

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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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

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in

COMPUTER SCIENCE AND ENGINEERING

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ENGINEERING BENGALURU-

(Autonomous Institution under VTU)

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Bull Temple Road, Bangalore 560019
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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 **PADMANJALI A (1BM20CS102)**, 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 year 2022. The Lab report has been approved as it satisfies the academic requirements in respect of a **Analysis and Design of Algorithms - (19CS4PCADA)** work prescribed for the said degree.

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Course Outcome :

CO1	Ability to analyze time complexity of Recursive and Non-Recursive algorithms using asymptotic notations.
CO2	Ability to design efficient algorithms using various design techniques.
CO3	Ability to apply the knowledge of complexity classes P, NP, and NP-Complete and prove certain problems are NP-Complete
CO4	Ability to conduct practical experiments to solve problems using an appropriate designing method and find time efficiency.

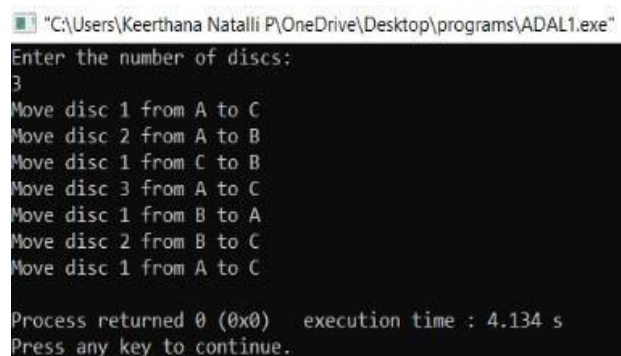
#Program 1:

Write a recursive program to Solve

a. Towers-of-Hanoi problem

```
#include<stdio.h>
void tower(int n,char from,char to,char aux)
{
if(n==1)
{
printf("Move disc 1 from %c to %c\n",from,to);
return;
}
tower(n-1,from,aux,to);
printf("Move disc %d from %c to %c\n",n,from,to);
tower(n-1,aux,to,from);
} int
main() {
int n;
printf("Enter the number of discs:\n");
scanf("%d",&n); tower(n,'A','C','B');
return 0;
}
```

Output:



The screenshot shows a Windows command prompt window with the title bar "C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL1.exe". The program has been executed with 3 discs. The output shows the sequence of moves required to solve the Towers of Hanoi problem: "Enter the number of discs:", "3", "Move disc 1 from A to C", "Move disc 2 from A to B", "Move disc 1 from C to B", "Move disc 3 from A to C", "Move disc 1 from B to A", "Move disc 2 from B to C", "Move disc 1 from A to C". At the bottom, it says "Process returned 0 (0x0) execution time : 4.134 s" and "Press any key to continue."

b. To find GCD

```
#include<stdio.h> int
gcd(int n1,int n2)
{
if(n2!=0)
{
return gcd(n2,n1%n2);
} else
return n1;
} int main()
{ int n1,n2; printf("Enter the value of n1 and n2:\n");
scanf("%d%d",&n1,&n2); printf("The gcd of %d and
%d is %d",n1,n2,gcd(n1,n2)); return 0;
}
```

Output:

"C:\Users\Keerthana Natali P\OneDrive\Desktop\programs\ADAL2.exe"

Enter the value of n1 and n2:

36

48

The gcd of 36 and 48 is 12

Process returned 0 (0x0) execution time : 5.787 s

Press any key to continue.

#Program 2:

Implement Recursive Binary search and Linear search and determine the time required to search an element. Repeat the experiment for different values of N and plot a graph of the time taken versus N.

- **Binary Search**

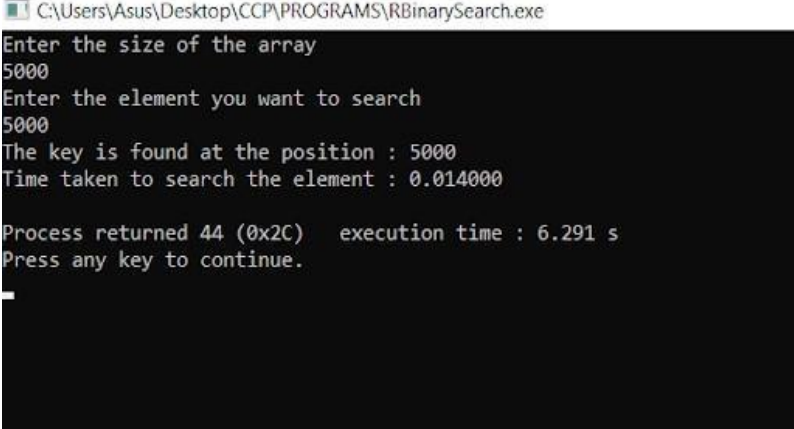
```
#include<stdio.h> #include<time.h>
int RBinarySearch(int arr[],int low,int high,int key)
{   int mid;
    delay();
    if(low>high)
        return -1;   mid =
    (low+high)/2;
    if(arr[mid] == key)
        return mid;   else if(key
    > arr[mid])        return
    RBinarySearch(arr,mid+1,high,key);
    else
        return RBinarySearch(arr,low,mid-1,key);
}

void delay()
{   int temp;   for(int
i=0;i<80000;i++)
temp = 387/2382;
}

void main()
{   int n,key;
    clock_t start,end;
    printf("Enter the size of the array\n");
    scanf("%d",&n);
    int nums[n];   for(int
i=0;i<n;i++)
    nums[i]=i+1;
    printf("Enter the element you want to search\n");
    scanf("%d",&key);
    start = clock();
```

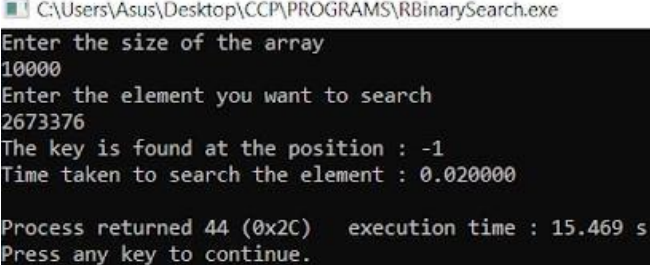
```
int ans = RBinarySearch(nums,0,n-1,key);
end = clock();
printf("The key is found at the position : %d\n",ans+1);
printf("Time taken to search the element : %lf\n",(double)(end-start)/CLOCKS_PER_SEC); }
```

Output:



```
C:\Users\Asus\Desktop\CCP\PROGRAMS\RBinarySearch.exe
Enter the size of the array
5000
Enter the element you want to search
5000
The key is found at the position : 5000
Time taken to search the element : 0.014000

Process returned 44 (0x2C)   execution time : 6.291 s
Press any key to continue.
```



```
C:\Users\Asus\Desktop\CCP\PROGRAMS\RBinarySearch.exe
Enter the size of the array
10000
Enter the element you want to search
2673376
The key is found at the position : -1
Time taken to search the element : 0.020000

Process returned 44 (0x2C)   execution time : 15.469 s
Press any key to continue.
```

