] < = val)
                down ++;
        while (x [up] > val)
                up - -;
        if (down < up)
        {
            t = x [down];
```

```
                x [down] = x [up];
                x [up] = t;
            }
        }
        x [/b] = x [up];
        x [up] = val;
        return up;
        }
```

Q.1(c) Write a function for DFS traversal of graph. **[5]**

Ans.: Depth first search :

```
# include <stuio.h>
int adj [10] [10] = {0} visited [10] = { 0 }, n :
void dfs (int  node)
{
    int i;
    visited[node] = 1
    printef ("%d", node +1);
    for (i = 0 ; i < n ; i ++)
    if (adj [node] [i] = = 1 visited [i] = = 0)
    dfs(i);
}

dfs(0)
void main ( )
{
    int  e, i, v1, v2, node;
    printf ("Enter no. of nodes \n");
    scanf ("%d", &n);
    printf ("Enter no. of edges \n");
    scanf (" % d", & e);
    for (i = 0; i < e ; i ++)
    {
        printf ("Enter edge \n");
        scanf ("%d%d", & v1, v2);
        adj [v1 – 1] [v2 – 1] = adj[v2 – 1] [v1 – 1] = 1
    }
    printf ("Enter starting vertex \n")
    scanf  ("%d", & nodes);
    dfs (node–1);
}
```

Q.2(a) Write a C program to convert infix expression into postfix Expression. **[10]**

Ans.: Implementation :

```
# include<stdio.h>
# include<string.h>
# define MAX 50
```

```
type def struct stack
{
      char S[MAX];
      int tos;
} stack;
void push (stack * t, char ele)
{
      t → s [+ + t → tos] = ele;
}
int isempty (stack*t)
{
      return (t→ tos = = −1);
}
char pop (stack * t)
{
      char z = t → s [t → tos];
      t → tos − − ;
      return z;
}
char stacktop (stack * t)
{
      return (t→ s [t→ tos];
}
int isoperand  (char ch)
{
      if (ch > = 'a' & & ch < = 'z' || ch > = 'A' & & ch < = 'z')
            return 1;
      else return 0;
}
int ipr (char ch)
{
      switch (ch)
      {
            case 'c'   : return 3;
            case '*'   :
            case'/'    :
            case '%'  : return 2;
            case '+'   :
            case'−'    : return 1;
      }
      return −1;
}
int rpr (char ch)
{
      switch (ch)
      {
            case 'c'   : return 0;
```

```
            case '*'  :
            case'/'   :
            case '%' : return 2;
            case'+'   :
            case '–'  : return 1;
        }
        return -1 ;
}
void convert (char in[ ] , char post [ ])
{
        stack x :
        int l = strlen (in), i, k = 0;
        char ele;
        x –tos = –1;
        for (i=0 : i < l : i ++)
        {
            if (in[i] = = 'c')
                push (2x, in [i]);
            else if (in[i] = = ' ) ')
            {
                while (1)
                {
                    ele = pop (&x);
                    if (ele = = 'C')
                        break;
                    post [k ++] = ele;
                }
            }
            else if (is operand (in [i]))
                post [k++] = in [i]
            else if (isempty (&x))
                push (&x, in [i]);
            else if (ipr (in[i]) > rpr [stacktop (&x)))
                push (&x, in[i];
            else
            {
                while (isempty (&x) = = 0 && ipr (in[i] < rpr (stacktop(&x)))
                {
                    ele = pop (& x);
                    post [k ++] = ele;
                }
                push (&x, in [i]);
            }
        }
        while (isempty (&x) = = 0)
        {
            ele = pop (&x);
```

