VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

Analysis and Design of Algorithms

Submitted by
ABHINAV KUMAR (1BM21CS003)

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

B.M.S. COLLEGE OF ENGINEERING
(Autonomous Institution under VTU)
BENGALURU-560019

May-2023 to July-2023

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 **ABHINAV KUMAR(1BM21CS003),**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 May-2023 to July-2023. The Lab report has been approved as it satisfies the academic requirements in respect of **Analysis and Design of Algorithms (22CS4PCADA)** work prescribed for the said degree.

Antara Roy Choudhury	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. a) Breadth First Search

Aim: To print all the nodes reachable from a given starting node in a digraph using BFS method

Code:

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

int main(void)
{
    printf("Enter the number of vertices: ");
    int n;
    scanf("%d", &n);
    int i, j;
    int **adjMatrix = (int **)malloc(n * sizeof(int *));
    for (i = 0; i < n; i++)
    {
        adjMatrix[i] = (int *)malloc(n * sizeof(int));
        for (j = 0; j < n; j++)
        {
            adjMatrix[i][j] = 0;
        }
    }

    printf("Enter the adjacency matrix:\n");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < n; j++)
```

```
    {
        scanf("%d", &adjMatrix[i][j]);
    }
}

printf("Enter the starting vertex: ");
int src;
scanf("%d", &src);

printf("Breadth First Traversal is as (starting from vertex %d):\n", src);
bool visited[n];
for (i = 0; i < n; i++)
{
    visited[i] = false;
}

int queue[n];
int front = 0, rear = 0;

visited[src] = true;
queue[rear++] = src;

while (front != rear)
{
    int currentVertex = queue[front++];
    printf("%d ", currentVertex);

    for (int adjacent = 0; adjacent < n; adjacent++)
    {
```

```
            if (adjMatrix[currentVertex][adjacent] && !visited[adjacent])
            {
                visited[adjacent] = true;
                queue[rear++] = adjacent;
            }
        }
    }

    for (i = 0; i < n; i++)
    {
        free(adjMatrix[i]);
    }
    free(adjMatrix);
}
```

Output:

```
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc BFS.c -o BFS } ; if ($?) { .\BFS }
Enter the number of vertices: 6
Enter the adjacency matrix:
0 1 1 1 0 0
1 0 0 1 1 0
1 0 0 1 0 1
1 1 1 0 1 1
0 1 0 1 0 1
0 0 1 1 1 0
Enter the starting vertex: 0
Breadth First Traversal is as (starting from vertex 0):
0 1 2 3 4 5
PS D:\codes\ADA Lab>
```

1. b) Depth First Search

Aim: To check whether a given graph is connected or not using DFS method

Code:

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

void DFS(int vertex, int **adjMatrix, bool *visited, int n)
{
    printf("%d ", vertex);
    visited[vertex] = true;
    for (int adjacent = 0; adjacent < n; adjacent++)
    {
        if (adjMatrix[vertex][adjacent] && !visited[adjacent])
        {
            DFS(adjacent, adjMatrix, visited, n);
        }
    }
}

int main(void)
{
    printf("Enter the number of vertices: ");
    int n;
    scanf("%d", &n);
    int i, j;
    int **adjMatrix = (int **)malloc(n * sizeof(int *));
```

```
for (i = 0; i < n; i++)
{
   adjMatrix[i] = (int *)malloc(n * sizeof(int));
   for (j = 0; j < n; j++)
   {
      adjMatrix[i][j] = 0;
   }
}

printf("Enter the adjacency matrix:\n");
for (i = 0; i < n; i++)
{
   for (j = 0; j < n; j++)
   {
      scanf("%d", &adjMatrix[i][j]);
   }
}

printf("Enter the starting vertex: ");
int src;
scanf("%d", &src);

printf("Depth First Traversal is as (starting from vertex %d):\n", src);
bool visited[n];
for (i = 0; i < n; i++)
{
   visited[i] = false;
}
```

```
    DFS(src, adjMatrix, visited, n);

    for (i = 0; i < n; i++)
    {
        free(adjMatrix[i]);
    }
    free(adjMatrix);
}
```

