VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

Analysis and Design of Algorithms

Submitted by

B C Surag (1BM21CS037)

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 **B C Surag(1BM21CS037),** who is 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.

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

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.

Code:

```
#include<stdio.h>
#include<conio.h>

int a[15][15],n;
void bfs(int);

void main() {
 int i,j,root;
 printf("\nEnter the no of nodes:\t");
 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 source node:\t");
 scanf("%d",&root);
 bfs(root);
}

void bfs(int root) {
 int q[15],f=0,r=-1,vis[15],i,j;
```

```
for(j=1;j<=n;j++)
   vis[j]=0;
vis[root]=1;
r=r+1;
q[r]=root;
while(f<=r) {
i=q[f];
f=f+1;
 for(j=1;j<=n;j++)
 {
  if(a[i][j]==1&&vis[j]!=1) {
   vis[j]=1;
   r=r+1;
   q[r]=j;
  }
 }
}
for(j=1;j<=n;j++) {
 if(vis[j]!=1)
  printf("\nNode %d is not reachable",j);
 else{
  printf("\nNode %d is reachable",j);
 }
}
```

Output:

```
Enter the no of nodes:  4

Enter the adjacency matrix:
1 0 0 1
1 1 0 0
1 1 1 1
1 0 0 1

Enter the source node:  1

Node reachability from node 1:
Node 0 is reachable
Node 1 is reachable
Node 2 is not reachable
Node 3 is reachable
```

```
#include<stdio.h>
#include<conio.h>

int a[10][10],n,vis[10];
int dfs(int root){
   int j;
    vis[root]=1;
    for(j=1;j<=n;j++)
     if(a[root][j]==1&&vis[j]!=1)
     dfs(j);
    for(j=1;j<=n;j++) {
     if(vis[j]!=1)
      return 0;
    }
    return 1;
}
void main()
{
 int i,j,root,ans;
 for(j=1;j<=n;j++)
 vis[j]=0;
 printf("\nEnter the no of nodes:\t");
 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 source node:\t");
 scanf("%d",&root);
 ans=dfs(root);
 if(ans==1)
  printf("\nGraph is connected\n");
 else
  printf("\nGraph is not connected\n");
 getch();
}
```

Output:

```
Enter the no of nodes:  4

Enter the adjacency matrix:
1 0 0 1
1 1 0 0
1 1 1 1
1 0 0 1

Enter the source node:  1

Graph is not connected
```

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: 4
Enter adjacency matrix:
1 0 0 1
1 1 0 0
1 1 1 1
1 0 1 1
Order is: 1 2 3 4
```

3. **Implement Johnson Trotter algorithm to generate permutations.**

Code:

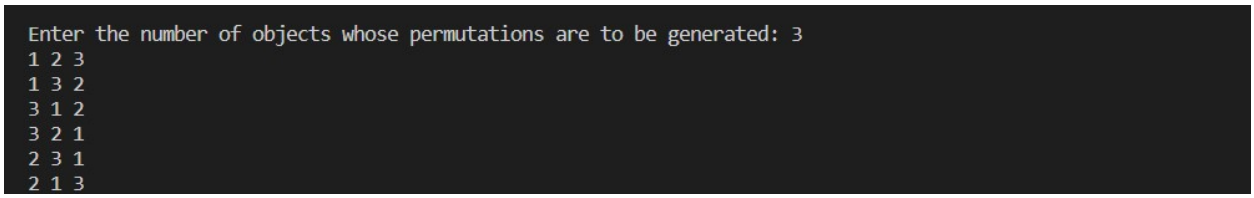
```
#include<stdio.h>
#include<stdbool.h>

