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)
BENGALURU-560019
June-2023 to Sep-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 **Chinmay N Hegde (1BM21CS044),** 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 Sep-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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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.

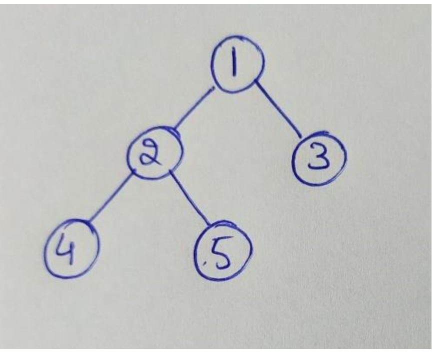
PROGRAM-1

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.

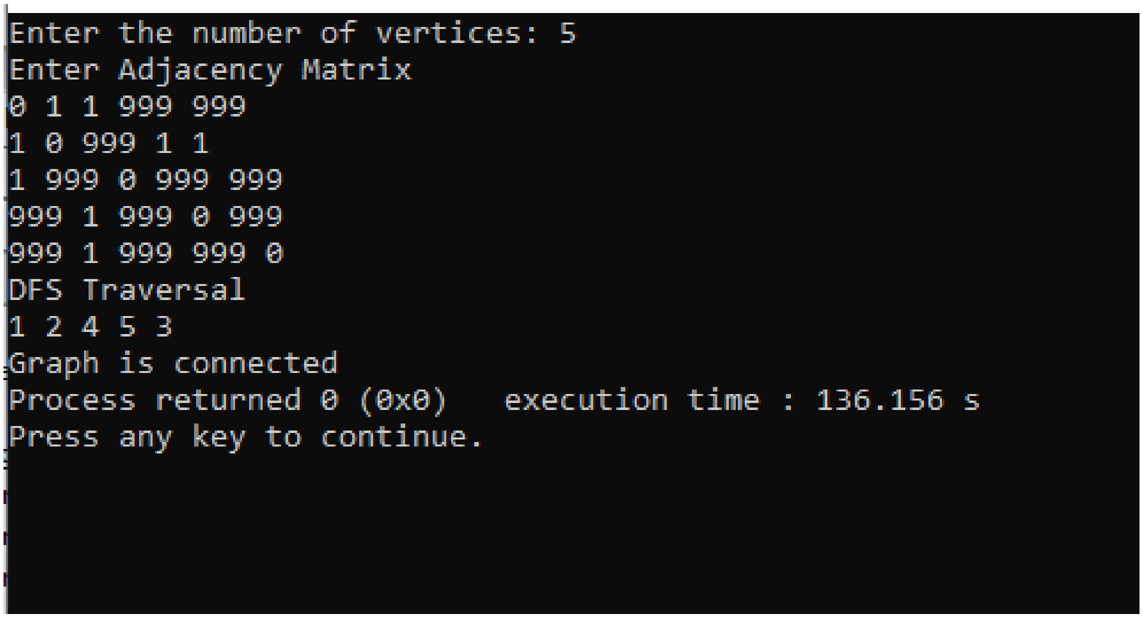
DFS

```
#include <stdio.h>
void DFS(int);
void connected();
int A[10][10], vis[10], n;
int main()
{
    printf("Enter the number of vertices: ");
    scanf("%d", &n);
    printf("Enter Adjacency Matrix\n");
    for (int i = 1; i <= n; i++)
    {
        for (int j = 1; j <= n; j++)
        {
            scanf("%d", &A[i][j]);
        }
    }
    printf("DFS Traversal\n");
    for (int i = 1; i <= n; i++)
    {
        vis[i] = 0;
    }
    DFS(1);
    connected();
    return 0;
}
void DFS(int v)
{
    vis[v] = 1;
    printf("%d ", v);
    for (int i = 1; i <= n; i++)
    {
        if (A[v][i] == 1 && vis[i] == 0)
        {
            DFS(i);
        }
    }
}
void connected()
{
    for (int i = 1; i <= n; i++)
    {
        if (vis[i] == 0)
            printf(“Graph is not connected”);
            return;
    }
    printf(“Graph is connected”);
}
```

GRAPH:



OUTPUT:

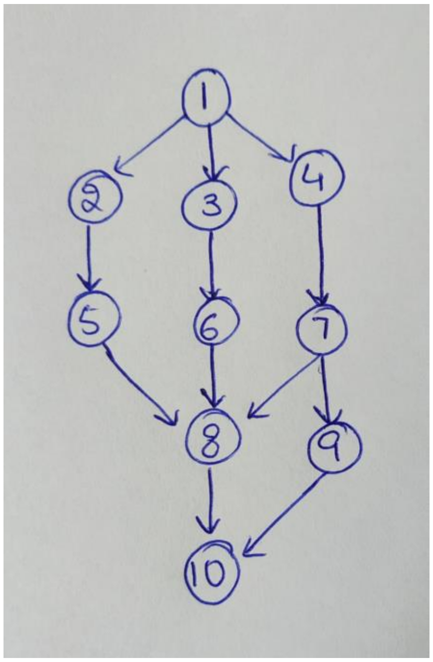


```
Enter the number of vertices: 5
Enter Adjacency Matrix
0 1 1 999 999
1 0 999 1 1
1 999 0 999 999
999 1 999 0 999
999 1 999 999 0
DFS Traversal
1 2 4 5 3
Graph is connected
Process returned 0 (0x0)   execution time : 136.156 s
Press any key to continue.
```

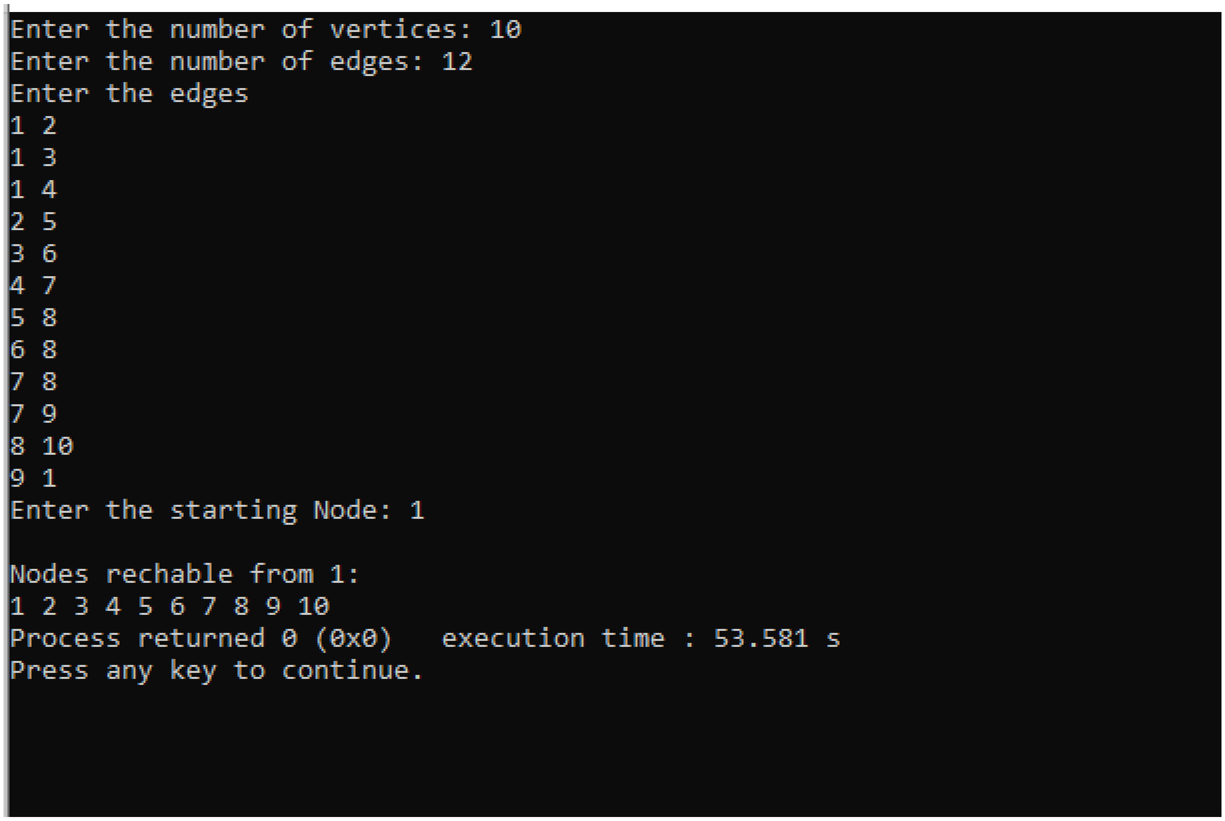
BFS

```
#include<stdio.h>
void BFS(int);

int Q[10],F=-1,R=-1;
int A[10][10],vis[10];
int n,m;

int main(){
    int v,u,st;
    printf("Enter the number of vertices\n");
    scanf("%d",&n);
    for(int i=1;i<=n;i++){
        for(int j=1;j<=n;j++){
            A[i][j]=0;
        }
    }

    printf("Enter the number of edges\n");
    scanf("%d",&m);
    printf("Enter the edges\n");
    for(int i=1;i<=m;i++){
        scanf("%d %d",&u,&v);
        A[u][v]=1;
    }

    for(int i=1;i<=n;i++){
        vis[i]=0;
    }

    printf("Enter the starting Node\n");
    scanf("%d",&st);
    printf("Nodes rechable from %d\n",st);

    BFS(st);
    return 0;
}
void BFS(int v){
    int u;
    vis[v]=1;
    Q[++R]=v;

    while(F<=R){
        u=Q[++F];
        printf("%d ",u);
        for(int i=1;i<=n;i++){
           if(A[u][i]==1 && vis[i]==0){

            Q[++R]=i;
            vis[i]=1;
           }
        }

    }
}
```

GRAPH:



OUTPUT:



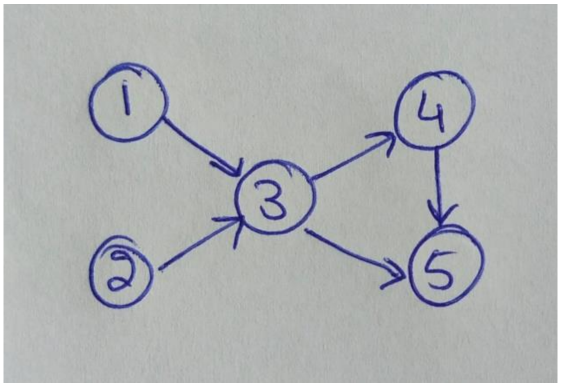
```
Enter the number of vertices: 10
Enter the number of edges: 12
Enter the edges
1 2
1 3
1 4
2 5
3 6
4 7
5 8
6 8
7 8
7 9
8 10
9 1
Enter the starting Node: 1

Nodes rechable from 1:
1 2 3 4 5 6 7 8 9 10
Process returned 0 (0x0)   execution time : 53.581 s
Press any key to continue.
```

PROGRAM-2

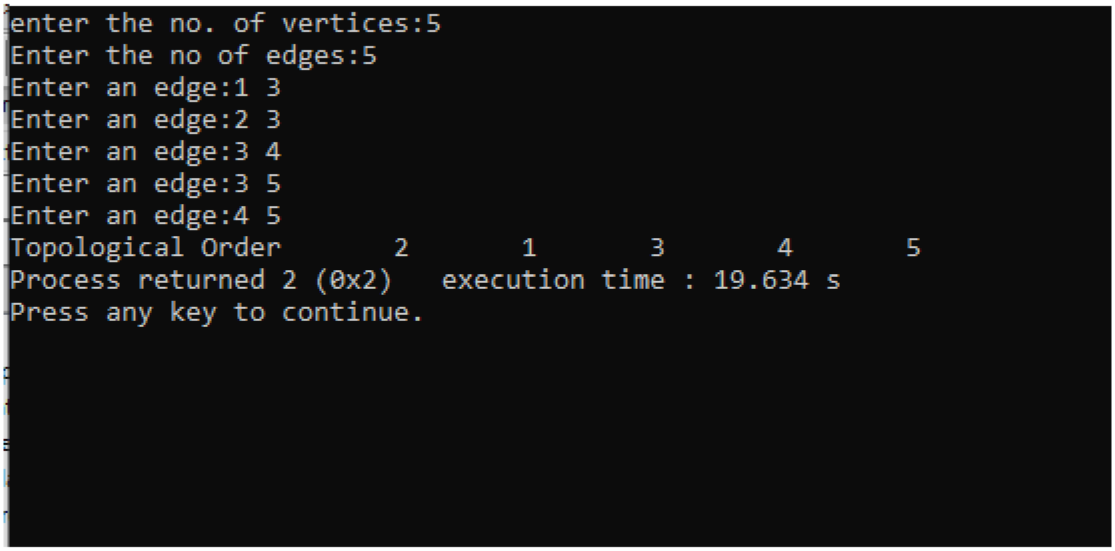
Write program to obtain the Topological ordering of vertices in a given digraph.

```
#include <stdio.h>
void DFS(int);
int A[10][10], vis[10], EXP[10], J = 0;
int n, m;
int main()
{
    int v, u;
    printf("Enter the number of vertices\n");
    scanf("%d", &n);
    for (int i = 1; i <= n; i++)
    {
        for (int j = 1; j <= n; j++)
        {
            A[i][j] = 0;
        }
    }
    printf("Enter the number of edges\n");
    scanf("%d", &m);
    printf("Enter the edges\n");
    for (int i = 1; i <= m; i++)
    {
        scanf("%d %d", &u, &v);
        A[u][v] = 1;
    }
    for (int i = 1; i <= n; i++)
        vis[i] = 0;
    for (int i = 1; i <= n; i++)
    {
        if (vis[i] == 0)
        {
            DFS(i);
        }
    }
    printf("Topological traversal\n");
    for (int i = n - 1; i >= 0; i--)
    {
        printf("%d ", EXP[i]);
    }
}
void DFS(int v)
{
    int i;
    vis[v] = 1;
    for (int i = 1; i <= n; i++)
    {
        if (A[v][i] == 1 && vis[i] == 0)
        {
            DFS(i);
        }
    }
    EXP[J++] = v;
}
```

