VISVESVARAYA TECHNOLOGICAL UNIVERSITY

“JnanaSangama”, Belgaum -590014, Karnataka.

LAB REPORT
on

Analysis and Design of Algorithms

Submitted by

DEEPINI S (1BM21CS050)

in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
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B. M. S. College of Engineering,

Bull Temple Road, Bangalore 560019

(Affiliated To Visvesvaraya Technological University, Belgaum)

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "**Analysis and Design of Algorithms**" carried out by **Deepini S (1BM21CS050),** who is a bonafide student of **B.M.S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the academic semester June-2023 to September-2023. The Lab report has been approved as it satisfies the academic requirements in respect of a **Analysis and Design of Algorithms (22CS4PCADA)** work prescribed for the said degree.

Radhika A D
Assistant Professor
Department of CSE
BMSCE, Bengaluru

Dr. Jyothi S Nayak
Professor and Head
Department of CSE
BMSCE, Bengaluru

Index Sheet

Course Outcome

CO1	Analyze time complexity of Recursive and Non-recursive algorithms using asymptotic notations.
CO2	Apply various design techniques for the given problem.
CO3	Apply the knowledge of complexity classes P, NP, and NP-Complete and prove certain problems are NP-Complete
CO4	Design efficient algorithms and conduct practical experiments to solve problems.

WEEK 1

Write program to do the following:

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

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

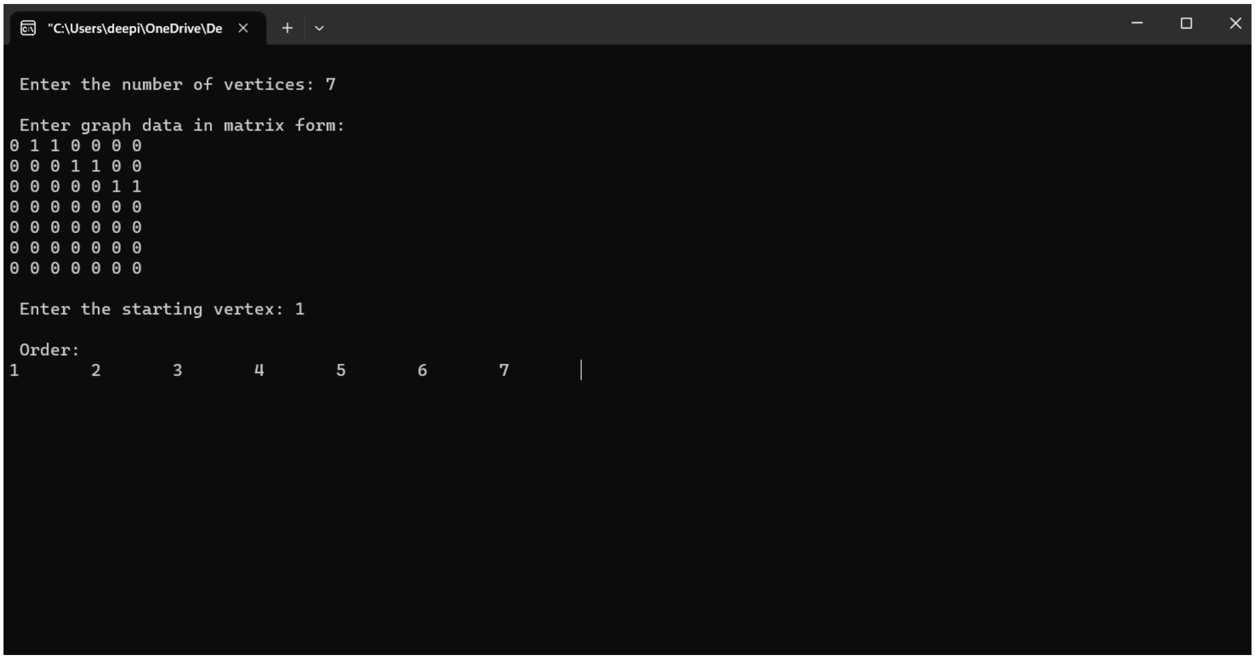
BFS

CODE:

```
 #include<stdio.h>

 #include<math.h>

int a[20][20],q[20],visited[20],n,i,j,f=0,r=-1;

void bfs(int v)

{

for(i=1;i<=n;i++)

if(a[v][i] && !visited[i])

q[++r]=i;

if(f<=r)

{

visited[q[f]]=1;
bfs(q[f++]);
}
}
void main()
{
int v;
printf("\n Enter the number of vertices:");
 scanf("%d",&n);
for(i=1;i<=n;i++)
{
q[i]=0;
visited[i]=0;
}
printf("\n Enter graph data in matrix form:\n");
for(i=1;i<=n;i++)
for(j=1;j<=n;j++)
scanf("%d",&a[i][j]);
printf("\n Enter the starting vertex:");
 scanf("%d",&v);
bfs(v);
printf("\n Order:\n");
 printf("%d\t",v);
```

```
for(i=0;i<=n;i++)

if(visited[i])

  printf("%d\t",i);

}
```

OUTPUT :

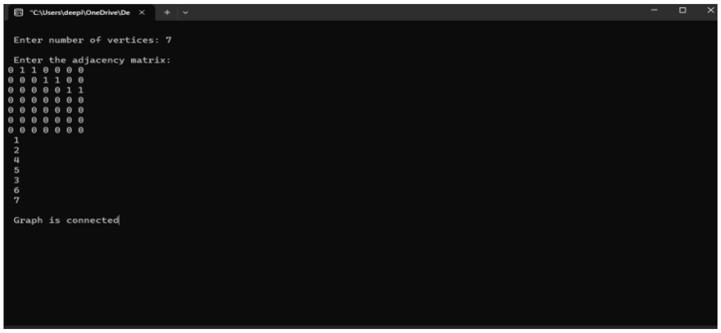


```
 Enter the number of vertices: 7

 Enter graph data in matrix form:
0 1 1 0 0 0 0
0 0 0 1 1 0 0
0 0 0 0 0 1 1
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

 Enter the starting vertex: 1

 Order:
1       2       3       4       5       6       7
```