Output:

```
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc DFS.c -o DFS } ; if ($?) { .\DFS }
Enter the number of vertices: 5
Enter the adjacency matrix:
0 1 1 1 1
1 0 0 0 0
1 0 0 0 0
1 0 0 0 0
1 0 0 0 0
Enter the starting vertex: 1
Depth First Traversal is as (starting from vertex 1):
1 0 2 3 4
```

2. Topological Sorting

Aim: To obtain the Topological ordering of vertices in a given digraph

Code:

```
#include <stdio.h>

int main()
{
   int n;
   printf("Enter the no of vertices: ");
   scanf("%d", &n);
   int a[n][n], indeg[n], flag[n];

   int i, j, k, count = 0;
   printf("Enter the 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;
      flag[i] = 0;
   }
```

```
    for (i = 0; i < n; i++)
        for (j = 0; j < n; j++)
            indeg[i] = indeg[i] + a[j][i];

    printf("\nThe topological order is: ");

    while (count < n)
    {
        for (k = 0; k < n; k++)
        {
            if ((indeg[k] == 0) && (flag[k] == 0))
            {
                printf("%d ", (k + 1));
                flag[k] = 1;
            }

            for (i = 0; i < n; i++)
            {
                if (a[i][k] == 1)
                    indeg[k]--;
            }
        }

        count++;
    }

    return 0;
}
```

Output:

```
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc TopoSort.c -o TopoSort } ; if ($?) { .\TopoSort }
Enter the no of vertices: 4
Enter the adjacency matrix:
0 1 1 0
0 0 0 1
0 0 0 1
0 0 0 0

The topological order is: 1 2 3 4
```

3. Johnson Trotter algorithm

Aim: To generate permutations of n numbers using Johnson Trotter algorithm

Code:

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

bool LR = true;
bool RL = false;

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

int getMobile(int a[], bool dir[], int n)
{
   int i;
   int prev = 0, mobile = 0;

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

```
        if (dir[a[i] - 1] == RL && i != 0)
        {
            if (a[i] > a[i - 1] && a[i] > prev)
            {
                mobile = a[i];
                prev = mobile;
            }
        }

        if (dir[a[i] - 1] == LR && i != n - 1)
        {
            if (a[i] > a[i + 1] && a[i] > prev)
            {
                mobile = a[i];
                prev = mobile;
            }
        }
    }

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

int Perm(int a[], bool dir[], int n)
{
    int temp;
    int mobile = getMobile(a, dir, n);
```

```
int pos = search(a, n, mobile);

if (dir[a[pos - 1] - 1] == RL)
{
   temp = a[pos - 1];
   a[pos - 1] = a[pos - 2];
   a[pos - 2] = temp;
}
else if (dir[a[pos - 1] - 1] == LR)
{
   temp = a[pos];
   a[pos] = a[pos - 1];
   a[pos - 1] = temp;
}

for (int i = 0; i < n; i++)
{
   if (a[i] > mobile)
   {
      if (dir[a[i] - 1] == LR)
         dir[a[i] - 1] = RL;
      else if (dir[a[i] - 1] == RL)
         dir[a[i] - 1] = LR;
   }
}

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

```
    }
    printf(" ");
}

int fact(int n)
{
    int fact = 1;

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

void perms(int n)
{
    int a[n];
    bool dir[n];

    for (int i = 0; i < n; i++)
    {
        a[i] = i + 1;
        printf("%d", a[i]);
    }
    printf("\n");

    for (int i = 0; i < n; i++)
        dir[i] = RL;
```

```
    for (int i = 1; i < fact(n); i++)
        Perm(a, dir, n);
}

int main(void)
{
    int n;
    printf("Enter the value of n: ");
    scanf("%d", &n);
    perms(n);
}
```

Output:

```
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc JohnsonTrotter.c -o JohnsonTrotter } ; if ($?) { .\JohnsonTrotter }
Enter the value of n: 4
1234 1243 1423 4123 4132 1432 1342 1324 3124 3142 3412 4312 4321 3421 3241 3214 2314 2341 2431 4231 4213 2413 2143 2134
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc JohnsonTrotter.c -o JohnsonTrotter } ; if ($?) { .\JohnsonTrotter }
Enter the value of n: 3
123 132 312 321 231 213
```

```
For Value of n=5 : The following Permutations are possible-
12345 12354 12534 15234 51234 51243 15243 12543 12453 12435 14235 14253
14523 15423 51423 54123 45123 41523 41253 41235 41325 41352 41532 45132
54132 51432 15432 14532 14352 14325 13425 13452 13542 15342 51342 51324
15324 13524 13254 13245 31245 31254 31524 35124 53124 53142 35142 31542
31452 31425 34125 34152 34512 35412 53412 54312 45312 43512 43152 43125
43215 43251 43521 45321 54321 53421 35421 34521 34251 34215 32415 32451
32541 35241 53241 53214 35214 32514 32154 32145 23145 23154 23514 25314
52314 52341 25341 23541 23451 23415 24315 24351 24531 25431 52431 54231
45231 42531 42351 42315 42135 42153 42513 45213 54213 52413 25413 24513
24153 24135 21435 21453 21543 25143 52143 52134 25134 21534 21354 21345
```

4. Merge Sort

Aim: To sort a given set of N integer elements using Merge Sort technique, compute its time taken for different values of N and record the time taken to sort

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

void merge(int arr[], int p, int q, int r)
{
   int n1 = q - p + 1;
   int n2 = r - q;
   int L[n1], M[n2];

   for (int i = 0; i < n1; i++)
      L[i] = arr[p + i];
   for (int j = 0; j < n2; j++)
      M[j] = arr[q + 1 + j];

   int i, j, k;
   i = 0;
   j = 0;
   k = p;

   while (i < n1 && j < n2)
   {
      if (L[i] <= M[j])
```

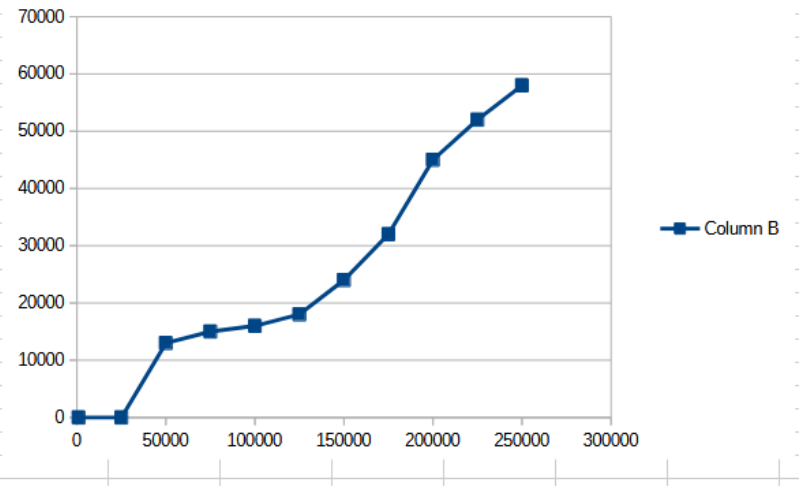
```
        {
            arr[k] = L[i];
            i++;
        }
        else
        {
            arr[k] = M[j];
            j++;
        }
        k++;
    }

    while (i < n1)
    {
        arr[k] = L[i];
        i++;
        k++;
    }

    while (j < n2)
    {
        arr[k] = M[j];
        j++;
        k++;
    }
}

void mergeSort(int arr[], int l, int r)
{
```

```
    if (l < r)
    {
        int m = l + (r - l) / 2;

        mergeSort(arr, l, m);
        mergeSort(arr, m + 1, r);

        merge(arr, l, m, r);
    }
}

int main(void)
{
    int n;
    printf("Enter the no of elements: ");
    scanf("%d", &n);
    int arr[n];

    // printf("Enter the elements: ");
    srand(time(0));
    for (int i = 0; i < n; i++)
    {
        arr[i] = rand();
    }

    clock_t st, end;
    st = clock();
    mergeSort(arr, 0, n - 1);
    end = clock();
```

```
    double time_taken = (((double)(end - st)) / CLOCKS_PER_SEC);

    printf("\nSorted array: ");
    for (int i = 0; i < n; i++)
        printf("%d ", arr[i]);

    printf("\nTime taken: %lf micro seconds\n", time_taken * 1000000);
}
```