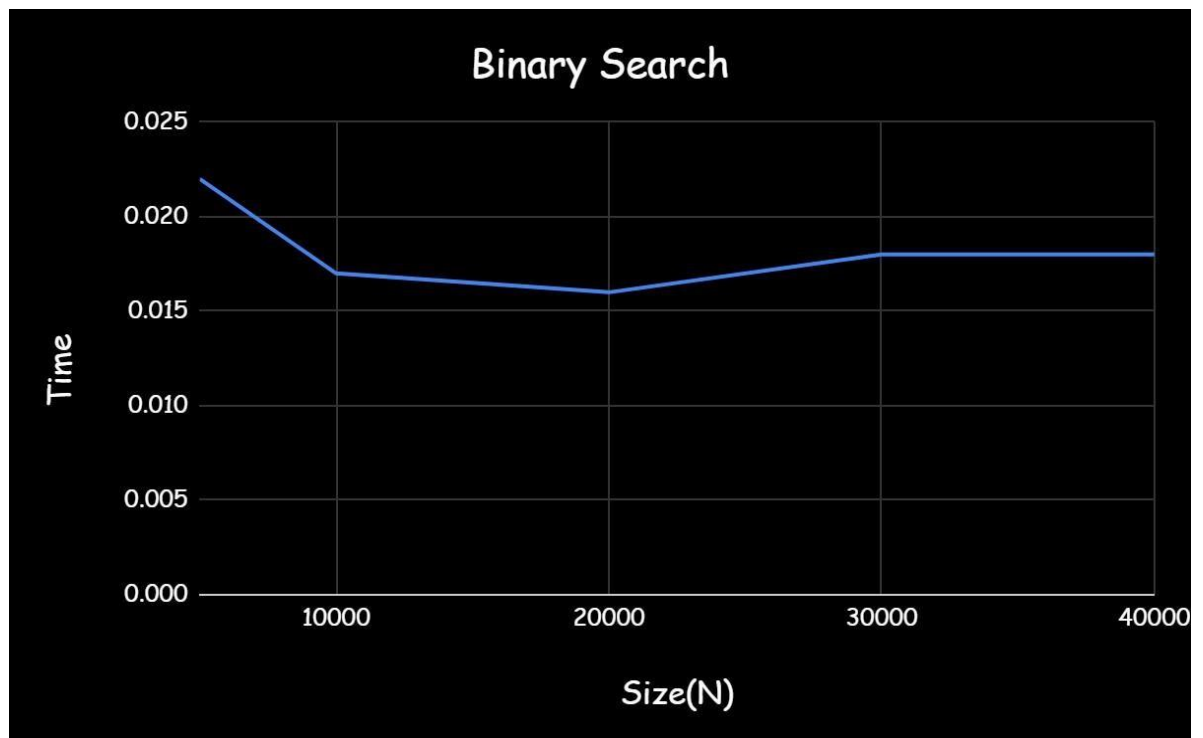


```
C:\Users\Asus\Desktop\CCP\PROGRAMS\RBinarySearch.exe
Enter the size of the array
20000
Enter the element you want to search
20000
The key is found at the position : 20000
Time taken to search the element : 0.019000

Process returned 44 (0x2C)   execution time : 10.076 s
Press any key to continue.
```

Graph:

Time Complexity: $O(\log n)$



• Linear Search

```
#include<stdio.h> #include<time.h>
int RLinearSearch(int arr[],int key,int index,int length)
{   delay();
if(index<length)
    {
        if(arr[index] == key)
        {
            return index;
        }
    }
else
    return RLinearSearch(arr,key,index+1,length);
}
if(index>=length)
{
    return -1;
}
}

void delay()
{   int temp;   for(int
i=0;i<8000;i++)
temp = 387/2382;
}

void main()
{   int n,key;
clock_t start,end;
    printf("Enter the size of the array\n");
scanf("%d",&n);
int nums[n];   for(int
i=0;i<n;i++)
nums[i]=i+1;
    printf("Enter the element you want to search\n");
scanf("%d",&key);
    start = clock();
    int ans = RLinearSearch(nums,key,0,n);
    end = clock();
    printf("The key is found at the position : %d\n",ans+1);
    printf("Time taken to search the element : %lf\n",(double)(end-start)/CLOCKS_PER_SEC); }
```

Output:

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

```
Enter the size of the array
5000
Enter the element you want to search
5000
The key is found at the position : 5000
Time taken to search the element : 0.065000

Process returned 44 (0x2C)   execution time : 5.413 s
Press any key to continue.
```

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

```
Enter the size of the array
1000
Enter the element you want to search
1000
The key is found at the position : 1000
Time taken to search the element : 0.015000

Process returned 44 (0x2C)   execution time : 13.459 s
Press any key to continue.
```

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

```
Enter the size of the array
3000
Enter the element you want to search
3000
The key is found at the position : 3000
Time taken to search the element : 0.047000

Process returned 44 (0x2C)   execution time : 10.042 s
Press any key to continue.
```

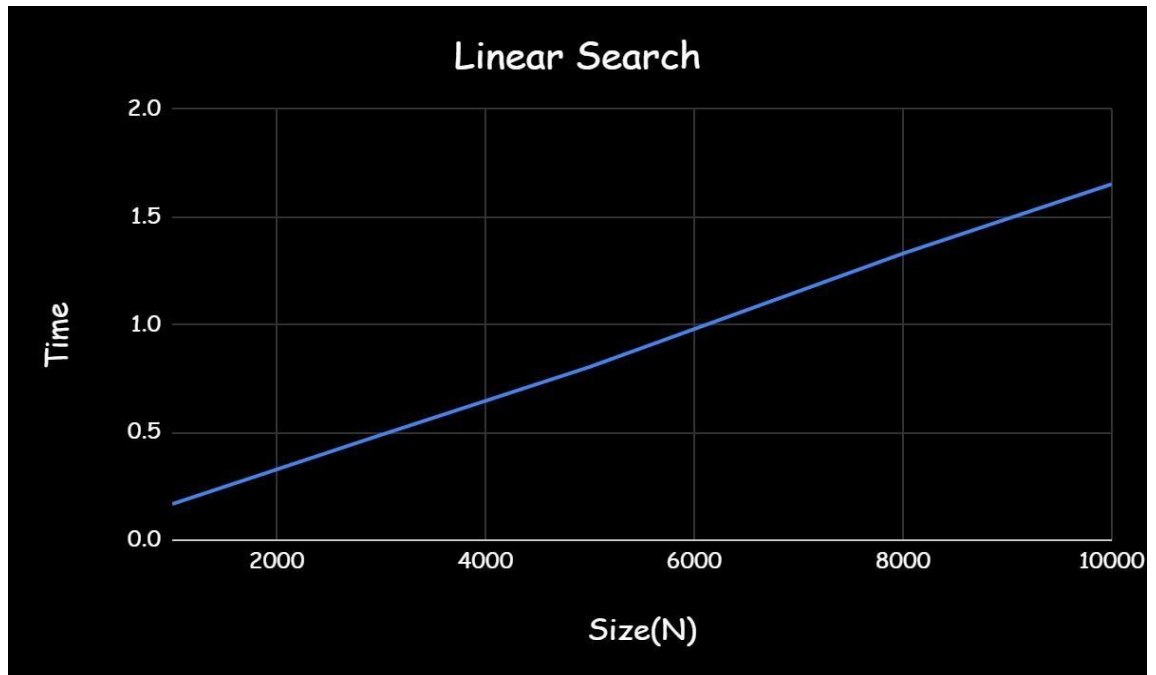
"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

```
Enter the size of the array
10000
Enter the element you want to search
10000
The key is found at the position : 10000
Time taken to search the element : 0.137000

Process returned 44 (0x2C)   execution time : 6.081 s
Press any key to continue.
```

Graph:

Time Complexity: $O(n)$



#Program 3:

Sort a given set of N integer elements using Selection 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> void
selSort(int a[],int n)
{
    int s,temp,k,m;
    for(int i=0;i < n-1 ;i++)
    {
        s =
a[i];
        for(k = i+1 ;k < n;k++)
        {
            if(a[k] < s)
            {
                s =
a[k];
                m
= k;
            }
        }
        temp = s;
        a[m] = a[i];
        a[i] = temp;
    }
}

void main()
{
    int n,key;
    clock_t start,end;
    printf("Enter the size of the array\n");
    scanf("%d",&n);
    int nums[n];   for(int
i=0;i<n;i++)
    nums[i]=rand();
    printf("Array before sorting\n");
    for(int i=0;i<n;i++)
    printf("%d\t",nums[i]);   start =
clock();   selSort(nums,n);   end
= clock();
    printf("\n\nArray after sorting\n");
```

