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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



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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 **CHAITANYA RAVINDRA(1BM21CS041)**, 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.

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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. Write program to do the following:

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

```
#include<stdio.h>
int n,i,j,visited[10],queue[10],front=0,rear=-1;
int adj[10][10];
void bfs(int v)
{
    for(i=1;i<=n;i++)
        if(adj[v][i] && !visited[i])
            queue[++rear]=i;
    if(front<=rear)
    {
        visited[queue[front]]=1;
        bfs(queue[front++]);
    }
}
int main()
{
    int v;
    printf("Enter the number of vertices\n");
    scanf("%d",&n);
    for(i=1;i<=n;i++)
    {
        queue[i]=0;
        visited[i]=0;
    }
    printf("Enter graph data in the form of adjacency matrix\n");
    for(i=1;i<=n;i++)
    {
        for(j=1;j<=n;j++)
        {
            scanf("%d",&adj[i][j]);
        }
    }
    printf("\nEnter the starting vertex\n");
    scanf("%d",&v);
```

```

    bfs(v);
    printf("The nodes which are reachable are:\n");
    for(i=1;i<=n;i++)
    {
        if(visited[i])
        {
            printf("%d\t",i);
        }
        else
        {
            printf("node not visited");
        }
    }
    return 1;
}

```

Output:

```

Enter the number of vertices
5
Enter graph data in the form of adjacency matrix
0 1 0 1 0
1 0 1 1 0
0 1 0 0 1
1 1 0 0 1
0 0 1 1 0

Enter the starting vertex
1
The nodes which are reachable are:
1      2      3      4      5

```

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

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

```
int a[20][20],visited[20],n;
```

```
void dfs(int v)
```

```
{
```

```
    int i;
```

```
    visited[v]=1;
```

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

```
    {
```

```

        if(a[v][i] && !visited[i])
        {
            printf("\n%d->%d",v,i);
            dfs(i);
        }
    }
}
int main()
{
    int i,j,count=0;
    printf("Enter number of vertices ");
    scanf("%d",&n);
    for(i=0;i<n;i++)
    {
        for(j=0;j<n;j++)
        {
            visited[i]=0;
            a[i][j]=0;
        }
    }
    for(i=0;i<n;i++)
    {
        for(j=0;j<n;j++)
        {
            scanf("%d",&a[i][j]);
        }
    }
    dfs(0);
    for(i=0;i<n;i++)
    {
        if(visited[i])
            count++;
    }
    if(count==n)
    {
        printf("\nGraph is connected\n");
    }
    else

```

```
    {  
        printf("Graph is disconnected");  
    }  
    return 1;  
}
```

Output:

```
Enter number of vertices 5  
0 1 0 1 0  
1 0 1 1 0  
0 1 0 0 1  
1 1 0 0 1  
0 0 1 1 0  
  
0->1  
1->2  
2->4  
4->3  
Graph is connected
```


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

```
#include<stdio.h>
void dfs(int);
int a[10][10],vis[10],exp[10],n,j,m;

void main()
{

    int i,x,y;
    printf("enter the number of vertices\n");
    scanf("%d",&n);
    for(i=1;i<=n;i++)
    {
        for(j=1;j<=n;j++)
        {
            a[i][j]=0;
        }
        vis[j]=0;
    }
    printf("Enter the number of edges\n");
    scanf("%d",&m);
    for(i=1;i<=m;i++)
    {
        printf("Enter an edge\n");
        scanf("%d%d",&x,&y);
        a[x][y]=1;
    }
    j=0;
    for(i=1;i<=n;i++)
    {
        if(vis[i]==0)
            dfs(i);
    }
    printf("The topological sort\n");
    for(i=n-1;i>=0;i--)
    {
```

```

        printf("%d\t",exp[i]);
    }
}
void dfs(int v)
{
    int i;
    vis[v]=1;
    for(i=1;i<=n;i++)
    {
        if(a[v][i]==1 && vis[i]==0)
        {
            dfs(i);
        }
    }
    exp[j++]=v;
}

```

Output:

```

1
enter the number of vertices
5
Enter the number of edges
6
Enter an edge
1 2
Enter an edge
2 4
Enter an edge
4 5
Enter an edge
5 3
Enter an edge
3 1
Enter an edge
1 2
The topological sort
1      2      4      5      3

