

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

“JnanaSangama”, Belgaum -590014, Karnataka.



LAB REPORT on

Analysis and Design of Algorithms

Submitted by

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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)

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Department of Computer Science and Engineering



CERTIFICATE

This is to certify that the Lab work entitled "**Analysis and Design of Algorithms**" carried out by **S Rakhal(1BM22CS229)**, 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 April-2024 to August-2024. The Lab report has been approved as it satisfies the academic requirements in respect of an **Analysis and Design of Algorithms (23CS4PCADA)** work prescribed for the said degree.

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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)Find All Disappeared Numbers

Given an array nums of n integers where nums[i] is in the range [1, n], return an array of all the integers in the range [1, n] that do not appear in nums.

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

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

```
void swapArray(int* arr, int first, int second) {  
    int temp = arr[first];  
    arr[first] = arr[second];  
    arr[second] = temp;  
}
```

```
void cyclicSort(int* arr, int size) {  
    int i = 0;  
    while (i < size) {  
        if (arr[i] != arr[arr[i] - 1] && arr[i] <= size) {  
            swapArray(arr, i, arr[i] - 1);  
        } else {  
            i++;  
        }  
    }  
}
```

```
int* findDisappearedNumbers(int* nums, int numsSize, int* returnSize) {  
    int* result = (int*)malloc(sizeof(int) * numsSize);  
    *returnSize = 0;
```

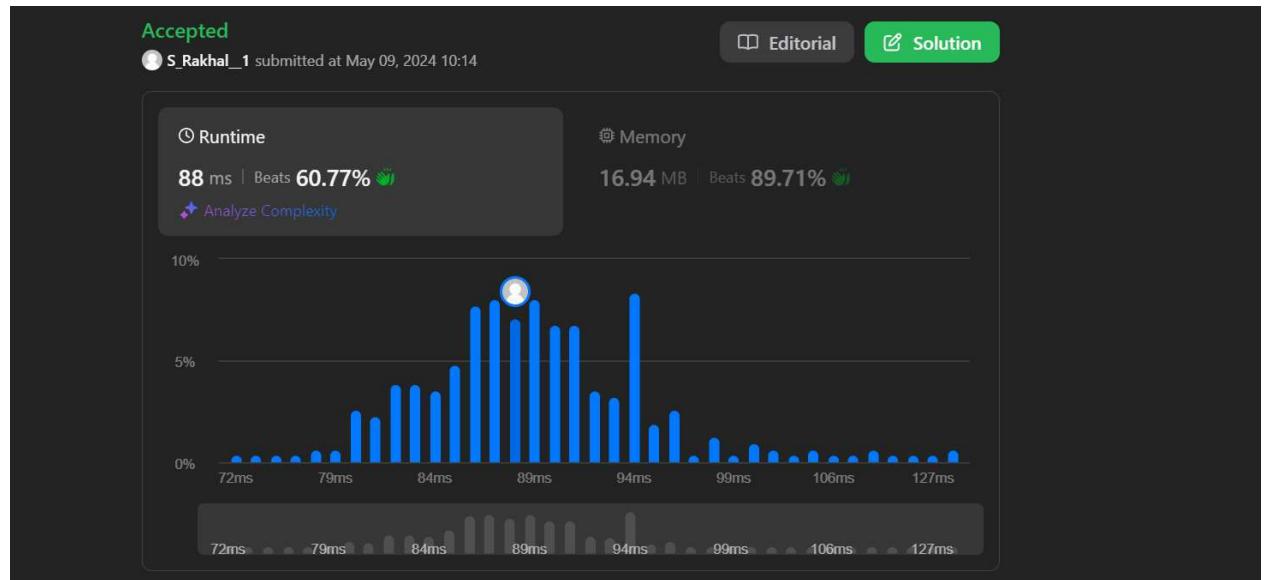
```

cyclicSort(nums, numsSize);

for (int i = 0; i < numsSize; i++) {
    if (nums[i] != i + 1) {
        result[(*returnSize)++] = i + 1;
    }
}

return result;
}

```



2) Zig zag or level order traversal

Given the root of a binary tree, return the zigzag level order traversal of its nodes' values. (i.e., from left to right, then right to left for the next level and alternate between).

