Design and Analysis of Algorithms Lab Manual for Diploma in Karnataka

RJS Polytechnic

Vinayaka VM

Design and Analysis of Algorithms

RJS POLYTECHNIC, BENGALURU

Vinayaka VM | Computer Science | August 24, 2017

Prerequisites

Knowledge of Data Structures.

Course Objectives

1. Write sorting programs using Divide-and-Conquer techniques.

2. Implement to find the minimum cost spanning tree and shortest path using different Greedy techniques.

3. Construct DFS, BFS programs and topological ordering using Decrease-and-Conquer technique.

4. Implement knapsack, travelling salesperson.

Course Outcome

On successful completion of the course, the students will be able to attain CO:

	Course Outcome	**Experiment linked**	**CL**	**Teaching Hrs**
CO1	Demonstrate Quick sort and Merge sort and calculate the time required to sort the elements.	***1,2***	***U,A,AL***	**12**
CO2	Implement the topological ordering of vertices, travelling salesman problem and Knapsack problem.	***3 to 5***	***U,A***	**18**
CO3	Construct programs to check graph is connected or not using BFS and DFS methods	***6,7***	***U,A,AL***	**15**
CO4	Implement programs on divide and conquer, decrease and conquer	***8,9***	***U,A,AL***	**15**
CO5	Experiment finding the minimum cost of spanning tree using Prim's algorithms and shortest path using Dijkstra' algorithm.	***10,11***	***U,A,AL***	**18**
			Total sessions	**78**

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Vinayaka V.M. , Lecturer Computer Science Department, RJS Polytechnic. Qualified with M.Tech., GATE, and KSET. Work experience in Bapuji Instiute of Engineering and Technology, Davanagere.

Table of contents Page

1 Sort a given set of elements using the Quick sort method and determine the time required to sort the elements. Repeat the experiment for different values of n.	5-8
2 Sort a given set of elements using merge sort method and determine the time required to sort the elements. Repeat the experiment for different of values of n.	9-11
3 Write a program to obtain the topological ordering of vertices in a given digraph.	12-13
4 Implement travelling salesman problem.	14-16
5 Implement the knapsack problem (0/1).	17-19
6 Print all the nodes reachable from a given starting node in a digraph using BFS method.	20-23
7 Check whether a given graph is connected or not using DFS method.	24-26
8 Write a program to implement binary search using divide and conquer technique	27-28
9 Write a program to implement insertion sort using decrease and conquer technique	29-30
10 Find minimum cost spanning tree of a given undirected path using a Prim's algorithm.	31-33
11 From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.	34-36

1 Sort a given set of elements using the Quick sort method and determine the time required to sort the elements. Repeat the experiment for different values of n.

ALGORITHM *Quicksort*(A[left..right])
//Sorts a subarray by quicksort
//Input: Subarray A[0..n-1]
//Output: Subarray A[left..right] sorted in increasing order
if left < right
    split← Partition (A[left.. right]) //split is split position bisecting array A
    Quicksort(A[left.. split-1])
    Quicksort(A[split+1..right])

ALGORITHM *Partition*(A[left.. right])
//Splits a subarray using first element as a pivot
//Input: Subarray of array A[0..n-1]
//Output: Partition of A[left..right], with split position returned
pivot←A[left]
i ← left; j ← right+1
repeat
    repeat i ← i+1 until A[i]>=pivot
    repeat j ← j-1 until A[j]<=pivot
    swap(A[i],A[j])
until i>=j
swap(A[i],A[j])
swap (A[left],A[right])
return j

C code:

```
#include<stdio.h>
#include<conio.h>
#include<stdlib.h>
#include<time.h>
#define SIZE 10
void Quick(int A[SIZE],int,int);
int partition(int A[SIZE],int,int);
void swap(int A[SIZE],int*,int*);
int n;
int main()
{
        int i;
        int A[SIZE];
        clock_t begin,end;
        double time_required;
        clrscr();
```

```
	printf("\n Sorting using Quick sort\n");
	printf("==================================\n");
	printf("\n Enter the total number of elements:");
	scanf("%d",&n);
	for(i=0;i<n;i++)
	{
		printf("Enter the number %d:",i+1);
		scanf("%d",&A[i]);
	}
	begin=clock();
	Quick(A,0,n-1);
	end=clock();
	printf("\n==================================\n");
	printf("\n Sorted elements are:\n");
	printf("==================================\n");
	for(i=0;i<n;i++)
	printf("\t %d",A[i]);
	time_required=1.0*((double)(end-begin));
	printf("\n The time required is :%f",time_required);
	getch();
	return 0;
}
int partition(int A[SIZE],int low,int high)
{
	int pivot=A[low],i=low,j=high;
	while(i<=j)
	{
		while(A[i]<=pivot)
			i++;
		while(A[j]>pivot)
			j--;
		if(i<j)
			swap(A,&i,&j);
	}
	swap(A,&low,&j);
	return j;
}
void swap(int A[SIZE],int *i,int *j)
{
	int temp;
	temp=A[*i];
	A[*i]=A[*j];
	A[*j]=temp;
}
void Quick(int A[SIZE],int low,int high)
{
	int m,i;
	if(low<high)
	{
		m=partition(A,low,high);
		Quick(A,low,m-1);
		Quick(A,m+1,high);
	}
}
```

OUTPUT:

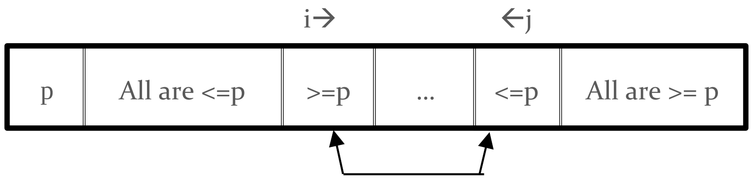
Sorting using Quick sort

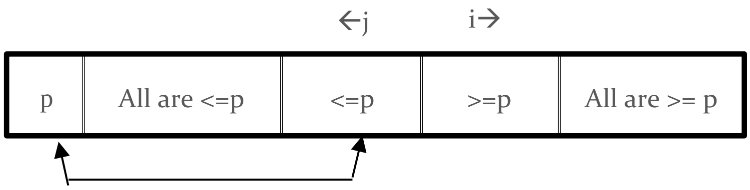
Enter the total number of elements: 5
Enter the number 1 : 2
Enter the number 2 : 6
Enter the number 3 : 4
Enter the number 4 : 9
Enter the number 5 : 1

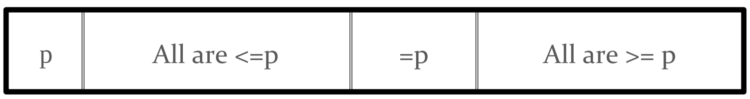
Sorted elements are :

1 3 4 6 9

The time required is : 0.000000







0	**1**	**2**	**3**	**4**
	i			j
2	6	4	9	1
		i	j	
2	1	4	9	6
		ij		
2	1	4	9	6
	j	i		
2	1	4	9	6
ij			i	j
1	2	**4**	9	6
			ij	
1	2	**4**	9	6
		j	i	
1	2	**4**	9	6
				ij
1	2	4	**9**	6
				ji
1	2	4	**9**	6
1	2	4	6	9
1	2	4	**6**	9
1	2	4	6	9

2 Sort a given set of elements using merge sort method and determine the time required to sort the elements. Repeat the experiment for different of values of n.