GRAPH:



OUTPUT:



```
enter the no. of vertices:5
Enter the no of edges:5
Enter an edge:1 3
Enter an edge:2 3
Enter an edge:3 4
Enter an edge:3 5
Enter an edge:4 5
Topological Order       2       1       3       4       5
Process returned 2 (0x2)   execution time : 19.634 s
Press any key to continue.
```

PROGRAM-3

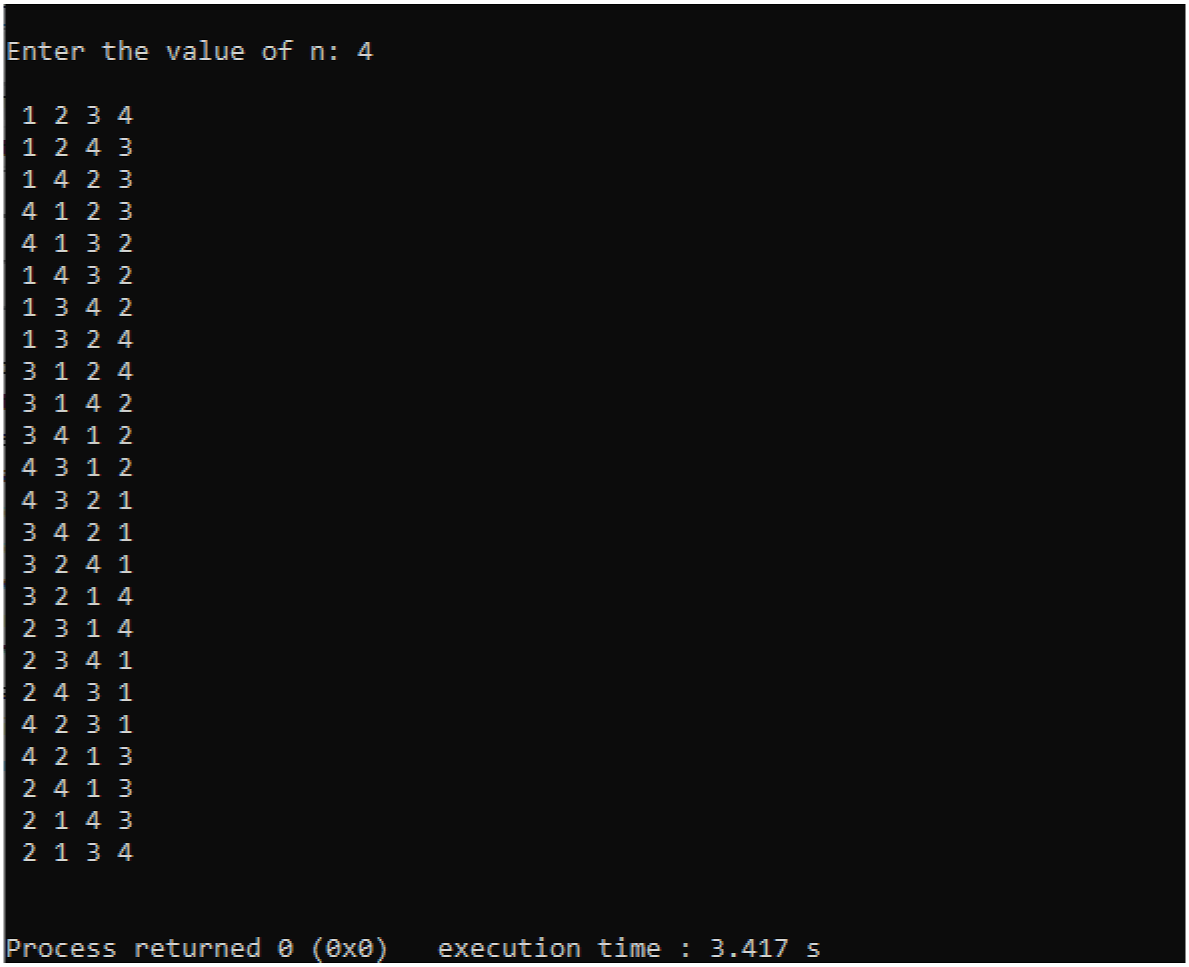
Implement Johnson Trotter algorithm to generate permutations.

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

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

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

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

int printOnePerm(int a[], int dir[], int n)
{
    int mobile = getMobile(a, dir, n);
    int pos = searchArr(a, n, mobile);

    if (dir[a[pos - 1] - 1] == RIGHT_TO_LEFT)
    {
        printf("\n");
        int temp;
        temp = a[pos - 1];
        a[pos - 1] = a[pos - 2];
        a[pos - 2] = temp;
    }

    else if (dir[a[pos - 1] - 1] == LEFT_TO_RIGHT)
    {
        printf("\n");
        int temp;
        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] == 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]);
}
```

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

void printPermutation(int n)
{

    int a[n];
    int dir[n];

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

int main()
```

```
{
    int n;
    printf("\nEnter the value of n: ");
    scanf("%d", &n);
    printf("\n");
    printPermutation(n);
    printf("\n");
    return 0;
}
```

OUTPUT:



```
Enter the value of n: 4

 1 2 3 4
 1 2 4 3
 1 4 2 3
 4 1 2 3
 4 1 3 2
 1 4 3 2
 1 3 4 2
 1 3 2 4
 3 1 2 4
 3 1 4 2
 3 4 1 2
 4 3 1 2
 4 3 2 1
 3 4 2 1
 3 2 4 1
 3 2 1 4
 2 3 1 4
 2 3 4 1
 2 4 3 1
 4 2 3 1
 4 2 1 3
 2 4 1 3
 2 1 4 3
 2 1 3 4


Process returned 0 (0x0)   execution time : 3.417 s
```

PROGRAM-4

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

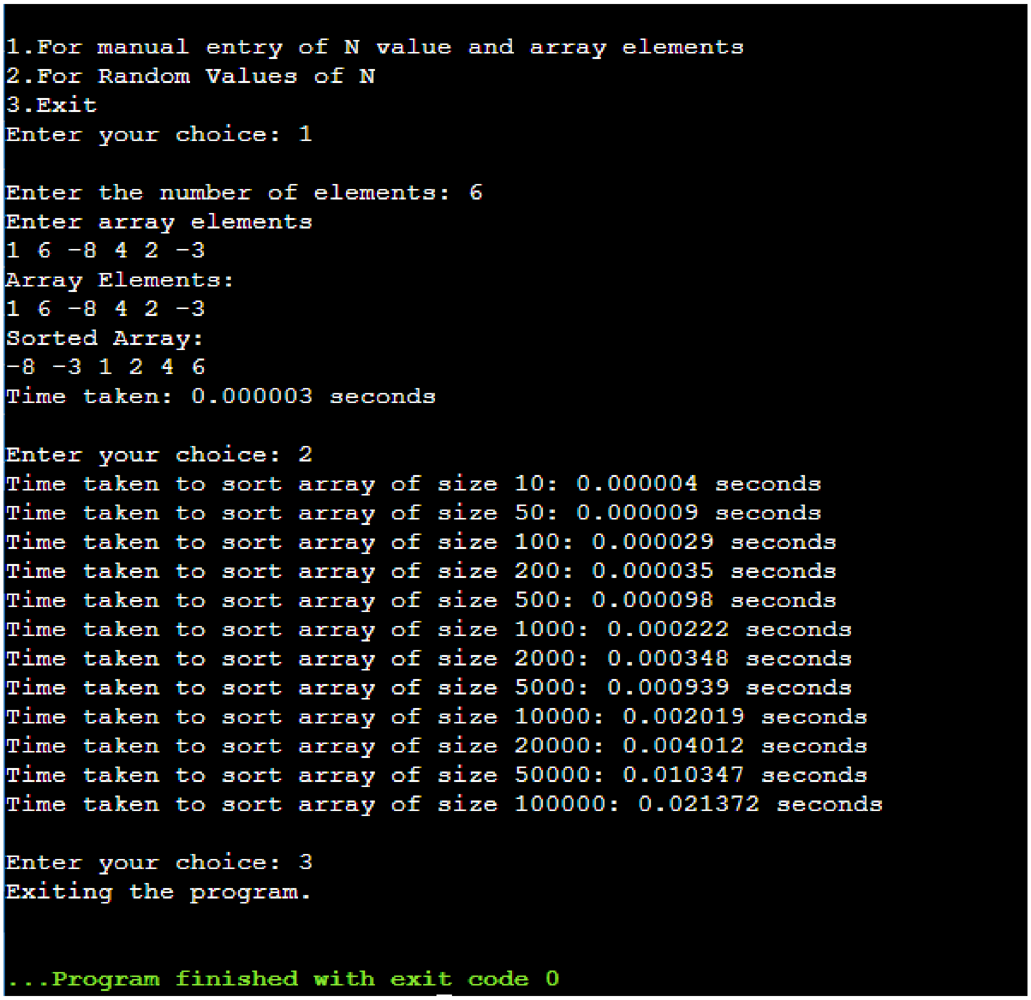
```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

void merge(int arr[], int l, int m, int r)
{
    int i, j, k;
    int n1 = m - l + 1;
    int n2 = r - m;

    int L[n1], R[n2];

    for (i = 0; i < n1; i++)
        L[i] = arr[l + i];
    for (j = 0; j < n2; j++)
        R[j] = arr[m + 1 + j];

    i = 0;
    j = 0;
    k = l;
    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];
        i++;
        k++;
    }

    while (j < n2)
    {
        arr[k] = R[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()
{

    int ch;
    int n;
    int A[100];
    clock_t start_time, end_time;
    printf("\n1.For manual entry of N value and array elements\n2.For Random Values of N\n3.Exit");

    while (1)
    {
        printf("\nEnter your choice: ");
        scanf("%d", &ch);
        switch (ch)
        {
        case 1:

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

```
printf("Enter array elements\n");
for (int i = 0; i < n; i++)
{
    scanf("%d", &A[i]);
}

printf("Array Elements: \n");
for (int i = 0; i < n; i++)
{
    printf("%d ", A[i]);
}

start_time = clock();

mergeSort(A, 0, n - 1);

end_time = clock();
double taken_time = (double)(end_time - start_time) / CLOCKS_PER_SEC;

printf("\nSorted Array: \n");
for (int i = 0; i < n; i++)
{
    printf("%d ", A[i]);
}

printf("\nTime taken: %f seconds\n", taken_time);
break;
```

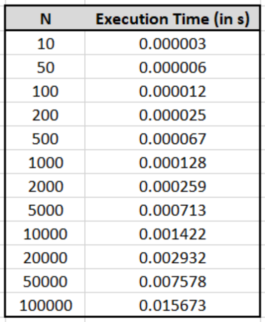
```
case 2:
    srand(time(NULL));

    int sizes[] = {10, 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 50000, 100000};
    int num_sizes = sizeof(sizes) / sizeof(sizes[0]);

    for (int i = 0; i < num_sizes; i++)
    {
        int N = sizes[i];
        int arr[N];

        for (int j = 0; j < N; j++)
        {
            arr[j] = rand() % 1000;
        }

        clock_t start = clock();
        mergeSort(arr, 0, N - 1);
        clock_t end = clock();

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

        printf("Time taken to sort array of size %d: %lf seconds\n", N, time_taken);
    }
    break;

case 3:
    printf("Exiting the program.\n");
```

```
            exit(0);

        default:
            printf("Invalid choice");
            break;
        }
    }

    return 0;
}
```

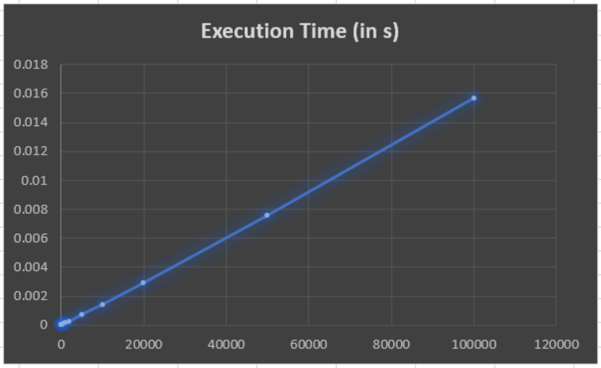
OUTPUT:



```
1.For manual entry of N value and array elements
2.For Random Values of N
3.Exit
Enter your choice: 1

Enter the number of elements: 6
Enter array elements
1 6 -8 4 2 -3
Array Elements:
1 6 -8 4 2 -3
Sorted Array:
-8 -3 1 2 4 6
Time taken: 0.000003 seconds

Enter your choice: 2
Time taken to sort array of size 10: 0.000004 seconds
Time taken to sort array of size 50: 0.000009 seconds
Time taken to sort array of size 100: 0.000029 seconds
Time taken to sort array of size 200: 0.000035 seconds
Time taken to sort array of size 500: 0.000098 seconds
Time taken to sort array of size 1000: 0.000222 seconds
Time taken to sort array of size 2000: 0.000348 seconds
Time taken to sort array of size 5000: 0.000939 seconds
Time taken to sort array of size 10000: 0.002019 seconds
Time taken to sort array of size 20000: 0.004012 seconds
Time taken to sort array of size 50000: 0.010347 seconds
Time taken to sort array of size 100000: 0.021372 seconds

Enter your choice: 3
Exiting the program.