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

/** 
 * Return an array of arrays of integers. The size of the returned array is *returnSize.
 * The sizes of the arrays are returned as *columnSizes array.
 */
int** zigzagLevelOrder(struct TreeNode* root, int* returnSize, int** columnSizes) {
    if (root == NULL) {
        *returnSize = 0;
        *columnSizes = NULL;
        return NULL;
    }

    // Initialize the result array
    int** res = (int**)malloc(sizeof(int*) * 2048);
    *columnSizes = (int*)malloc(sizeof(int) * 2048);
    *returnSize = 0;

    // Initialize the queue
    struct TreeNode** queue = (struct TreeNode**)malloc(sizeof(struct TreeNode*) * 2048);
    int front = 0, rear = 0;
```

```

// Add the root to the queue
queue[rear++] = root;

// Traverse the tree in a zigzag manner
bool zigzag = false;
while (front != rear) {
    int size = rear - front;
    res[*returnSize] = (int*)malloc(sizeof(int) * size);
    (*columnSizes)[*returnSize] = size;

    for (int i = 0; i < size; i++) {
        struct TreeNode* node = queue[front++];
        if (zigzag) {
            res[*returnSize][size - i - 1] = node->val;
        } else {
            res[*returnSize][i] = node->val;
        }

        if (node->left) {
            queue[rear++] = node->left;
        }
        if (node->right) {
            queue[rear++] = node->right;
        }
    }
}

```

```
(*returnSize)++;  
zigzag = !zigzag;  
}
```

```
free(queue);  
return res;  
}
```



3)Increasing Order Search Tree

Given the root of a binary search tree, rearrange the tree in in-order so that the leftmost node in the tree is now the root of the tree, and every node has no left child and only one right child.

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

void dfs(struct TreeNode *node, int *list, int *size) {
    if (node == NULL) {
        return;
    }
    list[*size] = node->val;
    (*size)++;
    dfs(node->left, list, size);
    dfs(node->right, list, size);
}

struct TreeNode *increasingBST(struct TreeNode *root) {
    int *list = (int *)malloc(sizeof(int) * 1000); // Assuming the list size is less than 1000
    int size = 0;
    dfs(root, list, &size);

    // Sort the list
    for (int i = 0; i < size - 1; i++) {
        for (int j = 0; j < size - i - 1; j++) {
            if (list[j] > list[j + 1]) {
```

```

        int temp = list[j];
        list[j] = list[j + 1];
        list[j + 1] = temp;
    }
}

}

// Create the new tree
struct TreeNode *res = (struct TreeNode *)malloc(sizeof(struct TreeNode));
res->val = list[0];
res->left = NULL;
res->right = NULL;
struct TreeNode *temp = res;
for (int i = 1; i < size; i++) {
    struct TreeNode *node = (struct TreeNode *)malloc(sizeof(struct TreeNode));
    node->val = list[i];
    node->left = NULL;
    node->right = NULL;
    temp->right = node;
    temp = node;
}
free(list);
return res;
}

```

Accepted

S_Rakhal_1 submitted at May 16, 2024 08:17

Editorial

Solution

Runtime

3 ms | Beats 54.41%

Analyze Complexity

Memory

6.40 MB | Beats 5.88%



Write a program to obtain the Topological ordering of vertices in a given digraph using Source Removal method.

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

#define MAX_VERTICES 100

typedef struct Queue
{
    int items[MAX_VERTICES];
    int front;
    int rear;
} Queue;

void enqueue(Queue *q, int value);
int dequeue(Queue *q);
int isEmpty(Queue *q);

void topologicalSort(int n, int graph[][MAX_VERTICES]);

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

    int graph[MAX_VERTICES][MAX_VERTICES] = {0};
```

```

printf("Enter the adjacency matrix of the graph:\n");
for (int i = 0; i < n; i++)
{
    for (int j = 0; j < n; j++)
    {
        scanf("%d", &graph[i][j]);
    }
}
printf("\nTopological sorting of vertices:\n");
topologicalSort(n, graph);

return 0;
}

```

```

void topologicalSort(int n, int graph[][MAX_VERTICES])
{
    int indegree[MAX_VERTICES] = {0};
    Queue q;
    q.front = -1;
    q.rear = -1;

    for (int i = 0; i < n; i++)
    {
        for (int j = 0; j < n; j++)
        {
            if (graph[i][j] == 1)

```