ALGORITHM *Mergesort*(A[0..n-1])

```
//Sorts array A[0..n-1] by recursive mergesort
//Input: An array A[0 ..n-1]
//Output: Array A[0..n-1] sorted in increasing order
if n>1
   copy A[0.. n/2 -1] to B[0..n/2 -1]
   copy A[n/2.. n-1] to C[0.. n/2 – 1]
   Mergesort(B[0 ..n/2 -1])
   Mergesort(C[0 .. n/2])
   Merge (B,C,A)
```

ALGORITHM *Merge*(B[0 ..v-1], C[0 ..m-1], A[0 ..v+m-1])

```
//Merges two sorted arrays into one sorted array
//Input: Arrays B[0..v -1] and C[0.. m-1] both sorted
//Output: Sorted array A[0..v+m-1]
i ← 0; j ← 0; k← 0
while i < v and j < m do
    if B[i]<=C[j]
        A[k] ← B[i]; i← i+1
    else A[k] ← C[j]; j← j+1
    k ← k+1
if i = v
    copy C[j..m-1] to A[k ..v+m-1]
else copy B[i..p-1] to A[k .. v+m-1]
```

C code:

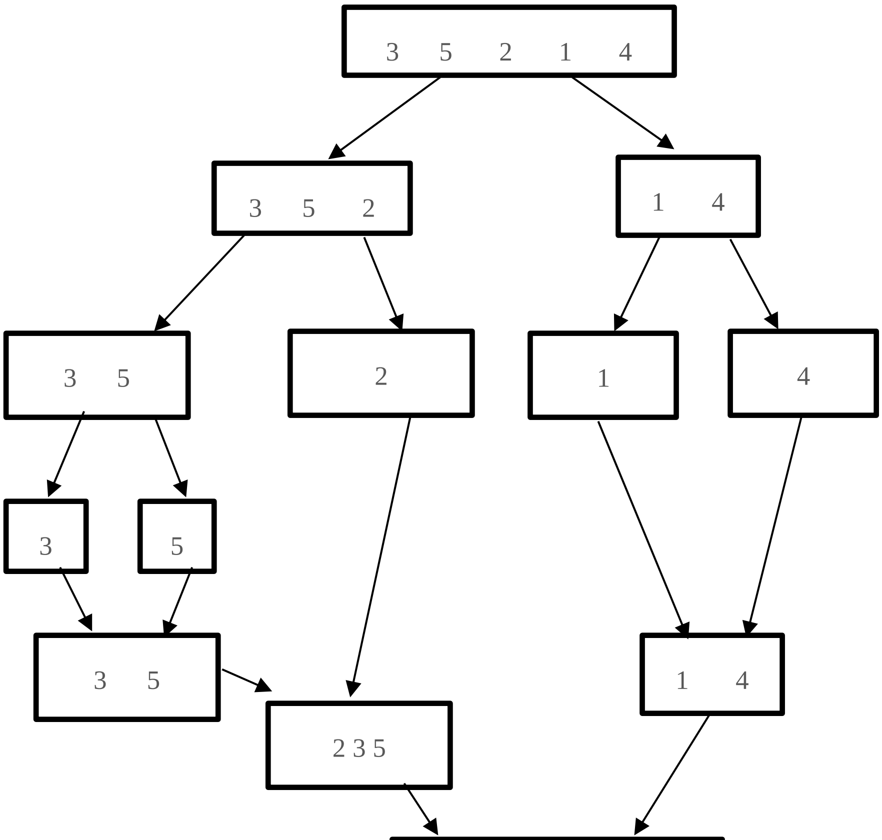
```
#include<conio.h>
#include<stdio.h>
#include<stdlib.h>
#include<time.h>
int main()
{
        int i,low,high,n;
        int A[10];
        clock_t begin,end;
        double time_required;
        void MergeSort(int A[10],int low,int high);
        void Display(int A[10],int n);
        clrscr();
        printf("\n\n Sorting using merge sort\n");
        printf("\n How many elements are there?\n");
        scanf("%d",&n);
        printf("\n Enter the elements:\n");
        for(i=0;i<n;i++)
                scanf("%d",&A[i]);
```

```
	low=0;
	high=n-1;
	begin=clock();
	MergeSort(A,low,high);
	end=clock();
	Display(A,n);
	time_required=1.0*((double)(end-begin))/CLOCKS_PER_SEC;
	printf("\n The time required is:%2f",time_required);
	getch();
	return 0;
}
void MergeSort(int A[10],int low,int high)
{
	int mid;
	void combine(int A[10],int low,int mid,int high);
	if(low<high)
	{
		mid=(low+high)/2;
		MergeSort(A,low,mid);
		MergeSort(A,mid+1,high);
		combine(A,low,mid,high);
	}
}
void combine(int A[10],int low,int mid,int high)
{
	int i,j,k;
	int temp[10];
	k=low;
	i=low;
	j=mid+1;
	while(i<=mid&&j<=high)
	{
		if(A[i]<=A[j])
		{
			temp[k]=A[i];
			k++;
			i++;
		}
		else
		{
			temp[k]=A[j];
			k++;
			j++;
		}
	}
	while(i<=mid)
	{
		temp[k]=A[i];
		k++;
		i++;
	}
	while(j<=high)
	{
		temp[k]=A[j];
```

```
                k++;
                j++;
        }
        for(k=low;k<=high;k++)
                A[k]=temp[k];
}
void Display(int A[10],int n)
{
        int i;
        printf("\n\n the sorted list is....\n");
        for(i=0;i<n;i++)
                printf("%d\t",A[i]);
}
```

OUTPUT:

Sorting using merge sort
How many elements are there?
5
Enter the elements:
3 5 2 1 4
The sorted list is ….
1 2 3 4 5
The time required is : 0.000000



3 Write a program to obtain the topological ordering of vertices in a given digraph.

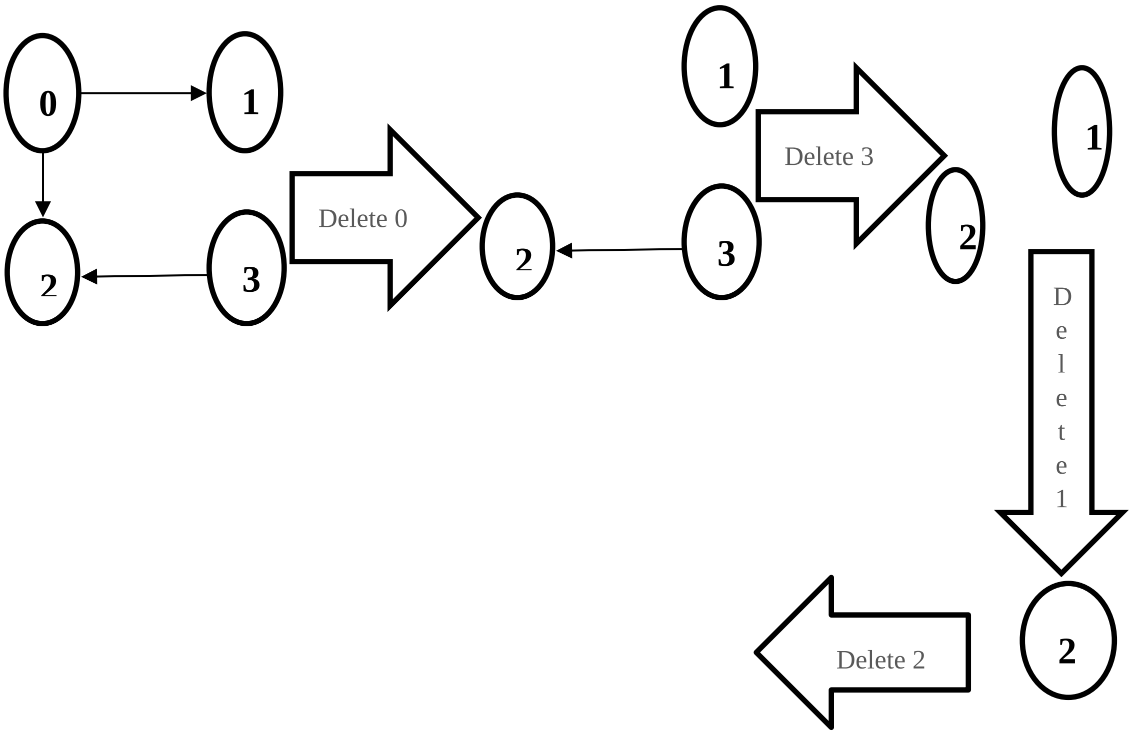
ALGORITHM Topological Sort
Step1: From a given graph find a vertex with no incoming edges.
Step2: Delete it along with all the edges outgoing from it.
Step3: Note the vertices that are deleted.
Step4: Print all these recorded vertices in the order they are deleted. This gives topologically sorted list.

```
#include<stdio.h>
#include<conio.h>
#define TRUE 1
#define FALSE 0
int main()
{
        int i,j,k;
        int n,a[10][10],in[10],visit[10];
        int count=0;
        clrscr();
        printf("\n\nTopological sorting");
        n=4;
        for(i=0;i<n;i++)
        {
                for(j=0;j<n;j++)
                {
                        a[i][j]=0;
                }
        }
        printf("\n Graph is created as follows:");
        printf("\n The node '0'and '1' are connected");
        a[0][1]=1;
        printf("\n The node '0' and '2' are connected");
        a[0][2]=1;
        printf("\n The node '3' and '2' are connected");
        a[3][2]=1;
        for(i=0;i<n;i++)
        {
                in[i]=0;
                visit[i]=FALSE;
        }
        for(i=0;i<n;i++)
                for(j=0;j<n;j++)
                        in[i]=in[i]+a[j][i];
        printf("\n\n The topological order is:");
        while(count<n)
        {
                   for(k=0;k<n;k++)
                   {
                        if((in [k]==0)&&(visit [k]==0))
```

```
                    {
                            printf("%d",k);
                            visit[k]=TRUE;
                    }
                    for(i=0;i<n;i++)
                    {
                            if(a[i][k]==1)
                                    in[k]--;
                    }
                }
            count++;
        }
        getch();
        return 0;
    }
```