```
for(int i=0;i<n;i++)  
printf("%d\t",nums[i]);  
    printf("\n\nTime taken to sort the element : %f\n",(double)(end-start)/CLOCKS_PER_SEC);  
}
```

Output:

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

Enter the size of the array
10000

Time taken to sort the element : 0.113000

Process returned 44 (0x2C) execution time : 2.473 s
Press any key to continue.

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

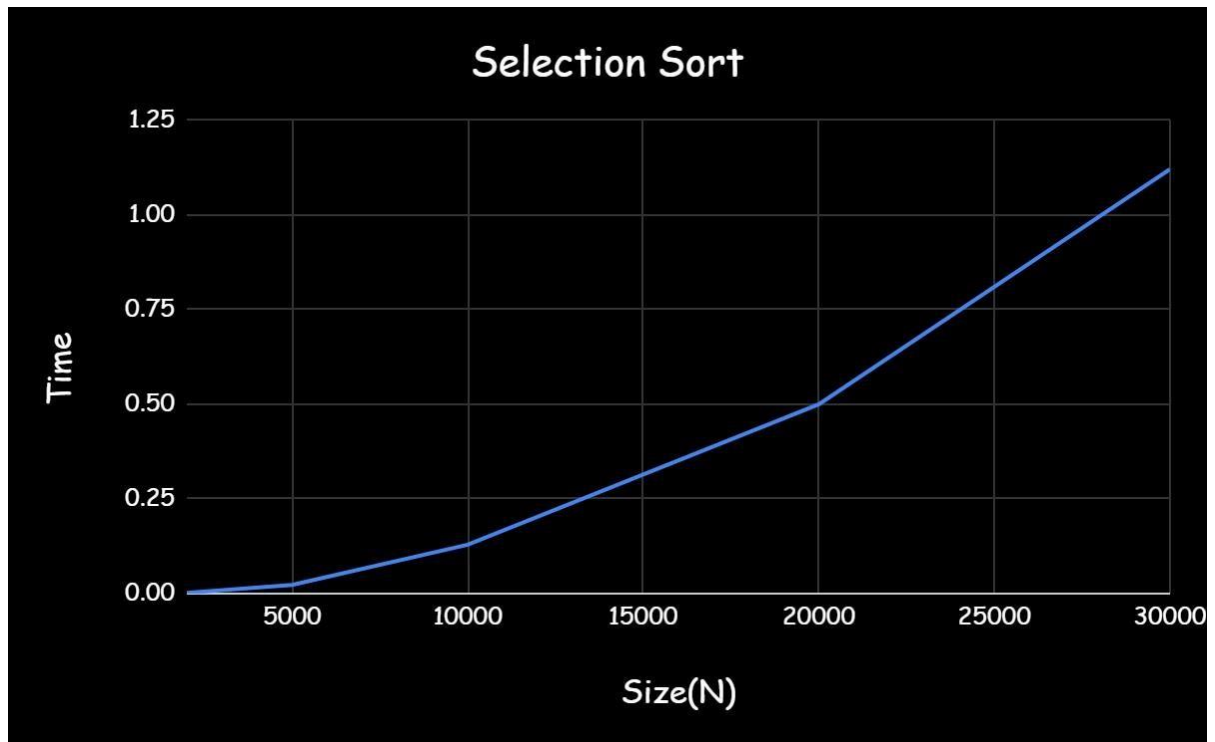
Enter the size of the array
20000

Time taken to sort the element : 0.414000

Process returned 44 (0x2C) execution time : 7.722 s
Press any key to continue.
_

Graph:

Time Complexity: $O(n^2)$



#Program 4:

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> #include<conio.h>
int a[20][20], q[20], visited[20], n, i, j, f = 0, r = -1;
void bfs(int v) { for(i = 1; i <= n; i++) if(a[v][i]
&& !visited[i])
q[++r] = i;
if(f <= r)
{
visited[q[f]] = 1;
bfs(q[f++]);
}
}

void main() {
int
v;
printf("Enter the number of vertices: ");
scanf("%d",&n);
for(i=1; i <= n; i++) {
q[i] = 0;
visited[i] = 0;
}
printf("\nEnter graph data in matrix form:\n");
for(i=1; i<=n; i++) { for(j=1;j<=n;j++) {
scanf("%d", &a[i][j]);
}
}
printf("Enter the starting vertex: ");
scanf("%d", &v);
bfs(v);
printf("\nThe node which are reachable are:");
for(i=1; i <= n; i++) {
if(visited[i])
printf(" %d", i);
else {
printf("\nBFS is not possible. All nodes are not reachable!");
break;
}
```

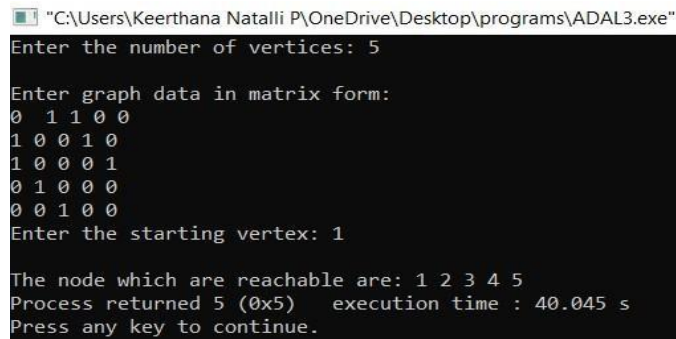


```

    }
}
}

```

Output:



```

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"
Enter the number of vertices: 5

Enter graph data in matrix form:
0 1 1 0 0
1 0 0 1 0
1 0 0 0 1
0 1 0 0 0
0 0 1 0 0
Enter the starting vertex: 1

The node which are reachable are: 1 2 3 4 5
Process returned 5 (0x5)   execution time : 40.045 s
Press any key to continue.

```

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

```

#include <stdio.h>
#include<time.h> int
a[20][20],reach[20],n;
void dfs(int v) {
    int i;
    reach[v]=1; for (i=1;i<=n;i++)
        if(a[v][i] && !reach[i]) {
            printf("\n %d->%d",v,i);
            dfs(i);
        }
} void main()
{   clock_t
start,end;
    int i,j,count=0;
    printf("\n Enter number of
vertices:");   scanf("%d",&n);   for
(i=1;i<=n;i++) {
        reach[i]=0;
        for (j=1;j<=n;j++)
            a[i][j]=0;

```

```

    }
    printf("\n Enter the adjacency matrix:\n");
    for (i=1;i<=n;i++)
for (j=1;j<=n;j++)
        scanf("%d",&a[i][j]);
        dfs(1);
        printf("\n"); for
(i=1;i<=n;i++) {
            if(reach[i])
count++;
        }
        if(count==n)          printf("\n
Graph is connected");        else
        printf("\n Graph is not connected");
    }

```

Output:

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

```

Enter number of vertices:5

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

1->2
2->4
1->3
3->5

Graph is connected
Process returned 20 (0x14)   execution time : 30.167 s
Press any key to continue.

```

#Program 5:

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

```
#include<stdio.h>
#include<time.h>
void insertionSort(int a[],int n)
{   int
j,key;
    for(int i=1;i<=n-1;i++)
    {       key = a[i];
for(j=i-1;j>=0;j--)
    {
        if(a[j] > key)
        {
            a[j+1] = a[j];
        }
    }
    else
break;
        a[j+1] = key;
    }
}

void main()
{   int n,key;
clock_t start,end;
    printf("Enter the size of the array\n");
scanf("%d",&n);   int
nums[n];   for(int
i=0;i<n;i++)
nums[i]=rand();   start
= clock();
insertionSort(nums,n);
end = clock();
    printf("\nTime taken to sort the element : %f\n",(double)(end-start)/CLOCKS_PER_SEC); }
```

Output:

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

Enter the size of the array

5000

Time taken to sort the element : 0.016000

Process returned 43 (0x2B) execution time : 77.740 s

Press any key to continue.

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

Enter the size of the array

20000

Time taken to sort the element : 0.204000

Process returned 43 (0x2B) execution time : 5.721 s

Press any key to continue.

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

Enter the size of the array

30000

Time taken to sort the element : 0.465000

Process returned 43 (0x2B) execution time : 6.446 s

Press any key to continue.