Output with input size vs time graph:

Merge Sort	
Input Size	Time taken (in micro seconds)
1000	0
25000	0
50000	13000
75000	15000
100000	16000
125000	18000
150000	24000
175000	32000
200000	45000
225000	52000
250000	58000




```
Given array is
12 11 13 5 6 7

Sorted array is
5 6 7 11 12 13
```

5. Quick Sort

Aim: To sort a given set of N integer elements using Quick Sort technique and compute its time taken

Code:

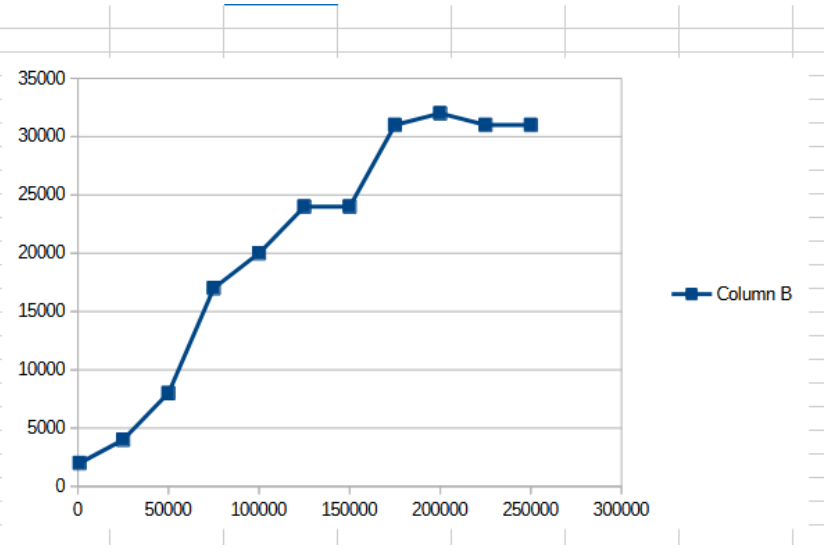
```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

void swap(int *a, int *b)
{
    int t = *a;
    *a = *b;
    *b = t;
}

int partition(int arr[], int low, int high)
{
    int pivot = arr[high];
    int i = (low - 1);

    for (int j = low; j <= high - 1; j++)
    {
        if (arr[j] < pivot)
        {
            i++;
            swap(&arr[i], &arr[j]);
        }
    }
```

```
    swap(&arr[i + 1], &arr[high]);

    return (i + 1);
}

void quickSort(int arr[], int low, int high)
{
    if (low < high)
    {
        int pi = partition(arr, low, high);

        quickSort(arr, low, pi - 1);
        quickSort(arr, pi + 1, high);
    }
}

int main(void)
{
    int n;
    printf("Enter the no of elements: ");
    scanf("%d", &n);
    int arr[n];

    // printf("Enter the elements: ");
    srand(time(0));
    for (int i = 0; i < n; i++)
    {
        arr[i] = rand();
    }
```

```
    clock_t st, end;
    st = clock();
    quickSort(arr, 0, n - 1);
    end = clock();
    double time_taken = (((double)(end - st)) / CLOCKS_PER_SEC);
    printf("\nSorted array: ");
    for (int i = 0; i < n; i++)
        printf("%d ", arr[i]);
    printf("\nTime taken: %lf micro seconds\n", time_taken * 1000000);
}
```

Output with input size vs time graph:

Quick Sort	
Input Size	Time taken (in micro seconds)
1000	2000
25000	4000
50000	8000
75000	17000
100000	20000
125000	24000
150000	24000
175000	31000
200000	32000
225000	31000
250000	31000




```
Given array is
12 11 13 5 6 7

Sorted array is
5 6 7 11 12 13
```

6. Heap Sort

Aim: To sort a given set of N integer elements using Heap Sort technique and compute its time taken

Code:

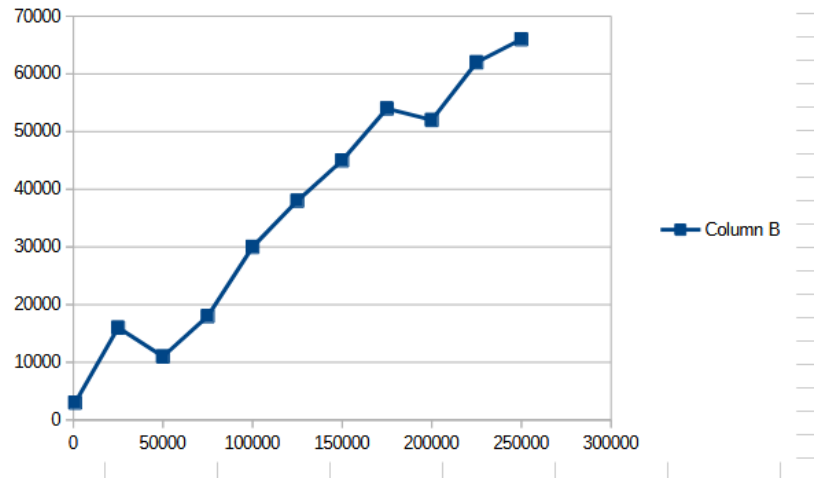
```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

void swap(int *a, int *b)
{
    int temp = *a;
    *a = *b;
    *b = temp;
}

void heapify(int arr[], int N, int i)
{
    int largest = i;
    int left = 2 * i + 1;
    int 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)
    {
        swap(&arr[i], &arr[largest]);
        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--)
    {
        swap(&arr[0], &arr[i]);
        heapify(arr, i, 0);
    }
}

int main(void)
{
    int n;
    printf("Enter the size of array: ");
    scanf("%d", &n);
```

```
    int arr[n];

    // printf("Enter the elements: ");
    srand(time(0));
    for (int i = 0; i < n; i++)
    {
        arr[i] = rand();
    }

    clock_t st, end;
    st = clock();
    heapSort(arr, n);
    end = clock();
    double time_taken = (((double)(end - st)) / CLOCKS_PER_SEC);

    printf("\nSorted array: ");
    for (int i = 0; i < n; i++)
        printf("%d ", arr[i]);

    printf("\nTime taken: %lf micro seconds\n", time_taken * 1000000);
}
```

Output with input size vs time graph:

Heap Sort	
Input Size	Time taken (in micro seconds)
1000	3000
25000	16000
50000	11000
75000	18000
100000	30000
125000	38000
150000	45000
175000	54000
200000	52000
225000	62000
250000	66000




```
Given array is
12 11 13 5 6 7

Sorted array is
5 6 7 11 12 13
```

7. 0/1 Knapsack Problem

Aim: To optimize(maximize) the items in the knapsack for our requirement using 0/1 Knapsack algorithm