```

3. Implement Johnson Trotter algorithm to generate permutations.

```
#include<stdio.h>

#define RIGHT_TO_LEFT 0
#define LEFT_TO_RIGHT 1

int searchArr(int a[],int n,int mobile)
{
    int i;
    for(i=0;i<n;i++)
    {

        if(a[i]==mobile)
            return i+1;
    }
    return -1;
}

int getMobile(int a[],int dir[],int n)
{
    int i,mobile_prev=0,mobile=0;
    for(i=0;i<n;i++)
    {

        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;
    }
}

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;
    }
}

}

return mobile;
}

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

```

```

temp=*a;

*a=*b;

*b=temp;
}

void printOnePerm(int a[],int dir[],int n)
{
    int i;

    int mobile=getMobile(a,dir,n);

    int pos=searchArr(a,n,mobile);

    if(dir[a[pos-1]-1]==RIGHT_TO_LEFT)

        swap(&a[pos-1],&a[pos-2]);

    else if(dir[a[pos-1]-1]==LEFT_TO_RIGHT)

        swap(&a[pos],&a[pos-1]);

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

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

    }

    printf(" ");
}

int fact(int n)
{

    int i, res=1;

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

        res*=i;

    return res;
}

void printPermutations(int n)
{

    int i, a[n];

    int dir[n];

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

    {

        a[i]=i+1;

```

```

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

int main()
{
    int n;

    printf("Enter the number of digits\n");

    scanf("%d",&n);

    printf("Permutations of the sequence :");

    printPermutations(n);return 0;
}

```

Output:

```

Enter the number of digits
4
Permutations of the sequence :1234
1243 1423 4123 4132 1432 1342 1324 3124 3142 3412 4312 4321 3421 3241 3214 2314 2341 2431 4231 4213 2413 2143 2134

```

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.

```
#include<stdio.h>
#include<time.h>
#include<stdlib.h>
void merge(int arr[],int l,int r,int m)
{
    int i,j,k;

    int n1=m-l+1;
    int n2=r-m;
    int left[n1], right[n2];
    for(i=0;i<n1;i++)
    {
        left[i]=arr[l+i];
    }
    for(j=0;j<n2;j++)
    {
        right[j]=arr[m+1+j];
    }
    i=0;
    j=0;
    k=l;
    while(i<n1 && j<n2)
    {
        if(left[i]<=right[j])
        {
            arr[k]=left[i];
            i++;
        }
        else
        {
            arr[k]=right[j];
            j++;
        }
        k++;
    }
}
```



```

while(i<n1)
{
    arr[k]=left[i];
    i++;
    k++;
}
while(j<n2)
{
    arr[k]=right[j];
    j++;
    k++;
}
}
void mergesort(int arr[], int l, int r)
{
    int mid;
    if(l<r)
    {
        mid=l+(r-l)/2;
        mergesort(arr,l,mid);
        mergesort(arr,mid+1,r);
        merge(arr,l,r,mid);
    }
}
void print(int arr[],int n)
{
    int i;
    for(i=0;i<n;i++)
    {
        printf("%d\t",arr[i]);
    }
}

void main()
{
    int arr[200000],n,i;
    clock_t st,et;
    float ts;

```

```

printf("Enter the size of the array\n");
scanf("%d",&n);
for(i=0;i<n;i++)
{
    arr[i]=rand();
}
if(n<=20)
{
    printf("before sorting \n");
    print(arr,n);
}

st=clock();

mergesort(arr,0,n-1);

et=clock();
ts=(float)(et-st)/CLOCKS_PER_SEC;
if(n<=20)
{
    printf("\nafter sorting using mergesort\n");
    print(arr,n);
}

//print(arr,n);
printf("\nTime taken \t %f ",ts);

}