OUTPUT:

Topological sorting
Graph is created as follows:
The node ‘0’ and ‘1’ are connected
The node ‘0’ and ‘2’ are connected
The node ‘3’ and ‘2’ are connected
The topological order is : 0312



4 Implement travelling salesman problem.

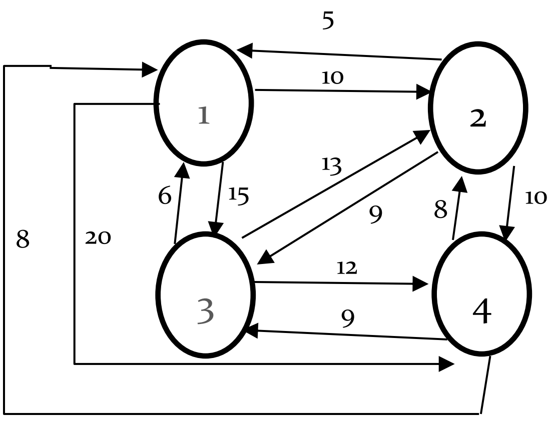
ALGORITHM Travelling Salesman
Step1: Generate a set of all the tours starting from and ending at city ‘1’.
Step2: Calculate length of all the tours generated in step1.
Step3: Select the minimum length tour as the optimal solution.
If more than one such tours exist, break the tie randomly.

```
#include<stdio.h>
#include<conio.h>
#define MAX 10
typedef struct
{
	int nodes[MAX];
	int vertex;
	int min;
}path_node;
path_node TSP(int source,path_node list,int Element[] [MAX],int max_no_cities)
{
	int i,j;
	path_node new_list,new_path,new_min;
	if(list.vertex==0)
	{
		new_min.min=Element[source][1];
		new_min.nodes[max_no_cities-1]=source;
		new_min.vertex=max_no_cities;
		return new_min;
	}
	for(i=0;i<list.vertex;i++)
	{
		new_list.vertex=0;
		for(j=0;j<list.vertex;j++)
			if(i!=j)
				new_list.nodes[new_list.vertex++]=list.nodes[j];
		new_path=TSP(list.nodes[i],new_list,Element,max_no_cities);
		new_path.min=Element[source][list.nodes[i]]+new_path.min;
		new_path.nodes[max_no_cities-list.vertex -1]=source;
		if(i==0)
			new_min=new_path;
		else if(new_path.min<new_min.min)
			new_min=new_path;
	}
	return new_min;
}
void display(path_node path)
{
	int i;
	printf("\n\n the minimum costis%d\n",path.min);
	printf("\n The path is.....\n");
	for(i=0;i<path.vertex;i++)
		printf("%d__",path.nodes[i]);
```

```
	printf("%d",path.nodes[0]);
}
main()
{
	int i,j,Element[MAX][MAX],max_no_cities;
	path_node graph,Path;
	clrscr();
	printf("\n How many numbers of cities are there?");
	scanf("%d",&max_no_cities);
	if(max_no_cities==0)
	{
		printf("error:There is no city for processing the TSP");
	}
	else
	{
		for(i=1;i<=max_no_cities;i++)
		{
			for(j=1;j<=max_no_cities;j++)
				if(i==j)
					Element[i][i]=0;
				else
				{
					printf("enter distance from city %d to %d?",i,j);
					scanf("%d",&Element[i][j]);
				}
			if(i>1)
				graph.nodes[i-2]=i;
		}
		graph.vertex=max_no_cities-1;
		Path=TSP(1,graph,Element,max_no_cities);
		display(Path);
	}
	getch();
	return 1;
}
```

OUTPUT:

How many number of cities are there? 4
enter the distance from city 1 to 2? 10
enter the distance from city 1 to 3? 15
enter the distance from city 1 to 4? 20
enter the distance from city 2 to 1? 5
enter the distance from city 2 to 3? 9
enter the distance from city 2 to 4? 10
enter the distance from city 3 to 1? 6
enter the distance from city 3 to 2? 13
enter the distance from city 3 to 4? 12
enter the distance from city 4 to 1? 8
enter the distance from city 4 to 2? 8
enter the distance from city 4 to 3? 9
the minimum cost is 35
The path is …..
1_2_4_3_1



TOUR	LENGTH
1→2→3→4→1	l = 10+9+12+8 = 39
1→3→2→4→1	l = 15+13+10+8 = 46
1→4→2→3→1	l = 20+8+9+6 = 43
1→4→3→2→1	l = 20+9+13+5 = 47
1→2→4→3→1	l = 10+10+9+6 = 35 optimal
1→3→4→2→1	l = 15+12+8+5 = 40