```

    {
        indegree[j]++;
    }
}

for (int i = 0; i < n; i++)
{
    if (indegree[i] == 0)
    {
        enqueue(&q, i);
    }
}

while (!isEmpty(&q))
{
    int vertex = dequeue(&q);
    printf("%d ", vertex);

    for (int i = 0; i < n; i++)
    {
        if (graph[vertex][i] == 1)
        {
            if (--indegree[i] == 0)
            {
                enqueue(&q, i);
            }
        }
    }
}

```

```

        }
    }
}
}

printf("\n");

}

void enqueue(Queue *q, int value)
{
    if (q->rear == MAX_VERTICES - 1)
    {
        printf("Queue is full\n");
    }

    else
    {
        if (q->front == -1)
        {
            q->front = 0;
        }

        q->rear++;
        q->items[q->rear] = value;
    }
}

int dequeue(Queue *q)

```

```

{
    int item;
    if (isEmpty(q))
    {
        printf("Queue is empty\n");
        item = -1;
    }
    else
    {
        item = q->items[q->front];
        q->front++;
        if (q->front > q->rear)
        {
            q->front = q->rear = -1;
        }
    }
    return item;
}

```

```

int isEmpty(Queue *q)
{
    if (q->rear == -1)
    {
        return 1;
    }
    else
    {

```

```
    return 0;  
}  
}
```

```
Enter the number of vertices in the graph: 5
```

```
Enter the adjacency matrix of the graph:
```

```
0 1 1 0 0  
0 0 1 0 0  
0 0 0 1 1  
0 0 0 0 1  
0 0 0 0 0
```

```
Topological sorting of vertices:
```

```
0 1 2 3 4
```

2. Implement Johnson Trotter algorithm to generate permutations

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

#define MAX_N 10
#define LEFT 0
#define RIGHT 1

typedef struct
{
    int value;
    int direction;
} Element;

void printPermutations(int n);
void generatePermutations(Element permutation[], int n);
int findLargestMobile(Element permutation[], int n);

int main()
{
    int n;
    printf("Enter the number of elements (max %d): ", MAX_N);
    scanf("%d", &n);

    if (n > MAX_N || n <= 0)
    {
        printf("Invalid input size. Please enter a valid number between 1 and %d.\n", MAX_N);
```

```

    return 1;
}

printf("Permutations of %d elements:\n", n);
printPermutations(n);
return 0;
}

void printPermutations(int n)
{
    Element permutation[MAX_N];
    for (int i = 0; i < n; i++)
    {
        permutation[i].value = i + 1;
        permutation[i].direction = LEFT;
    }

    for (int i = 0; i < n; i++)
    {
        printf("%d ", permutation[i].value);
    }
    printf("\n");
    generatePermutations(permutation, n);
}

void generatePermutations(Element permutation[], int n)
{

```

```

while (true)
{
    int mobileIdx = findLargestMobile(permuation, n);

    if (mobileIdx == -1)
    {
        break;
    }

    int swapIdx = mobileIdx + (permuation[mobileIdx].direction == LEFT ? -1 : 1);
    Element temp = permuation[mobileIdx];
    permuation[mobileIdx] = permuation[swapIdx];
    permuation[swapIdx] = temp;

    for (int i = 0; i < n; i++)
    {
        if (permuation[i].value > permuation[swapIdx].value)
        {
            permuation[i].direction = (permuation[i].direction == LEFT) ? RIGHT : LEFT;
        }
    }

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

```

```

int findLargestMobile(Element permutation[], int n)
{
    int mobileIdx = -1;
    int maxMobileValue = -1;
    for (int i = 0; i < n; i++)
    {
        int direction = permutation[i].direction;
        int adjacentIdx = i + (direction == LEFT ? -1 : 1);
        if (adjacentIdx >= 0 && adjacentIdx < n &&
            permutation[i].value > permutation[adjacentIdx].value &&
            permutation[i].value > maxMobileValue)
        {
            mobileIdx = i;
            maxMobileValue = permutation[i].value;
        }
    }
    return mobileIdx;
}

```

Enter the number of elements (max 10): 3

Permutations of 3 elements:

1 2 3

1 3 2

3 1 2

3 2 1

2 3 1

2 1 3



Brute force pattern Matching

```
#include<stdio.h>
#include<conio.h>
#include<stdlib.h>
void main()
{
    int i,j,k,n,m,flag=0;
    char t[40],p[30];
    clrscr();
    printf("Enter text: ");
    gets(t);
    printf("\nEnter pattern: ");
    gets(p);
    n=strlen(t);
    m=strlen(p);
    for(i=0;i<=n-m;i++)
    {
        j=0;
        while(j<m && p[j]==t[j+i])
        {
            j++;
            if(j==m)
            {
                flag=1;
                k=i+1;
            }
        }
    }
}
```

```
else
    flag=0;
}
}
if(flag==1)
    printf("\nPattern found at position: %d\n ",k);
else
    printf("\nPattern not found in text \n");
getch();
}
```

```
Enter text: mca programme
Enter pattern: programme
Pattern found at position: 5
```

3. 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.

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

void merge(int arr[], int left, int mid, int right)
{
    int n1 = mid - left + 1;
    int n2 = right - mid;

    int L[n1], R[n2];

    for (int i = 0; i < n1; i++)
        L[i] = arr[left + i];
    for (int j = 0; j < n2; j++)
        R[j] = arr[mid + 1 + j];

    int i = 0;
    int j = 0;
    int k = left;

    while (i < n1 && j < n2)
    {
        if (L[i] <= R[j])
        {
            arr[k] = L[i];
            i++;
        }
        else
        {
            arr[k] = R[j];
            j++;
        }
        k++;
    }

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

    while (j < n2)
        arr[k++] = R[j++];
}
```

```

    i++;
}
else
{
    arr[k] = R[j];
    j++;
}
k++;
}

while (i < n1)
{
    arr[k] = L[i];
    i++;
    k++;
}
while (j < n2)
{
    arr[k] = R[j];
    j++;
    k++;
}
}

```

```

void mergeSort(int arr[], int left, int right)
{
    if (left < right)
    {

```

```

        int mid = left + (right - left) / 2;

        mergeSort(arr, left, mid);
        mergeSort(arr, mid + 1, right);

        merge(arr, left, mid, right);
    }

}

void printArray(int arr[], int size)
{
    for (int i = 0; i < size; i++)
        printf("%d ", arr[i]);
    printf("\n");
}

int main()
{
    int n;
    clock_t start, end;
    double cpu_time_used;

    printf("Enter the number of elements: ");
    scanf("%d", &n);

    int arr[n];

```

```

printf("Enter %d integers:\n", n);
for (int i = 0; i < n; i++)
    scanf("%d", &arr[i]);

printf("Unsorted array: ");
printArray(arr, n);

start = clock();
mergeSort(arr, 0, n - 1);
end = clock();
cpu_time_used = ((double)(end - start)) / CLOCKS_PER_SEC;

printf("Sorted array: ");
printArray(arr, n);

printf("Time taken to sort: %f seconds\n", cpu_time_used);

return 0;
}

```

```

Enter the number of elements: 6
Enter 6 integers:
3 4 1 6 3 2
Unsorted array: 3 4 1 6 3 2
Sorted array: 1 2 3 3 4 6
Time taken to sort: 0.000000 seconds

```

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

```
#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);
    }
}

void printArray(int arr[], int size)
{
    for (int i = 0; i < size; i++)
        printf("%d ", arr[i]);
    printf("\n");
}

int main()
{
    int n;
    clock_t start, end;
    double cpu_time_used;

```

```

printf("Enter the number of elements: ");
scanf("%d", &n);
int arr[n];

printf("Enter %d integers:\n", n);
for (int i = 0; i < n; i++)
    scanf("%d", &arr[i]);

printf("Unsorted array: ");
printArray(arr, n);
start = clock();

quickSort(arr, 0, n - 1);

end = clock();
cpu_time_used = ((double)(end - start)) / CLOCKS_PER_SEC;
printf("Sorted array: ");
printArray(arr, n);
printf("Time taken to sort: %f seconds\n", cpu_time_used);

return 0;
}

```

```

Enter the number of elements: 10
Enter 10 integers:
9 7 5 2 4 6 8 1 10 0
Unsorted array: 9 7 5 2 4 6 8 1 10 0
Sorted array: 0 1 2 4 5 6 7 8 9 10
Time taken to sort: 0.000000 seconds

```

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

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

void heapify(int arr[], int n, int i)
{
    int largest = i;
    int l = 2 * i + 1;
    int r = 2 * i + 2;

    if (l < n && arr[l] > arr[largest])
        largest = l;

    if (r < n && arr[r] > arr[largest])
        largest = r;

    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);
    }
}