#define left_to_right true
#define right_to_left false

int getPosOfMobile(int a[], int n, int mobile) {
   for (int i = 0; i < n; i++) {
      if (a[i] == mobile)
         return i + 1;
   }
   return 0;
}

int getMobile(int a[], bool dir[], int n) {
   int mobile_prev = 0, mobile = 0;
   for (int i = 0; i < n; i++) {
      // direction 0 represents RIGHT TO LEFT.
      if (dir[a[i] - 1] == right_to_left && i != 0) {
         if (a[i] > a[i - 1] && a[i] > mobile_prev) {
            mobile = a[i];
            mobile_prev = mobile;
         }
      }

      // direction 1 represents LEFT TO RIGHT.
      if (dir[a[i] - 1] == left_to_right && i != n - 1) {
         if (a[i] > a[i + 1] && a[i] > mobile_prev) {
            mobile = a[i];
            mobile_prev = mobile;
         }
      }
   }
```

```
    if (mobile == 0 && mobile_prev == 0)
        return 0;
    else
        return mobile;
}


void produceOnePermutation(int a[], bool dir[], int n) {
    int mobile = getMobile(a, dir, n);
    int pos = getPosOfMobile(a, n, mobile);


    if (dir[a[pos - 1] - 1] == right_to_left) {
        int temp = a[pos - 1];
        a[pos - 1] = a[pos - 2];
        a[pos - 2] = temp;
    } else if (dir[a[pos - 1] - 1] == left_to_right) {
        int temp = a[pos];
        a[pos] = a[pos - 1];
        a[pos - 1] = temp;
    }

    // changing the directions for elements
    // greater than largest mobile integer.
    for (int i = 0; i < n; i++) {
        if (a[i] > mobile) {
            if (dir[a[i] - 1] == left_to_right)
                dir[a[i] - 1] = right_to_left;
            else if (dir[a[i] - 1] == right_to_left)
                dir[a[i] - 1] = left_to_right;
        }
    }

    for (int i = 0; i < n; i++)
        printf("%d ", a[i]);
    printf("\n");
}
```

```
int fact(int n)
{
   int result=1;
   for(int i=1;i<=n;i++)
   {
      result*=i;
   }
   return result;
}

void producePermutation(int n) {
   // To store the current permutation
   int a[n];

   // To store the current directions
   bool dir[n];

   // Storing the elements from 1 to n and
   // printing the first permutation.
   for (int i = 0; i < n; i++) {
      a[i] = i + 1;
      printf("%d ", a[i]);
   }
   printf("\n");

   // Initially all directions are set
   // to RIGHT TO LEFT i.e. 0.
   for (int i = 0; i < n; i++)
      dir[i] = right_to_left;

   // For generating permutations in order.
   for (int i = 1; i < fact(n); i++)
      produceOnePermutation(a, dir, n);
}



void main()
{
   int n;
```

```
    printf("\nEnter the number of objects whose permutations are to be generated: ");
    scanf("%d",&n);
    producePermutation(n);
}
```

Output:



4. **Sort a given set of N integer elements using Merge Sort technique and compute its time taken. Run the program for different values of N and record the time taken to sort.**

Code:

```
#include <stdio.h>
#include <stdlib.h>
void merge(int low,int mid,int high,int a[])
{
   int c[50];
   int i,j,k;
   i=low;
   j=mid+1;
   k=low;
   while(i<=mid&&j<=high)
   {
      if(a[i]<a[j])
      {
         c[k]=a[i];
         i++;
         k++;
      }
      else{
         c[k]=a[j];
         j++;
         k++;
      }
   }
   while(i<=mid)
   {
      c[k]=a[i];
      k++;
      i++;
   }
   while(j<=high)
   {
      c[k]=a[j];
      k++;
```

```
        j++;
    }
    for(i=low;i<=high;i++)
    {
        a[i]=c[i];
    }
}
void mergeSort(int low, int high,int a[])
{
    if(low<high)
    {
        int mid=(low+high)/2;
        mergeSort(low, mid, a);
        mergeSort(mid+1,high,a);
        merge(low, mid, high, a);
    }
}
void main()
{
    int n;
     printf("\nEnter the size");
    scanf("%d",&n);
    int i, a[50], low=0, high=n-1;
    printf("Enter the elements to be sorted: ");
    for(i=0;i<n;i++)
    {
        scanf("%d",&a[i]);
    }
    mergeSort(low, high, a);
    for(i=0;i<n;i++)
    {
        printf("%d\t",a[i]);
    }
}
```

Output:

```
Enter the size5
Enter the elements to be sorted: -3 100 5 10 -7
-7      -3      5       10      100
```

5. **Sort a given set of N integer elements using Quick Sort technique and compute its time taken.**

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 elements : ");
   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;
}
```

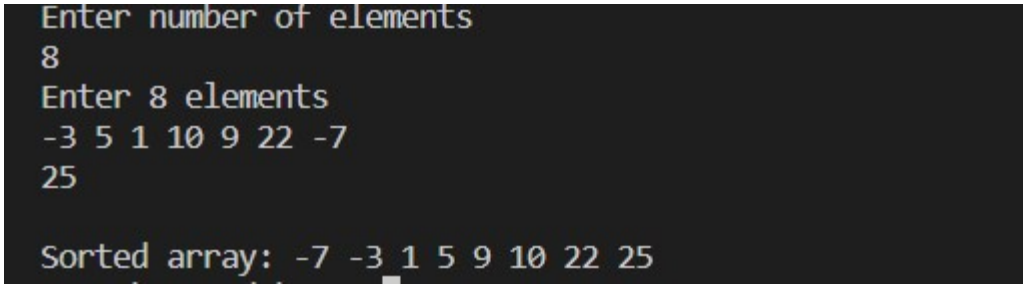
Output:

6. **Sort a given set of N integer elements using Heap Sort technique and compute its time taken.**

```
#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:



7. Implement 0/1 Knapsack problem using dynamic programming.

Code:

```
#include <stdio.h>
#include <conio.h>
void knapsack();
int max(int, int);
int i, j, n, m, p[10], w[10], v[10][10];
void main()
{
   printf("\nEnter the no. of items:\n");
   scanf("%d", &n);
   printf("\nEnter the weight of the each item:\n");
   for (i = 1; i <= n; i++)
   {
      scanf("%d", &w[i]);
   }
   printf("\nEnter the profit of each item:\n");
   for (i = 1; i <= n; i++)
   {
      scanf("%d", &p[i]);
   }
   printf("\nEnter the knapsack's capacity:\n");
   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("\nThe output is:\n");
   for (i = 0; i <= n; i++)

   {
      for (j = 0; j <= m; j++)
      {
         printf("%d  ", v[i][j]);
      }
      printf("\n\n");
   }
   printf("\nThe optimal solution is %d", v[n][m]);
   printf("\nThe 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:4

Enter the weight of the each item:2 1 3 2

Enter the profit of each item:12 10 20 15

Enter the knapsack's capacity:5

The output is:
0  0  0  0  0  0
0  0  12  12  12  12
0  10  12  22  22  22
0  10  12  22  30  32
0  10  15  25  30  37

The optimal solution is 37
The solution vector is:
1       1       0       1
```

8. Implement all pair shortest path problem using Floyd's Algorithm.

Code:

```
#include<stdio.h>
void main()
{
   int i,j,k,n,p[10][10],o[10][10];

   printf("Enter number of nodes \n");
   scanf("%d",&n);

   printf("Enter %dX%d adjacency matrix of \n",n,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++)
   o[i][j]=p[i][j];

   for(k=0;k<n;k++)
   for(i=0;i<n;i++)
   for(j=0;j<n;j++)
   if(p[i][j] > p[k][j]+p[i][k])
   p[i][j]=p[k][j]+p[i][k];

   printf("\nOringinal Adjacency Matrix \n");
   for(i=0;i<n;i++)
   {
      for(j=0;j<n;j++)
      printf("%d ",o[i][j]);
      printf("\n");
   }
   printf("\nUpdated Adjacency Matrix \n");
   for(i=0;i<n;i++)
   {
      for(j=0;j<n;j++)
      printf("%d ",p[i][j]);
      printf("\n");
   }
}
```

Output:


Enter number of nodes
4
Enter 4X4 adjacency matrix of
0 1 999 4
999 0 999 999
8 2 0 999
999 6 5 0
Original 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

9. Find Minimum Cost Spanning Tree of a given undirected graph using prims and kruskals Algorithm.

Prims algorithm Code:

```
#include<stdio.h>
float cost[10][10];
int vt[10],et[10][10],vis[10],j,n;
float sum=0;
int x=1;
int e=0;
void prims();

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;
 }
}
```

Output:

```
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
```

Kruskal's algorithm Code:

```
#include<stdio.h>
#include<conio.h>

int find(int v,int parent[10])
{
  while(parent[v]!=v)
  {
    v=parent[v];
  }
  return v;
}

void union1(int i,int j,int parent[10])
{
  if(i<j)
    parent[j]=i;
  else
    parent[i]=j;
}

void kruskal(int n,int a[10][10])
{
  int count,k,min,sum,i,j,t[10][10],u,v,parent[10];
  count=0;
  k=0;
  sum=0;
  for(i=0;i<n;i++)
    parent[i]=i;
  while(count!=n-1)
  {
    min=999;
    for(i=0;i<n;i++)
    {
          for(j=0;j<n;j++)
          {

            if(a[i][j]<min && a[i][j]!=0)
            {
        min=a[i][j];
        u=i;
        v = j;
          }
```

```
            }
        }
        i=find(u,parent);
        j=find(v,parent);
        if(i!=j)
        {
            union1(i,j,parent);
            t[k][0]=u;
            t[k][1]=v;
            k++;
            count++;
            sum=sum+a[u][v];
        }
        a[u][v]=a[v][u]=999;
    }
    if(count==n-1)
    {
        printf("spanning tree\n");
        for(i=0;i<n-1;i++)
        {
            printf("%d %d\n",t[i][0]+1,t[i][1]+1);
        }
        printf("cost of spanning tree=%d\n",sum);
    }
    else
        printf("spanning tree does not exist\n");
}


void main()
{
    int n,i,j,a[10][10];

    printf("Enter the number of nodes\n");
    scanf("%d",&n);
    printf("Enter the adjacency matrix\n");
    for(i=0;i<n;i++)
      for(j=0;j<n;j++)
            scanf("%d",&a[i][j]);
    kruskal(n,a);
}
```

Output:

```
Enter the number of nodes
5
Enter the 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
spanning tree
2 3
4 5
2 4
1 2
cost of spanning tree=11
```

10. 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>
void  dijkstras();
int c[10][10],n,src;
void main()
{
 int i,j;
 printf("\nEnter 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",&c[i][j]);
  }
 }
 printf("\nEnter the source node:\t");
 scanf("%d",&src);
 dijkstras();
 getch();
}

void dijkstras()
{
  int vis[10],dist[10],u,i,j,count,min;
  for(j=1;j<=n;j++)
  {
   dist[j]=c[src][j];
  }
  for(j=1;j<=n;j++)
  {
   vis[j]=0;
  }
  dist[src]=0;
  vis[src]=1;
  count=1;
  while(count!=n)
  {
```

```
  min=9999;
  for(j=1;j<=n;j++)
  {
   if(dist[j]<min&&vis[j]!=1)
   {
    min=dist[j];
    u=j;
   }
  }
  vis[u]=1;
  count++;
  for(j=1;j<=n;j++)
  {
   if(min+c[u][j]<dist[j]&&vis[j]!=1)
   {
    dist[j]=min+c[u][j];
   }
  }
 }
 printf("\nThe shortest distance is:\n");
 for(j=1;j<=n;j++)
 {
  printf("\n%d to %d=%d ",src,j,dist[j]);
 }
}
```