...Program finished with exit code 0
```



N	Execution Time (in s)
10	0.000003
50	0.000006
100	0.000012
200	0.000025
500	0.000067
1000	0.000128
2000	0.000259
5000	0.000713
10000	0.001422
20000	0.002932
50000	0.007578
100000	0.015673



PROGRAM-5

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

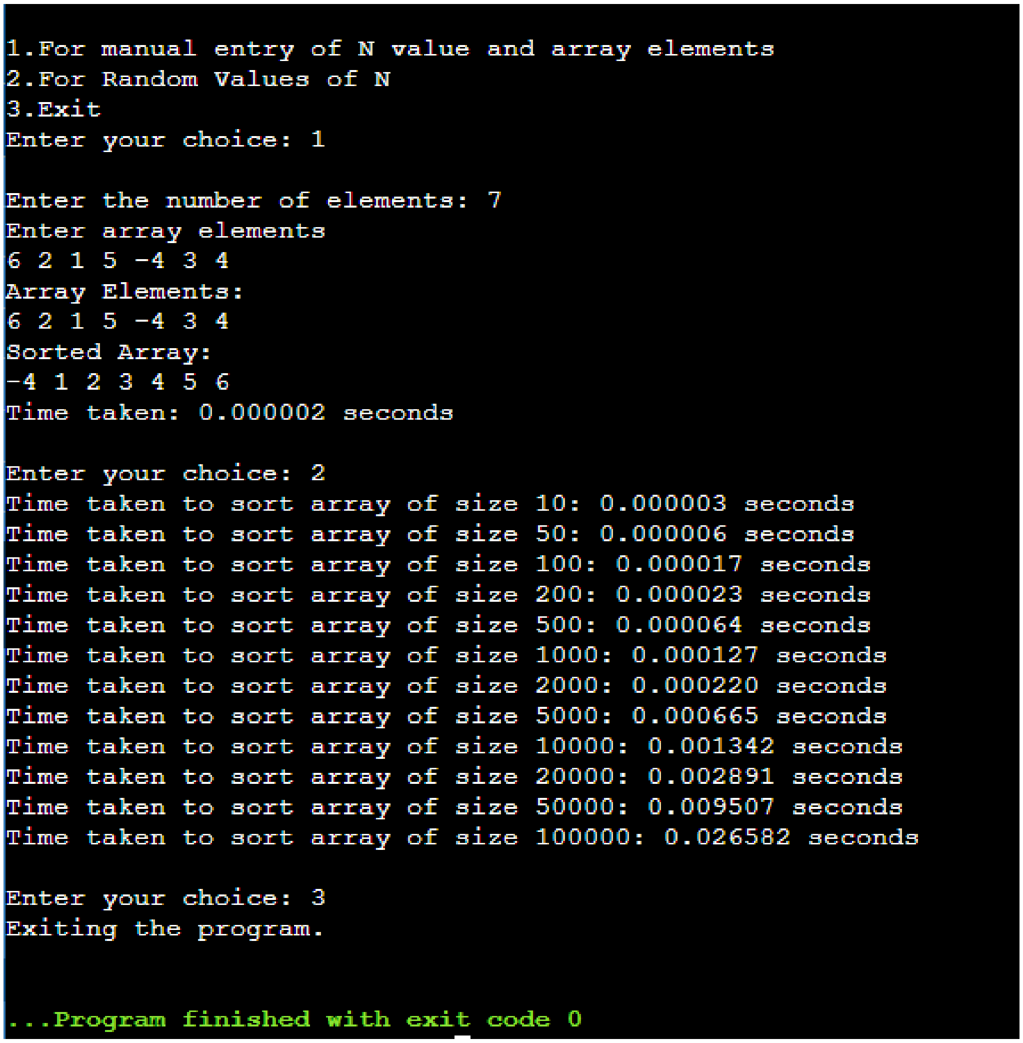
```
#include <stdio.h>

#include <stdlib.h>

#include <time.h>


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++;

            int temp = arr[i];

            arr[i] = arr[j];

            arr[j] = temp;

        }

    }


    int temp = arr[i + 1];

    arr[i + 1] = arr[high];

    arr[high] = temp;


    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()
{
    int ch;
    int n;
    int A[100];
    clock_t start_time, end_time;

    printf("\n1.For manual entry of N value and array elements\n2.For Random Values of
N\n3.Exit");

    while (1)
    {
        printf("\nEnter your choice: ");
        scanf("%d", &ch);

        switch (ch)
```

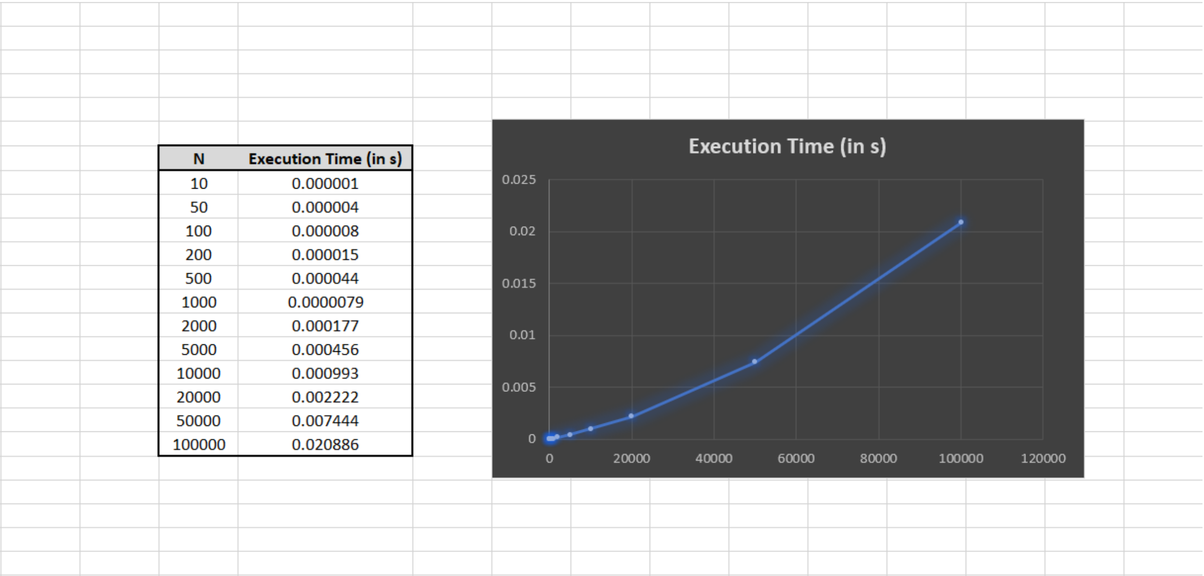
```
{
case 1:
    printf("\nEnter the number of elements: ");
    scanf("%d", &n);
    printf("Enter array elements\n");
    for (int i = 0; i < n; i++)
    {
        scanf("%d", &A[i]);
    }

    printf("Array Elements: \n");
    for (int i = 0; i < n; i++)
    {
        printf("%d ", A[i]);
    }

    start_time = clock();
    quickSort(A, 0, n - 1);
    end_time = clock();

    printf("\nSorted Array: \n");
    for (int i = 0; i < n; i++)
    {
        printf("%d ", A[i]);
    }

    double taken_time = (double)(end_time - start_time) / CLOCKS_PER_SEC;
    printf("\nTime taken: %f seconds\n", taken_time);
```

```
            break;

        case 2:
            srand(time(NULL));

            int sizes[] = {10, 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 50000, 100000};
            int num_sizes = sizeof(sizes) / sizeof(sizes[0]);

            for (int i = 0; i < num_sizes; i++)
            {
                int N = sizes[i];
                int arr[N];

                for (int j = 0; j < N; j++)
                {
                    arr[j] = rand() % 1000;
                }

                clock_t start = clock();
                quickSort(arr, 0, N - 1);
                clock_t end = clock();

                printf("Time taken to sort array of size %d: %lf seconds\n", N, ((double)(end - start)) / CLOCKS_PER_SEC);
            }
            break;

        case 3:
            printf("Exiting the program.\n");
            exit(0);

        default:
            printf("Invalid choice\n");
            break;
        }
    }

    return 0;
}
```

OUTPUT:



```
1.For manual entry of N value and array elements
2.For Random Values of N
3.Exit
Enter your choice: 1

Enter the number of elements: 7
Enter array elements
6 2 1 5 -4 3 4
Array Elements:
6 2 1 5 -4 3 4
Sorted Array:
-4 1 2 3 4 5 6
Time taken: 0.000002 seconds

Enter your choice: 2
Time taken to sort array of size 10: 0.000003 seconds
Time taken to sort array of size 50: 0.000006 seconds
Time taken to sort array of size 100: 0.000017 seconds
Time taken to sort array of size 200: 0.000023 seconds
Time taken to sort array of size 500: 0.000064 seconds
Time taken to sort array of size 1000: 0.000127 seconds
Time taken to sort array of size 2000: 0.000220 seconds
Time taken to sort array of size 5000: 0.000665 seconds
Time taken to sort array of size 10000: 0.001342 seconds
Time taken to sort array of size 20000: 0.002891 seconds
Time taken to sort array of size 50000: 0.009507 seconds
Time taken to sort array of size 100000: 0.026582 seconds

Enter your choice: 3
Exiting the program.


...Program finished with exit code 0
```



N	Execution Time (in s)
10	0.000001
50	0.000004
100	0.000008
200	0.000015
500	0.000044
1000	0.0000079
2000	0.000177
5000	0.000456
10000	0.000993
20000	0.002222
50000	0.007444
100000	0.020886

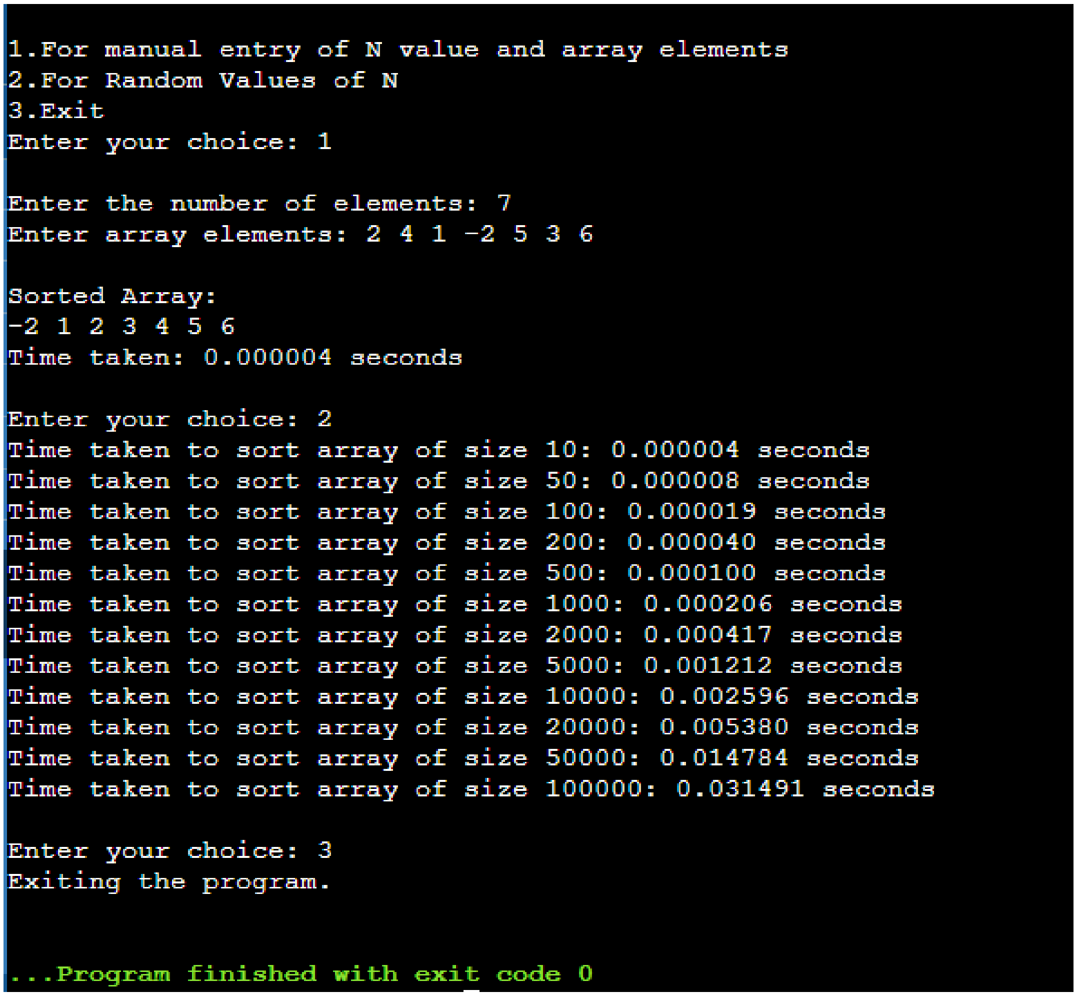
PROGRAM-6

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

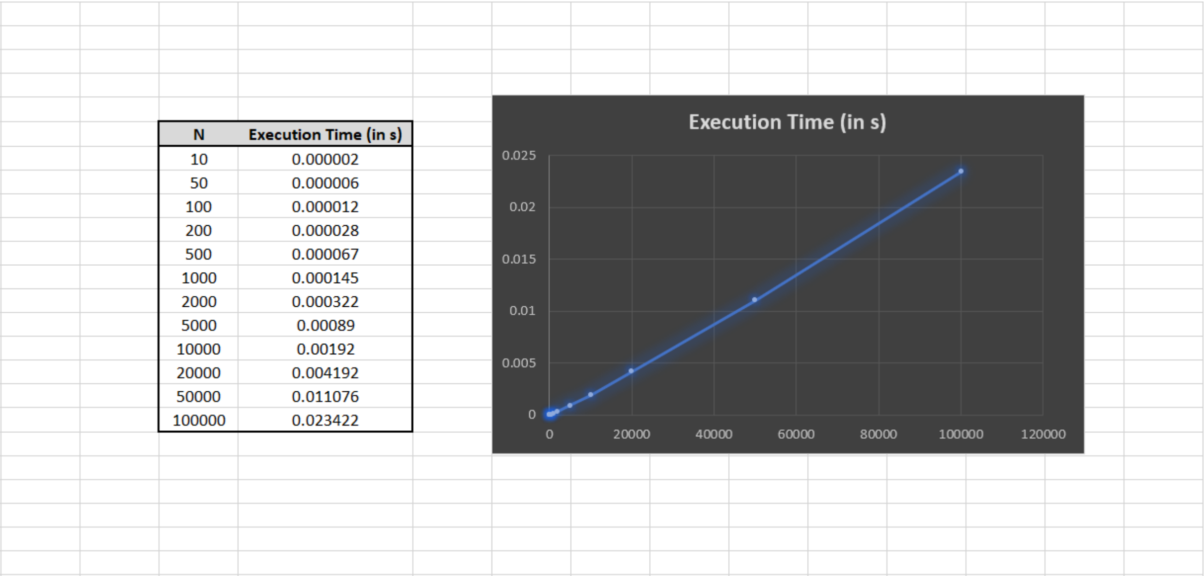
```
#include <stdio.h>