```
            post [k ++] = ele;
        }
        post [k] = '10';
}
void main ( )
{
        char infix [MAX], postfix [MAX] ;
        printf ("\n \n Enter infix expression:");
        gets (infix);
        convert (infix, postfix);
        printf ("Postfix = % \n", postfix);
}
```

Q.2(b) Write a function to implement Binary Search on sorted set of Integer. [10]

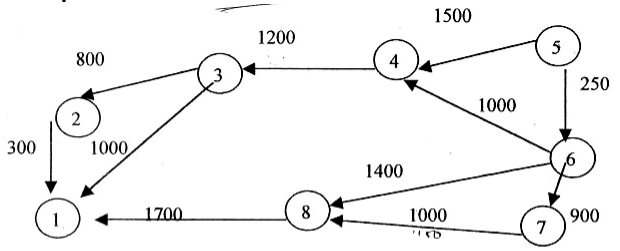
Ans.: A graph can be used to find a shortest path between two destinations. In order to find a shortest path we use Dijkstra's algorithm. It uses the following greedy criterion :

From the remaining vertices, select a vertex that has a shortest path from the initial vertex.

Algorithm Shortest Path (cost, start, preced, distance)
Cost : Cost Matrix.
Start : Staring vertex in the graph from where the distance needs to be calculated.
Preced: array that stores the previous node to the node in the minimum spanning tree.
Distance: Stores the shortest distance between 'start' node and the i^{th} node.
Post Condition : The distance array is returned with the shortest distance to each node.

1) Initialize the distance [] to infinity.
2) Initialize the selected array to FALSE selected [] = 0
3) current=start
4) distance[current] = 0
5) selected [current] = TRUE
6) While (all the nodes are not selected)
   i) Consider the smallest distance INFINITY' small = INFINITY'
   ii) currentdistance = distance [current]
   iii) for (i=1; 1< = N; I++)
      (a) distance [I] = currentdistance + cost [current] [I]
      (b) Mindistance = Find (distance [I])
   iv) Current = Mindistance Vertex
   v) selected [current] = TRUE
7) end.

Example : Find a shortest Path from Node 5 to all other nodes.



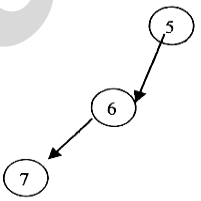
Form 5 : Distance[I] = 0+ ....

Ά	ά	ά	1500	0	250	ά	ά
1	2	3	4	5	6	7	8

Path to 6 = {5, 6} = 250

From 6 : Distance [I] = 250+

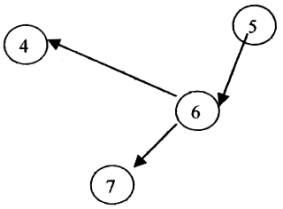
ά	ά	ά	1250	0	250	1150	1650
1	2	3	4	5	6	7	8



path to 7 = {5, 6, 7} = 1150

From 7 : Distance [I] = 1150+

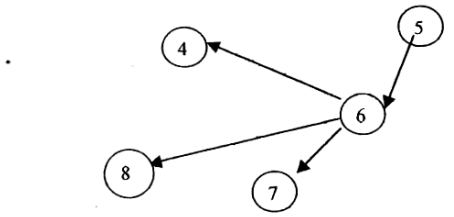
ά	ά	ά	1250	0	250	1150	1650
1	2	3	4	5	6	7	8



path to 4 = {5, 6, 4} = 1250

From 4 : Distance [I] = 1250+

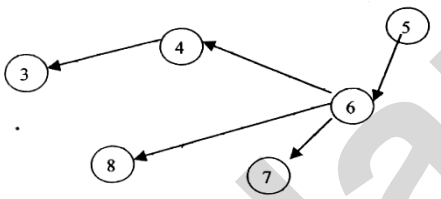
ά	ά	2450	~~1250~~	0	250	~~1150~~	1650
1	2	3	4	5	6	7	8



path to 8 = {5, 6, 8} = 1650

From 8 : Distance [I] = 1650 +

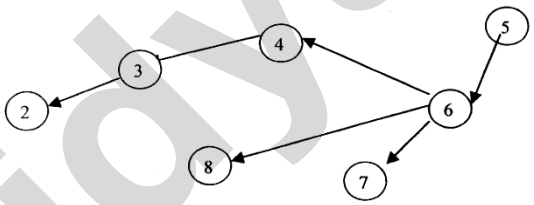
3350	A	2450	~~1250~~	0	250	~~1150~~	~~1650~~
1	2	3	4	5	6	7	8



path to 4 = {5, 6, 4, 3} = 2450

From 3 : Distance [I] = 2450+

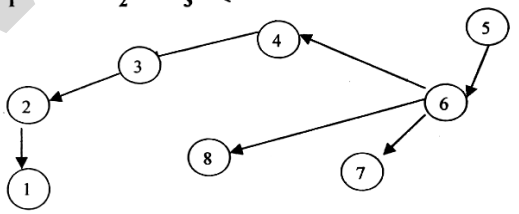
3350	3250	~~2450~~	~~1250~~	0	250	~~1150~~	~~1650~~
1	2	3	4	5	6	7	8



path to 2 = {5, 6, 4, 3, 2} = 3250

From 2

3350	~~3250~~	~~2450~~	~~1250~~	0	250	~~1150~~	~~1650~~
1	**2**	**3**					



path to 1 = {5, 6, 8, 1} = 3350

Q.3(a) Write a program in C to implement circular queue using always. **[10]**

Ans.: Array implementation of circular Queue :