5 Implement the knapsack problem (0/1).

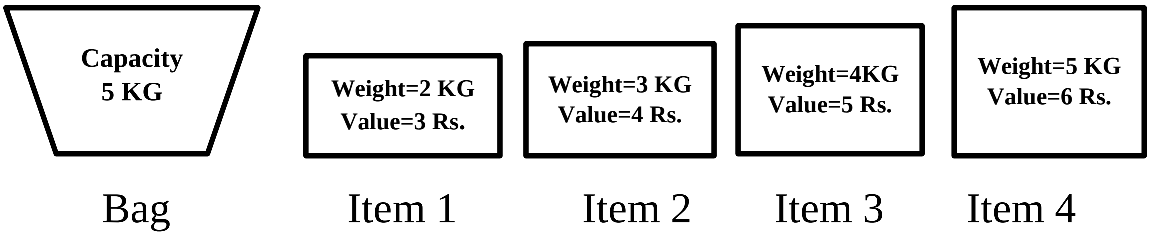
ALGORITHM Knapsack
Step1: Generate all the combinations of given items in a subset.
Step2: Calculate total weight of all the subsets generated in step1.
Step3: Eliminate the subsets whose total weight exceeds the capacity of knapsack.
Step4: Calculate total value of items in each subset that is remaining.
Step5: Select the subset which has highest total value as the feasible solution.
If there are more than one such subsets, break the tie randomly.

```
#include<stdio.h>
#include<conio.h>
#include<stdlib.h>
int table[5][6];

void main()
{
  int w[ ]={0,2,3,4,5};
  int v[ ]={0,3,4,5,6};
  int W=5;
  int n=4;
  int i,j;
  void DKP(int n, int W, int w[], int v[]);
  clrscr();
  printf("\n\t\t 0/1 Knapsack Problem");
  for (i=0;i<=n;i++)
  {
        for (j=0;j<=W;j++)
        {
                table[i][j]=0;
        }
  }
  DKP(n,W,w,v);
  getch();
}

void DKP(int n, int W,int w[5], int v[5])
{
  void find_item(int ,int, int[]);
  int i,j;
  int val1,val2;
  for(i=0;i<=n;i++)
  {
    for(j=0;j<=W;j++)
    {
      table[i][0]=0;
      table[0][j]=0;
    }
  }
  for(i=1;i<=n;i++)
  {
   for(j=1;j<=W;j++)
```

```
    {
     if(j<w[i])
          table[i][j]=table[i-1][j];
     else if (j>=w[i])
     {
           val1=table[i-1][j];
           val2=v[i]+table[i-1][j-w[i]];
           table[i][j]=(val1>val2?val1:val2);
    }
   }
  }
  printf("\n Table constructed \n");
  for (i=0;i<=n;i++)
  {
    for(j=0;j<=W;j++)
         printf("%d  ",table[i][j]);
    printf("\n");
  }
find_item(n,W,w);
}
void find_item(int i,int k,int w[5])
{
  printf("\nFor the Knapsack...");
  while(i>0 && k>0)
  {
    if (table[i][k]!=table[i-1][k])
    {
         printf("\nItem %d is selected",i);
         i=i-1;
         k=k-w[i];
    }
    else
         i=i-1;
  }
}
```

OUTPUT:

```
 0/1 Knapsack Problem
Table constructed
0 0 0 0 0 0
0 0 3 3 3 3
0 0 3 4 4 7
0 0 3 4 5 7
0 0 3 4 5 7
For the Knapsack…
Item 2 is selected
Item 1 is selected
```



Subset	Total weight	Total value
Null	**0**	**0**
{1}	**2**	**3**
{2}	**3**	**4**
{3}	**4**	**5**
{4}	**5**	**6**
{1,2}	**2+3=5**	**3+4=7 OPTIMAL**
{1,3}	2+4=6	3+5=8
{1,4}	2+5=7	3+6=9
{2,3}	3+4=7	4+5=9
{2,4}	3+5=8	4+6=10
{3,4}	4+5=9	5+6=11
{1,2,3}	2+3+4=9	3+4+5=12
{1,2,4}	2+3+5=10	3+4+6=13
{1,3,4}	2+4+5=11	3+5+6=14
{2,3,4}	3+4+5=12	4+5+6=15
{1,2,3,4}	2+3+4+5=14	3+4+5+6=18

CAPACITY OF BAG IS **5 KG**;

So in the subset of items less than or equal to 5 KG {1,2} has highest value. Hence we select item 1 and item 2.

6 Print all the nodes reachable from a given starting node in a digraph using BFS method.

ALGORITHM *BFS*(G)
// Implements a breadth first search traversal of a given graph
// Input: Graph G=<VERT,EDG>
//Output: Graph G with its verticies marked with consecutive integers in the order they are visited by the BFS traversal
mark each vertex VERT with 0 as a mark of being "not visited"
count← 0
for each vertex v in VERT do
  if v is marked with 0
    bfs(v)

bfs(v)
//visit all the unvisited vertices connected to vertex v by a path and numbers them in the order they are visited via global variable *count*
count← *count* +1; mark v with *count* and initialize a queue with v
while the queue is not empty do
  for each vertex w in VERT adjacent to the front vertex do
    if w is marked with 0
      count ← count +1; mark w with count
      add w to the queue
  remove the front vertex from the queue

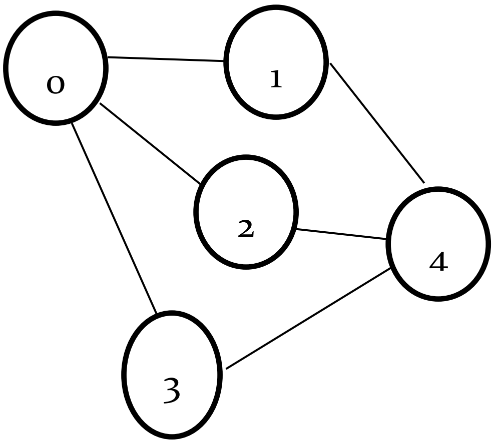
C code:

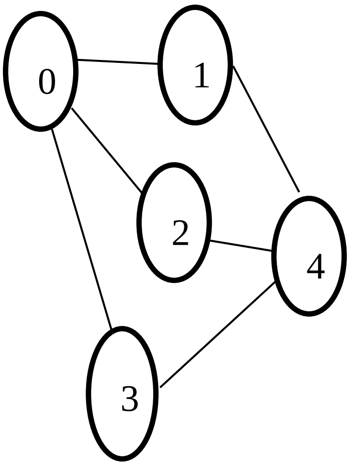
```
#include<stdio.h>
#include<conio.h>
#include<stdlib.h>
#define size 20
#define TRUE 1
#define FALSE 0
int g[size][size];
int visit[size];
int q[size];
int front,rear;
int n;
void main()
{
	int v1,v2;
	char ans;
	void create(),bfs(int v1);
	ans='y';
	clrscr();
	create();
	clrscr();
	printf("The adjacency matrix for the graph is\n");
	for(v1=0;v1<n;v1++)
	{
		for(v2=0;v2<n;v2++)
```

```
                printf("%d",g[v1][v2]);
            printf("\n");
        }
        getch();
        do
        {
            for(v1=0;v1<n;v1++)
                visit[v1]=FALSE;
            clrscr();
            printf("Entre the vertex from which you want to traverse:");
            scanf("%d",&v1);
            if(v1>=n)
                printf("invalid vertex\n");
            else
            {
                printf("The breath first search of the graph is\n");
                bfs(v1);
                getch();
            }
            printf("\n Do you want to traverse from any other node?");
            ans=getche();
        }while(ans=='y');
        exit(0);
}
void create()
{
        int v1,v2;
        char ans;
        ans='y';
        printf("\n This is a program to creat a graph");
        printf("\n The display is in breadth first manner");
        printf("\n Entre number of nodes: ");
        scanf("%d",&n);
        for(v1=0;v1<n;v1++)
            for(v2=0;v2<n;v2++)
                g[v1][v2]=FALSE;
        printf("\n Enter the vertices no starting from 0;");
        do
        {
            printf("\n Enter the vertices v1 and v2:");
            scanf("%d%d",&v1,&v2);
            if(v1>=n||v2>=n)
                printf("invalid vertex value\n");
            else
            {
                g[v1][v2]=TRUE;
                g[v2][v1]=TRUE;
            }
        printf("\n\n Add more edges??(y/n)");
        ans=getche();
        }while(ans=='y');
}
void bfs(int v1)
{
```

```
        int v2;
        visit[v1]=TRUE;
        front=rear=-1;
        q[++rear]=v1;
        while(front!=rear)
        {
                v1=q[++front];
                printf("%d\n",v1);
                for(v2=0;v2<n;v2++)
                {
                        if(g[v1][v2]=TRUE&&visit[v2]==FALSE)
                        {
                                q[++rear]=v2;
                                visit[v2]=TRUE;
                        }
                }
}
```