DFS

```
#include<stdio.h>
int a[20][20],reach[20],n;
void dfs(int v)
{
        int i;
        reach[v]=1;
        for(i=1;i<=n;i++)
        if(a[v][i] && !reach[i])
        {
        printf("\n %d",i);
        dfs(i);
        }
}
void main()
{
        int i,j,v,count=0, f=1;
        printf("\n Enter number of vertices:");
        scanf("%d",&n);
        for(i=1;i<=n;i++)
        {
           reach[i]=0;
          for(j=1;j<=n;j++)
             a[i][j]=0;}
        printf("\n Enter the adjacency matrix:\n");
        for(i=1;i<=n;i++)
        for(j=1;j<=n;j++)
        scanf("%d",&a[i][j]);
        printf(" %d",f);
        dfs(1);
        for(i=1;i<=n;i++)
        {
           if(reach[i])
           count++;
        }
        if(count==n)
        printf("\n Graph is connected");
        else
        printf("\n Graph is not connected");
}
```

OUTPUT :



```
 Enter number of vertices: 7

 Enter the adjacency matrix:
0 1 1 0 0 0 0
0 0 0 1 1 0 0
0 0 0 0 0 1 1
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
 1
 2
 4
 5
 3
 6
 7

 Graph is connected
```

WEEK 2

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

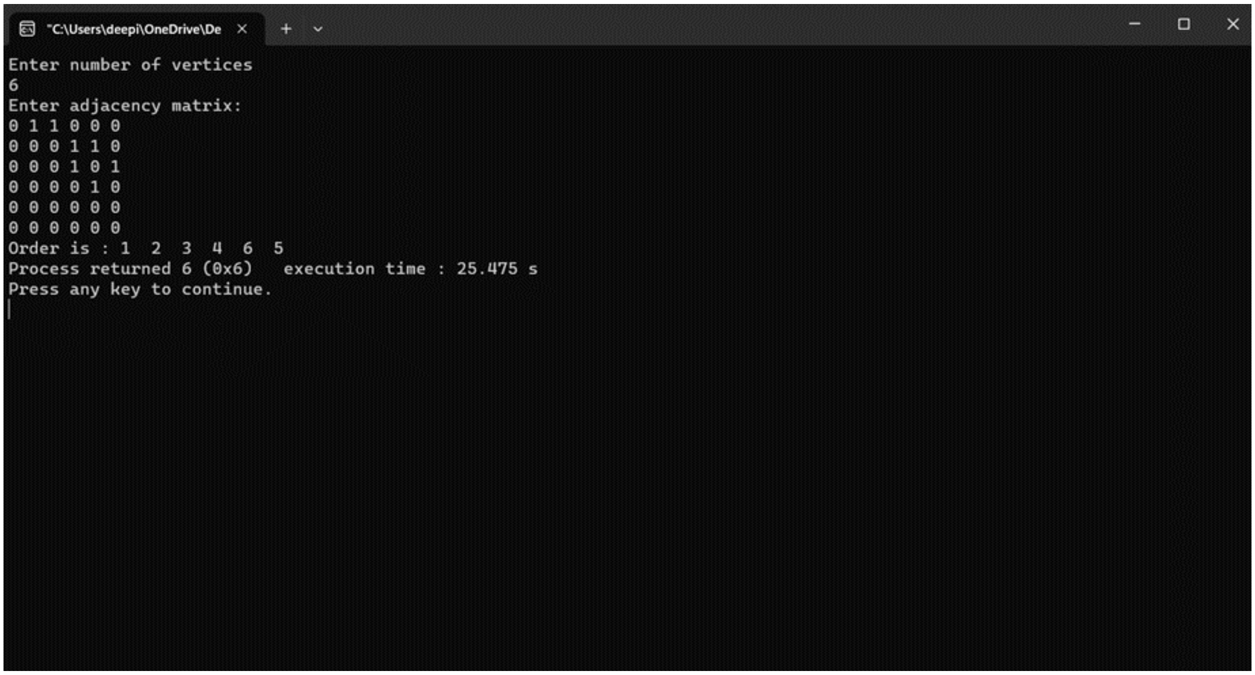
CODE:

```
#include<stdio.h>

 #include<conio.h>

void main()

{

int a[10][10],n,i,j;

int indeg[10],flag[10],c=0;

printf("Enter number of vertices \n");

scanf("%d",&n);

printf("Enter adjacency matrix: \n");

for(i=0;i<n;i++)

for(j=0;j<n;j++)

   scanf("%d",&a[i][j]);

for(i=0;i<n;i++)

   indeg[i]=0;

for(i=0;i<n;i++)
```

```
   flag[i]=0;
for(i=0;i<n;i++)
     for(j=0;j<n;j++)
         if(a[i][j]==1)
            indeg[j]+=1;
printf("Order is : ");
 while(c<=n)
{
for(i=0;i<n;i++)
{
if(indeg[i]==0 && flag[i]==0)
{
printf("%d ",i+1);
flag[i]=1;
}
}
for(i=0;i<n;i++)
{
if(flag[i]==1)
{
for(j=0;j<n;j++)
{
```

```
if(a[i][j]==1)
{
indeg[j]-=1;
a[i][j]=0;
}
c++;
}
}
```

OUTPUT :



```
Enter number of vertices
6
Enter adjacency matrix:
0 1 1 0 0 0
0 0 0 1 1 0
0 0 0 1 0 1
0 0 0 0 1 0
0 0 0 0 0 0
0 0 0 0 0 0
Order is : 1  2  3  4  6  5
Process returned 6 (0x6)   execution time : 25.475 s
Press any key to continue.
```

WEEK 3

Implement Johnson Trotter algorithm for permutations

CODE :

