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BATCH:- C-2
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ASSIGNMENT NO.5.

Aim :-

You have a business with several offices; you want to lease phone lines to connect them up with each other; and the phone company charges different amounts of money to connect different pairs of cities. You want a set of lines that connects all your offices with a minimum total cost. Solve the problem by suggesting appropriate data structures .

Objective:- To study the use of kruskal's and prims algorithm in given problem.

Theory:-

What is Minimum Spanning Tree?

Given a connected and undirected graph, a *spanning tree* of that graph is a subgraph that is a tree and connects all the vertices together. A single graph can have many different spanning trees. A *minimum spanning tree (MST)* or minimum weight spanning tree for a weighted, connected and undirected graph is a spanning tree with weight less than or equal to the weight of every other spanning tree. The weight of a spanning tree is the sum of weights given to each edge of the spanning tree.

How many edges does a minimum spanning tree has?

A minimum spanning tree has (V – 1) edges where V is the number of vertices in the given graph.

What are the applications of Minimum Spanning Tree?

See this for applications of MST.

Below are the steps for finding MST using Kruskal's algorithm

1. *Sort all the edges in non-decreasing order of their weight.*
2. *Pick the smallest edge. Check if it forms a cycle with the spanning tree formed so far. If cycle is not formed, include this edge. Else, discard it.*
3. *Repeat step#2 until there are (V-1) edges in the spanning tree.*

The step#2 uses Union-Find algorithm to detect cycle.

The algorithm is a Greedy Algorithm. The Greedy Choice is to pick the smallest weight edge that does not cause a cycle in the MST constructed so far.

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Algorithm:-

- create a forest *F* (a set of trees), where each vertex in the graph is a separate tree
- create a set *S* containing all the edges in the graph
- while *S* is nonempty and *F* is not yet spanning
  - remove an edge with minimum weight from *S*
  - if the removed edge connects two different trees then add it to the forest *F*, combining two trees into a single tree

At the termination of the algorithm, the forest forms a minimum spanning forest of the graph. If the graph is connected, the forest has a single component and forms a minimum spanning tree.

Program Code:-

```
#include <iostream>

#include<iomanip>

using namespace std;


const int MAX=10;

class EdgeList;  //forward declaration

class Edge              //USED IN KRUSKAL

{

        int u,v,w;

public:

        Edge(){} //Empty Constructor

        Edge(int a,int b,int weight)
```

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```
        {
                u=a;
                v=b;
                w=weight;
        }
        friend class EdgeList;
        friend class PhoneGraph;
};
//---- EdgeList Class ----------
class EdgeList
{
        Edge data[MAX];
        int n;
public:
        friend class PhoneGraph;
        EdgeList()
        { n=0;}
        void sort();
        void print();
```

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```
};
//----Bubble Sort for sorting edges in increasing weights' order ---//
void EdgeList::sort()
{
	Edge temp;
	for(int i=1;i<n;i++)
		for(int j=0;j<n-1;j++)
			if(data[j].w>data[j+1].w)
			{
				temp=data[j];
				data[j]=data[j+1];
				data[j+1]=temp;
			}
}
void EdgeList::print()
{
	int cost=0;
	for(int i=0;i<n;i++)
	{
		cout<<"\n"<<i+1<<" "<<data[i].u<<"--"<<data[i].v<<" = "<<data[i].w;
```

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```
                cost=cost+data[i].w;
        }
        cout<<"\nMinimum cost of Telephone Graph = "<<cost;
}
//------------ Phone Graph Class----------------
class PhoneGraph
{
        int data[MAX][MAX]={{0, 28, 0, 0, 0,10,0},
         {28,0,16,0,0,0,14},
         {0,16,0,12,0,0,0},
         {0,0,12,0,22,0,18},
         {0,0,0,22,0,25,24},
         {10,0,0,0,25,0,0},
         {0,14,0,18,24,0,0},
        };
        int n;

public:
        PhoneGraph(int num)
{
```

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```
                n=num;
}
        void readgraph();
        void printGraph();
        int mincost(int cost[],bool visited[]);
        int prim();
        void kruskal(EdgeList &spanlist);
        int find(int belongs[], int vertexno);
        void unionComp(int belongs[], int c1,int c2);
};
void PhoneGraph::readgraph()
{
        cout<<"Enter Adjacency(Cost) Matrix: \n";
        for(int i=0;i<n;i++)
        {
                for(int j=0;j<n; j++)
                        cin>>data[i][j];
        }
}
void PhoneGraph::printGraph()
```