```

```

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

```

```

int main()
{
    int n;
    clock_t start, end;

```

```

double cpu_time_used;

printf("Enter the number of elements: ");
scanf("%d", &n);

int arr[n];

printf("Enter %d integers:\n", n);
for (int i = 0; i < n; i++)
    scanf("%d", &arr[i]);

printf("Unsorted array: ");
printArray(arr, n);

start = clock();

heapSort(arr, n);

end = clock();

cpu_time_used = ((double)(end - start)) / CLOCKS_PER_SEC;

printf("Sorted array: ");
printArray(arr, n);

printf("Time taken to sort: %f seconds\n", cpu_time_used);

return 0;
}

```

```

Enter the number of elements: 7
Enter 7 integers:
4 2 3 5 1 6 7
Unsorted array: 4 2 3 5 1 6 7
Sorted array: 1 2 3 4 5 6 7
Time taken to sort: 0.000000 seconds

```

6. (a) Implement All Pair Shortest paths problem using Floyd's algorithm.

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

#define V 4

void printSolution(int dist[][V])
{
    printf("Shortest distances between every pair of vertices:\n");
    for (int i = 0; i < V; i++)
    {
        for (int j = 0; j < V; j++)
        {
            if (dist[i][j] == INT_MAX)
                printf("INF\t");
            else
                printf("%d\t", dist[i][j]);
        }
        printf("\n");
    }
}

void floydWarshall(int graph[][V])
{
    int dist[V][V];

```

```

for (int i = 0; i < V; i++)
    for (int j = 0; j < V; j++)
        dist[i][j] = graph[i][j];

for (int k = 0; k < V; k++)
{
    for (int i = 0; i < V; i++)
    {
        for (int j = 0; j < V; j++)
        {
            if (dist[i][k] != INT_MAX && dist[k][j] != INT_MAX && dist[i][k] + dist[k][j] < dist[i][j])
                dist[i][j] = dist[i][k] + dist[k][j];
        }
    }
}

printSolution(dist);
}

int main()
{
    int graph[V][V] = {
        {0, 5, INT_MAX, 10},
        {INT_MAX, 0, 3, INT_MAX},
        {INT_MAX, INT_MAX, 0, 1},
        {INT_MAX, INT_MAX, INT_MAX, 0}};
}

```

```
floydWarshall(graph);  
  
return 0;  
}
```

```
Shortest distances between every pair of vertices:
```

0	5	8	9
INF	0	3	4
INF	INF	0	1
INF	INF	INF	0

7. (a) Implement 0/1 Knapsack problem using dynamic programming.

```
#include <stdio.h>

int max(int a, int b)

{
    return (a > b) ? a : b;
}

int knapsack(int W, int wt[], int val[], int n)

{
    int i, w;
    int K[n + 1][W + 1];
    for (i = 0; i <= n; i++)
    {
        for (w = 0; w <= W; w++)
        {
            if (i == 0 || w == 0)
                K[i][w] = 0;
            else if (wt[i - 1] <= w)
                K[i][w] = max(val[i - 1] + K[i - 1][w - wt[i - 1]], K[i - 1][w]);
            else
                K[i][w] = K[i - 1][w];
        }
    }
    return K[n][W];
}
```

```

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

    int val[n], wt[n];

    printf("Enter values and weights of items:\n");
    for (int i = 0; i < n; i++)
    {
        printf("Enter value and weight for item %d: ", i + 1);
        scanf("%d %d", &val[i], &wt[i]);
    }

    printf("Enter maximum weight capacity of knapsack: ");
    scanf("%d", &W);

    int max_value = knapsack(W, wt, val, n);
    printf("Maximum value that can be obtained: %d\n", max_value);