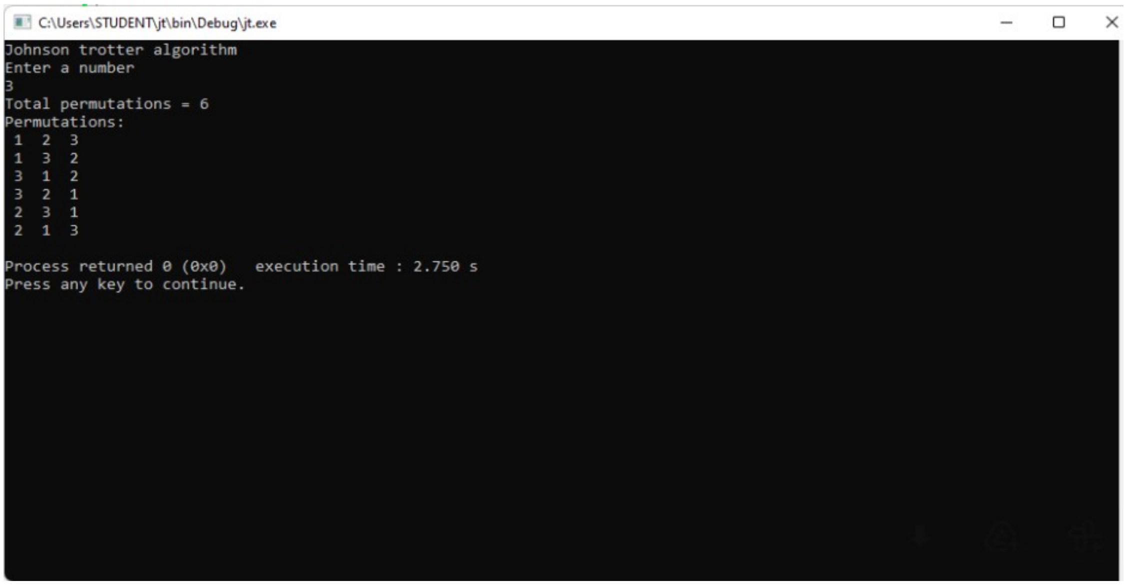
```
#include <stdio.h>
 #include <stdlib.h>
 int flag = 0;
int swap(int *a,int *b)
{
int t = *a;
*a = *b;
*b = t;
}

int search(int arr[],int n,int mobile)
{
int g;
for(g=0;g<n;g++)
{
 if(arr[g] == mobile)
return g+1;
else
flag++;
}
return -1;
}
int fm(int arr[],int d[],int n)
{
int mobile = 0; int mp = 0;
int i;
for(i=0;i<n;i++)
```

```
{
if((d[arr[i]-1] == 0) && i != 0)
{
if(arr[i]>arr[i-1] && arr[i]>mp)
{
mobile = arr[i]; mp = mobile;
}
else
flag++;
}
else if((d[arr[i]-1] == 1) && i != n-1)
{
if(arr[i]>arr[i+1] && arr[i]>mp)
    mobile = arr[i]; mp = mobile;
else
flag++;
}
else
flag++;

}
if((mp == 0) && (mobile == 0))
return 0;
else
return mobile;
}

void permut(int arr[],int d[],int n)
{
int i;
int mobile = fm(arr,d,n);
int pos = search(arr,n,mobile);
if(d[arr[pos-1]-1]==0)
swap(&arr[pos-1],&arr[pos-2]);
 else
swap(&arr[pos-1],&arr[pos]);
for(int i=0;i<n;i++)
```

```
{
if(arr[i] > mobile)
{
if(d[arr[i]-1]==0)
d[arr[i]-1] = 1;
 else
d[arr[i]-1] = 0;
}
}
for(i=0;i<n;i++)
{
printf(" %d ",arr[i]);
} }
int fact(int k)
{
int f = 1; int i = 0;
for(i=1;i<k+1;i++)
   f = f*i;
return f;
}

int main()
{
int n = 0; int i;
int j;
int z = 0;
printf("Johnson trotter algorithm \n");
printf("Enter a number\n"); scanf("%d",&n);
int arr[n],d[n];
z = fact(n);
printf("Total permutations = %d",z);
printf("\nPermutations: \n"); for(i=0;i<n;i++)
{
d[i] = 0;
arr[i] = i+1;
printf(" %d ",arr[i]);
}
```

```
printf("\n");
for(j=1;j<z;j++)
{
permut(arr,d,n);
printf("\n");
}
return 0;
}
```

OUTPUT :



```
Johnson trotter algorithm
Enter a number
3
Total permutations = 6
Permutations:
 1  2  3
 1  3  2
 3  1  2
 3  2  1
 2  3  1
 2  1  3

Process returned 0 (0x0)   execution time : 2.750 s
Press any key to continue.
```

WEEK 4

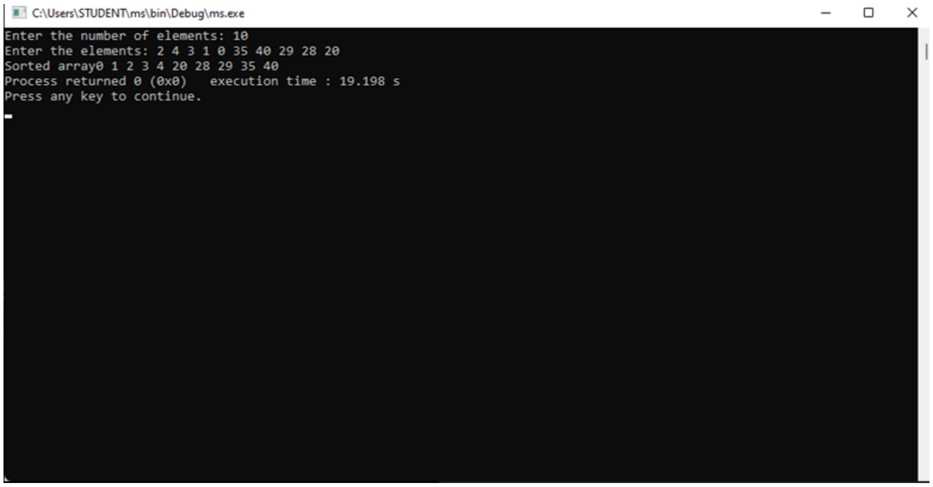
Sort a given set of N integer elements using Merge Sort technique

CODE:

```
#include <stdio.h>
 #include <stdlib.h>
void merge(int low,int mid,int high,int a[20],int m[20])
{
int i = low; int j = mid+1; int k = 0;
while(i<=mid && j<=high)
{
if(a[i]<a[j])
{
m[k] = a[i];
 i++;
k++;
}
else
{
m[k] = a[j];
j++;
k++;
}
}
while (i <= mid)
{
m[k] = a[i];
i++;
k++;
}
while (j <= high)
{
m[k] = a[j];
j++;
k++;
}
for(int i=0;i<k;i++)
    a[low+i] = m[i];
}
void merge_sort(int low,int high,int a[20],int merged[20])
{
if(low<high)
{
int mid = (low+high)/2;
merge_sort(low,mid,a,merged);
merge_sort(mid+1,high,a,merged);
 merge(low,mid,high,a,merged);
}
}
```

```
int main()
{
int n,a[30];
printf("Enter the number of elements:");
scanf("%d",&n);
printf("Enter the elements:");
for(int i=0;i<n;i++)
scanf("%d",&a[i]);
int merged[30];
merge_sort(0,n-1,a,merged);
printf("Sorted array");
for(int i=0;i<n;i++)
   printf("%d ",a[i]);
}
```