#include <stdlib.h>

#include <time.h>


void heapify(int arr[], int n, int i)

{

    int largest = i;

    int 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] and arr[largest]

        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--)
    {
        // Swap arr[0] and arr[i]
        int temp = arr[0];
        arr[0] = arr[i];
        arr[i] = temp;

        heapify(arr, i, 0);
    }
}

int main()
{
    int ch;
    int n;
    int arr[100];
    clock_t start_time, end_time;

    printf("\n1.For manual entry of N value and array elements\n2.For Random Values of N\n3.Exit");

    while (1)
    {
        printf("\nEnter your choice: ");
        scanf("%d", &ch);

        switch (ch)
        {
        case 1:

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

            printf("Enter array elements: ");
            for (int i = 0; i < n; i++)
            {
                scanf("%d", &arr[i]);
            }

            start_time = clock();
            heapSort(arr, n);
            end_time = clock();

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

            double taken_time = (double)(end_time - start_time) / CLOCKS_PER_SEC;
            printf("\nTime taken: %f seconds\n", taken_time);
            break;

        case 2:
            srand(time(NULL));

            int sizes[] = {10, 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 50000, 100000};
            int num_sizes = sizeof(sizes) / sizeof(sizes[0]);

            for (int i = 0; i < num_sizes; i++)
            {
                int N = sizes[i];
                int arr[N];

                for (int j = 0; j < N; j++)
                {
                    arr[j] = rand() % 1000;
                }

                clock_t start = clock();
                heapSort(arr, N);
                clock_t end = clock();
```

```
                printf("Time taken to sort array of size %d: %lf seconds\n", N, ((double)(end - start)) /
CLOCKS_PER_SEC);
            }
            break;

        case 3:
            printf("Exiting the program.\n");
            exit(0);

        default:
            printf("Invalid choice\n");
            break;
        }
    }

    return 0;
}
```

OUTPUT:



```
1.For manual entry of N value and array elements
2.For Random Values of N
3.Exit
Enter your choice: 1

Enter the number of elements: 7
Enter array elements: 2 4 1 -2 5 3 6

Sorted Array:
-2 1 2 3 4 5 6
Time taken: 0.000004 seconds

Enter your choice: 2
Time taken to sort array of size 10: 0.000004 seconds
Time taken to sort array of size 50: 0.000008 seconds
Time taken to sort array of size 100: 0.000019 seconds
Time taken to sort array of size 200: 0.000040 seconds
Time taken to sort array of size 500: 0.000100 seconds
Time taken to sort array of size 1000: 0.000206 seconds
Time taken to sort array of size 2000: 0.000417 seconds
Time taken to sort array of size 5000: 0.001212 seconds
Time taken to sort array of size 10000: 0.002596 seconds
Time taken to sort array of size 20000: 0.005380 seconds
Time taken to sort array of size 50000: 0.014784 seconds
Time taken to sort array of size 100000: 0.031491 seconds

Enter your choice: 3
Exiting the program.


...Program finished with exit code 0
```



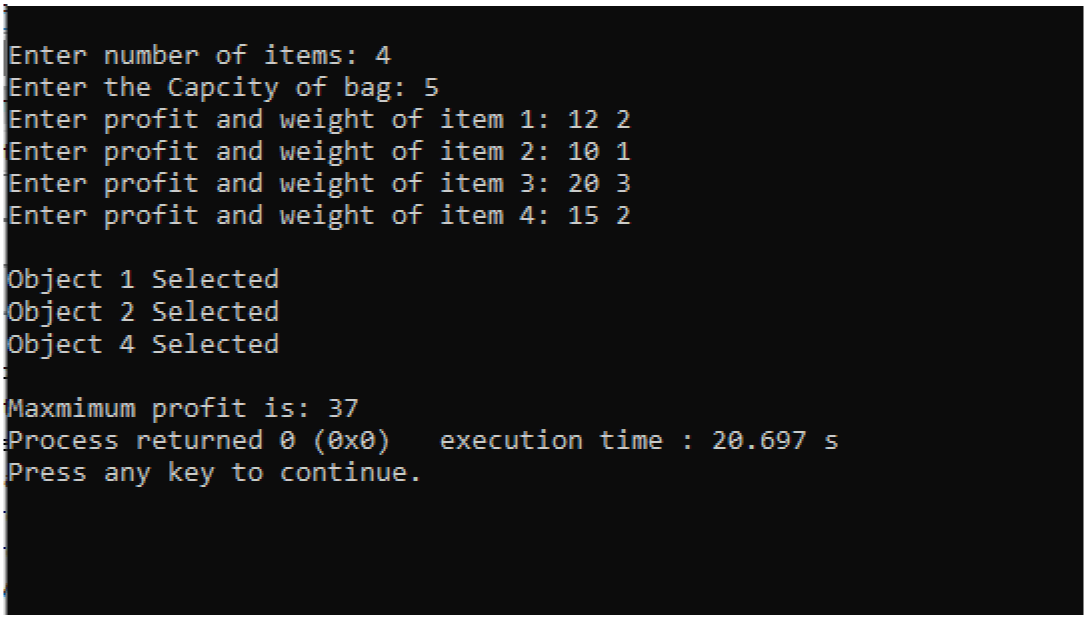
N	Execution Time (in s)
10	0.000002
50	0.000006
100	0.000012
200	0.000028
500	0.000067
1000	0.000145
2000	0.000322
5000	0.00089
10000	0.00192
20000	0.004192
50000	0.011076
100000	0.023422

PROGRAM-7

Implement 0/1 Knapsack problem using dynamic programming.

```
#include <stdio.h>
#include <stdlib.h>
int V[100][100];
int max(int a, int b)
{
    return a > b ? a : b;
}
int knapsack(int W, int N, int val[], int wt[])
{
    for (int i = 0; i <= N; i++)
    {
        for (int j = 0; j <= W; j++)
        {
            if (i == 0 || j == 0)
            {
                V[i][j] = 0;
            }
            else if (wt[i - 1] > j)
            {
                V[i][j] = V[i - 1][j];
            }
            else
            {
                V[i][j] = max(V[i - 1][j], V[i - 1][j - wt[i - 1]] + val[i - 1]);
            }
        }
    }
    return V[N][W];
}
void object_selecetd(int N, int W, int wt[])
{
    int X[N + 1];
    for (int i = 1; i <= N; i++)
    {
        X[i] = 0;
    }
    int i = N;
    int j = W;
    while (i != 0 && j != 0)
    {
        if (V[i][j] != V[i - 1][j])
        {
            X[i] = 1;
            j = j - wt[i - 1];
        }
        i--;
    }

    printf("\n");

    for (int i = 1; i <= N; i++)
    {
        if (X[i] == 1)
        {
            printf("Object %d Selected\n", i);
        }
    }
}

int main()
{
    int W, N;

    printf("\nEnter number of items: ");
    scanf("%d", &N);
    printf("Enter the Capcity of bag: ");
    scanf("%d", &W);

    int val[W], wt[N];

    for (int i = 0; i < N; i++)
    {
        printf("Enter profit and weight of item %d: ", i + 1);
        scanf("%d%d", &val[i], &wt[i]);
    }

    int result = knapsack(W, N, val, wt);
    object_selecetd(N, W, wt);
    printf("\nMaxmimum profit is: %d", result);
}
```

OUTPUT:



```
Enter number of items: 4
Enter the Capcity of bag: 5
Enter profit and weight of item 1: 12 2
Enter profit and weight of item 2: 10 1
Enter profit and weight of item 3: 20 3
Enter profit and weight of item 4: 15 2

Object 1 Selected
Object 2 Selected
Object 4 Selected

Maxmimum profit is: 37
Process returned 0 (0x0)   execution time : 20.697 s
Press any key to continue.
```

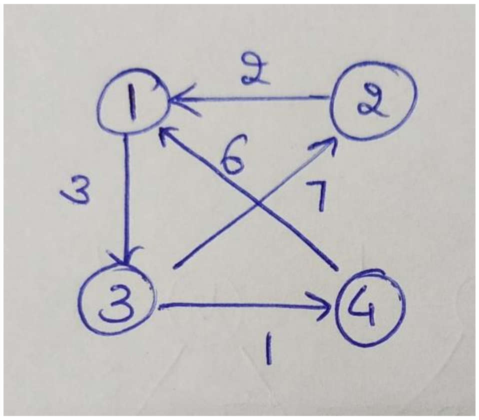
PROGRAM-8

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

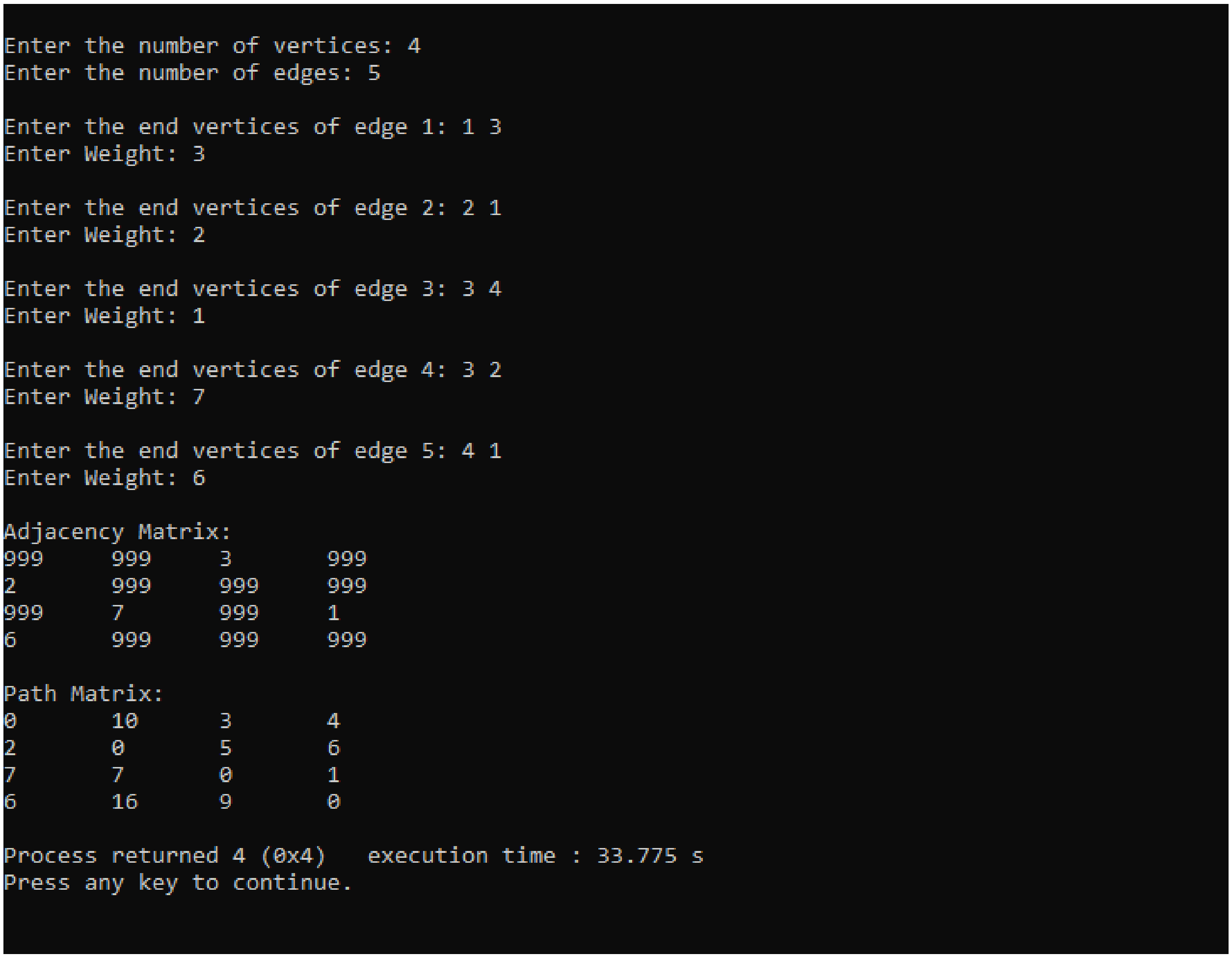
```
#include <stdio.h>

int min(int, int);
void floyds(int p[10][10], int n)
{
    int i, j, k;
    for (k = 1; k <= n; k++)
        for (i = 1; i <= n; i++)
            for (j = 1; j <= n; j++)
                if (i == j)
                    p[i][j] = 0;
                else
                    p[i][j] = min(p[i][j], p[i][k] + p[k][j]);
}

int min(int a, int b)
{
    if (a < b)
        return (a);
    else
        return (b);
}

void main()
{
```

```
int p[10][10], w, n, e, u, v, i, j;

printf("\nEnter the number of vertices: ");
scanf("%d", &n);
printf("Enter the number of edges: ");
scanf("%d", &e);

for (i = 1; i <= n; i++)
{
    for (j = 1; j <= n; j++)
        p[i][j] = 999;
}

for (i = 1; i <= e; i++)
{
    printf("\nEnter the end vertices of edge %d: ", i);
    scanf("%d%d", &u, &v);
    printf("Enter Weight: ");
    scanf("%d",&w);
    p[u][v] = w;
}

printf("\nAdjacency Matrix: \n");
for (i = 1; i <= n; i++)
{
    for (j = 1; j <= n; j++)
        printf("%d \t", p[i][j]);
    printf("\n");
    }

    floyds(p, n);

    printf("\nPath Matrix: \n");
    for (i = 1; i <= n; i++)
    {
        for (j = 1; j <= n; j++)
            printf("%d \t", p[i][j]);
        printf("\n");
    }

}
```

GRAPH:



OUTPUT:



```
Enter the number of vertices: 4
Enter the number of edges: 5

Enter the end vertices of edge 1: 1 3
Enter Weight: 3

Enter the end vertices of edge 2: 2 1
Enter Weight: 2

Enter the end vertices of edge 3: 3 4
Enter Weight: 1

Enter the end vertices of edge 4: 3 2
Enter Weight: 7

Enter the end vertices of edge 5: 4 1
Enter Weight: 6

Adjacency Matrix:
999     999     3       999
2       999     999     999
999     7       999     1
6       999     999     999

Path Matrix:
0       10      3       4
2       0       5       6
7       7       0       1
6       16      9       0

Process returned 4 (0x4)   execution time : 33.775 s
Press any key to continue.
```

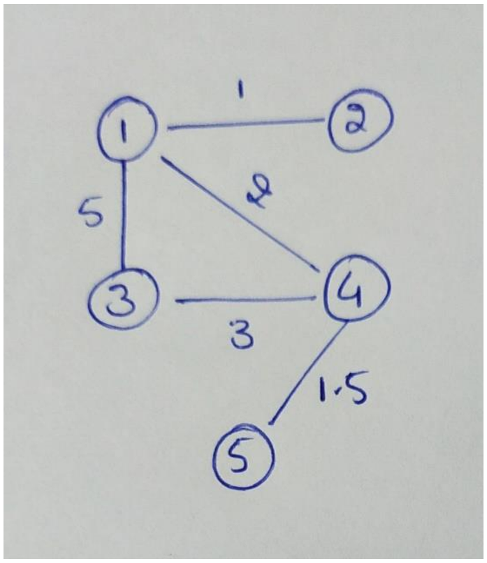
PROGRAM-9

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

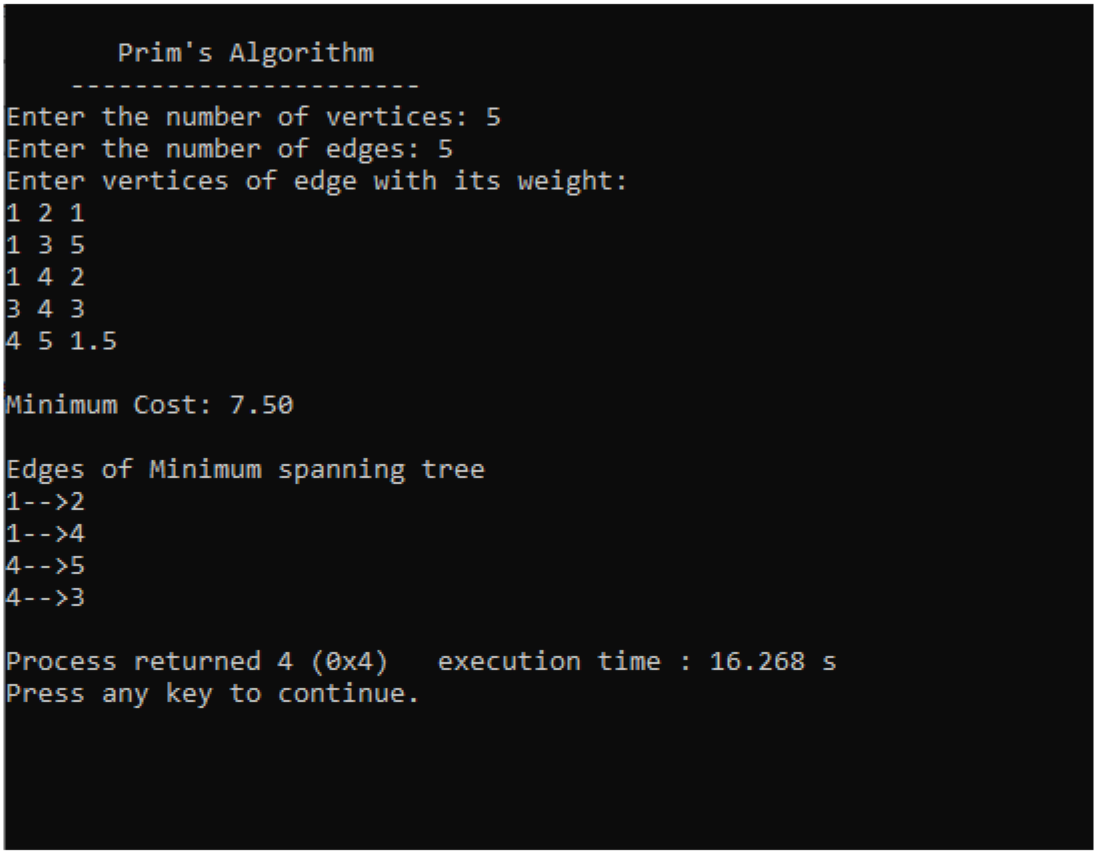
Prim's algorithm

```
#include <stdio.h>

int n, m, e = 0;

float sum = 0;

float costs[100][100];

int VT[100], ET[100][2], vis[20];


void prims()

{

    int u, v;

    int x = 1, j, K, min;

    VT[x] = 1;

    vis[x] = 1;

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

    {

        j = x;

        min = 999;

        while (j > 0)

        {

            K = VT[j];

            for (int m = 2; m <= n; m++)

            {

                if (costs[K][m] < min && vis[m] == 0)

                {
                    min = costs[K][m];
                    u = K;
                    v = m;
                }
            }
            j--;
        }
        VT[++x] = v;
        ET[i][0] = u;
        ET[i][1] = v;
        e++;
        vis[v] = 1;
        sum += costs[u][v];
    }
}

void main()
{
    printf("\n       Prim's Algorithm\n");
    printf("    ----------------------");
    int u, v;
    float w;
    printf("\nEnter the number of vertices: ");
    scanf("%d", &n);

    for (int i = 1; i <= n; i++)
    {
        for (int j = 1; j <= n; j++)
        {
            if (i == j)
                costs[i][j] = 0;
            else
                costs[i][j] = 999;
        }
    }
    printf("Enter the number of egdes: ");
    scanf("%d", &m);

    printf("Enter vertices of edge with its weight: \n");
    for (int i = 1; i <= m; i++)
    {
        scanf("%d%d%f", &u, &v, &w);
        costs[u][v] = costs[v][u] = w;
    }
    for (int i = 1; i <= n; i++)
    {
        vis[i] = 0;
    }
    prims();
    printf("\nMinimum Cost: %.2f\n", sum);
    printf("\nEdges of Minimum spanning tree\n");
    for (int i = 1; i <= e; i++)
    {
        printf("%d-->%d\n", ET[i][0], ET[i][1]);
    }
}
```

GRAPH:



OUTPUT:



```
       Prim's Algorithm
    ----------------------
Enter the number of vertices: 5
Enter the number of edges: 5
Enter vertices of edge with its weight:
1 2 1
1 3 5
1 4 2
3 4 3
4 5 1.5

Minimum Cost: 7.50

Edges of Minimum spanning tree
1-->2
1-->4
4-->5
4-->3

Process returned 4 (0x4)   execution time : 16.268 s
Press any key to continue.
```

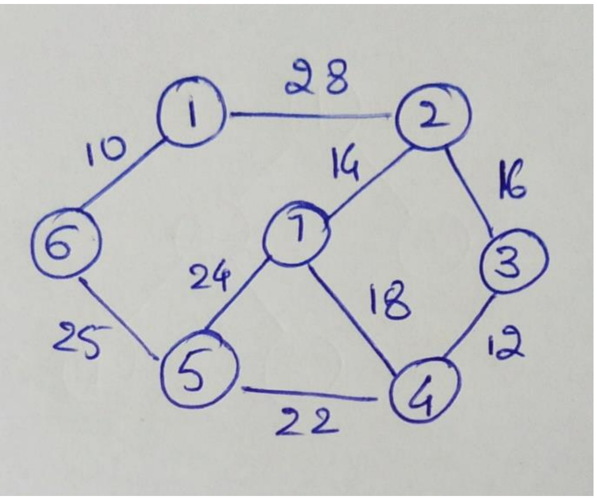
Kruskal’s algorithm

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

int n, m, parent[100];
int count = 0;
int ET[100][2];
int cost[100][100];
int sum = 0;

void unionn(int a, int b)
{
   if (a < b)
      parent[b] = a;
   else
      parent[a] = b;
}

int find(int a)
{
   while (parent[a] != a)
   {
      a = parent[a];
   }
   return a;
}
```

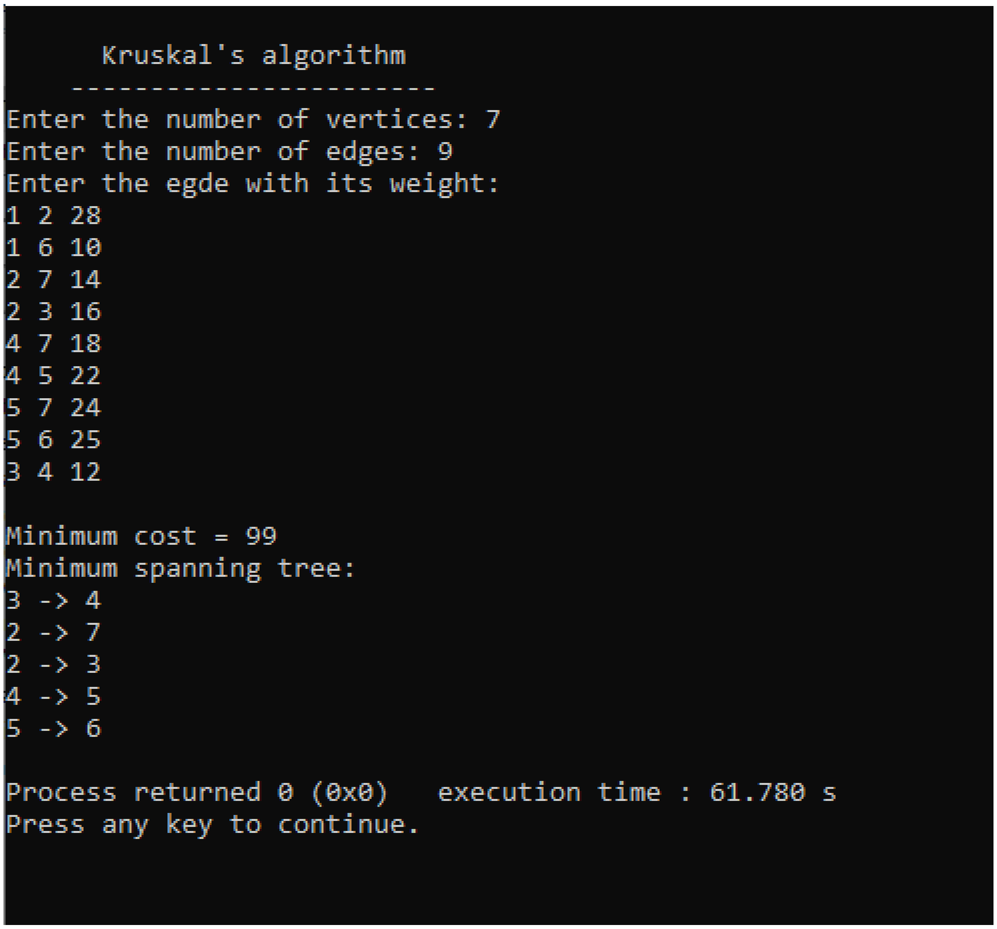
```
void kruskal()
{
    int k = 0;
    for (int i = 1; i <= n; i++)
    {
        parent[i] = i;
    }
    while (count != n - 1)
    {
        int min = 999;
        int u, v;
        for (int i = 1; i <= n; i++)
        {
            for (int j = 1; j <= n; j++)
            {
                if (cost[i][j] < min && cost[i][j] != 0)
                {
                    min = cost[i][j];
                    u = i;
                    v = j;
                }
            }
        }

        int x = find(u);
        int y = find(v);

        if (x != y)
        {
            ET[k][0] = u;
            ET[k][1] = v;
            k++;
            count++;
            sum += cost[u][v];
            unionn(x, y);
        }

        cost[u][v] = cost[v][u] = 999;
    }
}

int main()
{
    printf("\n      Kruskal's algorithm\n");
    printf("    ------------------------");
    int u, v, w;
    printf("\nEnter the number of vertices: ");
    scanf("%d", &n);

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

```
                cost[i][j] = 999;
        }
    }

    printf("Enter the number of edges: ");
    scanf("%d", &m);

    printf("Enter the egde with its weight: \n");
    for (int i = 1; i <= m; i++)
    {
        scanf("%d%d%d", &u, &v, &w);
        cost[u][v] = cost[v][u] = w;
    }

    kruskal();

    printf("\nMinimum cost = %d\n", sum);

    printf("Minimum spanning tree:\n");
    for (int i = 1; i < count; i++)
    {
        printf("%d -> %d\n", ET[i][0], ET[i][1]);
    }



    return 0;
}
```

GRAPH:



OUTPUT:



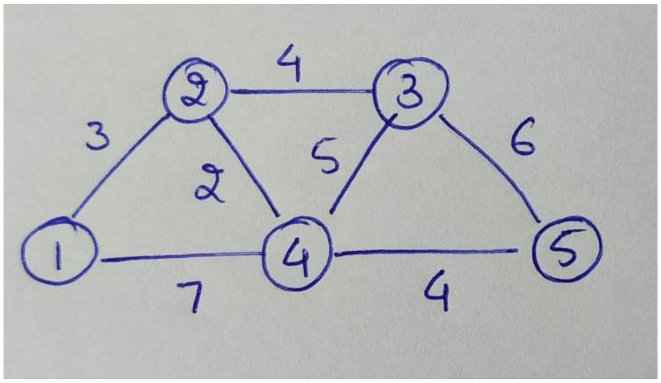
```
      Kruskal's algorithm
    -----------------------
Enter the number of vertices: 7
Enter the number of edges: 9
Enter the egde with its weight:
1 2 28
1 6 10
2 7 14
2 3 16
4 7 18
4 5 22
5 7 24
5 6 25
3 4 12