Output:

```
Enter number 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 source node:  1

The shortest distance is:

1 to 1=0
1 to 2=25
1 to 3=35
1 to 4=39
1 to 5=100
1 to 6=60
```

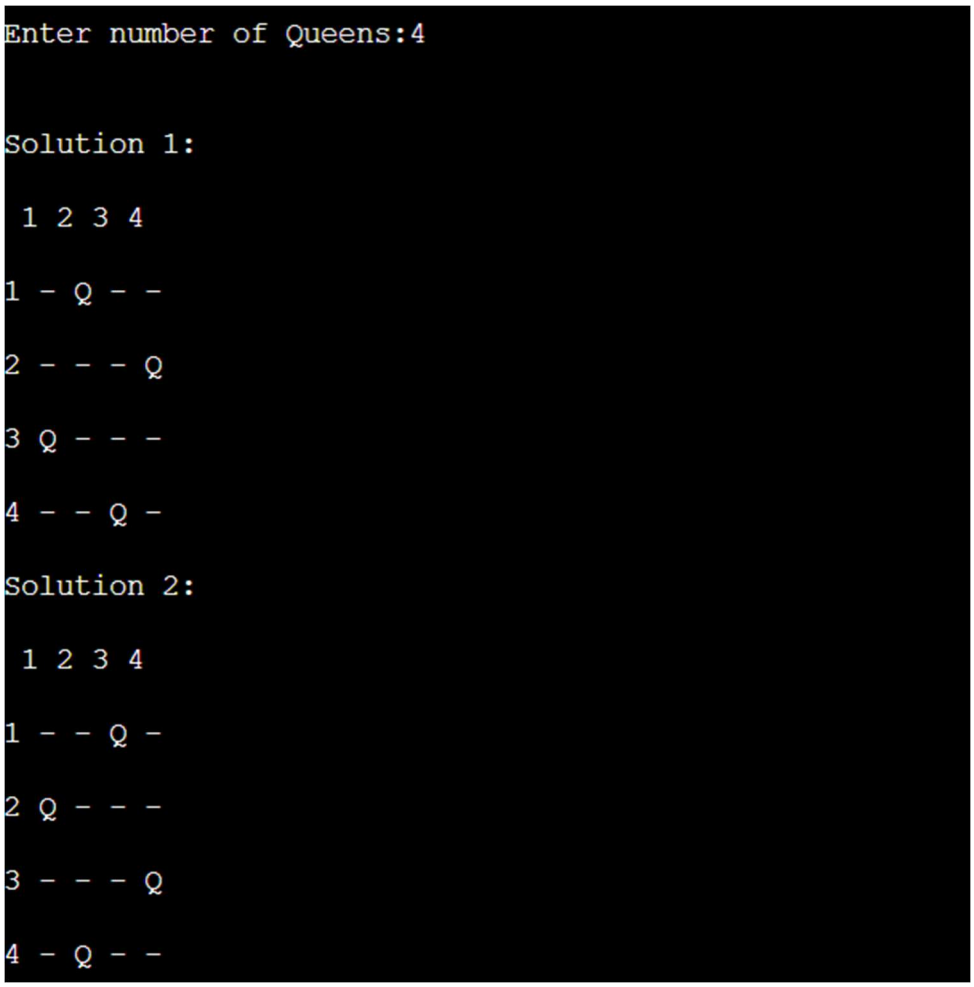
11. Implement "N-Queen's Problem" using backtracking

Code:

```
#include<stdio.h>
#include<math.h>

int board[20],count;

int main()
{
int n,i,j;
void queen(int row,int n);

printf("\n\nEnter 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(" %d",i);
for(i=1;i<=n;i++)
{
  printf("\n\n%d",i);
  for(j=1;j<=n;j++)
  {
   if(board[i]==j)
   printf(" Q");
   else
    printf(" -");
  }
}
}

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 - -