OUTPUT :



```
Enter the number of elements: 10
Enter the elements: 2 4 3 1 0 35 40 29 28 20
Sorted array0 1 2 3 4 20 28 29 35 40
Process returned 0 (0x0)   execution time : 19.198 s
Press any key to continue.
```

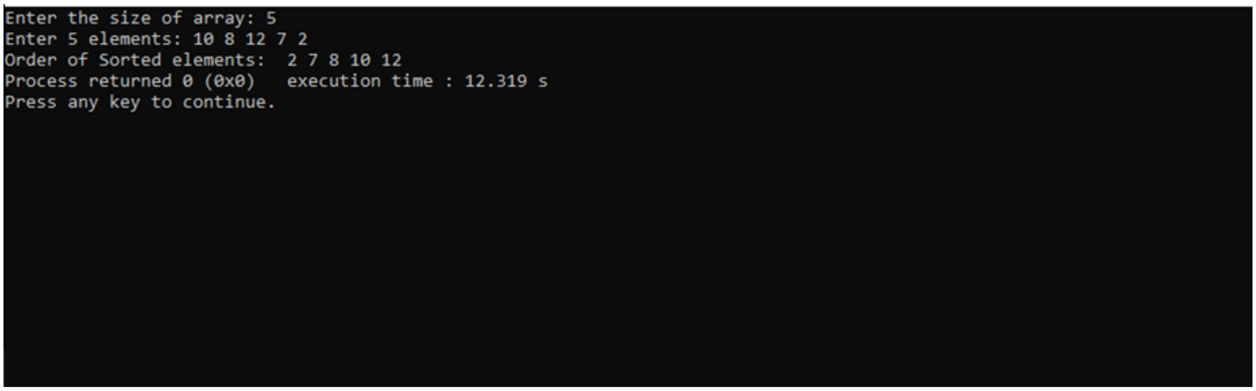
WEEK 5

Sort a given set of N integer elements using Quick Sort technique

CODE :

```
#include<stdio.h>
void quicksort(int number[25],int first,int last)
{
int i, j, pivot, temp;
 if(first<last)
{
pivot=first;
i=first;
j=last;
 while(i<j)
{
while(number[i]<=number[pivot]&&i<last)
 i++;
while(number[j]>number[pivot])
 j--;
if(i<j)
{
temp=number[i];
number[i]=number[j];
number[j]=temp;
}
}
temp=number[pivot];
number[pivot]=number[j];
number[j]=temp;
quicksort(number,first,j-1);
quicksort(number,j+1,last);
}

}
int main()
{
int i, count, number[25];
printf("Enter the size of array: ");
 scanf("%d",&count);
printf("Enter %d elements: ", count);
for(i=0;i<count;i++)
    scanf("%d",&number[i]);
quicksort(number,0,count-1);
printf("Order of Sorted elements: ");
for(i=0;i<count;i++)
printf(" %d",number[i]); return 0;
}
```

OUTPUT :



```
Enter the size of array: 5
Enter 5 elements: 10 8 12 7 2
Order of Sorted elements:  2 7 8 10 12
Process returned 0 (0x0)   execution time : 12.319 s
Press any key to continue.
```

WEEK 6

Implement 0/1 Knapsack problem using dynamic programming

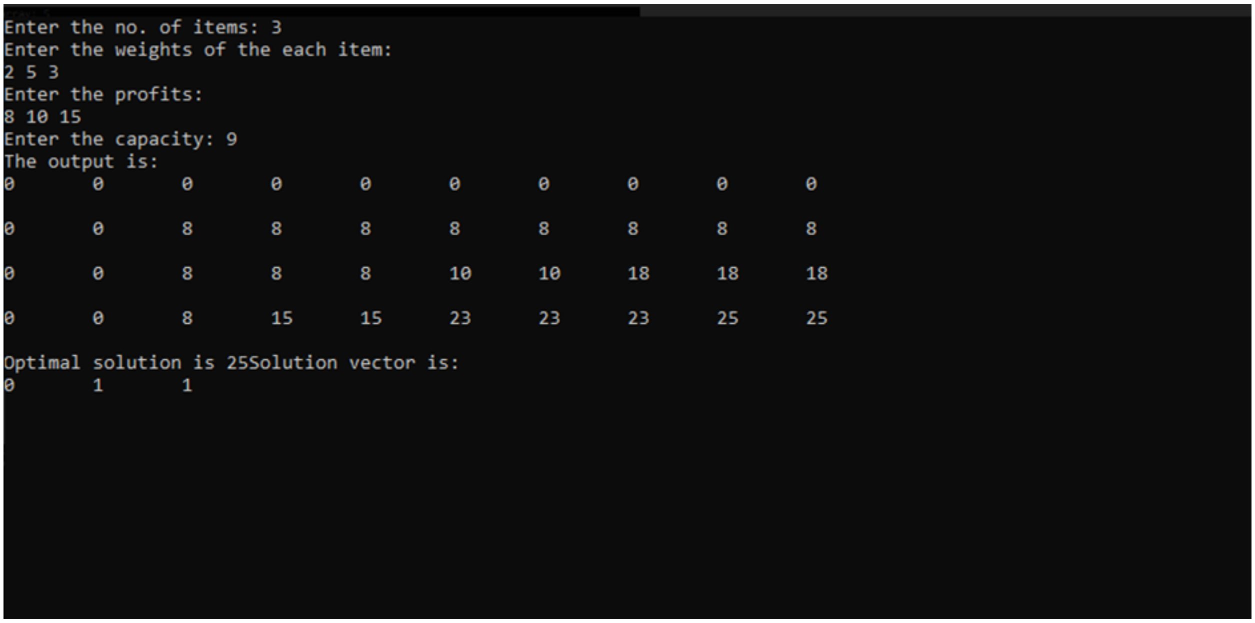
CODE :

```
#include<stdio.h>
#include<conio.h>
int i,j,n,m,p[10],w[10],v[10][10];
void main()
{
printf("Enter the no. of items:\t");
scanf("%d",&n);
printf("Enter the weights of the each item:\n");
 for(i=1;i<=n;i++)
scanf("%d",&w[i]);
printf("Enter the profits:\n");
for(i=1;i<=n;i++)
scanf("%d",&p[i]);
printf("Enter the capacity:");
scanf("%d",&m);
knapsack();
getch();
}
void knapsack()
{
int x[10];
for(i=0;i<=n;i++)
{

for(j=0;j<=m;j++)
{
```

```
if(i==0||j==0)
{
v[i][j]=0;
}
else if(j-w[i]<0)
{
v[i][j]=v[i-1][j];
}
else
{
v[i][j]=max(v[i-1][j],v[i-1][j-w[i]]+p[i]);
}
}
}
printf("The output is:\n");
for(i=0;i<=n;i++)
{
for(j=0;j<=m;j++)
  printf("%d\t",v[i][j]);
printf("\n\n");
}
printf("Optimal solution is %d",v[n][m]);
 printf("Solution vector is:\n");
for(i=n;i>=1;i--)
{
if(v[i][m]!=v[i-1][m])
{
x[i]=1;
m=m-w[i];
}
else
x[i]=0;
}
for(i=1;i<=n;i++)
```

```
printf("%d\t",x[i]);
}
int max(int x,int y)
{
if(x>y)
return x;
else
return y;
}
```