```
#include <stdio.h>
#define MAX 4
typedef struct queue
{
    int q [MAX];
    Int f, r, count;
} queue;

void insert (queue *t, int ele);
{
    if (t → count = = MAX)
    {
        printf ("\n queue overflow");
        return;
    }
    t → count + +;
    t → r(t → r+1) % MAX;
    t → q [t→r] = ele ;
}
int isempty (queue *t)
{
    if (t→ count = = 0)
        return 1;
    else return 0;
}
int delete1(queue * t)
{
    int z;
    if (isempty (t))
    {
        printf ("Queue underflow");
        return –1;
    }
    t → count – – ;
    z = t → q [ t →f];
    t → f = (t→ f + 1) % MAX;
    return z;
}
void display (queue *t)
{
    int i;
    if (isempty (t))
    {
        printf ("Queue empty \n");
        return;
```

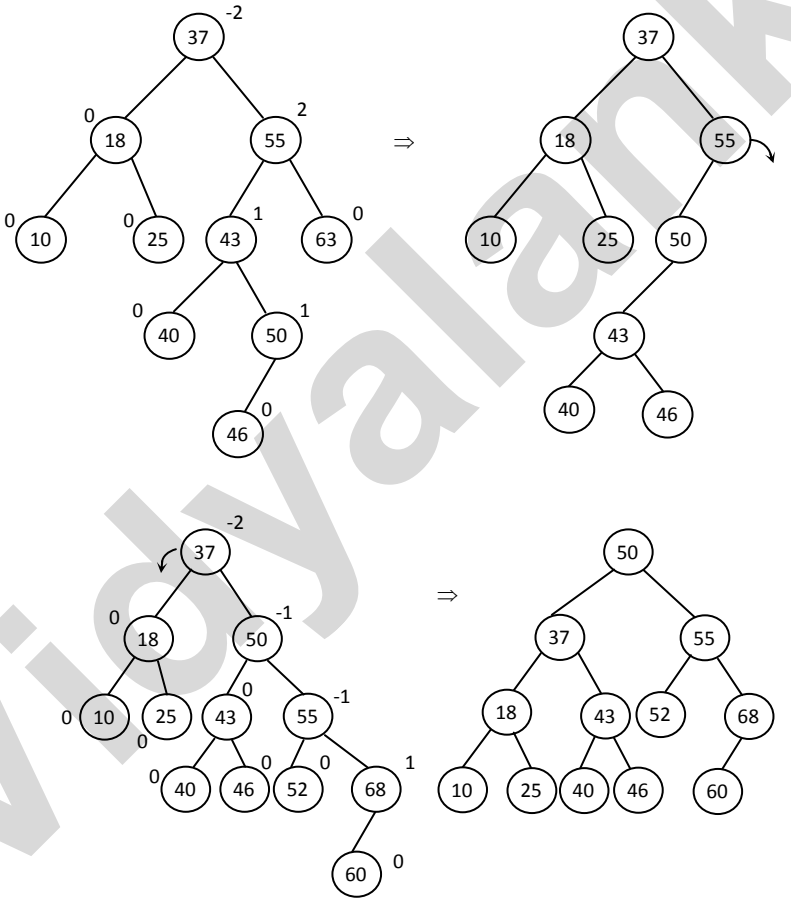
```
        }
        i = t → f;
        while (1)
        {
            printf ("% d", t → q [i] ;
            if (i = = t → r )
                break;
            i = (i  + 1) % MAX ;
        }
        printf("\n");
}
void main( )
{
        queue x;
        int ch, ele;
        x.f = 0;
        x.r = MAX –1;
        x.count = 0;
        while (1)
        {
            printf ("Enter choice  1] Insert,  2] Delete");
            printf ("3] Queue front 4] Display,  5] Exit");
                \n");
            scanf ("%d", &ch);
            if (ch = =5)
            break;
            switch (ch)
            {
                case 1 :  print f ("Enter element to be inserted");
                          scan f ("% d", & ele);
                          insert (&x ele);
                          display (&x);
                          break,
                case 2 :  if (isempty (&x))
                          printff ("\n Queue underflow");
                          else
                          {
                              ele = delete 1(& x);
                              printf ("Deleted element = "%d \n", ele) ;
                              display (& x);
                          }
                          break;
                case 3 :  if (isempty (&x))
                          printff ("\n Queue empty");
                          else
                          {
                              ele = queue front (& x);
```