Minimum cost = 99
Minimum spanning tree:
3 -> 4
2 -> 7
2 -> 3
4 -> 5
5 -> 6

Process returned 0 (0x0)   execution time : 61.780 s
Press any key to continue.
```

PROGRAM-10

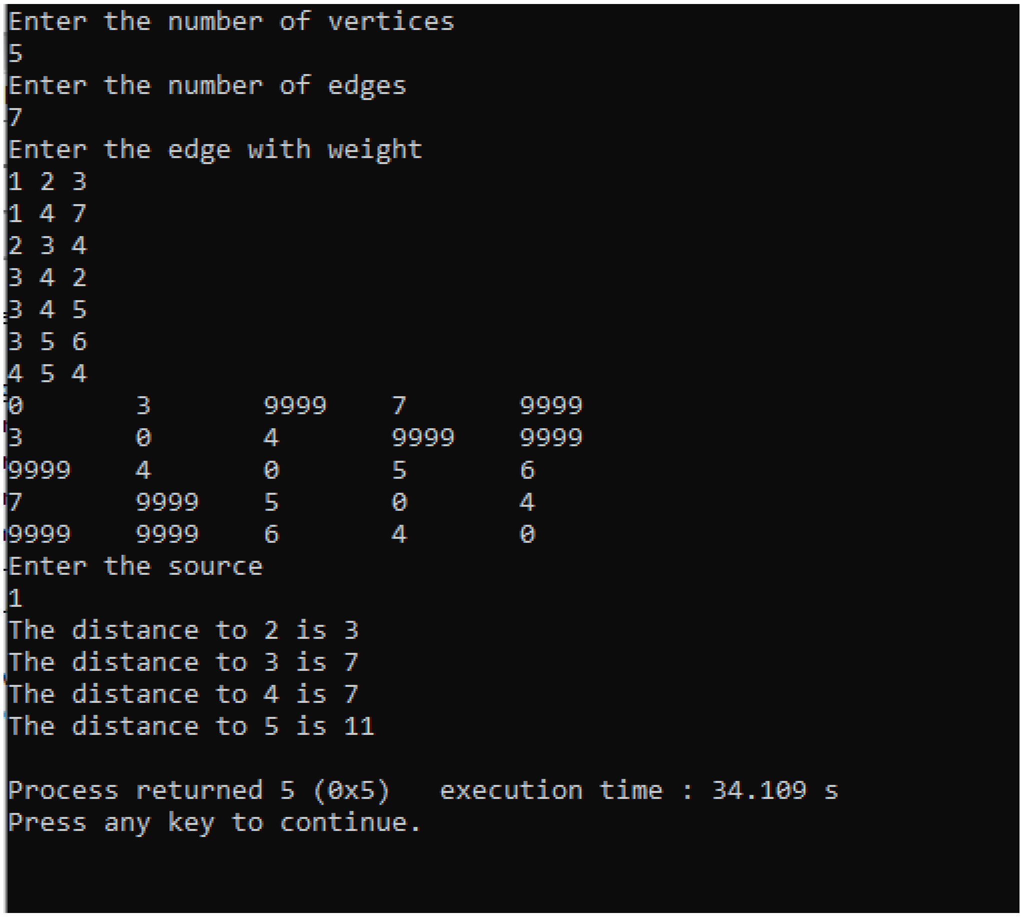
From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.

```
#include <stdio.h>

int dist[10], cost[100][100], n, vis[10], src;

void dijkstra()

{

    int count, min, u;

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

    {

        dist[i] = cost[src][i];

        vis[src] = 1;

    }

    count = 1;

    while (count < n)

    {

        min = 9999;

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

        {

            if (dist[i] < min && vis[i] == 0)

            {

                min = dist[i];

                u = i;

            }

        }

        vis[u] = 1;

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

        {
            if (dist[u] + cost[u][i] < dist[i] && vis[i] == 0)
            {
                dist[i] = dist[u] + cost[u][i];
            }
        }
        count++;
    }
}

void main()
{
    int m, u, v, w;
    printf("\n      Dijkstra's Algorithm\n");
    printf("    ------------------------");
    printf("\nEnter the number of vertices: ");
    scanf("%d", &n);
    for (int i = 1; i <= n; i++)
    {
        for (int j = 1; j <= n; j++)
        {
            if (i == j)
            {
                cost[i][j] = 0;
            }
            else
            {
                cost[i][j] = 9999;
            }
        }
    }
    printf("Enter the number of edges: ");
    scanf("%d", &m);
    printf("Enter the edge with its weight\n");
    for (int i = 1; i <= m; i++)
    {
        scanf("%d%d%d", &u, &v, &w);
        cost[v][u] = cost[u][v] = w;
    }
    printf("Enter the source\n");
    scanf("%d", &src);
    dijkstra();

    printf("\n");
    for (int i = 2; i <= n; i++)
        printf("The distance from %d --> %d is %d\n", src, i, dist[i]);
}
```

GRAPH:



OUTPUT:



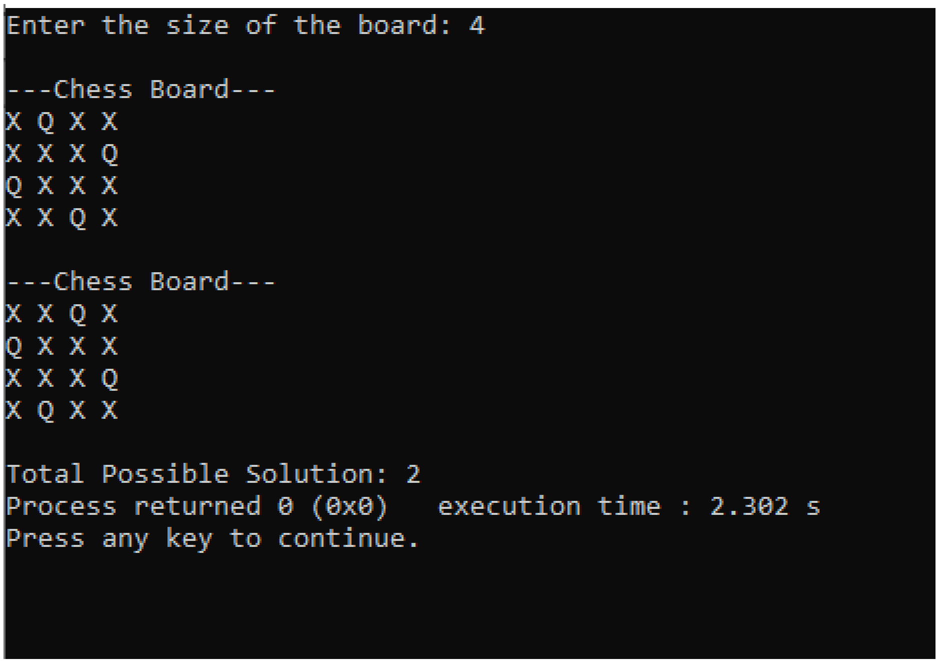
```
Enter the number of vertices
5
Enter the number of edges
7
Enter the edge with weight
1 2 3
1 4 7
2 3 4
3 4 2
3 4 5
3 5 6
4 5 4
0       3       9999    7       9999
3       0       4       9999    9999
9999    4       0       5       6
7       9999    5       0       4
9999    9999    6       4       0
Enter the source
1
The distance to 2 is 3
The distance to 3 is 7
The distance to 4 is 7
The distance to 5 is 11

Process returned 5 (0x5)   execution time : 34.109 s
Press any key to continue.
```

PROGRAM-11

Implement “N-Queens Problem” using Backtracking.

```
#include <stdio.h>

int n, count=0;

int isSafe(char board[n][n], int row, int col)
{
    for (int i = row - 1; i >= 0; i--)
    {
        if (board[i][col] == 'Q')
        {
            return 0;
        }
    }

    for (int i = row - 1, j = col - 1; i >= 0 && j >= 0; i--, j--)
    {
        if (board[i][j] == 'Q')
        {
            return 0;
        }
    }

    for (int i = row - 1, j = col + 1; i >= 0 && j < n; i--, j++)
    {
        if (board[i][j] == 'Q')
        {
            return 0;
        }
    }
    return 1;
}

void printBoard(char board[][n])
{
    printf("\n---Chess Board---\n");

    for (int i = 0; i < n; i++)
    {
        for (int j = 0; j < n; j++)
        {
            printf("%c ", board[i][j]);
        }
        printf("\n");
    }
}

void nQueens(char board[n][n], int row)
{
    if (row == n)
    {
        printBoard(board);
        count++;
        return;
    }
    for (int j = 0; j < n; j++)
    {
        if (isSafe(board, row, j) == 1)
        {
            board[row][j] = 'Q';
            nQueens(board, row + 1);
            board[row][j] = 'X';
        }
    }
}

int main()
{
    printf("Enter the size of the board: ");
    scanf("%d", &n);
    char board[n][n];
    for (int i = 0; i < n; i++)
    {
        for (int j = 0; j < n; j++)
        {
            board[i][j] = 'X';
        }
    }
    nQueens(board, 0);
    printf("\nTotal Possible Solution: %d ",count);
}
```

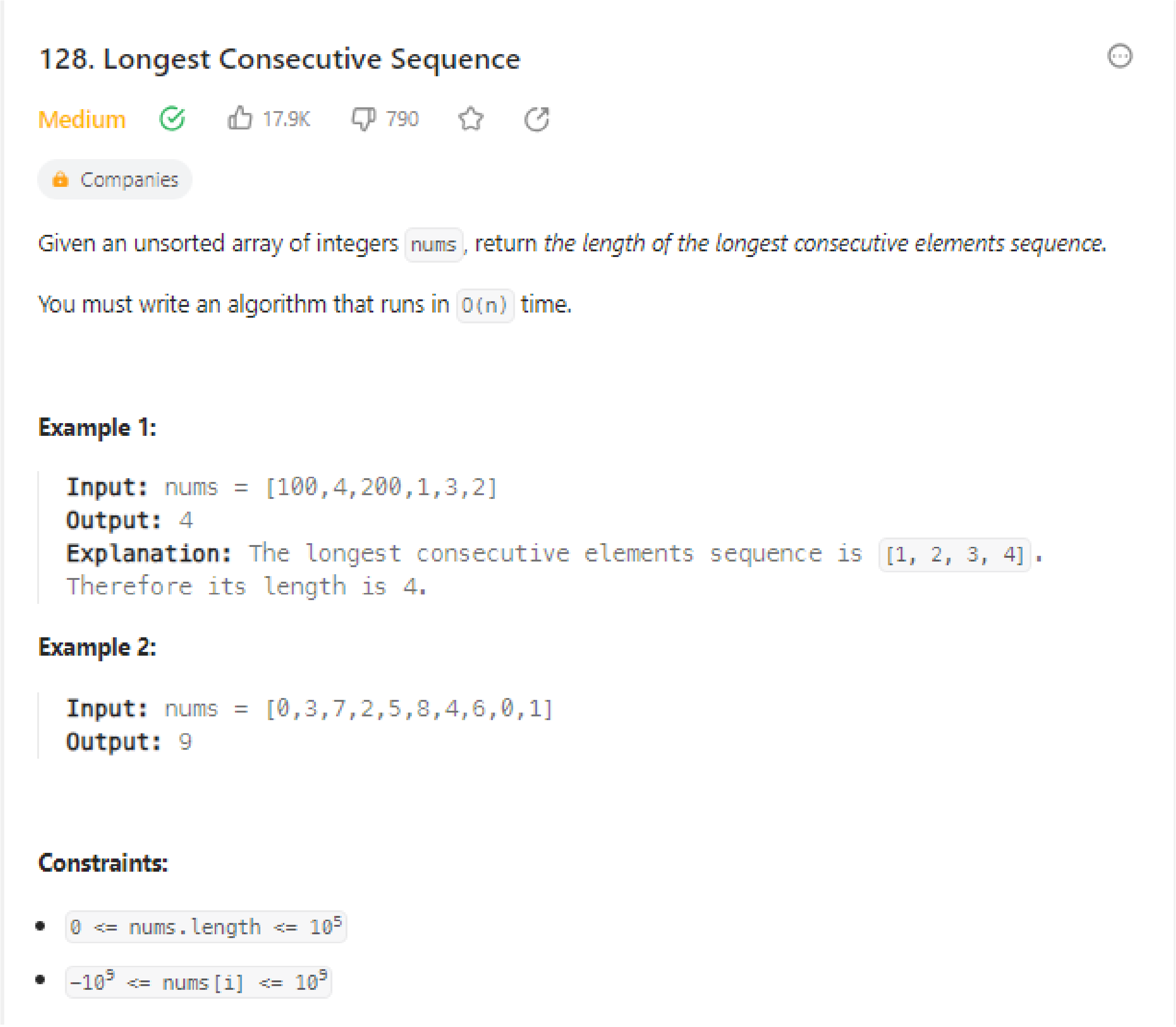
OUTPUT:



```
Enter the size of the board: 4

---Chess Board---
X Q X X
X X X Q
Q X X X
X X Q X

---Chess Board---
X X Q X
Q X X X
X X X Q
X Q X X

Total Possible Solution: 2
Process returned 0 (0x0)   execution time : 2.302 s
Press any key to continue.
```

LeetCode Problems

1.



128. Longest Consecutive Sequence

Given an unsorted array of integers `nums`, return *the length of the longest consecutive elements sequence.*

You must write an algorithm that runs in `O(n)` time.

Example 1:

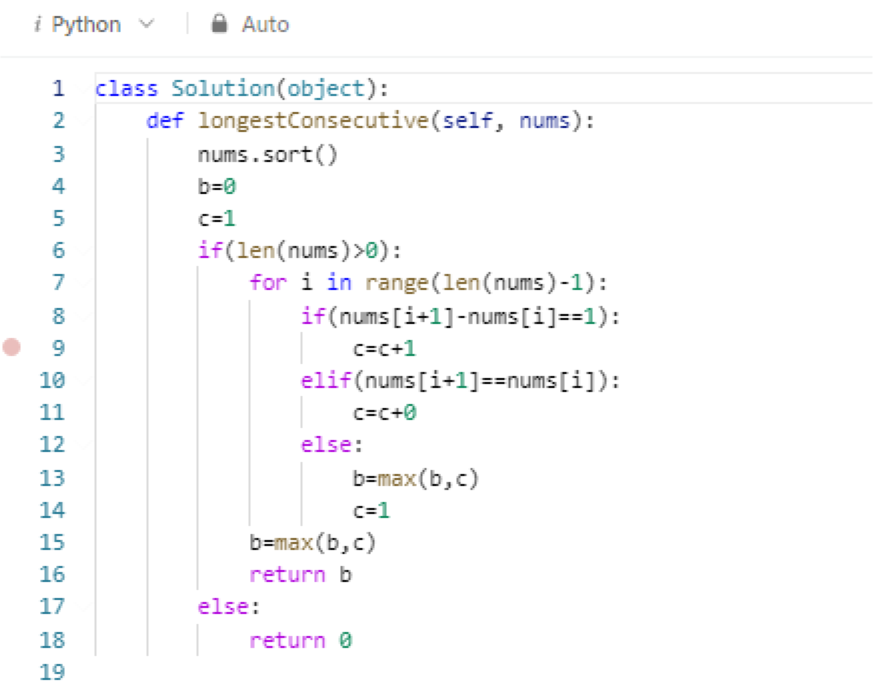
```
Input: nums = [100,4,200,1,3,2]
Output: 4
Explanation: The longest consecutive elements sequence is [1, 2, 3, 4].
Therefore its length is 4.
```

Example 2:

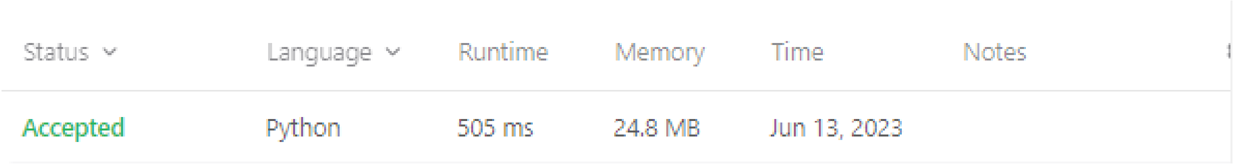
```
Input: nums = [0,3,7,2,5,8,4,6,0,1]
Output: 9
```

Constraints:

- $0 <= nums.length <= 10^5$
- $-10^9 <= nums[i] <= 10^9$

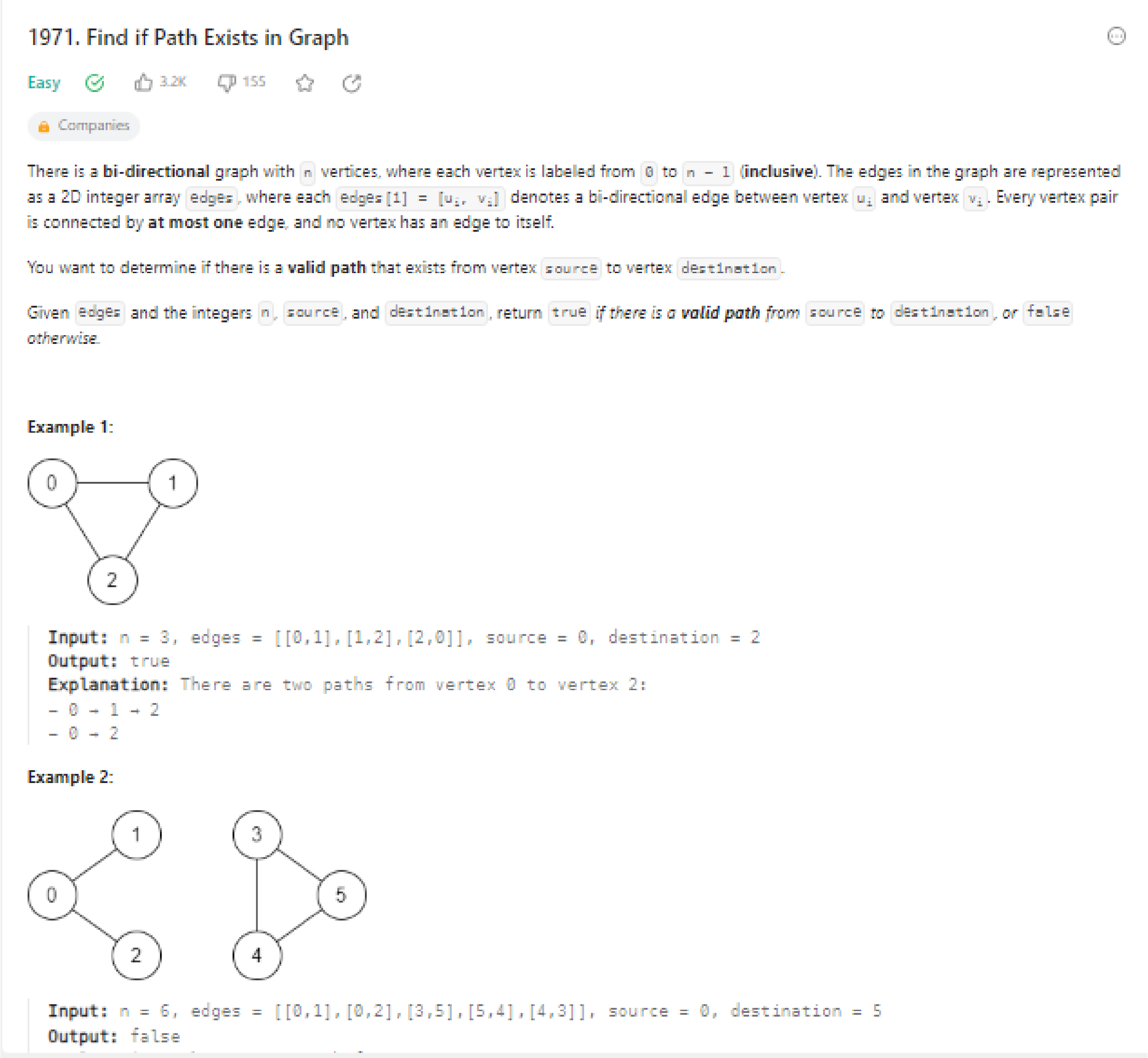


```
class Solution(object):
    def longestConsecutive(self, nums):
        nums.sort()
        b=0
        c=1
        if(len(nums)>0):
            for i in range(len(nums)-1):
                if(nums[i+1]-nums[i]==1):
                    c=c+1
                elif(nums[i+1]==nums[i]):
                    c=c+0
                else:
                    b=max(b,c)
                    c=1
            b=max(b,c)
            return b
        else:
            return 0
```



Status	Language	Runtime	Memory	Time	Notes
Accepted	Python	505 ms	24.8 MB	Jun 13, 2023	

2.



1971. Find if Path Exists in Graph

There is a **bi-directional** graph with `n` vertices, where each vertex is labeled from `0` to `n - 1` (**inclusive**). The edges in the graph are represented as a 2D integer array `edges`, where each `edges[i] = [ui, vi]` denotes a bi-directional edge between vertex `ui` and vertex `vi`. Every vertex pair is connected by **at most one** edge, and no vertex has an edge to itself.

You want to determine if there is a **valid path** that exists from vertex `source` to vertex `destination`.

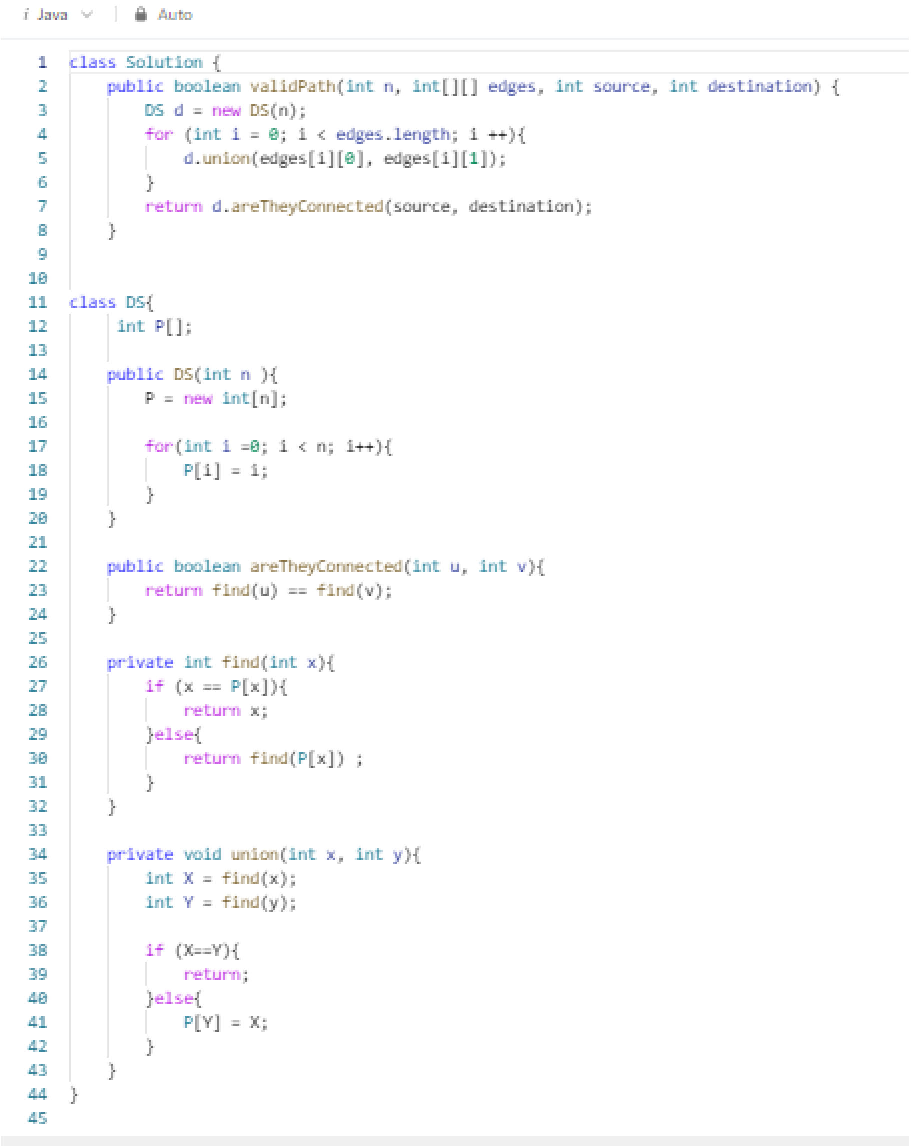
Given `edges` and the integers `n`, `source`, and `destination`, return `true` *if there is a* ***valid path*** *from* `source` *to* `destination`*, or* `false` *otherwise.*

Example 1:

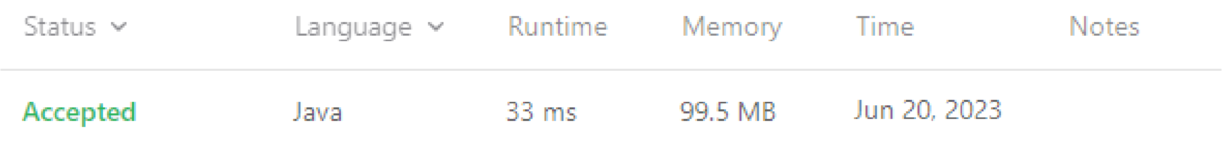
```
Input: n = 3, edges = [[0,1],[1,2],[2,0]], source = 0, destination = 2
Output: true
Explanation: There are two paths from vertex 0 to vertex 2:
- 0 → 1 → 2
- 0 → 2
```

Example 2:

```
Input: n = 6, edges = [[0,1],[0,2],[3,5],[5,4],[4,3]], source = 0, destination = 5
Output: false
```

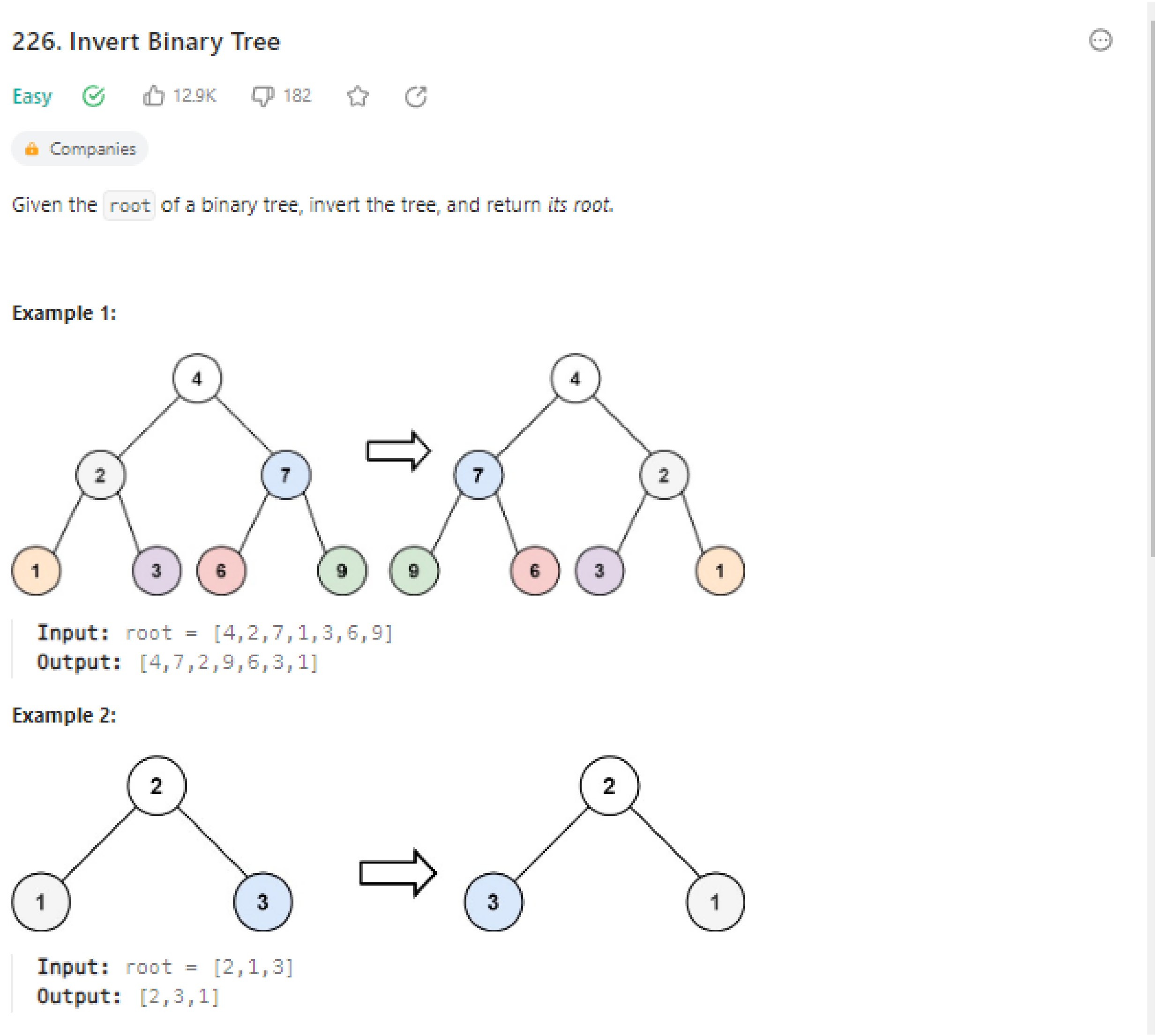