Graph:

Time Complexity: $O(n^2)$



#Program 6:

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

```
#include<stdio.h> int
main() {
    int i,j,k,n,a[10][10], indeg[10],flag[10],count=0;
    printf("Enter the no of vertices:\n"); scanf("%d",&n);
    printf("Enter the adjacency matrix: \n");
    for(i=0;i<n;i++){    printf("Enter
row%d\n", i+1); for(j=0;j<n;j++)
scanf("%d", &a[i][j]);
    }
    for(i=0;i<n;i++){
indeg[i]=0; flag[i]=0;
    }
    for(i=0;i<n;i++){
for(j=0;j<n;j++){
indeg[i]=indeg[i]+a[j][i];
    }
    }
    printf("\nThe Topological order is: ");
    while(count<n) {
for(k=0;k<n;k++){
    if((indeg[k]==0) && (flag[k]==0)){
        printf("%d\t",(k+1));
        flag[k]=1;
    }
    for(i=0;i<n;i++) {
        if(a[i][k]==1) indeg[k]--;
    }
    }
    count++;
} return
0;
}
```

Output:

 "C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\ADAL3.exe"

Enter the no of vertices:

5

Enter the adjacency matrix:

Enter row1

0 0 1 0 0

Enter row2

0 0 1 0 0

Enter row3

1 1 0 1 1

Enter row4

0 0 1 0 1

Enter row5

0 0 1 1 0

The Topological order is: 1 2 3 4 5

Process returned 0 (0x0) execution time : 39.469 s

Press any key to continue.

#Program 7:

Implement Johnson Trotter algorithm to generate permutations

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



```

}

void swap(int *m,int *n)
{   int temp;
temp = *m;
*m = *n;
*n = temp;
}

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) swap(&a[pos-1], &a[pos-2]);
else if (dir[a[pos] - 1] - 1 == LEFT_TO_RIGHT)
    swap(&a[pos], &a[pos-1]);
    for (int i = 0; i < n; i++)
    {
        if (a[i] > mobile)
        {
            if (dir[a[i] - 1] == LEFT_TO_RIGHT)
dir[a[i] - 1] = RIGHT_TO_LEFT;
            else if (dir[a[i] - 1] == RIGHT_TO_LEFT)
dir[a[i] - 1] = LEFT_TO_RIGHT;
        }
    }

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

    printf("\n");
}

int fact(int n)
{
    int res = 1;    for (int 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]);
    }
    printf("\n");

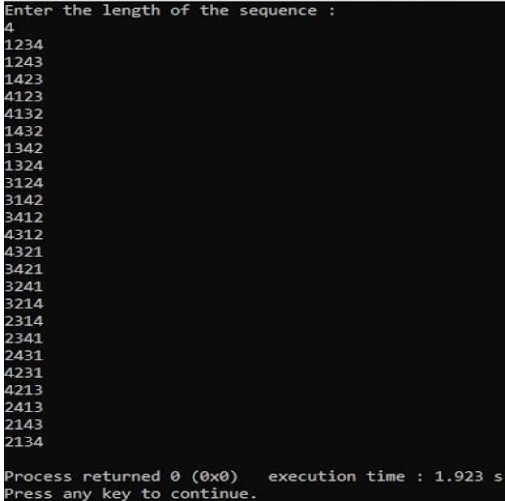
    for (int i = 0; i < n; i++)
        dir[i] = RIGHT_TO_LEFT;

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

int main()
{
    int n;
    printf("Enter the length of the sequence : \n");
    scanf("%d",&n);  printPermutation(n);
    return 0;
}

```

Output:



```

C:\Users\Asus\Desktop\CCP\PROGRAMS\jhonson_trotter.exe
Enter the length of the sequence :
4
1234
1243
1423
4123
4132
1432
1342
1324
3124
3142
3412
4312
4321
3421
3241
3214
2314
2341
2431
4231
4213
2413
2143
2134

Process returned 0 (0x0)   execution time : 1.923 s
Press any key to continue.

```

#Program 8:

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>
void merge(int a[],int s,int m,int e)
{   delay();   int merged[e-
s+1];   int i=s,j=m+1,k=0;
    while(i<=m && j<=e)
    {
        if(a[i]<a[j])
        {
            merged[k]=a[i];
            i++;
            k++;
        }
        else
        {
            merged[k]=a[j];
            j++;
            k++;
        }
    }
    while(i<=m)
    {
        merged[k]=a[i];
        i++;
        k++;
    }
    while(j<=e)
    {
        merged[k]=a[j];
        j++;
        k++;
    }
    for(int p=0;p<e-s+1;p++)
    a[s+p]=merged[p];
} void
delay() {
int temp ;
```

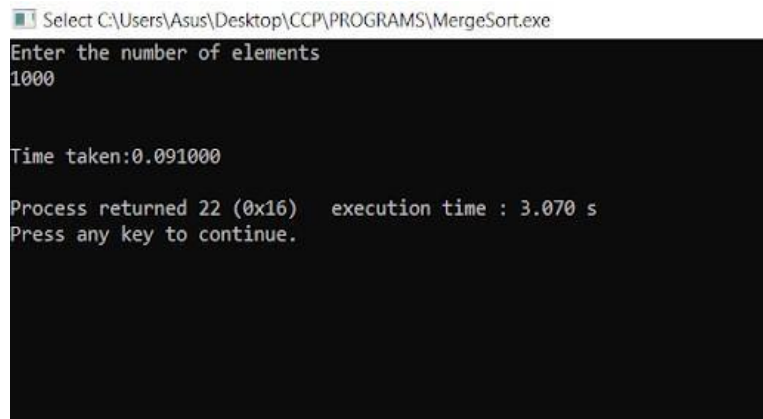
```
for(int i=0
;i<50000;i+
+)
temp=46/47
48;
}
```

```
void mergeSort(int a[],int s,int e)
{   if(e-s+1 ==
1)
return;
```

```
    int mid=(s+e)/2;
mergeSort(a,s,mid);
mergeSort(a,mid+1,e);
merge(a,s,mid,e);
}
```

```
void main() {
int n;   clock_t
start,end;
    printf("Enter the number of elements\n");
scanf("%d",&n);   int nums[n];   for(int
i=0;i<n;i++)      nums[i]=rand();
start=clock();   mergeSort(nums,0,n-1);
end=clock();
    printf("\n\nTime taken:%lf\n",(double)(end-start)/CLOCKS_PER_SEC); }
```

Output:



```
Select C:\Users\Asus\Desktop\CCP\PROGRAMS\MergeSort.exe
Enter the number of elements
1000

Time taken:0.091000

Process returned 22 (0x16)  execution time : 3.070 s
Press any key to continue.
```

```
C:\Users\Asus\Desktop\CCP\PROGRAMS\MergeSort.exe
Enter the number of elements
5000

Time taken:0.528000

Process returned 22 (0x16)   execution time : 7.991 s
Press any key to continue.
```

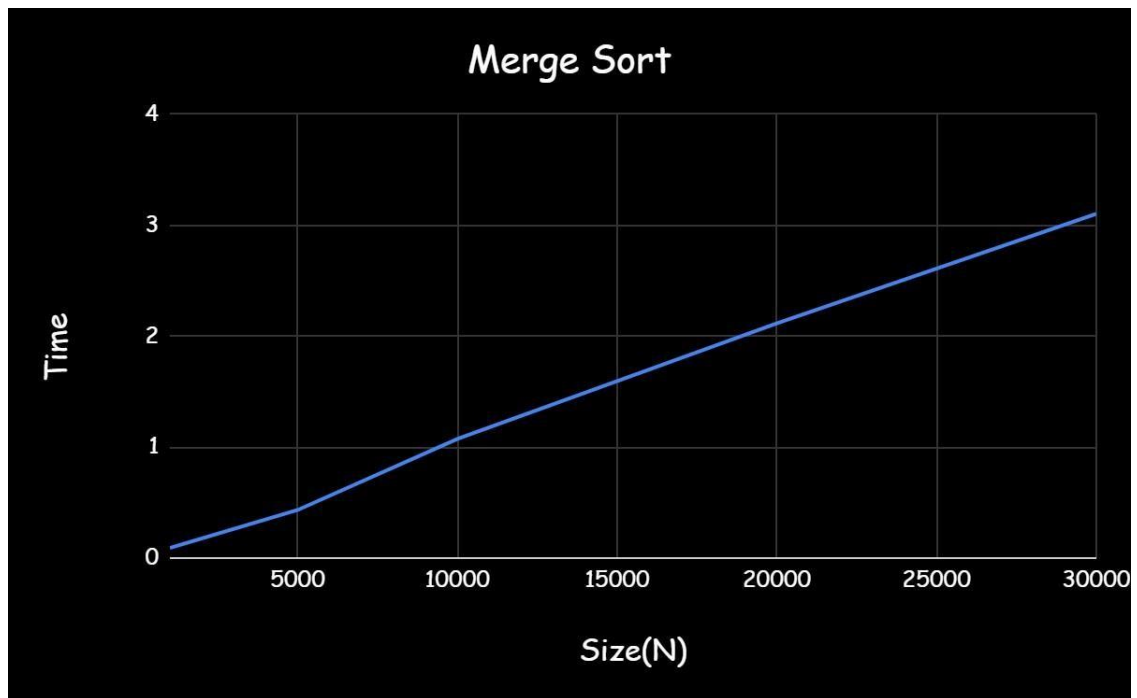
```
C:\Users\Asus\Desktop\CCP\PROGRAMS\MergeSort.exe
Enter the number of elements
10000