OUTPUT:
This is a program to create a graph
The display is in breadth first manner
Enter no of nodes: 5
Enter the vertices no starting from 0:
Enter the vertices v1 and v2: 0 1
Add more edges??(y/n) y
Enter the vertices v1 and v2 : 0 2
Add more edges??(y/n) y
Enter the vertices v1 and v2 : 0 3
Add more edges??(y/n) y
Enter the vertices v1 and v2 : 1 4
Add more edges??(y/n) y
Enter the vertices v1 and v2 : 2 4
Add more edges??(y/n) y
Enter the vertices v1 and v2 : 3 4
Add more edges??(y/n) n
The adjacency matrix for the graph is
01110
10001
10001
10001
01110
Enter the vertex from which you want to traverse: 0
The breadth first search of the graph is
0
1
2
3
4

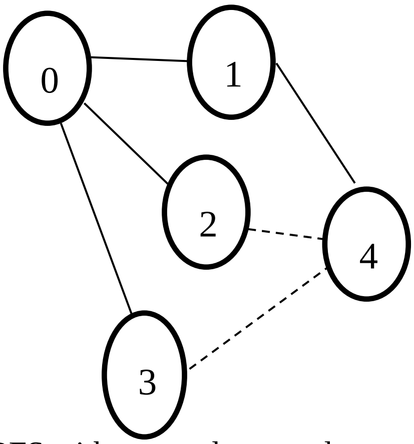




Graph

$0_1\ 1_2\ 2_3\ 3_4\ 4_5$

Traversal Sequence



BFS with tree and cross edges
Shown in solid and dotted line

7 Check whether a given graph is connected or not using DFS method.

ALGORITHM *DFS*(G)
//Implements a depth first search traversal of a given graph
// Input: Graph G = <VERT, EDG>
// Output: Graph G with its vertices marked with consecutive integers in the order they are first encountered by the DFS traversal
mark each vertex in VERT with 0 as a mark of being "not visited"
count ← 0
for each vertex v in VERT do
  if v is markded with 0
    dfs(v)

dfs(v)
//vistis recursively all the unvited vertices connected to vertex v by a path and numbers them in the order they are encountered via a global variable *count*
count ← *count* +1; mark v with *count*
for each vertex w in VERT adjacent to v do
  if w is marked with 0
    dfs(w)

C code:

```
#include        <stdio.h>
#include        <conio.h>
int dfs ( int source );
int ab = 0, i, j, n, m, a[10][10], vis[10],source, num = 1;
void main( )
{
        clrscr();
        printf ( "\nEnter the Number of Vertices: " );
        scanf ( "%d", &n );
        printf ( "\nEnter the Adjacency Matrix\n" );
        for ( i = 1; i <= n; i ++)
                for ( j = 1; j <= n; j ++ )
                        scanf("%d",&a[i][j]);
        printf ( "\nEnter the Starting Vertex: " );
        scanf ( "%d", &source );
        for ( i = 1; i <= n; i ++)
                vis[i] = 1;
        dfs ( source );
        if ( ab == ( n - 1 ) )
                printf ( "Connected Graph\n" );
        else
                printf ( "Unconnected Graph\n" );
        getch();
```

```
}

int dfs ( int source )
{
        vis[source] = 1;
        for ( i = 1; i <= n; i ++)
                if ( a[source][i] && vis[i] == 0 )
                {
                        ab ++;
                        dfs ( i );
                }
        return 0;
}
```

OUTPUT 1:

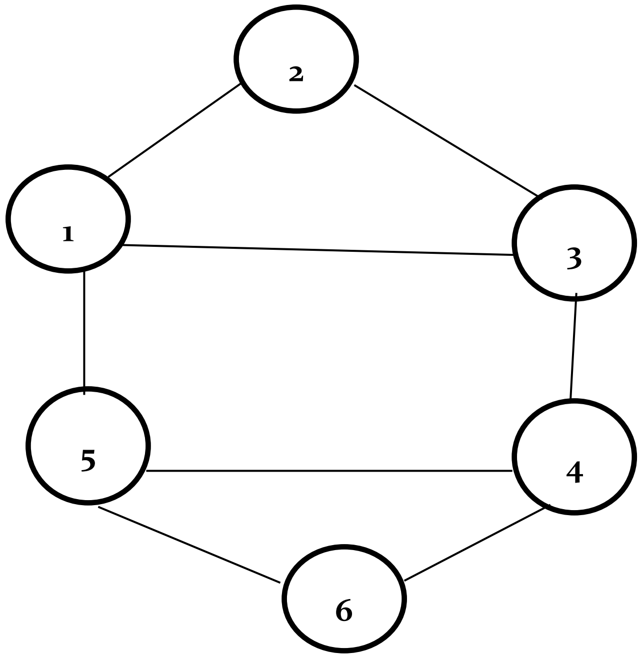
Enter the Number of Vertices:6

Enter the Adjacency Matrix

0 1 1 0 1 0
1 0 1 0 0 0
1 1 0 1 0 0
0 0 1 0 1 1
1 0 0 1 0 1
0 0 0 1 1 0

Enter the Starting Vertex:1

Connected Graph



OUTPUT 2:

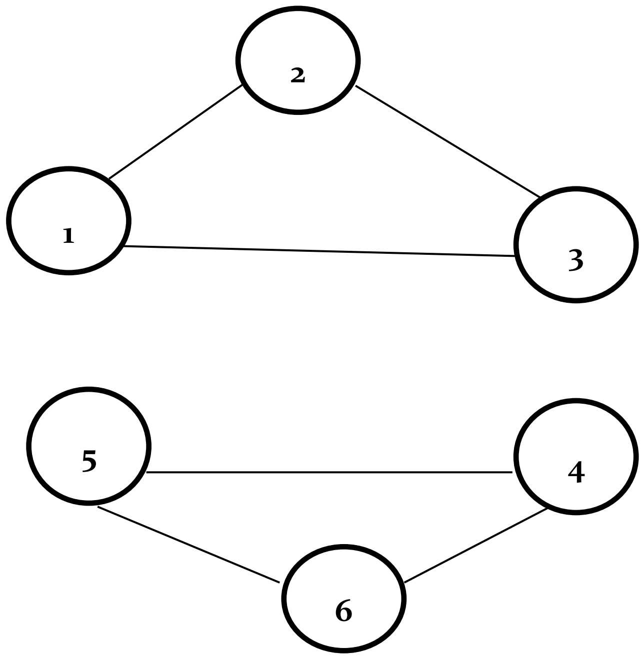
Enter the Number of Vertices:6

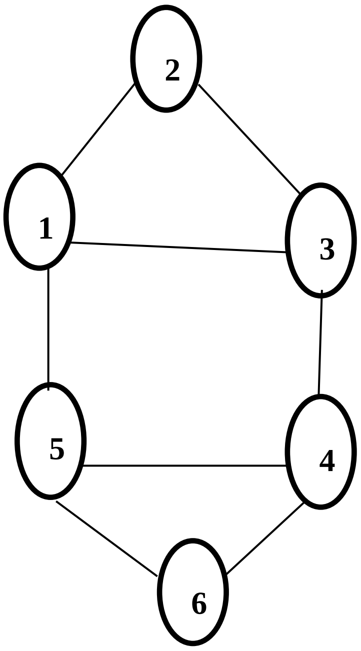
Enter the Adjacency Matrix

0 1 1 0 0 0
1 0 1 0 0 0
1 1 0 0 0 0
0 0 0 0 1 1
0 0 0 1 0 1
0 0 0 1 1 0

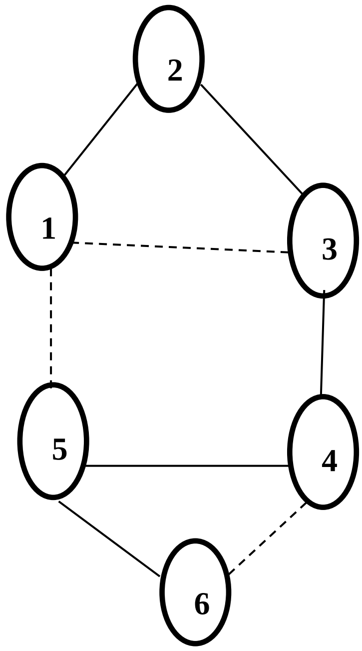
Enter the Starting Vertex:1

Unconnected Graph

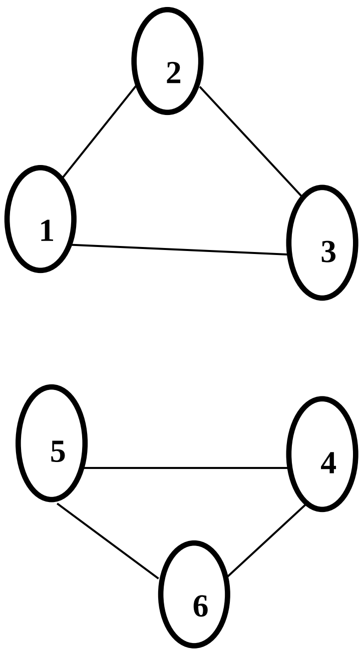




$1_1\ 2_2\ 3_3\ 4_4\ 5_5\ 6_6$

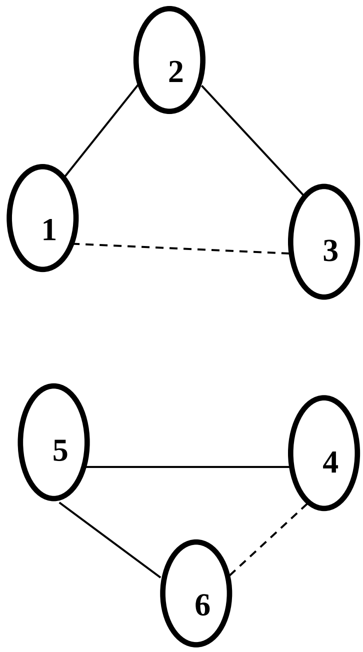


Graph | Traversal Sequence | DFS with tree and back edges shown in solid and dotted lines respectively



$1_1\ 2_2\ 3_3$

$4_1\ 5_2\ 6_3$



Graph | Traversal Sequence | DFS forest with tree and back edges Shown in solid and dotted lines respectively

8 Write a program to implement binary search using divide and conquer technique

ALGORTIHM *BinSearch*(A[0 .. n-1], KEY)
// Implements nonrecursive binay search
// Input: An array A[0 ..n-1] sorted in ascending order and a search key KEY
// Output: An index of the array's element that is equal to KEY or -1 if there is no such element
left ← 0; right ← n-1
while left <= right do
   middle ← (left + right) /2
   if KEY =A[middle] return middle
   else if KEY < A [middle] right ← middle -1
   else left ← middle +1
return -1

C Code:

```
#include <stdio.h>
#include <conio.h>
#define SIZE 10
int n;
void main()
{
	int A[SIZE],KEY,i,flag;
	int BinSearch(int A[SIZE],int KEY);
	clrscr();
	printf("\nHow many elements in an array?");
	scanf("%d",&n);
	printf("\nEnter the elements");
	for (i=0;i<n;i++)
		scanf("%d",&A[i]);
	printf("Enter the element which is to be searched:");
	scanf("%d",&KEY);
	flag=BinSearch(A,KEY);
	if (flag==-1)
		printf("\nThe Element is not present");
	else
		printf("\nThe element is at A[%d] location",flag);
	getch();
}
int BinSearch(int A[SIZE],int KEY)
{
	int low,high,m;
	low=0;
	high=n-1;
	while(low<=high)
	{
		m=(low+high)/2;
		if(KEY==A[m])
			return m;
		else if (KEY<A[m])
```

```
                    high=m-1;
            else
                    low=m+1;
        }
        return -1;
}
```

OUTPUT:
Case 1:
How many elements in an array? 13
Enter the elements
3 14 27 31 39 42 55 70 74 81 85 93 98
Enter the element which is to be searched: 70
The element is at A[7] location

Case 2:
How many elements in an array? 5
Enter the elements
10 20 30 40 50
Enter the element which is to be searched: 80
The element is not present

$$\underbrace{A[0]\dots A[m-1]}_{\substack{\text{search here if}\\ K<A[m]}} \quad \overset{\overset{K}{\updownarrow}}{A[m]} \quad \underbrace{A[m+1]\dots A[n-1]}_{\substack{\text{search here if}\\ K>A[m]}}.$$

As an example, let us apply binary search to searching for $K = 70$ in the array

3	14	27	31	39	42	55	70	74	81	85	93	98

The iterations of the algorithm are given in the following table:

index	0	1	2	3	4	5	6	7	8	9	10	11	12
value	3	14	27	31	39	42	55	70	74	81	85	93	98
iteration 1	*l*						*m*						*r*
iteration 2								*l*		*m*			*r*
iteration 3								*l,m*	*r*				

9 Write a program to implement insertion sort using decrease and conquer technique

ALGORITHM *InsertionSort*(A[0..n-1])

```
//Sorts a given array by insertion sort
//Input: An array A[0..n-1] of n orderable elements
//Output: Array A[0..n-1] sorted in increasing order
For i←1 to n-1 do
    v←A[i]
    j←i-1
    while j>=0 and A[j]> v do
            A[j+1] ← A[j]
            j ← j-1
   A[j+1] ← v
```

C code:

```
#include <stdio.h>
#include <conio.h>
void main()
{
        int A[10],n,i;
        void Insert_sort(int A[10],int n);
        clrscr();
        printf ("\nInsertion Sort");
        printf("\nHow many elements are there?");
        scanf("%d",&n);
        printf("\nEnter the elements\n");
        for (i=0;i<n;i++)
                scanf("%d",&A[i]);
        Insert_sort(A,n);
        getch();
}
void Insert_sort(int A[10],int n)
{
        int i,j,temp;
        for(i=1;i<=n-1;i++)
        {
                temp=A[i];
                j=i-1;
                while((j>=0)&&(A[j]>temp))
                {
                        A[j+1]=A[j];
                        j=j-1;
                }
                A[j+1]=temp;
        }
        printf("\nThe sorted list of elements is \n");
        for (i=0;i<n;i++)
                printf("\n%d",A[i]);
}
```

OUTPUT:
Insertion Sort
How many elements are there? 5
Enter the elements
30 20 10 40 50
The sorted list of elements is
10
20
30
40
50

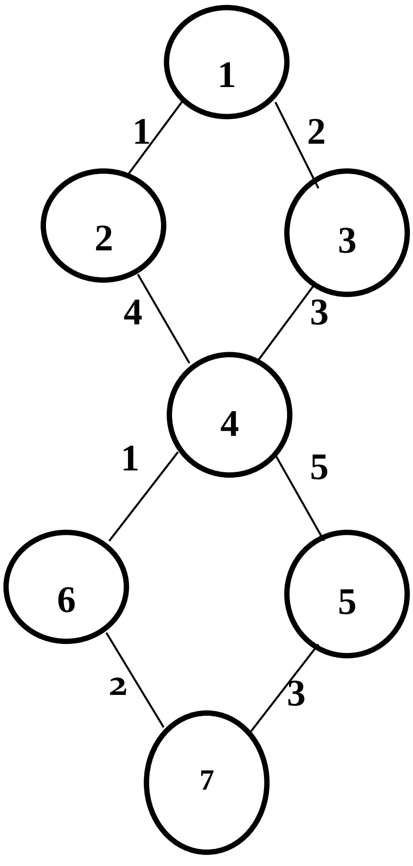
A [0] < = … < = A [j] < A[j+1] <= … <= A[i-1] | A[i] … A[n-1]
Smaller than or equal to A[i] greater than A[i]

Fig: Iteration of insertion sort:
A[i] is inserted in its proper position among the preceding elements previously sorted

30 | **20** 10 40 50
20 30 | **10** 40 50
10 20 30 | **40** 50
10 20 30 40 | **50**
10 20 30 40 50