```java
class Solution {
    public boolean validPath(int n, int[][] edges, int source, int destination) {
        DS d = new DS(n);
        for (int i = 0; i < edges.length; i ++){
            d.union(edges[i][0], edges[i][1]);
        }
        return d.areTheyConnected(source, destination);
    }


class DS{
     int P[];

    public DS(int n ){
        P = new int[n];

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

    public boolean areTheyConnected(int u, int v){
        return find(u) == find(v);
    }

    private int find(int x){
        if (x == P[x]){
            return x;
        }else{
            return find(P[x]) ;
        }
    }

    private void union(int x, int y){
        int X = find(x);
        int Y = find(y);

        if (X==Y){
            return;
        }else{
            P[Y] = X;
        }
    }
}
```



Status	Language	Runtime	Memory	Time	Notes
Accepted	Java	33 ms	99.5 MB	Jun 20, 2023	

3.



226. Invert Binary Tree

Easy 12.9K 182

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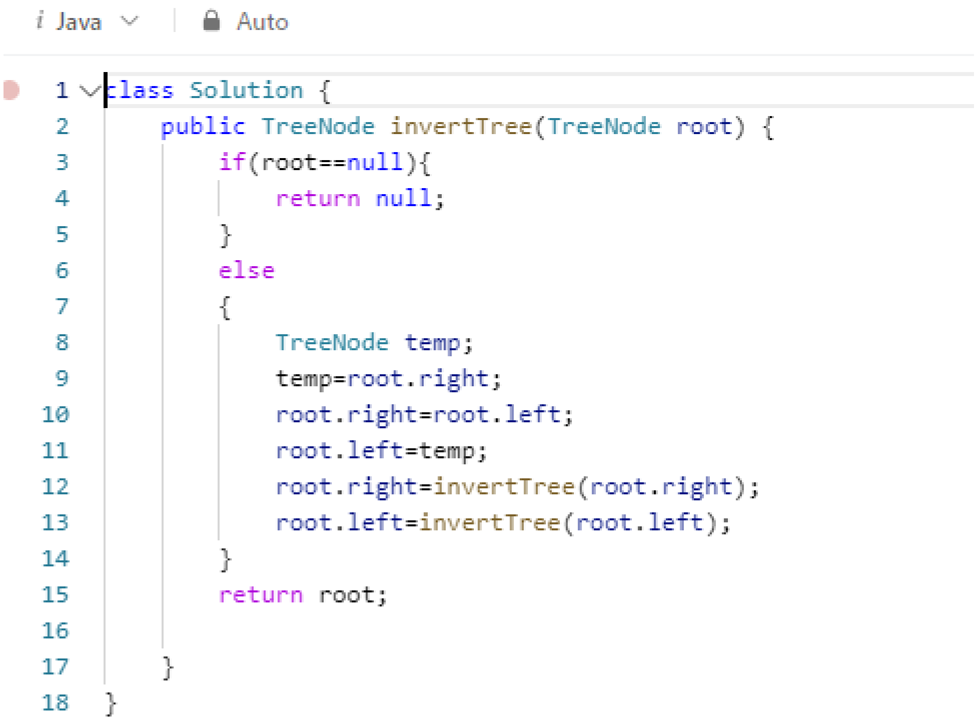
Given the `root` of a binary tree, invert the tree, and return *its root*.

Example 1:

```
Input: root = [4,2,7,1,3,6,9]
Output: [4,7,2,9,6,3,1]
```

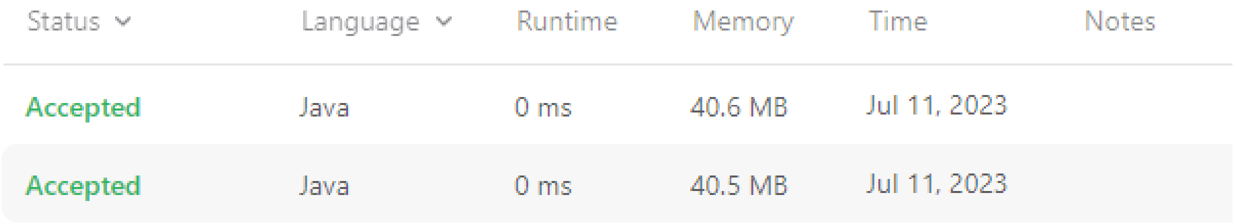
Example 2:

```
Input: root = [2,1,3]
Output: [2,3,1]
```



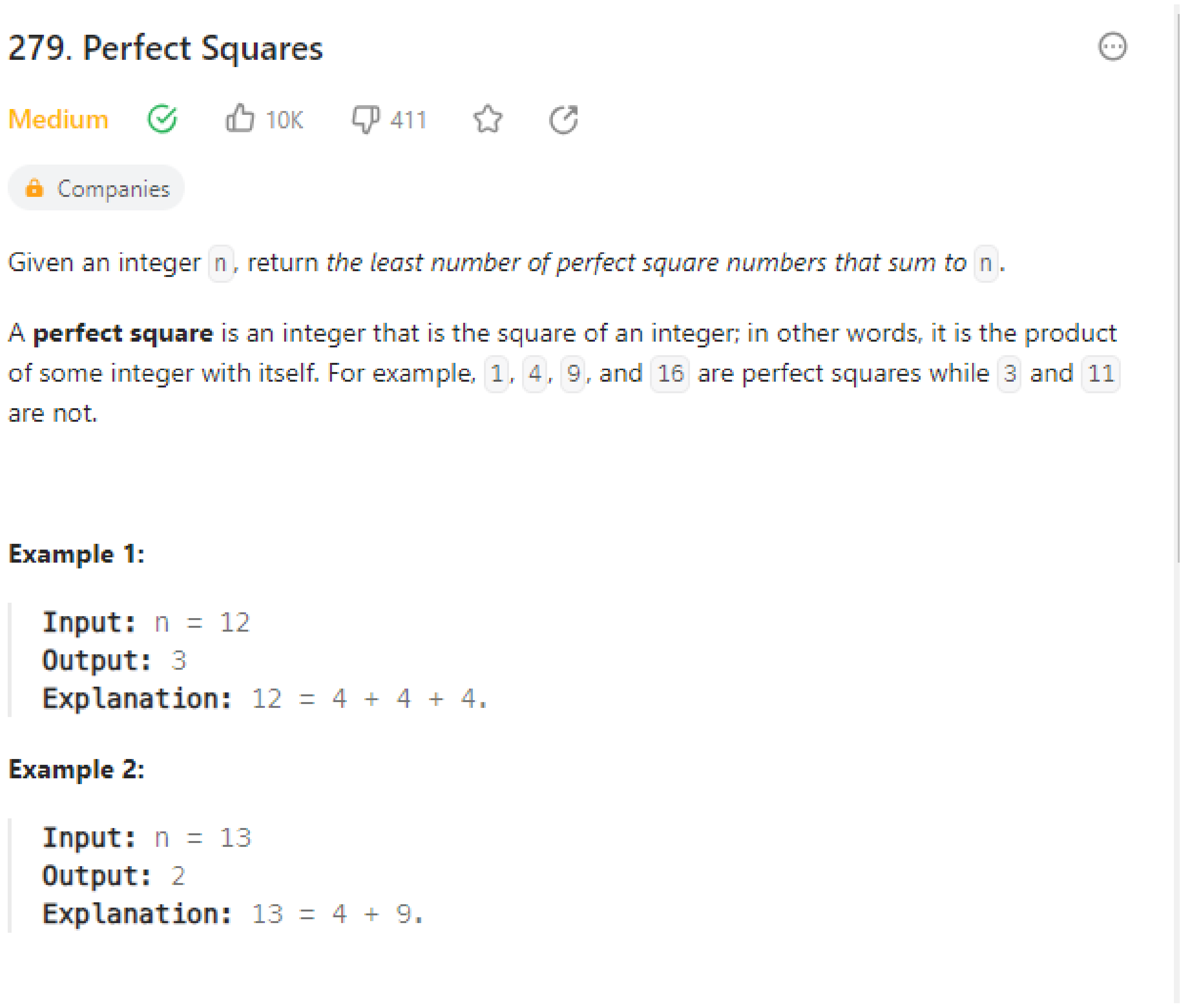
```java
class Solution {
    public TreeNode invertTree(TreeNode root) {
        if(root==null){
            return null;
        }
        else
        {
            TreeNode temp;
            temp=root.right;
            root.right=root.left;
            root.left=temp;
            root.right=invertTree(root.right);
            root.left=invertTree(root.left);
        }
        return root;

    }
}
```



Status	Language	Runtime	Memory	Time	Notes
Accepted	Java	0 ms	40.6 MB	Jul 11, 2023	
Accepted	Java	0 ms	40.5 MB	Jul 11, 2023	

4.



279. Perfect Squares

Given an integer `n`, return *the least number of perfect square numbers that sum to* `n`.

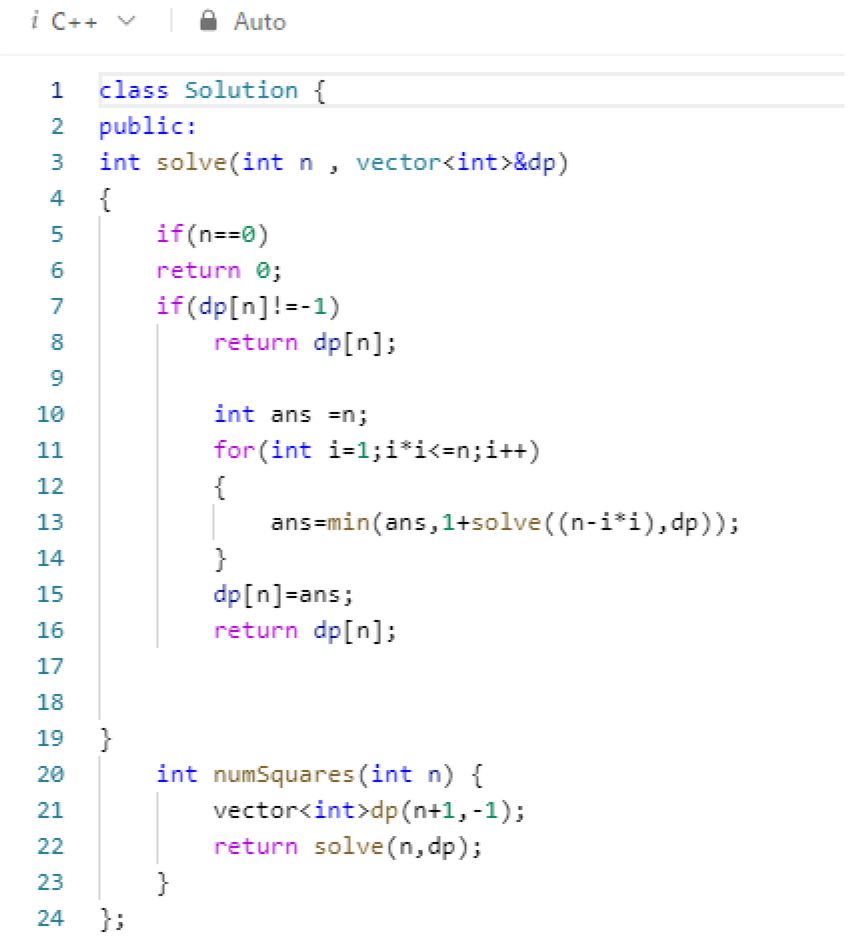
A **perfect square** is an integer that is the square of an integer; in other words, it is the product of some integer with itself. For example, `1`, `4`, `9`, and `16` are perfect squares while `3` and `11` are not.

Example 1:

```
Input: n = 12
Output: 3
Explanation: 12 = 4 + 4 + 4.
```

Example 2:

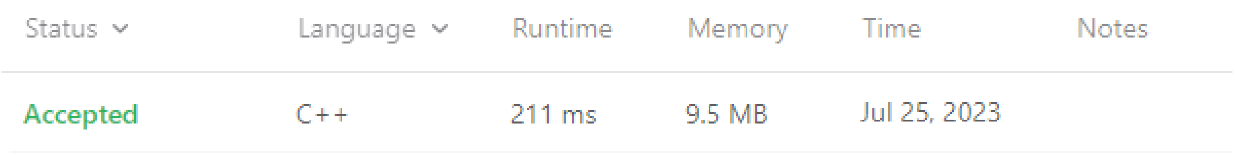
```
Input: n = 13
Output: 2
Explanation: 13 = 4 + 9.
```



```
class Solution {
public:
int solve(int n , vector<int>&dp)
{
    if(n==0)
    return 0;
    if(dp[n]!=-1)
        return dp[n];

        int ans =n;
        for(int i=1;i*i<=n;i++)
        {
            ans=min(ans,1+solve((n-i*i),dp));
        }
        dp[n]=ans;
        return dp[n];


}
    int numSquares(int n) {
        vector<int>dp(n+1,-1);
        return solve(n,dp);
    }
};
```



Status	Language	Runtime	Memory	Time	Notes
Accepted	C++	211 ms	9.5 MB	Jul 25, 2023	