OUTPUT :



```
Enter the no. of items: 3
Enter the weights of the each item:
2 5 3
Enter the profits:
8 10 15
Enter the capacity: 9
The output is:
0       0       0       0       0       0       0       0       0       0

0       0       8       8       8       8       8       8       8       8

0       0       8       8       8       10      10      18      18      18

0       0       8       15      15      23      23      23      25      25

Optimal solution is 25Solution vector is:
0       1       1
```

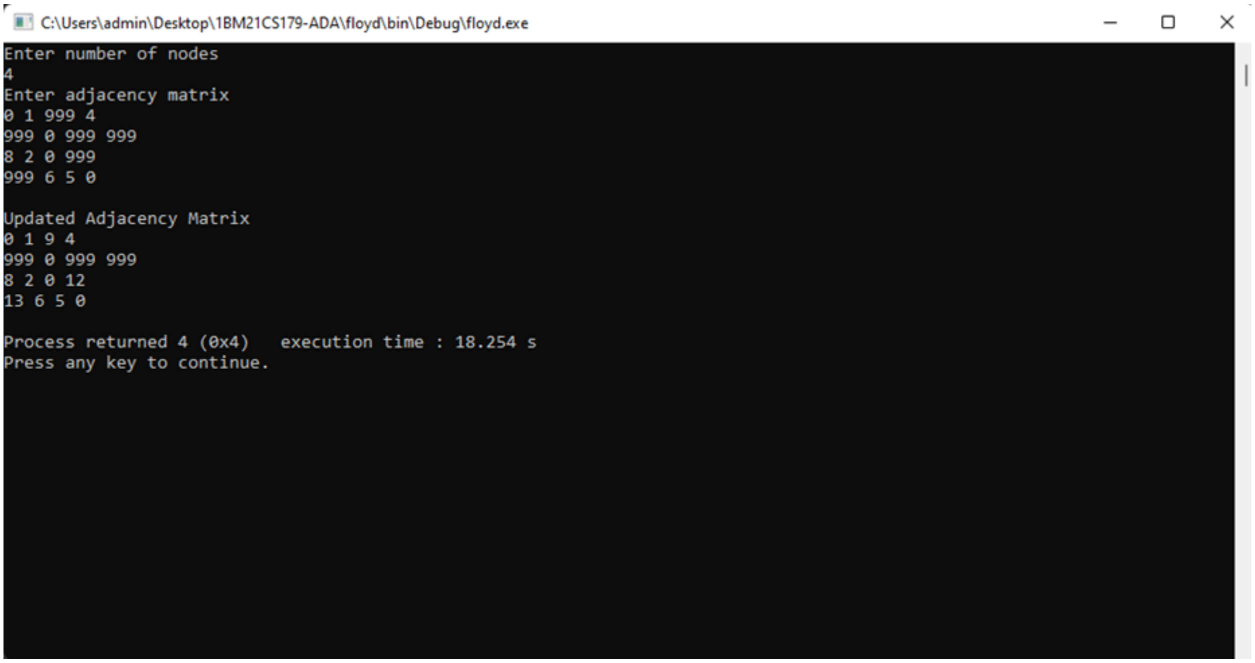
WEEK 7

Implement All Pair Shortest paths problem using Floyd's algorithm.

CODE :

```
#include<stdio.h>
 void main()
{
int i,j,k,n,adj[10][10],ori[10][10];
 printf("Enter number of nodes \n");
scanf("%d",&n);
printf("Enter adjacency matrix \n");
for(i=0;i<n;i++)
{
for(j=0;j<n;j++)
scanf("%d",&p[i][j]);
}
for(i=0;i<n;i++)
for(j=0;j<n;j++)
ori[i][j]=adj[i][j];
 for(k=0;k<n;k++)
 for(i=0;i<n;i++)
for(j=0;j<n;j++)
if(adj[i][j] > adj[k][j]+adj[i][k])
adj[i][j]=adj[k][j]+adj[i][k];
printf("\nUpdated Matrix \n");
for(i=0;i<n;i++)
{
for(j=0;j<n;j++)
 printf("%d ",adj[i][j]);
}
}
```

OUTPUT :


C:\Users\admin\Desktop\1BM21CS179-ADA\floyd\bin\Debug\floyd.exe

```
Enter number of nodes
4
Enter adjacency matrix
0 1 999 4
999 0 999 999
8 2 0 999
999 6 5 0

Updated Adjacency Matrix
0 1 9 4
999 0 999 999
8 2 0 12
13 6 5 0

Process returned 4 (0x4)   execution time : 18.254 s
Press any key to continue.
```

WEEK 8

Find Minimum Cost Spanning Tree of a given undirected graph using Prim’s and Kruskal’s algorithm