```

Output:

```

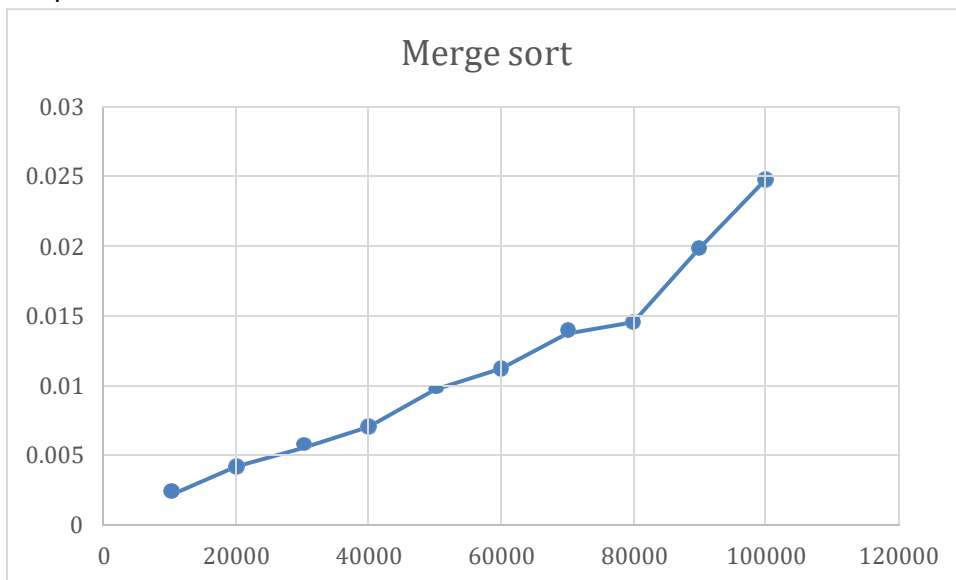
Enter the size of the array
6
before sorting
41 18467 6334 26500 19169 15724
after sorting using mergesort
41 6334 15724 18467 19169 26500

```

Table of values:

Input size(n)	Time taken
10000	0.002114
20000	0.00418
30000	0.005486
40000	0.007019
50000	0.00969
60000	0.011191
70000	0.013704
80000	0.014539
90000	0.019828
100000	0.024749

Graph:



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

```
#include<stdio.h>
#include<time.h>
#include<stdlib.h>
void swap(int *a,int *b)
{
    int temp;
    temp=*a;
    *a=*b;
    *b=temp;
}
int partition(int arr[],int l,int r)
{
    //ascending order
    int pivot=arr[r];
    int i=l-1,j;
    for(j=l;j<=r-1;j++)
    {
        if(arr[j]<pivot)
        {
            i++;
            swap(&arr[i],&arr[j]);
        }
    }
    swap(&arr[i+1],&arr[r]);
    return (i+1);
}
void quicksort(int arr[],int l,int r)
{
    int split;
    if(l<r)
    {
        split=partition(arr,l,r);
        quicksort(arr,l,split-1);
        quicksort(arr,split+1,r);
    }
}
```

```

}
void print(int arr[],int n)
{
    int i;
    for(i=0;i<n;i++)
    {
        printf("%d\t",arr[i]);
    }
}
void main()
{
    int arr[200000],n,i;
    clock_t st,et;
    float ts;
    printf("Enter the size of the array\n");
    scanf("%d",&n);
    for(i=0;i<n;i++)
    {
        arr[i]=rand();
    }
    if(n<=20)
    {
        printf("before sorting \n");
        print(arr,n);
    }
    st=clock();
    //print(arr,n);
    quicksort(arr,0,n-1);
    et=clock();
    ts=(float)(et-st)/CLOCKS_PER_SEC;
    if(n<=20)
    {
        printf("\nafter sorting using quicksort\n");
        print(arr,n);
    }

    printf("\nTime taken \t %f ",ts);
}