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```
{
        cout<<"\nAdjacency (COST) Matrix: \n";
        for(int i=0;i<n;i++)
        {
                for(int j=0;j<n;j++)
                {
                        cout<<setw(3)<<data[i][j];
                }
                cout<<endl;
        }
}
int PhoneGraph::mincost(int cost[],bool visited[]) //finding vertex with minimum cost
{
        int min=9999,min_index; //initialize min to MAX value(ANY) as temporary
        for(int i=0;i<n;i++)
        {
                if(visited[i]==0 && cost[i]<min)
                {
                        min=cost[i];
                        min_index=i;
```

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```
                }
        }
        return min_index; //return index of vertex which is not visited and having
minimum cost


}
int PhoneGraph::prim()
{
        bool visited[MAX];
        int parents[MAX]; //storing vertices
        int cost[MAX]; //saving minimum cost
        for(int i=0;i<n;i++)
        {
                cost[i]=9999;  //set cost as infinity/MAX_VALUE
                visited[i]=0; //initialize visited array to false
        }


        cost[0]=0; //starting vertex cost
        parents[0]=-1; //make first vertex as a root


        for(int i=0;i<n-1;i++)
```

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```
{
        int k=mincost(cost,visited); //minimum cost elemets index
        visited[k]=1; //set visited

        for(int j=0;j<n;j++)//for adjacent verices comparision
        {
                if(data[k][j] && visited[j]==0 && data[k][j] < cost[j])
                {
                        parents[j]=k;
                        cost[j]=data[k][j];
                }
        }
}
cout<<"Minimum Cost Telephone Map:\n";
for(int i=1;i<n;i++)
{
        cout<<i<<" -- "<<parents[i]<<" = "<<cost[i]<<endl;
}
int mincost=0;
for (int i = 1; i < n; i++)
```

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```
                mincost+=cost[i];                       //data[i][parents[i]];
        return mincost;
}
//------- Kruskal's Algorithm
void PhoneGraph::kruskal(EdgeList &spanlist)
{
        int belongs[MAX]; //Separate Components at start (No Edges, Only vertices)
        int cno1,cno2;          //Component 1 & 2
        EdgeList elist;
        for(int i=1;i<n;i++)
                for(int j=0;j<i;j++)
                {
                        if(data[i][j]!=0)
                        {
                                elist.data[elist.n]=Edge(i,j,data[i][j]); //constructor for
initializing edge
                                elist.n++;
                        }
                }
        elist.sort(); //sorting in increasing weight order
        for(int i=0;i<n;i++)
```

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```
            belongs[i]=i;


        for(int i=0;i<elist.n;i++)
        {
            cno1=find(belongs,elist.data[i].u); //find set of u
            cno2=find(belongs,elist.data[i].v); ////find set of v
            if(cno1!=cno2) //if u & v belongs to different sets
            {
                spanlist.data[spanlist.n]=elist.data[i]; //ADD Edge to spanlist
                spanlist.n=spanlist.n+1;
                unionComp(belongs,cno1,cno2); //ADD both components to same
set
            }
        }
}
void PhoneGraph::unionComp(int belongs[],int c1,int c2)
{
        for(int i=0;i<n;i++)
        {
            if(belongs[i]==c2)
                belongs[i]=c1;
```

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```
        }
}
int PhoneGraph::find(int belongs[],int vertexno)
{
        return belongs[vertexno];
}

//--------- MAIN PROGRAM----------------------------------
int main() {
        int vertices,choice;
        EdgeList spantree;
        cout<<"Enter Number of cities: ";
        cin>>vertices;
        PhoneGraph p1(vertices);
        //p1.readgraph();
        do
        {
                cout<<"\n1.Find Minimum Total Cost(By Prim's Algorithm)"
                                <<"\n2.Find Minimum Total Cost(by Kruskal's Algorithms)"
                                <<"\n3.Re-Read Graph(INPUT)"
```