    return 0;
}

```

```
Enter number of items: 3
Enter values and weights of items:
Enter value and weight for item 1: 60 10
Enter value and weight for item 2: 100 20
Enter value and weight for item 3: 120 30
Enter maximum weight capacity of knapsack: 50
Maximum value that can be obtained: 220
```

8. (a) Find Minimum Cost Spanning Tree of a given undirected graph using Prim's algorithm.

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

#define V 5

int minKey(int key[], int mstSet[])
{
    int min = INT_MAX, min_index;
    for (int v = 0; v < V; v++)
        if (mstSet[v] == 0 && key[v] < min)
            min = key[v], min_index = v;
    return min_index;
}

void printMST(int parent[], int graph[V][V])
{
    printf("Edge \tWeight\n");
    for (int i = 1; i < V; i++)
        printf("%d - %d \t%d \n", parent[i], i, graph[i][parent[i]]);
}

void primMST(int graph[V][V])
{
    int parent[V];

```

```

int key[V];
int mstSet[V];
for (int i = 0; i < V; i++)
    key[i] = INT_MAX, mstSet[i] = 0;
key[0] = 0;
parent[0] = -1;
for (int count = 0; count < V - 1; count++)
{
    int u = minKey(key, mstSet);
    mstSet[u] = 1;
    for (int v = 0; v < V; v++)
        if (graph[u][v] && mstSet[v] == 0 && graph[u][v] < key[v])
            parent[v] = u, key[v] = graph[u][v];
}
printMST(parent, graph);
}

int main()
{
    int graph[V][V] = {
        {0, 2, 0, 6, 0},
        {2, 0, 3, 8, 5},
        {0, 3, 0, 0, 7},
        {6, 8, 0, 0, 9},
        {0, 5, 7, 9, 0},
    };
    primMST(graph);
}

```

```
    return 0;  
}  
  
}
```

Edge	Weight
0 - 1	2
1 - 2	3
0 - 3	6
1 - 4	5

10) Find Minimum Cost Spanning Tree of a given undirected graph using Kruskal's algorithm.

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

#define MAX_VERTICES 20

struct Edge
{
    int src, dest, weight;
};

void Union(int parent[], int rank[], int x, int y);
int find(int parent[], int i);
void KruskalMST(struct Edge *edges, int V, int E);

int find(int parent[], int i)
{
    if (parent[i] != i)
        parent[i] = find(parent, parent[i]);
    return parent[i];
}

void Union(int parent[], int rank[], int x, int y)
{
    int xroot = find(parent, x);
```

```

int yroot = find(parent, y);
if (rank[xroot] < rank[yroot])
    parent[xroot] = yroot;
else if (rank[xroot] > rank[yroot])
    parent[yroot] = xroot;
else
{
    parent[yroot] = xroot;
    rank[xroot]++;
}
}

int compareEdges(const void *a, const void *b)
{
    struct Edge *edge1 = (struct Edge *)a;
    struct Edge *edge2 = (struct Edge *)b;
    return edge1->weight - edge2->weight;
}

void KruskalMST(struct Edge *edges, int V, int E)
{
    struct Edge result[V];
    int e = 0;
    int i = 0;

    qsort(edges, E, sizeof(struct Edge), compareEdges);

```

```

int parent[V];
int rank[V];
for (int v = 0; v < V; ++v)
{
    parent[v] = v;
    rank[v] = 0;
}

while (e < V - 1 && i < E)
{
    struct Edge next_edge = edges[i++];
    int u = find(parent, next_edge.src);
    int v = find(parent, next_edge.dest);
    if (u != v)
    {
        result[e++] = next_edge;
        Union(parent, rank, u, v);
    }
}

printf("Edges in the Minimum Spanning Tree:\n");
for (i = 0; i < e; ++i)
{
    printf("%d -- %d == %d\n", result[i].src, result[i].dest, result[i].weight);
}

```