Time taken:1.087000

Process returned 22 (0x16)   execution time : 2.595 s
Press any key to continue.
```

Graph:

Time Complexity : $O(n \log n)$



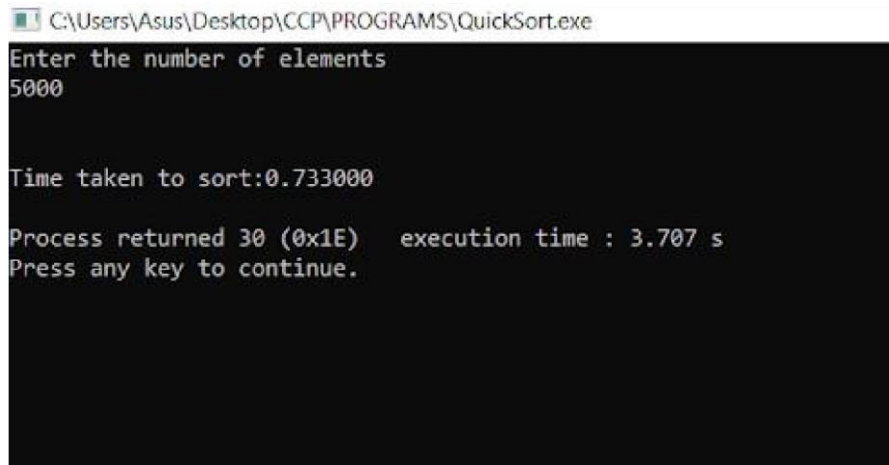
#Program 9:

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

```
#include<stdio.h>
#include<time.h>
void quicksort(int number[],int first,int last){
    int i, j, pivot, temp;
    delay();
    if(first<last){
        pivot=first;
        i=first;    j=last;
        while(i<j){
            while(number[i]<=number[pivot]&& i<last)
                i++;
            while(number[j]>number[pivot])    j--;
        }
        if(i<j){
            temp=number[i];
            number[i]=number[j];
            number[j]=temp;
        }
        temp=number[pivot];
        number[pivot]=number[j];    number[j]=temp;
        quicksort(number,first,j-1);
        quicksort(number,j+1,last);
    } } void
delay()
{    int temp ;    for(int i=0
;i<50000;i++)
temp=46/4748;
} void
main()
{    int n;
clock_t start,end;
    printf("Enter the number of elements\n");
    scanf("%d",&n);    int nums[n];
    for(int i=0;i<n;i++)
        nums[i]=rand();    start=clock();
```

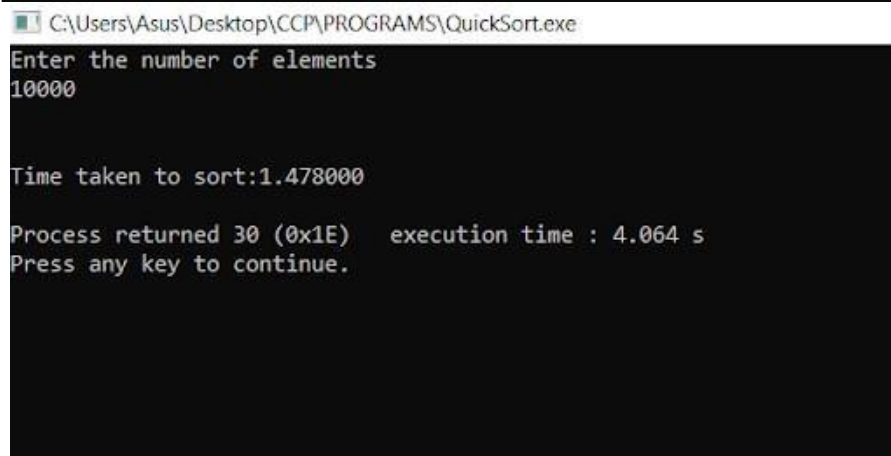
```
quicksort(nums,0,n-1);  
end=clock();  
printf("\n\nTime taken to sort:%lf\n", (double)(end-start)/CLOCKS_PER_SEC); }
```

Output:



A screenshot of a Windows command prompt window titled "C:\Users\Asus\Desktop\CCP\PROGRAMS\QuickSort.exe". The prompt shows the user entering "5000" for the number of elements. The program outputs "Time taken to sort:0.733000". Below this, it shows "Process returned 30 (0x1E) execution time : 3.707 s" and "Press any key to continue.".

```
C:\Users\Asus\Desktop\CCP\PROGRAMS\QuickSort.exe  
Enter the number of elements  
5000  
  
Time taken to sort:0.733000  
  
Process returned 30 (0x1E) execution time : 3.707 s  
Press any key to continue.
```



A screenshot of a Windows command prompt window titled "C:\Users\Asus\Desktop\CCP\PROGRAMS\QuickSort.exe". The prompt shows the user entering "10000" for the number of elements. The program outputs "Time taken to sort:1.478000". Below this, it shows "Process returned 30 (0x1E) execution time : 4.064 s" and "Press any key to continue.".

```
C:\Users\Asus\Desktop\CCP\PROGRAMS\QuickSort.exe  
Enter the number of elements  
10000  
  
Time taken to sort:1.478000  
  
Process returned 30 (0x1E) execution time : 4.064 s  
Press any key to continue.
```



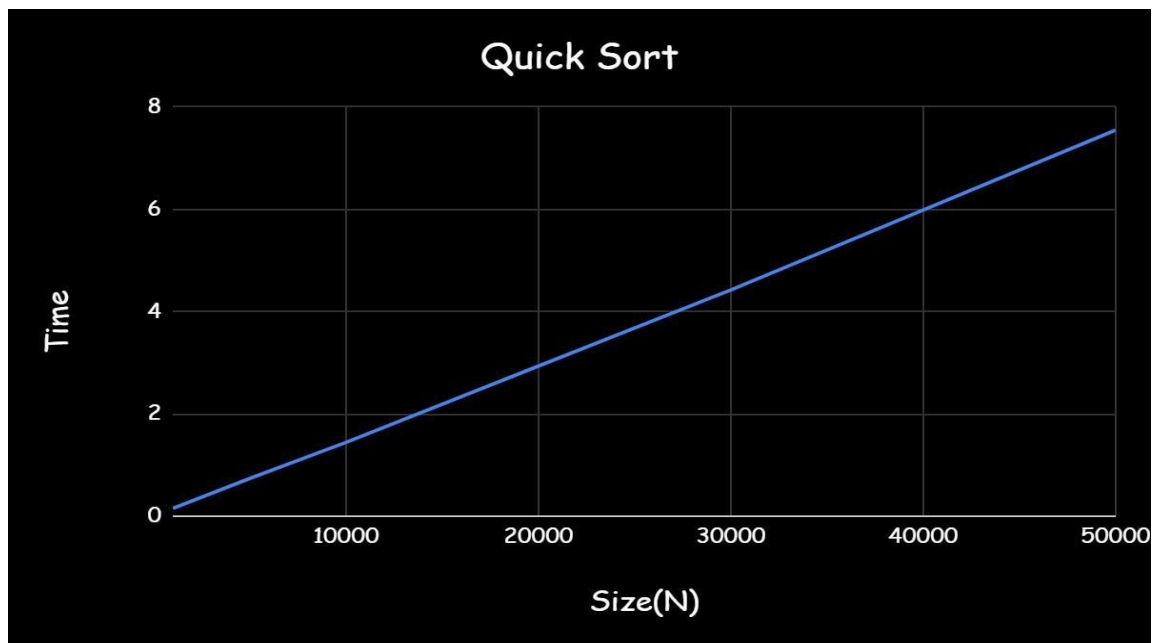
```
C:\Users\Asus\Desktop\CCP\PROGRAMS\QuickSort.exe
Enter the number of elements
20000