Prim’s

CODE :

```
 #include<stdio.h>
 float cost[10][10];
int vt[10],et[10][10],vis[10],j,n, x=1, e=0;
float sum=0;
void main()
{
int i;
printf("Enter the number of vertices\n");
scanf("%d",&n);
printf("Enter the cost adjacency matrix\n");
for(i=1;i<=n;i++)
for(j=1;j<=n;j++)
    scanf("%f",&cost[i][j]);
```

```
vis[i]=0;
prims();
printf("Edges of spanning tree\n");
for(i=1;i<=e;i++)
printf("%d,%d\t",et[i][0],et[i][1]);
printf("Weight=%f\n",sum);
}
void prims()
{
int s,m,k,u,v; float min; vt[x]=1;
vis[x]=1;
for(s=1;s<n;s++)
{
j=x;
min=999;
while(j>0)
{
k=vt[j];
for(m=2;m<=n;m++)
{
if(vis[m]==0)
{
if(cost[k][m]<min)
{
min=cost[k][m];
u=k;
v=m;
}
}
}
j--;
}
vt[++x]=v;
et[s][0]=u;
et[s][1]=v;
e++;
vis[v]=1;
sum=sum+min;
}
}
```

Kruskal’s

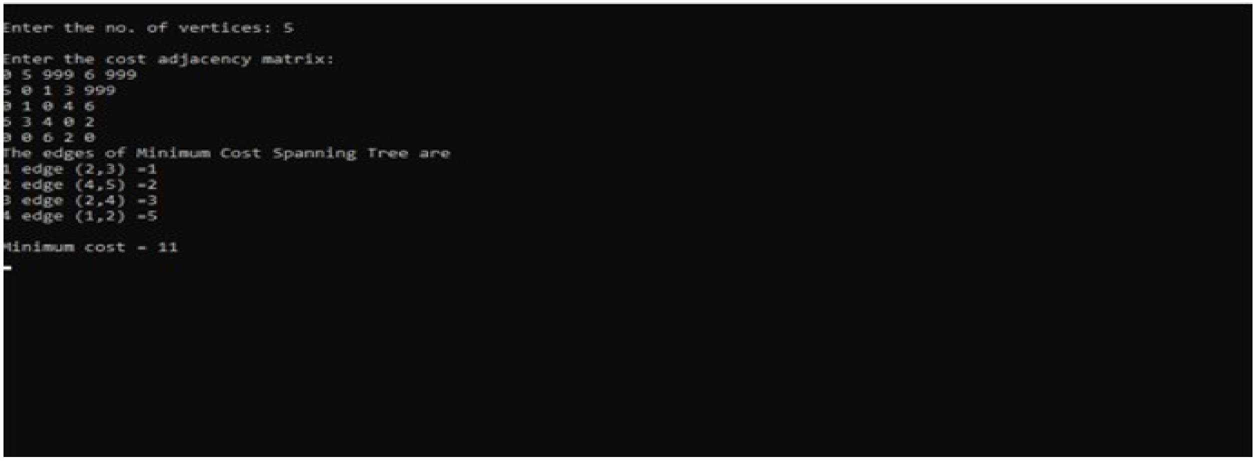
CODE :

```
#include <stdio.h>
int i,j,k,a,b,u,v,n,ne=1;
int min,mincost=0,cost[9][9],parent[9];
void main()
{
printf("\nEnter the no. of vertices:");
scanf("%d",&n);
printf("\nEnter the 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;
}
printf("The edges of Minimum Cost Spanning Tree are\n");
while(ne < n)
{
for(i=1,min=999;i<=n;i++)
{
```

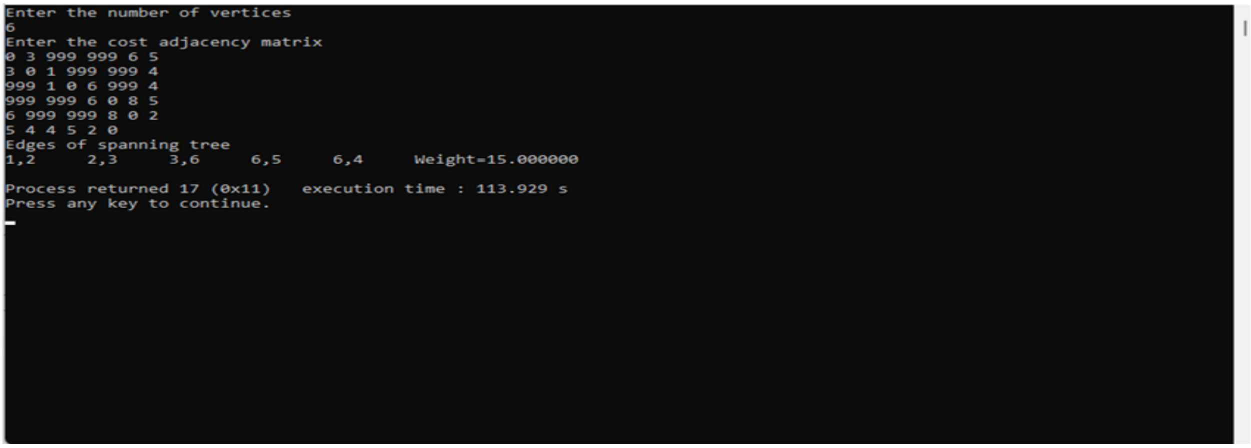
```
for(j=1;j <= n;j++)
{
if(cost[i][j] < min)
{
min=cost[i][j];
a=u=i;
b=v=j;
}
}
}
 u=find(u);
 v=find(v);
 if(uni(u,v))
       printf("%d edge (%d,%d) =%d\n",ne++,a,b,min);
       mincost +=min;
cost[a][b]=cost[b][a]=999;
}
printf("\n\tMinimum cost = %d\n",mincost);
}
int find(int i)
{
while(parent[i])
i=parent[i];
```

```
return i;
}
int uni(int i,int j)
{
if(i!=j)
parent[j]=i;
}
```

OUTPUT :



```
Enter the no. of vertices: 5

Enter the cost adjacency matrix:
0 5 999 6 999
5 0 1 3 999
0 1 0 4 6
6 3 4 0 2
0 0 6 2 0
The edges of Minimum Cost Spanning Tree are
1 edge (2,3) =1
2 edge (4,5) =2
3 edge (2,4) =3
4 edge (1,2) =5

Minimum cost = 11
```



```
Enter the number of vertices
6
Enter the cost adjacency matrix
0 3 999 999 6 5
3 0 1 999 999 4
999 1 0 6 999 4
999 999 6 0 8 5
6 999 999 8 0 2
5 4 4 5 2 0
Edges of spanning tree
1,2     2,3     3,6     6,5     6,4     Weight=15.000000

Process returned 17 (0x11)   execution time : 113.929 s
Press any key to continue.
```