```

int main()
{
    int V, E;
    printf("Enter the number of vertices: ");
    scanf("%d", &V);
    printf("Enter the number of edges: ");
    scanf("%d", &E);

    struct Edge edges[E];

    printf("Enter the source, destination, and weight of each edge:\n");
    for (int i = 0; i < E; ++i)
    {
        scanf("%d %d %d", &edges[i].src, &edges[i].dest, &edges[i].weight);
    }
    KruskalMST(edges, V, E);

    return 0;
}

```

```
Enter the number of vertices: 4
Enter the number of edges: 5
Enter the source, destination, and weight of each edge:
0 1 10
0 2 6
0 3 5
1 3 15
1 2 6
Edges in the Minimum Spanning Tree:
0 -- 3 == 5
0 -- 2 == 6
1 -- 2 == 6
```

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

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

#define MAX 100

int minDistance(int dist[], bool sptSet[], int V)
{
    int min = INT_MAX, min_index;

    for (int v = 0; v < V; v++)
        if (sptSet[v] == false && dist[v] <= min)
            min = dist[v], min_index = v;

    return min_index;
}

void printSolution(int dist[], int V)
{
    printf("Vertex \t Distance from Source\n");
    for (int i = 0; i < V; i++)
        printf("%d \t\t %d\n", i, dist[i]);
}
```

```

void dijkstra(int graph[MAX][MAX], int src, int V)

{
    int dist[V];
    bool sptSet[V];

    for (int i = 0; i < V; i++)
        dist[i] = INT_MAX, sptSet[i] = false;

    dist[src] = 0;

    for (int count = 0; count < V - 1; count++)
    {
        int u = minDistance(dist, sptSet, V);
        sptSet[u] = true;

        for (int v = 0; v < V; v++)
            if (!sptSet[v] && graph[u][v] && dist[u] != INT_MAX && dist[u] + graph[u][v] < dist[v])
                dist[v] = dist[u] + graph[u][v];
    }

    printSolution(dist, V);
}

int main()
{
    int V;

```

```

printf("Enter the number of vertices: ");
scanf("%d", &V);

int graph[MAX][MAX];
printf("Enter the adjacency matrix (enter 0 if there is no edge between two vertices):\n");
for (int i = 0; i < V; i++)
    for (int j = 0; j < V; j++)
        scanf("%d", &graph[i][j]);

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

dijkstra(graph, src, V);

return 0;
}

```

```

Enter the number of vertices: 5
Enter the adjacency matrix (enter 0 if there is no edge between two vertices):
0 10 0 0 5
10 0 1 0 2
0 1 0 4 0
0 0 4 0 3
5 2 0 3 0
Enter the source vertex: 0
Vertex  Distance from Source
0          0
1          7
2          8
3          8
4          5

```

9. Implement “N-Queens Problem” using Backtracking.

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

#define MAX_N 10

void printSolution(int board[MAX_N][MAX_N], int N)
{
    for (int i = 0; i < N; i++)
    {
        for (int j = 0; j < N; j++)
        {
            printf("%c ", board[i][j] ? 'Q' : '.');
        }
        printf("\n");
    }
}

bool isSafe(int board[MAX_N][MAX_N], int row, int col, int N)
{
    for (int i = 0; i < col; i++)
    {
        if (board[row][i])
        {
```

```

        return false;
    }

}

for (int i = row, j = col; i >= 0 && j >= 0; i--, j--)
{
    if (board[i][j])
    {
        return false;
    }
}

for (int i = row, j = col; i < N && j >= 0; i++, j--)
{
    if (board[i][j])
    {
        return false;
    }
}

return true;
}

```

```

bool solveNQueens(int board[MAX_N][MAX_N], int col, int N)
{
    if (col >= N)
    {

```

```

        return true;
    }

    for (int i = 0; i < N; i++)
    {
        if (isSafe(board, i, col, N))
        {
            board[i][col] = 1;

            if (solveNQueens(board, col + 1, N))
            {
                return true;
            }

            board[i][col] = 0;
        }
    }

    return false;
}

```

```

void solveNQueensWrapper(int N)
{
    int board[MAX_N][MAX_N] = {0};

    if (solveNQueens(board, 0, N))
    {
        printf("Solution found:\n");
    }
}

```

```

    printSolution(board, N);

}

else

{
    printf("Solution does not exist for N = %d\n", N);

}

int main()

{
    int N;

    printf("Enter the size of the chessboard (N): ");

    scanf("%d", &N);

    if (N <= 0 || N > MAX_N)

    {
        printf("Invalid input for N. Please enter a number between 1 and %d.\n", MAX_N);
        return 1;
    }

    solveNQueensWrapper(N);

    return 0;
}

```

```
Enter the size of the chessboard (N): 8
Solution found:
Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . . . . . . Q
. Q . . . . .
. . . Q . . . .
. . . . . Q . .
. . Q . . . . .
}
```