10 Find minimum cost spanning tree of a given undirected path using a Prim's algorithm.

ALGORITHM *Prim*(G)
//Prim's algorithm for constructing a minimum cost spanning tree
//Input: A weighted connected graph G=<V,E>
//Output: E_T, the set of edges composing a minimum spannig tree of G
$V_T \leftarrow \{v_0\}$ // the set of tree vertices can be initialized with any vertex
$E_T \leftarrow$ NULL
for i$\leftarrow$ 1 to |V|-1 do
    find a minimum weight edge e*=(v*,u*) among all the edges (v,u)
    such that v is in V_T and u is in V - V_T
    $V_T \leftarrow V_T$ U {u*}
    $E_T \leftarrow E_T$ U {e*}
return E_T



GRAPH:

C code:

```
#include<stdio.h>
int s[10], min, ne=1, minCost=0, cost[10][10];
int i, j, a, b, u, v, n;
void main()
{
        clrscr();
        printf("Enter The Number of Vertices: ");
        scanf("%d",&n);
        printf("Enter Cost Adjacency Matrix:\n");
        for(i=1;i<=n;i++)
                for(j=1;j<=n;j++)
                {
                        scanf("%d",&cost[i][j]);
                                if(cost[i][j]==0)
                                        cost[i][j]=999;
                }
        for(i=2;i<=n;i++)
                s[i]=0;
        s[1]=1;
        while(ne<=n)
        {
                for(i=1,min=999;i<=n;i++)
                        for(j=1;j<=n;j++)
                        if(cost[i][j]<min)
                                if(s[i]==0)continue;
                        else
                        {
                                min=cost[i][j];
                                a=u=i;
                                b=v=j;
                        }
```

```
                if(s[u]==0 || s[v]==0)
                {
                        printf("\nEdge[%d %d] : %d",a,b,min);
                        minCost+=min;
                        s[b]=1;
                }
                ne++;
                cost[a][b]=cost[b][a]=999;
        }
        printf("\nMin Cost: %d",minCost);
getch();
}
```

OUTPUT:

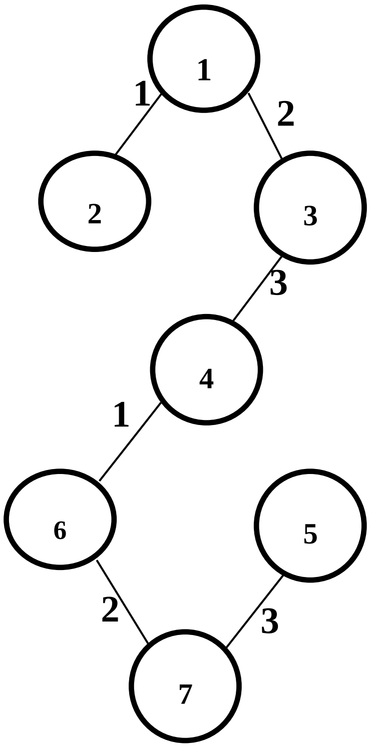
Enter Number of Vertices:7
Enter the Cost Adjacency Matrix :

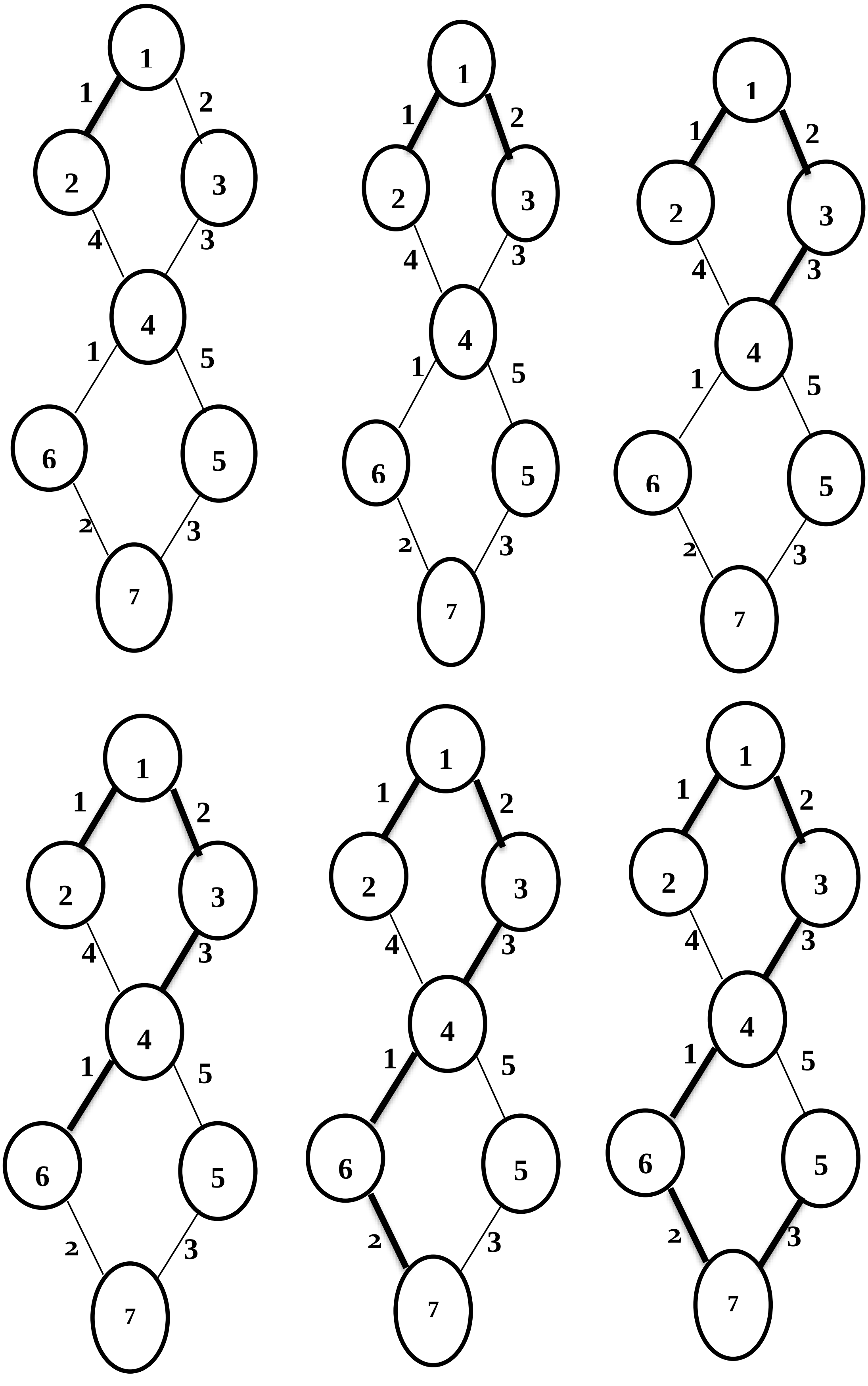
0	1	2	0	0	0	0
1	0	0	4	0	0	0
2	0	0	3	0	0	0
0	4	3	0	5	1	0
0	0	0	5	0	0	3
0	0	0	1	0	0	2
0	0	0	0	3	2	0

Edge(1 2) : 1
Edge(1 3) : 2
Edge(3 4) : 3
Edge(4 6) : 1
Edge(6 7) : 2
Edge(7 5) : 3

Min Cost: 12

Minimum Cost
Spanning Tree:





11 From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.

ALGORITHM *Dijkstra*(G,s)
//Dijkstra's algorithm for single source shortest paths
//Input: A weighted connected graph G = <V,E> with nonnegative weights and its vertex s
//Output: The length d_v of a shortest path from s to v and its penultimate vertex p_v for every vertex v in V
Initialize(Q) // initialize vertex priority queue to empty
For every vertex v in V
  d_v ← infinite; p_v ← null
  Insert (Q,v,d_v) // Initialize vertex priority in the priority queue
D_s ← 0; Decrease(Q,s,d_s) // update priority of s with d_s
V_T ← null
for i← 0 to |V|-1 do
  u* ← DeleteMin(Q) // delete the minimum priority element
  V_T ← V_T U {u*}
  for every vertex u in V – V_T that is adjacent to u* do
    if d_{u*}+w(u*,u); p_u ← u*
      Decrease (Q,u,d_u)

C code:

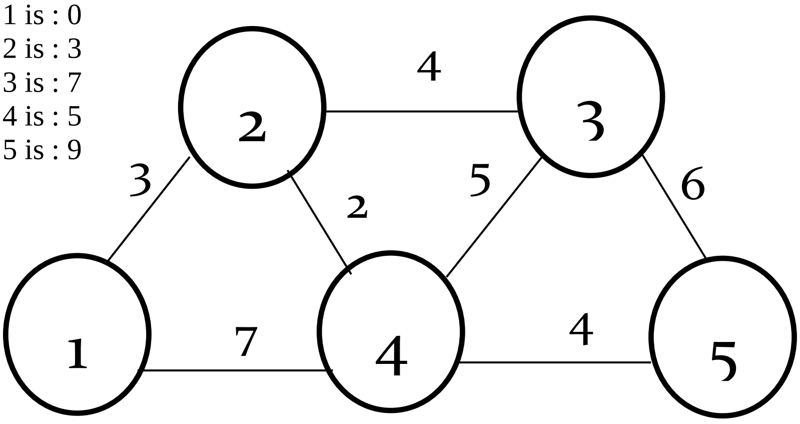
```
#include	<stdio.h>
#include	<conio.h>
int d[20], a[10][10], n;
void dijk(int ,int []);
void main()
{
	int i, j, s;
	clrscr();
	printf("Enter the Number of Vertices: ");
	scanf("%d",&n);
	printf("Enter Cost Adjacent Matrix:\n");
	for(i=1;i<=n;i++)
		for(j=1;j<=n;j++)
			scanf("%d",&a[i][j]);
	printf("Enter the Starting Vertex: ");
	scanf("%d",&s);
	dijk(s,d);
	for(i=1;i<=n;i++)
		printf("The Shortest path from %d to %d is: %d\n",s,i,d[i]);
	getch();
}

void dijk(int v, int d[20])
{
	int i, j, min, s[20], u, w;
	for(i=1;i<=n;i++)
```

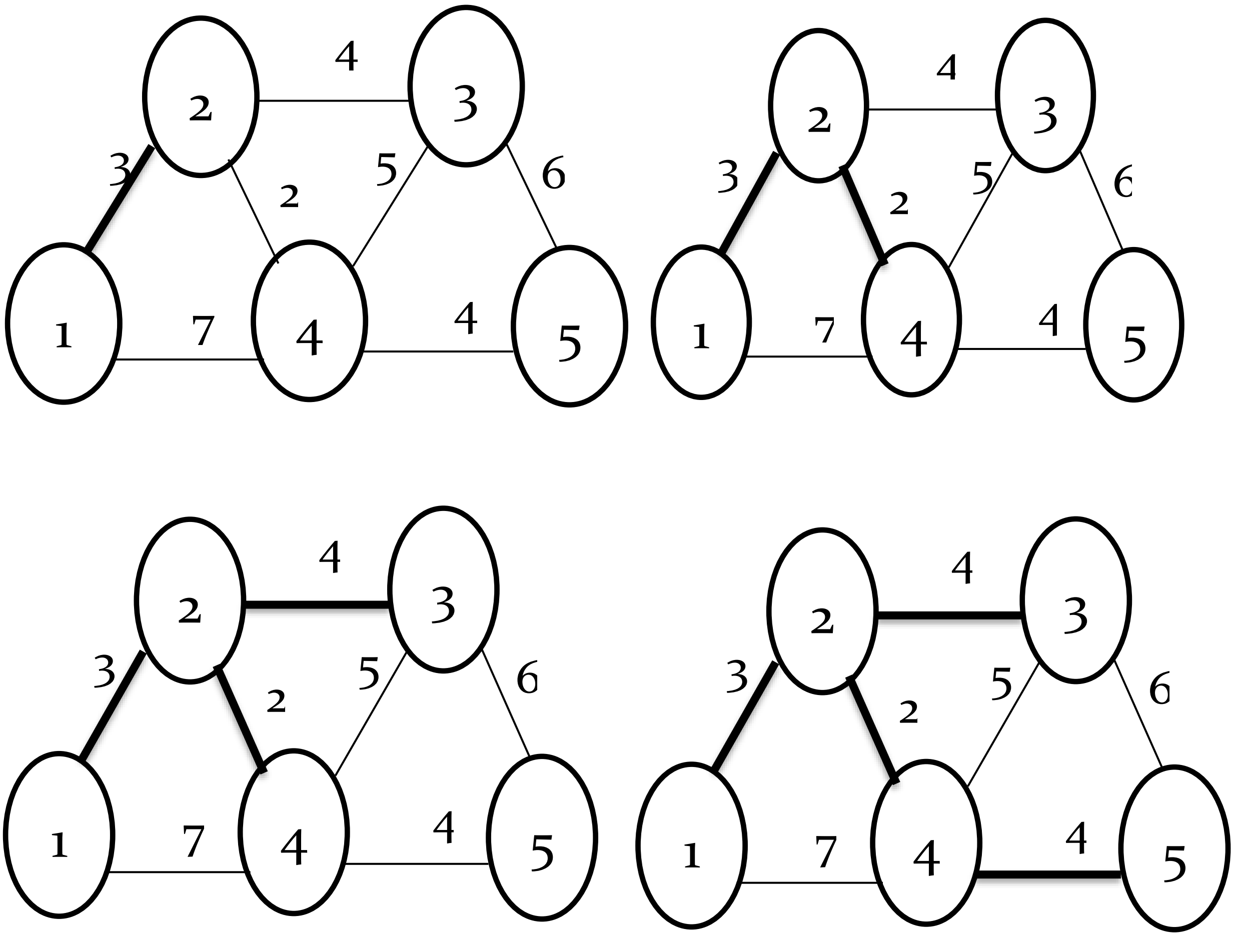
```
    {
        s[i]=0;
        d[i]=a[v][i];
    }
    s[v]=1;
    d[v]=0;
    for(j=2;j<=n;j++)
    {
        min=9999;
        for(i=1;i<=n;i++)
        {
            if(!s[i])
            {
                if(d[i]<min)
                {
                    min=d[i];
                    u=i;
                }
            }
        }
        s[u]=1;
        for(w=1;w<=n;w++)
        {
            if((a[u][w]!=9999) && (s[w]==0))
            {
                if(d[w]>(d[u]+a[u][w]))
                    d[w]=d[u]+a[u][w];
            }
        }
    }
}
```

Output:-
Enter the Number of Vertices: 5
Enter Cost Adjacent Matrix:

9999	3	9999	7	9999
3	9999	4	2	9999
9999	4	9999	5	6
7	2	5	9999	4
9999	9999	6	4	9999

Enter the Starting Vertex : 1
The Shortest path from 1 to 1 is : 0
The Shortest path from 1 to 2 is : 3
The Shortest path from 1 to 3 is : 7
The Shortest path from 1 to 4 is : 5
The Shortest path from 1 to 5 is : 9





2 4 3
3 2 5 6
1 7 4 4 5
2 4 3
3 2 5 6
1 7 4 4 5
2 4 3
3 2 5 6
1 7 4 4 5
2 4 3
3 2 5 6
1 7 4 4 5

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Vinayaka V M, Lecturer of Computer Science Department in RJS Polytechnic. Qualified with M.Tech., GATE and KSET. Work experience in Bapuji Institute of Engineering and Technology, Davanagere.