WEEK 9

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

CODE :

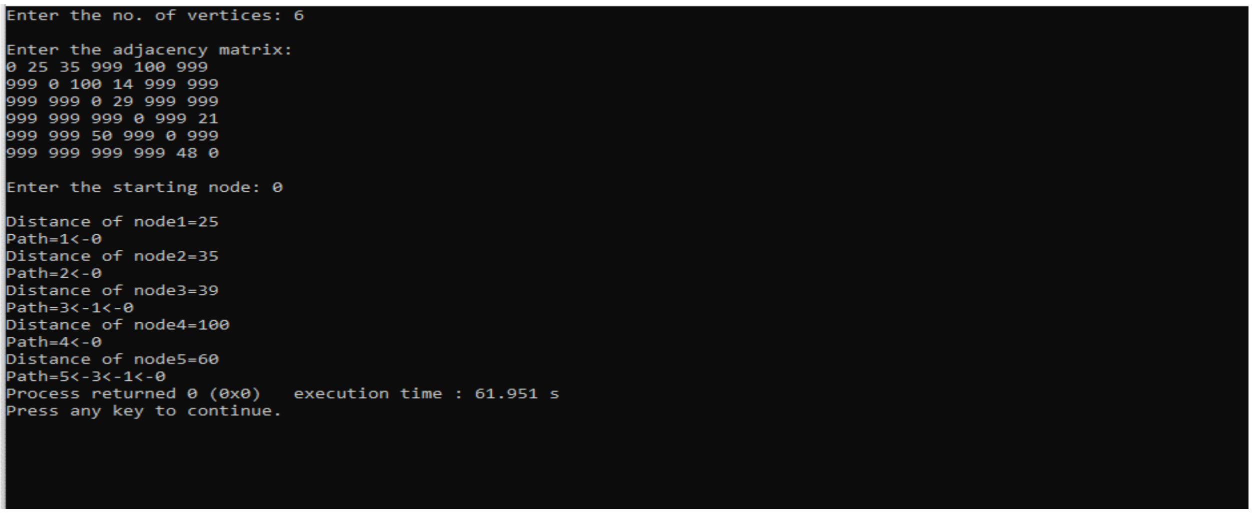
```
#include<stdio.h>
 #include<conio.h>
#define INFINITY 9999
#define MAX 10
int main()
{
int G[MAX][MAX],i,j,n,u;
 printf("Enter the no. of vertices:");
scanf("%d",&n);
printf("\nEnter the adjacency matrix:\n");
for(i=0;i<n;i++)
for(j=0;j<n;j++)
scanf("%d",&G[i][j]);
 printf("\nEnter the starting node:");
scanf("%d",&u);
```

```
 dijkstra(G,n,u);
 }

 void dijkstra(int G[MAX][MAX],int n,int start)
 {
 int cost[MAX][MAX],distance[MAX],pred[MAX];
 int visited[MAX],count,mindistance,nextnode,i,j;
  for(i=0;i<n;i++)
 for(j=0;j<n;j++)
 if(G[i][j]==0)
  cost[i][j]=INFINITY;

 else
 cost[i][j]=G[i][j];
  for(i=0;i<n;i++)
 distance[i]=cost[start][i];
 pred[i]=start;
  visited[i]=0;
 distance[start]=0;
 visited[start]=1;
count=1;
while(count<n-1)
```

```
{
mindistance=INFINITY;

for(i=0;i<n;i++)
 if(distance[i]<mindistance&&!visited[i])
mindistance=distance[i];
nextnode=i;
visited[nextnode]=1;
for(i=0;i<n;i++)
if(!visited[i])
if(mindistance+cost[nextnode][i]<distance[i])
   distance[i]=mindistance+cost[nextnode][i]; pred[i]=nextnode;
count++;
}

for(i=0;i<n;i++)
if(i!=start)
{
printf("\nDistance of node%d=%d",i,distance[i]);
printf("\nPath=%d",i);
j=i;
```

```
 do
{
j=pred[j]; printf("<-%d",j);
}while(j!=start);
}
}
```

OUTPUT :



```
Enter the no. of vertices: 6

Enter the adjacency matrix:
0 25 35 999 100 999
999 0 100 14 999 999
999 999 0 29 999 999
999 999 999 0 999 21
999 999 50 999 0 999
999 999 999 999 48 0

Enter the starting node: 0

Distance of node1=25
Path=1<-0
Distance of node2=35
Path=2<-0
Distance of node3=39
Path=3<-1<-0
Distance of node4=100
Path=4<-0
Distance of node5=60
Path=5<-3<-1<-0
Process returned 0 (0x0)   execution time : 61.951 s
Press any key to continue.
```