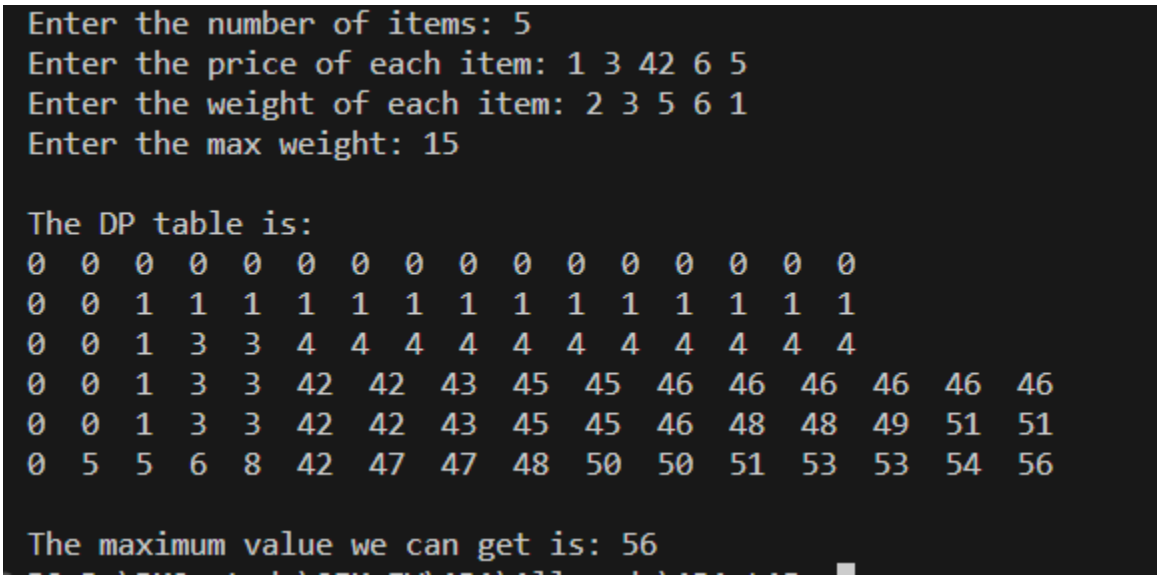
Code:

```
#include <stdio.h>


int main(void)
{
   printf("Enter the number of items: ");
   int n;
   scanf("%d", &n);

   printf("Enter the price of each item: ");
   int price[n];
   int i;
   for (i = 0; i < n; i++)
   {
      scanf("%d", &price[i]);
   }

   printf("Enter the weight of each item: ");
   int weight[n];
   for (i = 0; i < n; i++)
   {
      scanf("%d", &weight[i]);
   }

   printf("Enter the max weight: ");
```

```
    int W;
    scanf("%d", &W);

    printf("\nThe dp table is:\n");
    int dp[n + 1][W + 1];
    for (i = 0; i <= n; i++)
    {
        for (int j = 0; j <= W; j++)
        {
            if (i == 0 || j == 0)
            {
                dp[i][j] = 0;
            }
            else if (weight[i - 1] <= j)
            {
                dp[i][j] = (price[i - 1] + dp[i - 1][j - weight[i - 1]]) > dp[i - 1][j] ? (price[i - 1] + dp[i - 1][j - weight[i - 1]]) : dp[i - 1][j];
            }
            else
            {
                dp[i][j] = dp[i - 1][j];
            }
            printf("%d  ", dp[i][j]);
        }
        printf("\n");
    }

    printf("\nThe maximum value we can get is: %d", dp[n][W]);
```

```
    return 0;
}
```

Output:



8. Floyd's Algorithm

Aim: To find out the shortest path between all pairs of vertices

Code:

```
#include <stdio.h>

int main(void)
{
   printf("Enter the number of vertices: ");
   int n;
   scanf("%d", &n);

   printf("Enter the adjacency matrix(use 999 as infinity):\n");
   int adj[n][n];
   int i, j, k;
   for (i = 0; i < n; i++)
   {
      for (int j = 0; j < n; j++)
      {
         scanf("%d", &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[i][k] + adj[k][j])
                {
                    adj[i][j] = adj[i][k] + adj[k][j];
                }
            }
        }
    }

    printf("The shortest path matrix is:\n");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < n; j++)
        {
            printf("%d\t", adj[i][j]);
        }
        printf("\n");
    }
}
```

Output:

```
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc FloydWarshall.c -o FloydWarshall } ; if ($?) { .\FloydWarshall }
Enter the number of vertices: 4
Enter the adjacency matrix(use 999 as infinity):
0 5 999 10
999 0 3 999
999 999 0 1
999 999 999 0
The shortest path matrix is:
0       5       8       9
999     0       3       4
999     999     0       1
999     999     999     0
```