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```
                <<"\n4.Print Graph"
                <<"\n0. Exit"
                <<"\nEnter your choice: ";
        cin>>choice;
        switch(choice)
        {
        case 1:
                cout<<" Minimum cost of Phone Line to cities is: "<<p1.prim();
                break;
        case 2:
                p1.kruskal(spantree);
                spantree.print();
                break;
        case 3:
                p1.readgraph();
                break;
        case 4:
                p1.printGraph();
                break;
        default:
```

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```
                        cout<<"\nWrong Choice!!!";
                }
        }while(choice!=0);


        return 0;
}
/*      Sample INPUT: vertices =7
 *              {{0, 28, 0, 0, 0,10,0},
         {28,0,16,0,0,0,14},
         {0,16,0,12,0,0,0},
         {0,0,12,0,22,0,18},
         {0,0,0,22,0,25,24},
         {10,0,0,0,25,0,0},
         {0,14,0,18,24,0,0},
        };
        Minimum Cost: 99
*/
```

Output Screenshots:-

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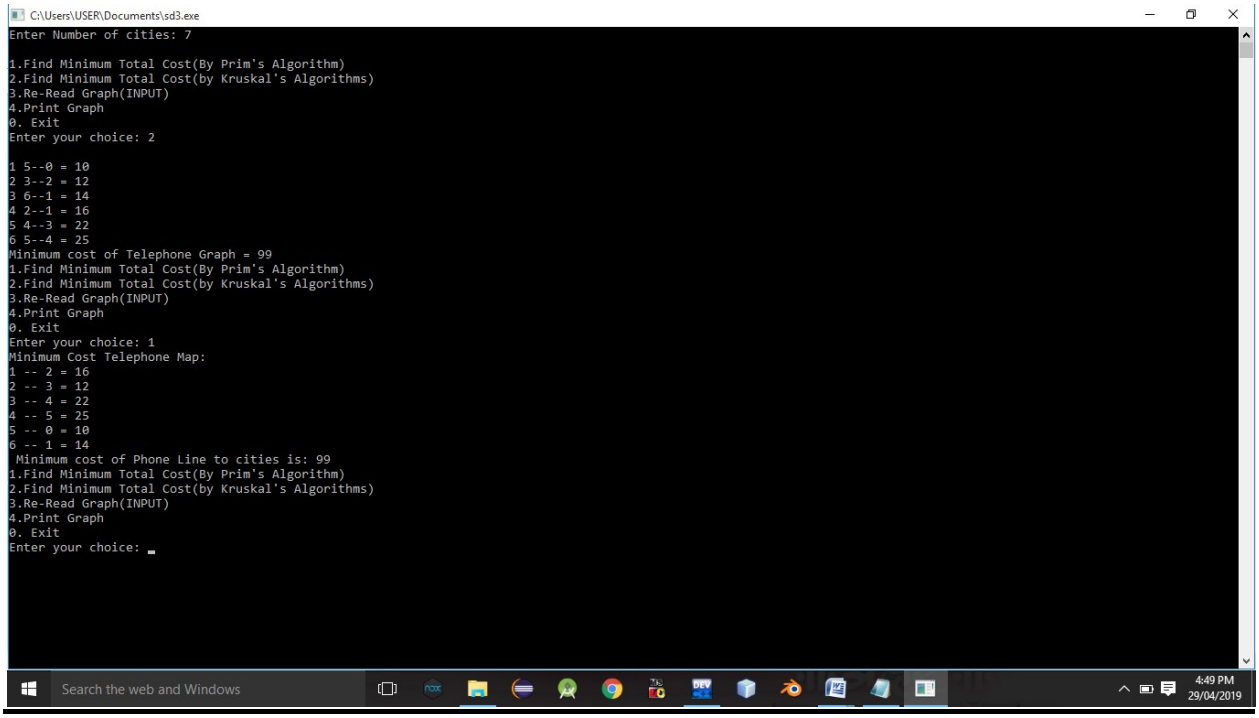

Conclusion:- Thus,we have studied implementation of kruskal's algorithm.