```

}

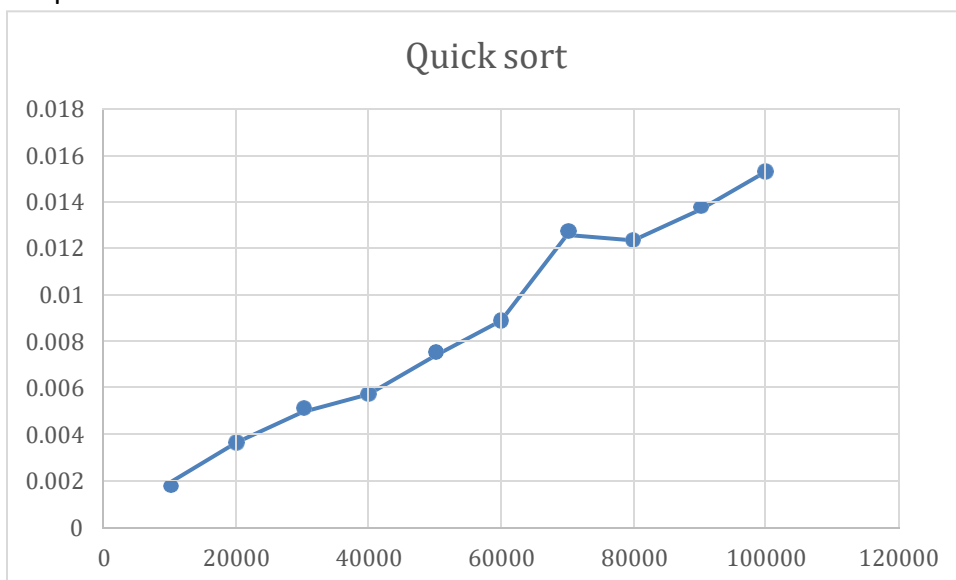
Output:

```
Enter the size of the array
5
before sorting
41      18467  6334   26500   19169
after sorting using quicksort
41      6334   18467  19169   26500
```

Table of values:

Input size(n)	Time taken
10000	0.001908
20000	0.003618
30000	0.004931
40000	0.005698
50000	0.00735
60000	0.008865
70000	0.012559
80000	0.012323
90000	0.013631
100000	0.015273

Graph:



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

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

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

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

```
void swap(int *a, int *b) {
```

```
    int temp = *a;
```

```
    *a = *b;
```

```
    *b = temp;
```

```
}
```

```
void heapify(int a[], int n, int i) {
```

```
    int largest = i, l = 2 * i + 1, r = 2 * i + 2;
```

```
    while (l < n && a[l] > a[largest]) {
```

```
        largest = l;
```

```
    }
```

```
    while (r < n && a[r] > a[largest]) {
```

```
        largest = r;
```

```
    }
```

```
    if (largest != i) {
```

```
        swap(&a[i], &a[largest]);
```

```
        heapify(a, n, largest);
```

```
    }
```

```
}
```

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

```
void heapsort(int a[], int n) {  
    int i;  
    // Create max heap  
    for (i = n / 2 - 1; i >= 0; i--) {  
        heapify(a, n, i);  
    }
```

```
    // Sort using deletion  
    for (i = n - 1; i >= 0; i--) {  
        swap(&a[0], &a[i]);  
        heapify(a, i, 0);  
    }  
}
```

```
int main() {
```



```

int n, i;

clock_t st, et;

float ts;

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

scanf("%d", &n);


// Dynamically allocate the array

int *a = (int *)malloc(n * sizeof(int));

if (a == NULL) {

    printf("Memory allocation failed.\n");

    return 1;

}


// Generate random values and place them in the array

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

    a[i] = rand();

}


st = clock();

heapsort(a, n);

et = clock();

ts = (float)(et - st) / CLOCKS_PER_SEC;


if (n <= 20) {

```

```

printf("\nAfter sorting elements are\n");

print(a, n);

}

// Free dynamically allocated memory

free(a);

printf("\nTime taken: %f seconds\n", ts);

return 0;

}