9. Prim's and Kruskal's algorithm

Aim: To find minimal spanning tree of a graph using Prim's and Kruskal's algorithms

Prim's Algorithm Code:

```
#include <stdio.h>

int main(void)
{
   printf("Enter the number of vertices: ");
   int n;
   scanf("%d", &n);

   printf("Enter the adjacency matrix:\n");
   int adj[n][n];
   int i, j, k;
   for (i = 0; i < n; i++)
   {
      for (int j = 0; j < n; j++)
      {
         scanf("%d", &adj[i][j]);
      }
   }

   int visited[n];
   for (i = 0; i < n; i++)
   {
      visited[i] = 0;
```

```
}

printf("Enter the starting vertex: ");
int start;
scanf("%d", &start);
visited[start] = 1;

printf("\nThe minimal spanning tree is:\nEdge : Weight\n");
for (k = 0; k < n - 1; k++)
{
   int min = 999;
   int u = 0;
   int v = 0;
   for (i = 0; i < n; i++)
   {
      if (visited[i])
      {
         for (j = 0; j < n; j++)
         {
            if (!visited[j] && adj[i][j])
            {
               if (min > adj[i][j])
               {
                  min = adj[i][j];
                  u = i;
                  v = j;
               }
            }
         }
```

```
        }
      }
      printf("%d - %d : %d\n", u, v, adj[u][v]);
      visited[v] = 1;
    }
}
```

Output:

```
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc Prims.c -o Prims } ; if ($?) { .\Prims }
Enter the number of vertices: 4
Enter the adjacency matrix:
0 2 0 6
2 0 3 8
0 3 0 5
6 8 5 0
Enter the starting vertex: 2

The minimal spanning tree is:
Edge : Weight
2 - 1 : 3
1 - 0 : 2
2 - 3 : 5
```

Kruskal's Algorithm Code:

```
#include <stdio.h>

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

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

int main(void)
{
   printf("Enter the number of vertices: ");
   int n;
   scanf("%d", &n);

   printf("Enter the adjacency matrix(use 999 as infinity):\n");
   int adj[n][n];
   int i;
   for (i = 0; i < n; i++)
```

```
{
    for (int j = 0; j < n; j++)
    {
        scanf("%d", &adj[i][j]);
    }
}

int parent[n];
for (i = 0; i < n; i++)
{
    parent[i] = i;
}

int count = 0, k = 0, min, sum = 0, j, t[n][n], u, v;

while (count != n - 1)
{
    min = 999;
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < n; j++)
        {
            if (adj[i][j] < min && adj[i][j] != 0)
            {
                min = adj[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 + adj[u][v];
    }
    adj[u][v] = adj[v][u] = 999;
}

if (count == n - 1)
{
    printf("The minimal spanning tree is as:\n");
    for (i = 0; i < n - 1; i++)
    {
        printf("%d -> %d\n", t[i][0], t[i][1]);
    }
    printf("Cost of spanning tree = %d\n", sum);
}
else
{
    printf("\nSpanning tree does not exist!");
```

```
    }
}
```

Output:

```
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc Kruskal.c -o Kruskal } ; if ($?) { .\Kruskal }
Enter the number of vertices: 4
Enter the adjacency matrix(use 999 as infinity):
0 2 0 6
2 0 3 8
0 3 0 5
6 8 5 0
The minimal spanning tree is as:
0 -> 1
1 -> 2
2 -> 3
Cost of spanning tree = 10
```

10. Dijkstra's Algorithm

Aim: To find shortest paths to other vertices from a given vertex in a weighted connected graph using Dijkstra's algorithm