Time taken to sort:2.929000

Process returned 30 (0x1E)   execution time : 8.815 s
Press any key to continue.
```

GRAPH :

Time Complexity : $O(n \log n)$



#Program 10:

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

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

void heapify(int a[], int n, int i)
{
    int largest = i; // Initialize largest as root
    int left = 2 * i + 1; // left child    int right
    = 2 * i + 2; // right child    // If left child
    is larger than root    if (left < n &&
    a[left] > a[largest])    largest = left;
    // If right child is larger than root
    if (right < n && a[right] > a[largest])
        largest = right;
    // If root is not largest
    if (largest != i) {
        // swap a[i] with a[largest]
        int temp = a[i];    a[i] =
        a[largest];
        a[largest] = temp;

        heapify(a, n, largest);
    }
}

void heapSort(int a[], int n)
{
    int i, temp;
    for ( i = n / 2 - 1; i >= 0; i--)
        heapify(a, n, i);

    for ( i = n - 1; i >= 0; i--) {

        temp = a[0];
        a[0] = a[i];
        a[i] = temp;

        heapify(a, i, 0);
    }
}
```

```

}

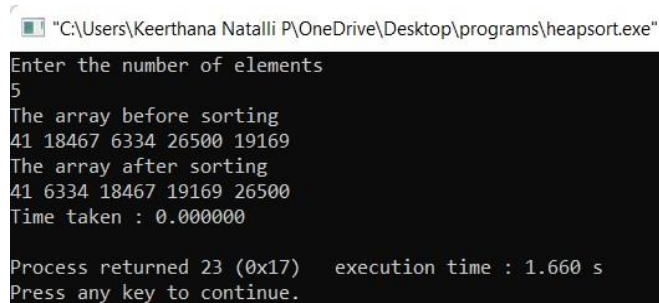
void printArr(int arr[], int n)
{
    int i;
    for ( i = 0; i < n; ++i)
    {
        printf("%d", arr[i]);
        printf(" ");
    }

}

int main() {
int i,n;
int a[100];
clrscr();
    printf("enter the no.of elements");
scanf("%d",&n);
    for(i=0;i<n;i++)
    {
a[i]=rand()%10; }
    printf("Before sorting array elements are - \n");
    printArr(a, n);
heapSort(a, n);
    printf("\nAfter sorting array elements are - \n");
    printArr(a, n);
getch();
return 0;
}

```

Output:



```

"C:\Users\Keerthana Natali P\OneDrive\Desktop\programs\heapsort.exe"
Enter the number of elements
5
The array before sorting
41 18467 6334 26500 19169
The array after sorting
41 6334 18467 19169 26500
Time taken : 0.000000

Process returned 23 (0x17)   execution time : 1.660 s
Press any key to continue.

```

#Program 11:

Implement Warshall's algorithm using dynamic programming.

```
#include<stdio.h> #define
nodes 4
void floyds(int p[nodes+1][nodes+1])
{
    for(int k=1;k<=nodes;k++)
    {
        for(int i=1;i<=nodes;i++)
        {
            for(int j=0;j<=nodes;j++)
            {
                p[i][j]=(p[i][j] || (p[i][k]&& p[k][j]));
            }
        }
    }
}

int max(int a,int b)
{    if(a > b)
return a;
else
return b;
}

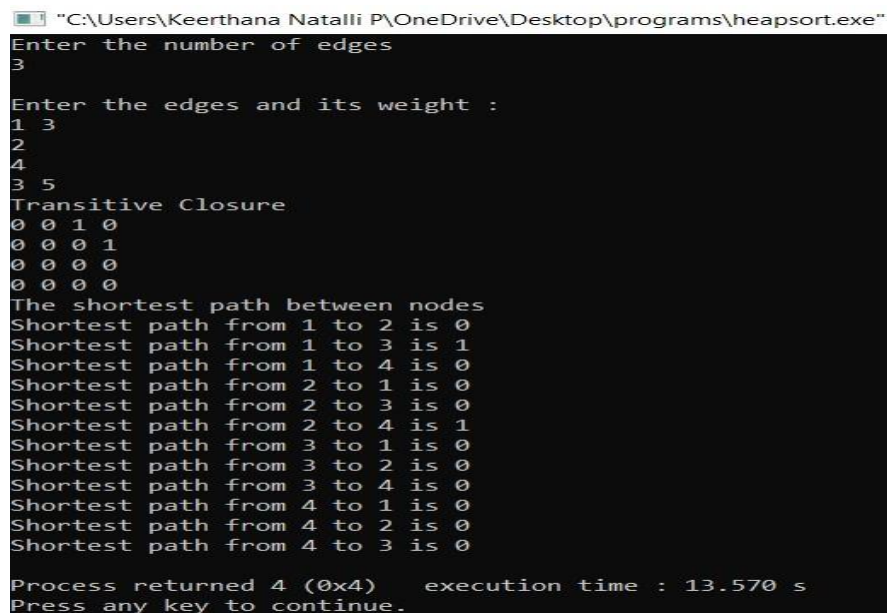
void main()
{    int e,u,v,w,p[nodes+1][nodes+1];
printf("\nEnter the number of edges\n");
scanf("%d",&e);    for(int
i=1;i<=nodes;i++)
        for(int j=1;j<=nodes;j++)
p[i][j] = 0;
    printf("\nEnter the edges and its weight :\n");
for(int i=1;i<=e;i++)
    {
        scanf("%d%d",&u,&v);
p[u][v]=1;
    }
    floyds(p);
printf("Transitive Closure\n");
for(int i=1;i<=nodes;i++)
```

```

    {
        for(int j=1;j<=nodes;j++)
printf("%d ",p[i][j]);    printf("\n");
    }
    printf("The shortest path between nodes\n");
for(int i=1;i<=nodes;i++)
    {
        for(int j=1;j<=nodes;j++)
        {
if(i!=j)
            printf("Shortest path from %d to %d is %d\n",i,j,p[i][j]);
        }
    }
}

```

Output:



```

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\heapsort.exe"
Enter the number of edges
3
Enter the edges and its weight :
1 3
2 4
3 5
Transitive Closure
0 0 1 0
0 0 0 1
0 0 0 0
0 0 0 0
The shortest path between nodes
Shortest path from 1 to 2 is 0
Shortest path from 1 to 3 is 1
Shortest path from 1 to 4 is 0
Shortest path from 2 to 1 is 0
Shortest path from 2 to 3 is 0
Shortest path from 2 to 4 is 1
Shortest path from 3 to 1 is 0
Shortest path from 3 to 2 is 0
Shortest path from 3 to 4 is 0
Shortest path from 4 to 1 is 0
Shortest path from 4 to 2 is 0
Shortest path from 4 to 3 is 0
Process returned 4 (0x4)    execution time : 13.570 s
Press any key to continue.