```

Output:

```

Enter the number of elements
5

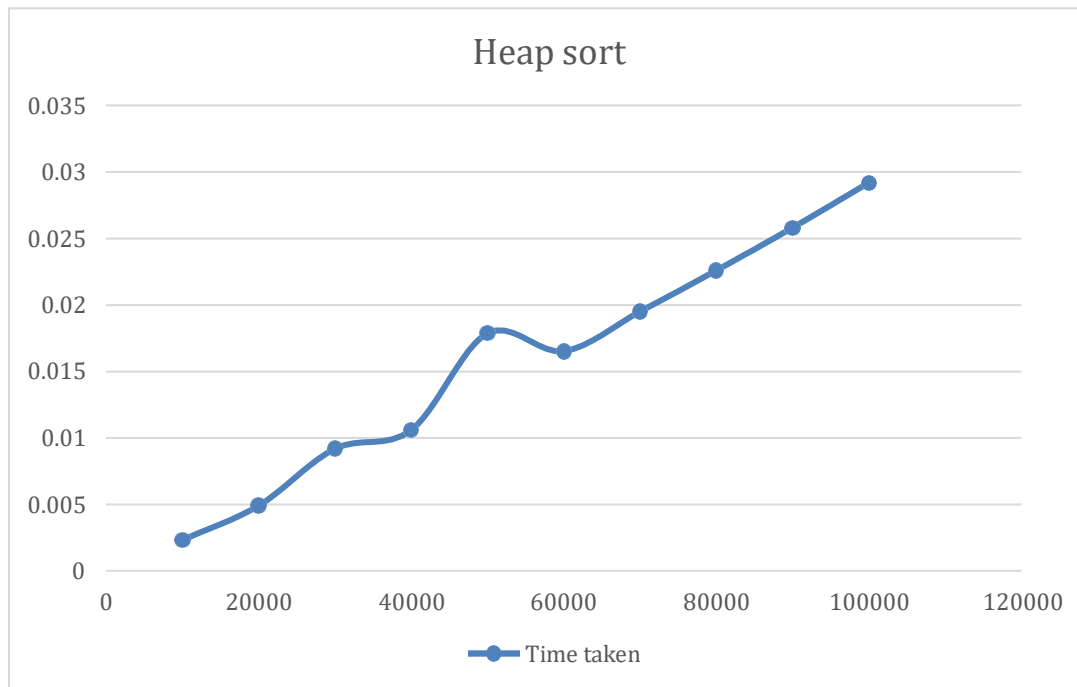
After sorting elements are
41      6334    18467    19169    26500

```

Table of values:

Input size(n)	Time taken
10000	0.002324
20000	0.004903
30000	0.009185
40000	0.010584
50000	0.017871
60000	0.016515
70000	0.019496
80000	0.022587
90000	0.025799
100000	0.029185

Graph:



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

```
#include<stdio.h>

void main()
{
    int i,j,w[10],p[10],opt[10][10],x[10],n,m;

    printf("Enter the number of items\n");

    scanf("%d",&n);

    printf("enter the weight and profit of each item\n");

    for(i=1;i<=n;i++)
    {
        scanf("%d %d",&w[i],&p[i]);
    }

    printf("enter the knapsack capacity\n");

    scanf("%d",&m);

    for(i=0;i<=n;i++)
    {
        for(j=0;j<=m;j++)
        {
            if(i==0 || j==0)
            {
                opt[i][j]=0;
            }

            else if(j-w[i]<0)
            {
```

```

        opt[i][j]=opt[i-1][j];
    }
    else
    {
        opt[i][j]=opt[i-1][j-w[i]]+p[i]>(opt[i-1][j])?opt[i-1][j-w[i]]+p[i):(opt[i-1][j]);
    }
}
}

//output
printf("\nknapsack table\n");
for(i=0;i<=n;i++)
{
    for(j=0;j<=m;j++)
    {
        printf("%d\t",opt[i][j]);
    }
    printf("\n");
}
for(i=n;i>=1;i--)
{
    if(opt[i][m]!=opt[i-1][m])
    {
        x[i]=1;
        m=m-w[i];
    }
}

```

```

    }

    else

    {

        x[i]=0;

    }

}

printf("\nitems selected are designated 1\n");

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

{

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

}

}

```

Output:

```

Enter the number of items
4
enter the weight and profit of each item
2 12
1 10
3 20
2 15
enter the knapsack capacity
5

knapsack table
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

items selected are designated 1
1 1 0 1

```

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

```
#include<stdio.h>

void main()
{
    int adj[10][10],n,i,j,k;
    int result[10][10];

    printf("Floyd's algorithm\n");
    printf("enter the number of vertices\n");
    scanf("%d",&n);
    printf("Enter the distance matrix for %d vertices\n",n);
    for(i=0;i<n;i++)
    {
        for(j=0;j<n;j++)
        {
            scanf("%d",&adj[i][j]);
            result[i][j]=adj[i][j];
        }
    }
    for(k=0;k<n;k++)
    {
        for(j=0;j<n;j++)
        {
            for(i=0;i<n;i++)
            {
```

```

        result[i][j]=result[i][j]<(result[i][k]+result[k][j])?result[i][j]:(result[i][k]+result[k][j]);
    }
}
}

printf("\nResult\n");
for(i=0;i<n;i++)
{
    for(j=0;j<n;j++)
    {
        printf("%d\t",result[i][j]);
    }
    printf("\n");
}
}