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <limits.h>

int main(void)
{
   printf("Enter the number of vertices: ");
   int n;
   scanf("%d", &n);
   int **arr = (int **)malloc(n * sizeof(int *));

   int i, j;
   printf("Enter cost matrix(use 999 for infinity):\n");
   for (i = 0; i < n; i++)
   {
      arr[i] = (int *)malloc(n * sizeof(int));
      for (j = 0; j < n; j++)
      {
         scanf("%d", &arr[i][j]);
      }
   }

   printf("Enter the source vertex: ");
```

```
    int src;
    scanf("%d", &src);

    int dist[n];
    int visited[n];
    for (i = 0; i < n; i++)
    {
        dist[i] = INT_MAX;
        visited[i] = 0;
    }
    dist[src] = 0;

    for (int count = 0; count < n - 1; count++)
    {
        int min = INT_MAX, min_index;
        for (i = 0; i < n; i++)
        {
            if (!visited[i] && dist[i] <= min)
            {
                min = dist[i], min_index = i;
            }
        }

        visited[min_index] = 1;

        for (i = 0; i < n; i++)
        {
            if (!visited[i] && arr[min_index][i] && dist[min_index] != INT_MAX &&
dist[min_index] + arr[min_index][i] < dist[i])
```

```
            {
                dist[i] = dist[min_index] + arr[min_index][i];
            }
        }
    }

    printf("The shortest path from source vertex %d to all other vertices is:\n", src);
    for (i = 0; i < n; i++)
    {
        printf("%d -> %d: %d\n", src, i, dist[i]);
    }


    for (i = 0; i < n; i++)
    {
        free(arr[i]);
    }
    free(arr);
}
```

Output:

```
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc Dijsktras.c -o Dijsktras } ; if ($?) { .\Dijsktras }
Enter the number of vertices: 4
Enter cost matrix(use 999 for infinity):
0  5  3  4
5  0  1  2
3  1  0  4
4  2  4  0
Enter the source vertex: 1
The shortest path from source vertex 1 to all other vertices is:
1 -> 0: 4
1 -> 1: 0
1 -> 2: 1
1 -> 3: 2
```

11. N – Queen's Problem

Aim: To calculate a solution to place N queens in an N x N chess board such that no two queens cancel each other

Code:

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

int n;

bool isSafe(int **arr, int x, int y)
{
   int row, col;

   for (row = 0; row < x; row++)
   {
      if (arr[row][y] == 1)
      {
         return false;
      }
   }

   for (row = x, col = y; row >= 0 && col >= 0; row--, col--)
   {
      if (arr[row][col] == 1)
      {
         return false;
```

```
        }
    }
    for (row = x, col = y; row >= 0 && col < n; row--, col++)
    {
        if (arr[row][col] == 1)
        {
            return false;
        }
    }

    return true;
}

bool nQueen(int **arr, int x)
{
    if (x >= n)
    {
        return true;
    }

    for (int col = 0; col < n; col++)
    {
        if (isSafe(arr, x, col))
        {
            arr[x][col] = 1;

            if (nQueen(arr, x + 1))
            {
                return true;
```

```
            }

            arr[x][col] = 0;
        }
    }

    return false;
}

int main(void)
{
    printf("Enter the size of board: ");
    scanf("%d", &n);
    int **arr = (int **)malloc(n * sizeof(int *));

    int i, j;
    for (i = 0; i < n; i++)
    {
        arr[i] = (int *)malloc(n * sizeof(int));
        for (j = 0; j < n; j++)
        {
            arr[i][j] = 0;
        }
    }

    if (nQueen(arr, 0))
    {
        for (i = 0; i < n; i++)
        {
```

```
            for (j = 0; j < n; j++)
            {
                printf("%d ", arr[i][j]);
            }
            printf("\n");
        }
    }
    else
    {
        printf("\nSolution does not exist!");
    }
}
```

Output:

```
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc NQueen.c -o NQueen } ; if ($?) { .\NQueen }
Enter the size of board: 4
0 1 0 0
0 0 0 1
1 0 0 0
0 0 1 0
PS D:\codes\ADA Lab> cd "d:\codes\ADA Lab\" ; if ($?) { gcc NQueen.c -o NQueen } ; if ($?) { .\NQueen }
Enter the size of board: 3

Solution does not exist!
```

```
Enter the size of board: 5
1 0 0 0 0
0 0 1 0 0
0 0 0 0 1
0 1 0 0 0
0 0 0 1 0
```