```

#Program 12:

Implement 0/1 Knapsack problem using dynamic programming.

```
#include<stdio.h> void
main()
{   int
n,cap;
    printf("Enter the number of items\n");
scanf("%d",&n);
    int w[n+1],p[n+1],included[n+1],count=0;
    printf("Enter the weight and profit obtained for each item\n");
for(int i=1;i<=n;i++)
    {
        scanf("%d%d",&w[i],&p[i]);
    }
    printf("Enter the capacity of the knapsack\n");
scanf("%d",&cap);   int mat[n+1][cap+1];
for(int i=0;i<=n;i++)    mat[i][0]=0;   for(int
i=0;i<=cap;i++)    mat[0][i]=0;

    for(int i=1;i<=n;i++)
    {
        for(int j=1;j<=cap;j++)
        {
            int prowithoutCurr = mat[i-1][j];
int prowithCurr = 0;

            int wtOfCurr = w[i];
            if(wtOfCurr <= j)
            {
                prowithCurr = p[i];
int rem = j - wtOfCurr;
                prowithCurr += mat[i-1][rem];
            }
            mat[i][j] = (prowithCurr > prowithoutCurr) ? prowithCurr : prowithoutCurr;
        }
    }
int i=n,j=cap;
while(i!=0 &&
j!=0)
{
    if(mat[i][j] != mat[i-1][j])
    {
```

```

        included[i]=1;
j = j-w[i];        i--;
        count++;
    }
else i--;
    }
    printf("Number of items included : %d\n",count);
printf("Sl.No\tWeight\tProfit\n");  for(int
i=1;i<=n;i++)
    {
        if(included[i])
        {
            printf("%d\t%d\t%d\n",i,w[i],p[i]);
        }
    }
    printf("Maximum profit obtained is %d\n",mat[n][cap]);
}

```

Output:

 "C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\heapsort.exe"

```

Enter the number of items
3
Enter the weight and profit obtained for each item
12 5
14 6
13 7
Enter the capacity of the knapsack
20
Number of items included : 1
Sl.No  Weight  Profit
2      14      6
3      13      7
Maximum profit obtained is 7

Process returned 29 (0x1D)   execution time : 14.204 s
Press any key to continue.

```

#Program 13:

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

```
#include<stdio.h> #define
nodes 4
void floyds(int p[nodes+1][nodes+1])
{
    for(int k=1;k<=nodes;k++)
    {
        for(int i=1;i<=nodes;i++)
        {
            for(int j=0;j<=nodes;j++)
            {
                p[i][j]=max(p[i][j] , p[i][k]&& p[k][j]);
            }
        }
    }
}

int max(int a,int b)
{    if(a > b)
return a;
else
return b;
}

void main()
{
    int e,u,v,w,p[nodes+1][nodes+1];
    printf("\nEnter the number of edges\n");
    scanf("%d",&e);    for(int
i=1;i<=nodes;i++)
        for(int j=1;j<=nodes;j++)
p[i][j] = 0;
    printf("\nEnter the edges and its weight :\n");
    for(int i=1;i<=e;i++)
    {
        scanf("%d%d",&u,&v);
p[u][v]=1;
    }
}
```

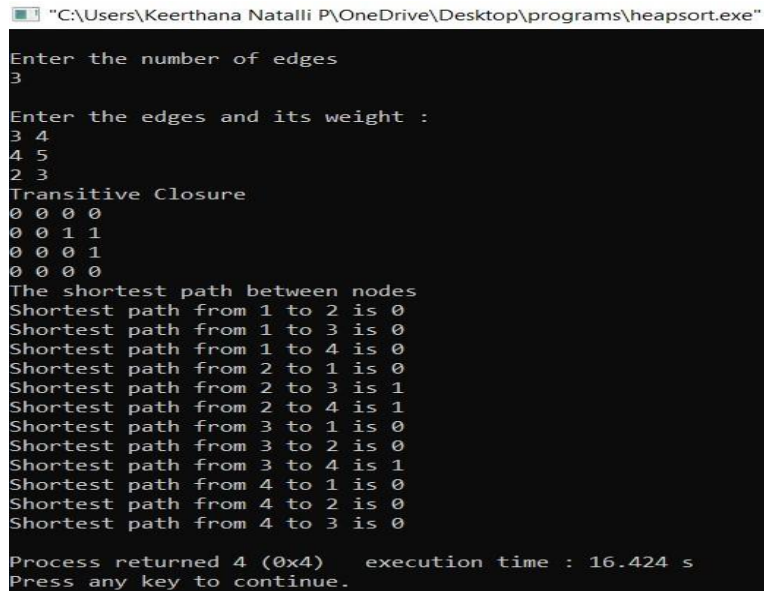


```

    floyds(p);
    printf("Transitive Closure\n");
    for(int i=1;i<=nodes;i++)
    {
        for(int j=1;j<=nodes;j++)
        printf("%d ",p[i][j]);    printf("\n");
    }
    printf("The shortest path between nodes\n");
    for(int i=1;i<=nodes;i++)
    {
        for(int j=1;j<=nodes;j++)
        {
            if(i!=j)
                printf("Shortest path from %d to %d is %d\n",i,j,p[i][j]);
        }
    }
}

```

Output:



```

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\heapsort.exe"
Enter the number of edges
3
Enter the edges and its weight :
3 4
4 5
2 3
Transitive Closure
0 0 0 0
0 0 1 1
0 0 0 1
0 0 0 0
The shortest path between nodes
Shortest path from 1 to 2 is 0
Shortest path from 1 to 3 is 0
Shortest path from 1 to 4 is 0
Shortest path from 2 to 1 is 0
Shortest path from 2 to 3 is 1
Shortest path from 2 to 4 is 1
Shortest path from 3 to 1 is 0
Shortest path from 3 to 2 is 0
Shortest path from 3 to 4 is 1
Shortest path from 4 to 1 is 0
Shortest path from 4 to 2 is 0
Shortest path from 4 to 3 is 0

Process returned 4 (0x4)   execution time : 16.424 s
Press any key to continue.

```

#Program 14:

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

```
#include<stdio.h> #include<conio.h>
int a,b,u,v,n,i,j,ne=1;
int visited[10]={0},min,mincost=0,cost[10][10]; void
main()
{
    printf("\nEnter the number of nodes:");
    scanf("%d",&n);
    printf("\nEnter the adjacency
matrix:\n"); for(i=1;i<=n;i++)
for(j=1;j<=n;j++)
    {
        scanf("%d",&cost[i][j]);
        if(cost[i][j]==0)
            cost[i][j]=999;
    }
    visited[1]=1;
    printf("\n");
    while(ne < n)
    {
        for(i=1,min=999;i<=n;i++)
            for(j=1;j<=n;j++)
                if(cost[i][j]< min)
                    if(visited[i]!=0)
                    {
                        min=cost[i][j];
                        a=u=i;
                        b=v=j;
                    }
        if(visited[u]==0 || visited[v]==0)
        {
            printf("\n Edge %d:(%d %d) cost:%d",ne++,a,b,min);
            mincost+=min;
            visited[b]=1;
        }
        cost[a][b]=cost[b][a]=999;
    }
    printf("\n Minimum cost=%d",mincost);
```

}

Output:

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\heapsort.exe"

```
Enter the number of nodes:3
Enter the adjacency matrix:
0 1 1
1 0 1
0 1 1

Edge 1:(1 2) cost:1
Edge 2:(1 3) cost:1
Minimun cost=2
Process returned 16 (0x10)   execution time : 25.969 s
Press any key to continue.
```

#Program 15:

Find Minimum Cost Spanning Tree of a given undirected graph using Kruskals algorithm.