```

Output:

```

Floyd's algorithm
enter the number of vertices
4
Enter the distance matrix for 4 vertices
0 999 3 999
2 0 999 999
999 7 0 1
6 999 999 0

Result
0      10      3      4
2      0      5      6
7      7      0      1
6      16      9      0

```


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

Prim's algorithm:

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

```
int cost[10][10], vt[10], et[10][10], vis[10], j, n;
```

```
int 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("%d", &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=%d\n", sum);
}

```

```

void prims()

{

    int s, min, m, k, u, v;

    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
5
enter the cost adjacency matrix
0 1 5 2 999
1 0 999 999 999
5 999 0 3 999
2 999 3 0 2
999 999 999 2 0
edges of spanning tree
1,2    1,4    4,5    4,3    weight=8

```

Kruskal's algorithm:

```
#include <stdio.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], t[i][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 1 5 2 999
1 0 999 999 999
5 999 0 3 999
2 999 3 0 2
999 999 999 2 0
spanning tree
0 1
0 3
3 4
2 3
cost of spanning tree=8

```

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

```
#include <stdio.h>

#define INFINITY 9999

#define MAX 10

void dijkstra(int G[MAX][MAX], int n, int startnode);

int main()
{
    int G[MAX][MAX], i, j, n, u;

    printf("Enter 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);

    return 0;
}

void dijkstra(int G[MAX][MAX], int n, int startnode)
{

```



```

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[startnode][i];

    pred[i] = startnode;

    visited[i] = 0;

}

distance[startnode] = 0;

visited[startnode] = 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 != startnode)
        {
            printf("\nDistance of node%d = %d", i, distance[i]);
            printf("\nPath = %d", i);

            j = i;
            do

```

```

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

```

Output:

```

Enter no. of vertices:6

Enter the adjacency matrix:
0 25 100 35 9999 9999
9999 0 9999 27 14 9999
9999 9999 0 50 9999 48
9999 9999 9999 0 29 9999
9999 9999 9999 9999 0 21
9999 9999 48 9999 9999 0

Enter the starting node:0

Distance of node1 = 25
Path = 1<-0
Distance of node2 = 100
Path = 2<-0
Distance of node3 = 35
Path = 3<-0
Distance of node4 = 39
Path = 4<-1<-0
Distance of node5 = 60
Path = 5<-4<-1<-0

```

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

```
#include <stdio.h>

#include <math.h>

int board[20], count;

int main()
{
    int n, i, j;

    void queen(int row, int n);

    printf(" - N Queens Problem Using Backtracking -");

    printf("\n\nEnter number of Queens:");

    scanf("%d", &n);

    queen(1, n);

    return 0;
}

// function for printing the solution

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) // for nxn board
    {
        if (board[i] == j)
            printf("\tQ"); // queen at i,j position
        else
            printf("\t-"); // empty slot
    }
}
}

```

/*function to check conflicts

If no conflict for desired position returns 1 otherwise returns 0*/

```

int place(int row, int column)

```

```

{
    int i;
    for (i = 1; i <= row - 1; ++i)
    {
        // checking column and diagonal conflicts
        if (board[i] == column)
            return 0;
    }
}

```

```

        else if (abs(board[i] - column) == abs(i - row))
            return 0;
    }

    return 1; // no conflicts
}

// function to check for proper positioning of queen
void queen(int row, int n)
{
    int column;
    for (column = 1; column <= n; ++column)
    {
        if (place(row, column))
        {
            board[row] = column; // no conflicts so place queen
            if (row == n)        // dead end
                print(n);        // printing the board configuration
            else                  // try queen with next position
                queen(row + 1, n);
        }
    }
}

```

Output:

- N Queens Problem Using Backtracking -

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	-	-