```
                        printf ("Queue front =%d" \n, ele);
                        display ( & x);
                    }
                    break;
            case 4 : display (& x);
                    break,
            default: printf ("\n Invalid choice");
        }
    }
}
```

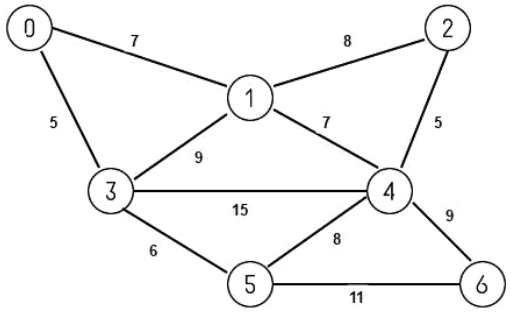
Q.3(b) Construct AVL Trees using following. **[10]**

37, 55, 18, 25, 68, 10, 43, 50, 40, 46, 52, 60

Ans.: 37, 55, 18, 25, 68, 10, 43, 50, 40, 46, 52, 60



Q.4(a) What is Minimum Spanning Tree? Draw the MST using kruskal's and prim's algorithm and find out the cost with all intermediate steps. **[10]**



Ans.: Informally, a minimum spanning tree of an undirected graph G is a tree formed from graph edges that connects all the vertices of G lot a lowest total cost. A MST exists if & only if G is connected.

The minimum spanning true is a tree because it is acyclic, it is spanning because it causes every vertex & it is minimum for the obvious reason. If we use to wire a house with a minimum of cable, then a minimum spanning tree problem needs to be solved.

By Prim's Algorithm :

V	Known	dv	pv	
0	0	0	0	
1	0	∞	0	Value zero
2	0	∞	0	
3	0	∞	0	
4	0	∞	0	
5	0	∞	0	
6	0	∞	0	

V	Known	dv	pv	
0	1	0	0	
1	0	7	0	(node)
2	0	∞	0	
3	0	5	0	(node)
4	0	∞	0	
5	0	∞	0	
6	0	∞	0	

After 0 is declared known.

V	Known	dv	pv	
0	1	0	0	
1	0	7	0	(node)
2	0	∞	0	
3	1	5	0	(node)

4	0	1 5	3	
5	0	6	0	
6	0	∞	0	

After 3 is declared known :

V	Known	dv	pv	
0	1	0	0	
1	0	7	0	(node)
2	0	∞	0	
3	1	5	0	(node)
4	0	8	5	
5	1	6	3	
6	0	11	5	

After 5 is declared known

V	Known	dv	pv	
0	1	0	0	
1	1	7	0	(node)
2	0	8	1	
3	1	5	0	(node)
4	0	7	1	
5	1	6	3	
6	0	11	5	

After 1 is declared known

V	Known	dv	pv	
0	1	0	0	
1	1	7	0	(node)
2	0	5	4	
3	1	5	0	(node)
4	1	7	1	
5	1	6	3	
6	0	9	4	

After 4 is declared known

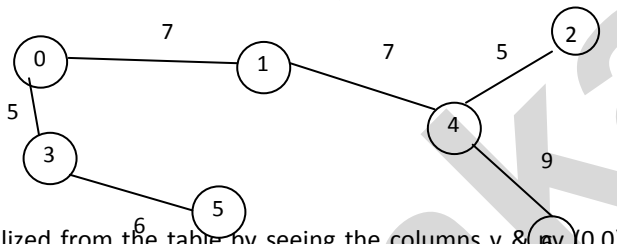
V	Known	dv	pv	
0	1	0	0	
1	1	7	0	(node)
2	1	5	4	
3	1	5	0	(node)
4	1	7	1	
5	1	6	3	
6	0	9	4	

After 2 is declared known

V	Known	dv	pv	
0	1	0	0	
1	1	7	0	(node)
2	1	5	4	
3	1	5	0	(node)
4	1	7	1	
5	1	6	3	
6	1	9	4	

After 6 is known & thus all are known constructing MST.

Final MST :



Total Cost = 39

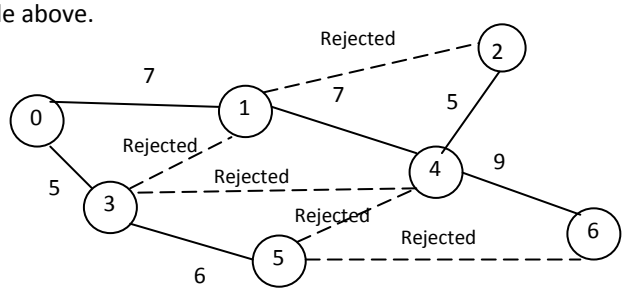
The edges are realized from the table by seeing the columns v & pv (0,0), (1,0), (2,4), (3,0), (4,1), (5,3), (6,4)

By Krushkal's Algorithm :

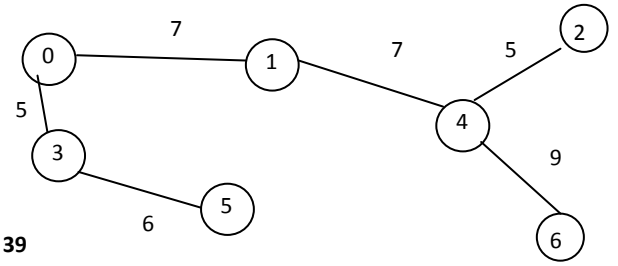
Sorting the edges in ascending order.

Edge	Weight	Action
(0,3)	5	Accepted
(2,4)	5	Accepted
(3,5)	6	Accepted
(0,1)	7	Accepted
(1,4)	7	Accepted
(1,2)	8	Rejected
(4,5)	8	Rejected
(1,3)	9	Rejected
(4,6)	9	Accepted
(5,6)	11	Rejected
(3,4)	15	Rejected

Kruskal's algorithm tries to put, every edge in the MST unless it forms a cycle i.e. if addition of any edge forms a cycle then that edge is rejected else it is accepted. The edges will be scanned in the sequence of the ascending order of their weights as shown in the table above.



Final MST :



Total Cost = 39

Q.4(b) Write a function to implement singly Linked list following operations : [10]

(i) Insert a node at specific Location (ii) Delete a node from end

(iii) Display the list

Ans.: General Linked List (Singly Linked List):

Implementation:

```
# include <stdio.h>
# include <stdlib.h>
typedef struct node
{
    int data;
    struct node * next;
}node;

typedef struct head
{
    node * start;
}head;

void insertpos (head*t, int ele, int pos)
{
    int i;
    node * p, *q;
    p = (node *) malloc (size of (node));
    p → data = ele;
    q = t → start;
    for (i = 0; i < pos – 2; i++)
        q = q → next;
    p → next = q → next;
    q → next = p;
}
```

pos	pos - 2
2	0
3	1
4	1

```
void display (head * t)
{
    node * q;
```

```
    if (t → start = = NULL)
    {
        printf ("Linked List empty \n");
        return;
    }
    q = t → start;
    while (q ! = NULL)
    {
        printf ("%d", q → data);
        q = q → next;
    }
    printf ("\n");
}

int delete end (heat * t)
{
    node * p, * q;
    if (t → start = = NULL)
    {
        printf ("LL Empty \n");
        return – 1;
    }

    if (t → start → next = = NULL)
    {
        p = t → start;
        t → start = NULL;
    }
    else
    {
        q = t → start;
        while (q → next → next ! = NULL)
                q = q → next;

        p = q → next;
            q → next = NULL;
    }
    return (p → data);
}
```

Q.5(a) Write a C function for following operations on Double Linked list [10]

(i) Insert Beginning (ii) Delete Beginning

Ans.:

```
typedef struct node
{
    int data;
    struct node * next, * prev;
```

```
} node;
typedef struct head
}
    node * start * last;
} head;
void insertbeg (head*t, int ele)
}
    node * p;
    p = (node *) malloc (size of (node));
    p → data = ele;
    p → next = p → prev = NULL;
    if (t → start = = NULL)
        t → start = t → last = p;
    else
    {
        p → next = t → start;
        t → start → prev = p;
        t → start = p;
    }
}

int deletebeg (head*t)
{
    node * p;
    if (t → start = = NULL)
    {
        printf ("DLL Empty \n");
        return – 1;
    }
    p = t → start;
    if(t → start = = t → last)
    if (t → start = t → last = NULL;
    else
    {
        t → start = t → start → next;
        t → start → prev = NULL;
    }
    return (p → data);
}
```

Q.5(b) Write a C function to perform Deletion operation in Binary Search Tree. [10]

Ans.:

```
void delete1 (head * t, int ele)
{
    node * q, * f;
    if (t → root = = NULL)
    {
```

```
        printf ("BST Empty \n");
        return;
}
q = t → root;
while (q! = NULL)
{
        if (ele = = q → data)
                break;
        if (ele < q → data)
                q = q → left;
        else    q = q → right;
}
if (q = = NULL)
{
        printf ("% d is not found \n", ele);
        return;
}
if (q → left = = NULL && q → right = = NULL)
{
        if (q = = t → root)
        {
                t → root = NULL;
                return;
        }
        f = father (t, q);
        if (f → left = = q)
                f → left = NULL;
        else f → right = NULL;
        return;
}

if (q → left ! = NULL)
{
        int val;
        node * max = findmax (q → left);
        val = max → data;
        delete 1(t, max → data);
        q → data = val;
        return;
}
if (q = = t → root)
{
        t → root = t → root → right;
        return;
}
f = father (t, q);
```

```
        if (f → left = = q)
            f → left = q → right;
        else f → right = q → right;
    }
```

Q.6 Attempt following (Any 2) [20]

Q.6(a) Explain B Tree & B+ Tree. [10]

Ans.: – B tree stands for Balanced Tree

- In B tree of order n(odd) :
  each node can contain
  max data = n–1
  maximum no. of children = n
  No. of children = no. of data + 1
  min data -= n/2 (except root)

- B + Tree :
  - In B Tree the element are stored on all the levels.
  - Hence the record pointers must be kept at all the levels and linear search in the leaf nodes is also not possible.
  - In achieve this we must have all the elements in leaf nodes only.
  - This can be done by performing following modification in B Tree.
    (i) When leaf node is split, the median is sent up and its copy is also retained in left child.
    (ii) All the leaf nodes must be linearly connect.
  - A B Tree with this modification is called B+ Tree

Q.6(b) Explain : [10]

(i) Various methods to represent graph in computer memory

(ii) Explain different Applications of Linked List

Ans.: (i) Graph Representation / Representing graph in memory

Graph can be represented in memory using any of the following method.

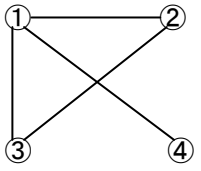
1) Adjacency matrix 2) Adjacency List

Adjacency Matrix :

- In this, a graph with n vertices can be represented using a square matrix of order x.
- The adjacency between the nodes can be stored using zeros & is as follows :

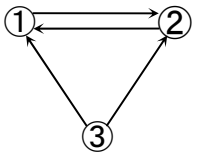
  adj (i, j) = 1 if (i, j) ∈ E(G)
  = 0 if (i, j) ∉ E(G)

Undirected :



	1	2	3	4
1	0	1	1	1
2	1	0	1	0
3	1	1	0	0
4	1	0	0	0

Directed :

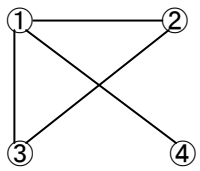


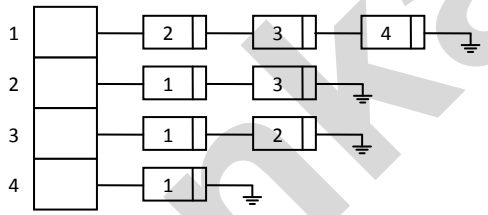
$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \end{bmatrix} \end{array}$$

Adjacency List :

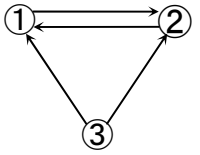
- In these the graph with n vertices is stored using an array of n linked list.
- Hence 1 node is mapped with n linked list which can be used to store all the nodes adjacent to that node.

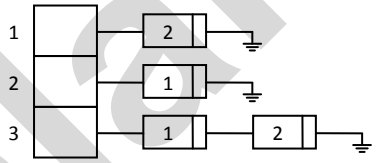
Undirected :





Directed :

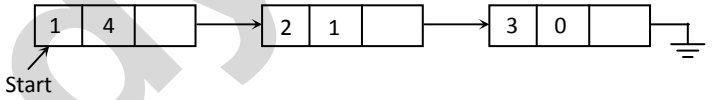




(ii) Application of Linked List :

Polynomial representation & addition.

- A Polynomial can be represented using linked list.
- Each node can store co–efficient, exponent and pointer to the next node.
  e.g. : $x^4 + 2x + 3$



Q.6(c) Explain a c program to implement Double Ended Queue. [10]

Ans.:

```
# include <stdio.h>
# define MAX 7
typedef struct queue
{
    int q [MAX]
    int f, r;
} queue;

void insert right (queue *t, in tele)
{
    if (t⟶ r = = MAX-1)
```

```
    {
        printf ("\n Queue overflow");
        return;
    }
    t → r + + ;
    t → q [t → r] = ele;
}
void insert left (queue *t, int ele)
{
    if (t → f = = –1)
    {
        printf ("\n Queue overflow");
        return;
    }
    t → q [t→ f] = ele;
    t → f – –;
}

int isempty (queue * t)
{
    if (t → f = = t → r)
    {
        return 1;
        else
        return 0;
    }
}

int deleteright (queue *t)
{
    int z;
    if (isempty (t))
    {
        printf ("\n Queue underflow").
        return–1;
    }
    z = t → q [t → r] ;
    t → r – – ;
    return z;
}

int deleteleft (queue * t)
{
    if (isempty (t))
    {
        printf ("Queue underflow");
        return–1;
```

```
        }
        t → f + +;
        return (t→q [t → f]) ;
}

void display (queue * t)
{
        int i
        if (isempty (t))
        {
                printf (“Queue Empty”);
                return;
        }
        for (i = t → f + 1 ; i < t → r ; i  + + )
        printf  (“ % d” t → q [ i ] );
        printf(“\n”);
}

void main( )
{
        queue x;
        int ch, ele;
        x.f = x.r = MAX 12;
        while (1)
        {
                printf (“Enter choice : 1] Insert right, 2] Insert left”);
                printf (“3] Delete right, 4] Delete left, 5] Display“);
                printf (“6] exit“);
                scanf (“%d”, &ch)
                if (ch = = 6)
                        breaks;
                switch (ch)
                {
                        Case 1 :  printf (“Enter element”);
                                  scanf (“%d”, & ele);
                                  insertright (& x, ele);
                                  display ( & x);
                                  break,
                        Case 2 :  printf (“Enter element”);
                                  scanf (“%d”, & ele);
                                  insertleft (&x, ele);
                                  display (& x);
                                  break;
                        Case 3 :  if (isempty ( &x))
                                  printf (“\n Queue underflow”)
                                  else
                                  {
```

```
                    ele = deleteright(&x));
                    printf "Deleted element = %d", ele");
                    display(&x);
                }
                break;
        Case 4 : if (isempty (&x))
                printf ("Queue underflow")
                else
                {
                    ele = deleteleft (&x);
                    printf ("Deleted element = % d", ele);
                    display (&x);
                }
                break ;
        Case 5 : display (&x);
                break;
                default:  printf ("Invalid choice")
    }
  }
}
```

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