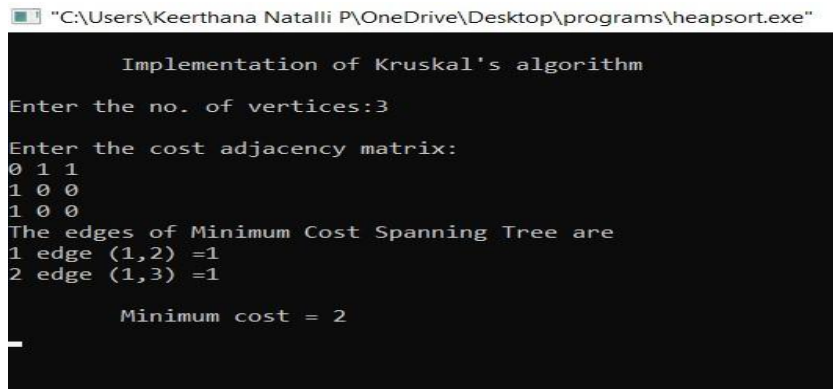
```
#include<stdio.h>
#include<conio.h>
#include<stdlib.h> int
i,j,k,a,b,u,v,n,ne=1;
int min,mincost=0,cost[9][9],parent[9];
int find(int); int uni(int,int); void
main()
{
clrscr();
printf("\n\tImplementation of Kruskal's algorithm\n");
printf("\nEnter the no. of vertices:");
scanf("%d",&n);
printf("\nEnter the cost adjacency matrix:\n");
for(i=1;i<=n;i++)
{
for(j=1;j<=n;j++)
{
scanf("%d",&cost[i][j]);    if(cost[i][j]==0)
cost[i][j]=999;
}
}
printf("The edges of Minimum Cost Spanning Tree are\n");
while(ne < n)
{
for(i=1,min=999;i<=n;i++)
{
for(j=1;j <= n;j++)
{
if(cost[i][j] < min)
{
min=cost[i][j];
a=u=i;
b=v=j;
}
}
}
u=find(u);    v=find(v);
```

```

        if(uni(u,v))
        {
            printf("%d edge (%d,%d) =%d\n",ne++,a,b,min);
            mincost +=min;
        }
        cost[a][b]=cost[b][a]=999;
    }
    printf("\n\tMinimum cost = %d\n",mincost);
    getch(); } int
find(int i) {
while(parent[i])
i=parent[i];
return i; }
int uni(int i,int j)
{
    if(i!=j)
    {
        parent[j]=i;    return 1;
    }
    return 0;
}

```

Output:



```

"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\heapsort.exe"

Implementation of Kruskal's algorithm
Enter the no. of vertices:3
Enter the cost adjacency matrix:
0 1 1
1 0 0
1 0 0
The edges of Minimum Cost Spanning Tree are
1 edge (1,2) =1
2 edge (1,3) =1

Minimum cost = 2

```

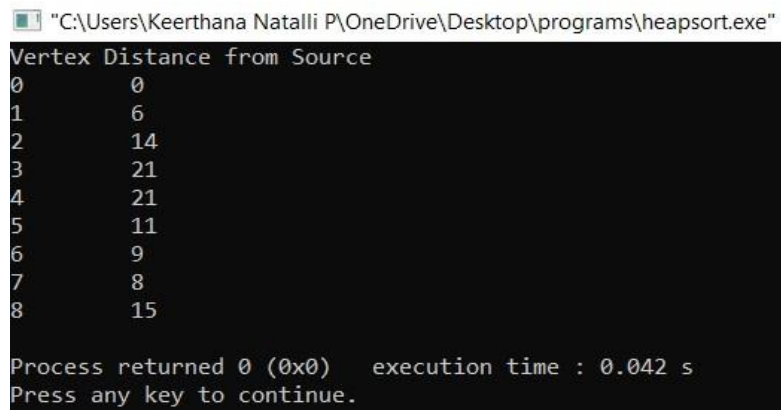
#Program 16:

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

```
#include <stdio.h> #define
V 9
int minDistance(int dist[], int sptSet[]) {
int min = 999, min_index; for (int v =
0; v < V; v++) if (sptSet[v] == 0 &&
dist[v] <= min) min = dist[v],
min_index = v; return min_index;
}
int printSolution(int dist[], int n) {
printf("Vertex Distance from Source\n");
for (int i = 0; i < V; i++)
printf("%d \t %d\n", i, dist[i]);
}
void dijkstra(int graph[V][V], int src) {
int dist[V]; int sptSet[V]; for (int i
= 0; i < V; i++) dist[i] = 999,
sptSet[i] = 0; dist[src] = 0;
for (int count = 0; count < V - 1; count++) {
int u = minDistance(dist, sptSet);
sptSet[u] = 1;
for (int v = 0; v < V; v++) if (!sptSet[v] && graph[u][v] && dist[u] != 999 && dist[u] +
graph[u][v] < dist[v]) dist[v] =
dist[u] + graph[u][v];
}
printSolution(dist, V);
} int main()
{
int graph[V][V] = { { 0, 6, 0, 0, 0, 0, 0, 8, 0 },
{ 6, 0, 8, 0, 0, 0, 0, 13, 0 },
{ 0, 8, 0, 7, 0, 6, 0, 0, 2 },
{ 0, 0, 7, 0, 9, 14, 0, 0, 0 },
{ 0, 0, 0, 9, 0, 10, 0, 0, 0 },
{ 0, 0, 6, 14, 10, 0, 2, 0, 0 },
{ 0, 0, 0, 0, 0, 2, 0, 1, 6 },
{ 8, 13, 0, 0, 0, 0, 1, 0, 7 },
{ 0, 0, 2, 0, 0, 0, 0, 6, 7, 0 }
}
```

```
};  
dijkstra(graph, 0);  
return 0;  
}
```

Output:



```
"C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\heapsort.exe"  
Vertex Distance from Source  
0      0  
1      6  
2     14  
3     21  
4     21  
5     11  
6      9  
7      8  
8     15  
  
Process returned 0 (0x0)   execution time : 0.042 s  
Press any key to continue.
```

#Program 17:

Implement “Sum of Subsets” using Backtracking. “Sum of Subsets” problem: Find a subset of a given set $S = \{s_1, s_2, \dots, s_n\}$ of n positive integers whose sum is equal to a given positive integer d . For example, if $S = \{1, 2, 5, 6, 8\}$ and $d = 9$ there are two solutions $\{1, 2, 6\}$ and $\{1, 8\}$. A suitable message is to be displayed if the given problem instance doesn't have a solution.

```
#include<stdio.h>
#include <stdlib.h> int
s[10] , x[10],d ;
void sumofsub ( int , int , int ) ;
void main ()
{
int n , sum = 0 ; int
i ;
printf ( " \n Enter the size of the set : " ) ;
scanf ( "%d" , &n ) ;
printf ( " \n Enter the set in increasing order:\n" ) ;
for ( i = 1 ; i <= n ; i++ ) scanf ("%d" , &s[i] ) ;
printf ( " \n Enter the value of d : \n " ) ;
scanf ( "%d" , &d ) ; for
( i = 1 ; i <= n ; i++ )
sum = sum + s[i] ; if (
sum < d || s[1] > d )
printf ( " \n No subset possible : " ) ; else
sumofsub ( 0 , 1 , sum ) ;
getch () ; }
void sumofsub ( int m , int k , int r )
{ int i=1
; x[k] = 1
;
if ( ( m + s[k] ) == d )
{ printf("Subset:"); for (
i = 1 ; i <= k ; i++ ) if (
x[i] == 1 ) printf (
"\t%d" , s[i] ) ; printf (
"\n" ) ; } else if ( m +
s[k] + s[k+1] <= d )
sumofsub ( m + s[k] , k
```



```
+ 1 , r - s[k] ) ; if ( ( m +  
r - s[k] >= d ) && ( m +  
s[k+1] <=d ) )  
{ x[k] =  
0;  
sumofsub ( m , k + 1 , r - s[k] ) ;  
}  
}
```

Output:

 "C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\heapsort.exe"

```
Enter the size of the set : 3  
  
Enter the set in increasing order:  
1 2 3  
  
Enter the value of d :  
2  
Subset: 2  
  
Process returned 13 (0xD)   execution time : 9.822 s  
Press any key to continue.
```

#Program 18:

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; }
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)
{
if(board[i]==j)
printf("\tQ");
else printf("\t-");
}
} }
int place(int row,int column)
{
int i;
for(i=1;i<=row-1;++i)
{
if(board[i]==column)
return 0;
else
if(abs(board[i]-column)==abs(i-row))
return 0; } return 1; }
void queen(int row,int n)
```

```
{ int
column;
for(column=1;column<=n;++column)
{
    if(place(row,column))
    {
        board[row]=column;
        if(row==n)    print(n);
        else
            queen(row+1,n);
    }
}
```

Output:

 "C:\Users\Keerthana Natalli P\OneDrive\Desktop\programs\heapsort.exe"

- N Queens Problem Using Backtracking -

Enter number of Queens:1

Solution 1:

1

1 Q

Process returned 0 (0x0) execution time : 1.445 s

Press any key to continue.