WEEK 10

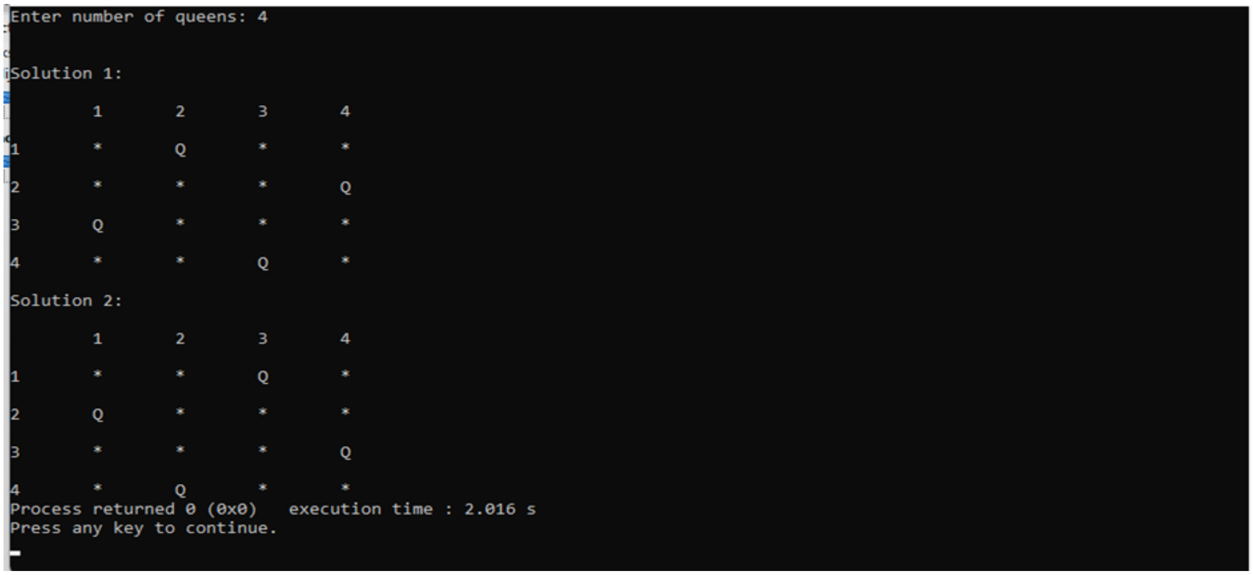
Implement N-Queen problem

CODE :

```
#include<stdio.h>
#include<math.h>
int board[20],count;
 int main()
{
int n,i,j;
 printf("Enter number of queens:");
 scanf("%d",&n);
queen(1,n);
 return 0;
}

void print(int n)
{
int i,j;
printf("\n\nSolution %d:\n\n",++count);
```

```
for(i=1;i<=n;++i)

printf("\t%d",i);

for(i=1;i<=n;++i)

{

printf("\n\n%d",i);

for(j=1;j<=n;++j)

{

if(board[i]==j)

printf("\tQ");

else

printf("\t*");

}

}

}

int place(int row,int column)

{

int i;

for(i=1;i<=row-1;++i)

{

if(board[i]==column)

return 0;

else
if(abs(board[i]-column)==abs(i-row))

return 0;

}

return 1;

}


void queen(int row,int n)

{

int column;

for(column=1;column<=n;++column)

{

if(place(row,column))

{

board[row]=column;

if(row==n)

print(n);

else

queen(row+1,n);

}

}

}
```

OUTPUT :



```
Enter number of queens: 4


Solution 1:

        1       2       3       4

1       *       Q       *       *

2       *       *       *       Q

3       Q       *       *       *

4       *       *       Q       *

Solution 2:

        1       2       3       4

1       *       *       Q       *

2       Q       *       *       *

3       *       *       *       Q

4       *       Q       *       *
Process returned 0 (0x0)   execution time : 2.016 s
Press any key to continue.
```

WEEK 11

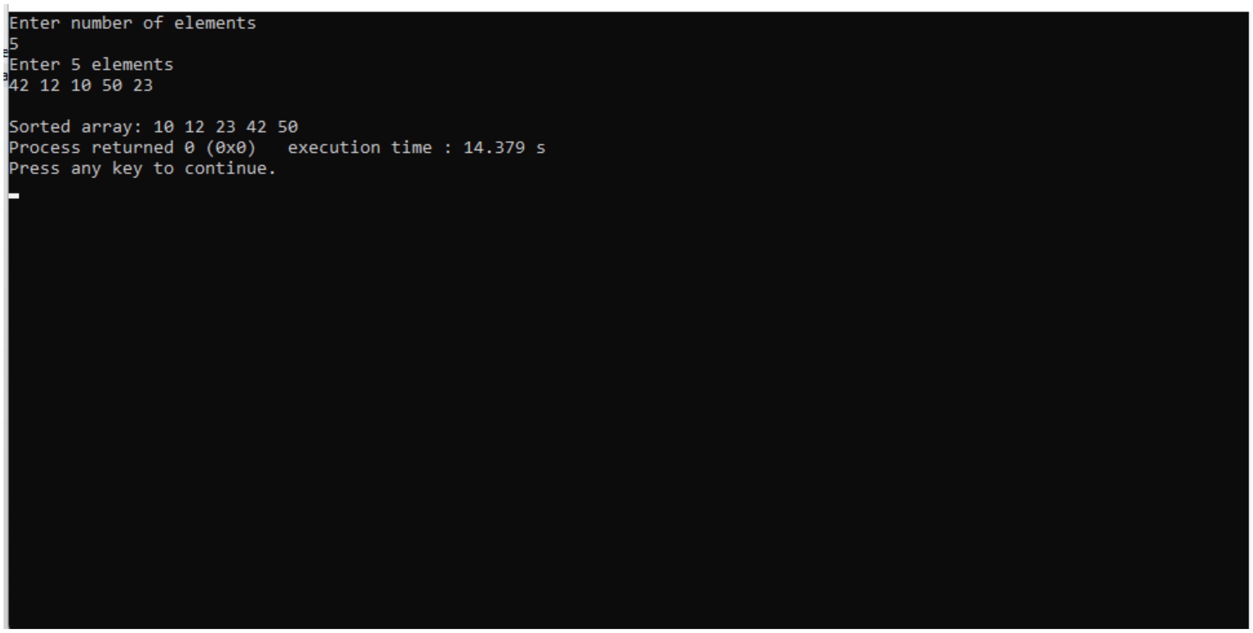
Sort a given set of N integer elements using Heap Sort technique

CODE :

```
#include <stdio.h>
void heapify(int arr[], int n, int i)
{
    int largest = i, left = 2 * i + 1, right = 2 * i + 2;
    if (left < n && arr[left] > arr[largest])
        largest = left;
    if (right < n && arr[right] > arr[largest])
        largest = right;
    if (largest != i)
    {
        int temp = arr[i];
        arr[i] = arr[largest];
        arr[largest] = temp;
        heapify(arr, n, largest);
    }
}
```

```
void heapsort(int arr[], int n)

{

    for (int i = n / 2 - 1; i >= 0; i--)

        heapify(arr, n, i);

    for (int i = n - 1; i >= 0; i--) {

        int temp = arr[0];

        arr[0] = arr[i];

        arr[i] = temp;

        heapify(arr, i, 0);

    }

}

int main()

{

    int arr[10], n, i;

    printf("Enter number of elements \n");

    scanf("%d", &n);

    printf("Enter %d elements \n", n);

    for (i = 0; i < n; i++)

        scanf("%d", &arr[i]);

    heapsort(arr, n);


    printf("\nSorted array: ");
    for (i = 0; i < n; i++)

        printf("%d ", arr[i]);


    return 0;

}
```

OUTPUT :



```
Enter number of elements
5
Enter 5 elements
42 12 10 50 23

Sorted array: 10 12 23 42 50
Process returned 0 (0x0)   execution time : 14.379 s
Press any key to continue.
```