VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

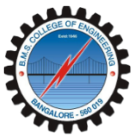
LAB REPORT
on

Analysis and Design of Algorithms

Submitted by

Akash M (1BM20CS006)

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
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(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 **Akash M(1BM20CS006),** 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 **Analysis and Design of Algorithms - (19CS4PCADA)** work prescribed for the said degree.

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15	Find Minimum Cost Spanning Tree of a given undirected graph using Kruskals algorithm.	
16	From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.	
17	Implement "Sum of Subsets" using Backtracking. "Sum of Subsets" problem: Find a subset of a given set S = {s1,s2,……,sn} 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.	
18	Implement "N-Queens Problem" using Backtracking.	

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.

```c
//1.Write a recursive program to
  //a. Solve Towers-of-Hanoi problem

#include<stdio.h>

void toh(int n,char s,char d,char a){
  if(n==1){
    printf("Moving from %c to %c\n",s,d);
    return;
  }
  toh(n-1,s,a,d);
  printf("Moving from %c to %c\n",s,d);
  toh(n-1,a,d,s);
}

int main(){
  int n;
  char s,d,a,temp;
  printf("Number of Discs :");
  scanf("%d",&n);
  printf("Enter the Names of Source Destination and Aux towers :");
  scanf("%c",&temp);
  scanf("%c %c %c",&s,&d,&a);
  toh(n,s,d,a);
}
```

Output:

```
Number of Discs :5
Enter the Names of Source Destination and Aux towers :a c
Moving from a to c
Moving from a to b
Moving from c to b
Moving from a to c
Moving from b to a
Moving from b to c
Moving from a to c
Moving from a to b
Moving from c to b
Moving from c to a
Moving from b to a
Moving from c to b
Moving from a to c
Moving from a to b
Moving from c to b
Moving from a to c
Moving from b to a
Moving from b to c
Moving from a to c
Moving from b to a
Moving from c to b
Moving from c to a
Moving from b to a
Moving from b to c
Moving from a to c
Moving from a to b
Moving from c to b
Moving from a to c
Moving from b to a
Moving from b to c
Moving from a to c
```

```c
//1.Write a recursive program to
  //b. T o find GCD
#include<stdio.h>

int gcd(int n, int m){
  if(m!=0){
    return gcd(m,n%m);
  }
  else{
    return n;
  }
}


int main(){
  int n,m;
  printf("Enter number for which GCD to be found :");
  scanf("%d %d",&n,&m);
  int res=gcd(n,m);
  printf("GCD of %d and %d is %d\n",n,m,res);
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % ./GCD
Enter number for which GCD to be found :366 60
GCD of 366 and 60 is 6
akashm@Akashs-MacBook-Pro ADAPrograms % ./GCD
Enter number for which GCD to be found :6 3
GCD of 6 and 3 is 3
akashm@Akashs-MacBook-Pro ADAPrograms % ./GCD
Enter number for which GCD to be found :66 6
GCD of 66 and 6 is 6
akashm@Akashs-MacBook-Pro ADAPrograms % ./GCD
Enter number for which GCD to be found :78 6
GCD of 78 and 6 is 6
akashm@Akashs-MacBook-Pro ADAPrograms % ./GCD
Enter number for which GCD to be found :78 12
GCD of 78 and 12 is 6
```

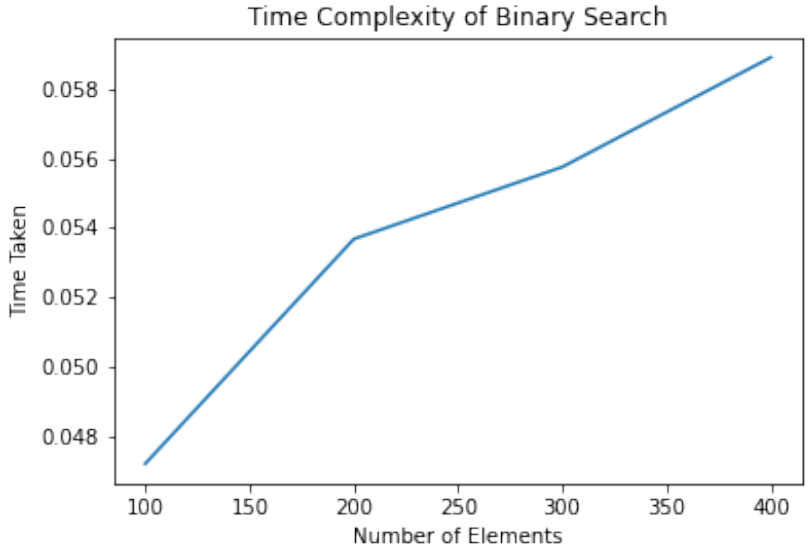
```c
//2.a. Implement Recursive Binary search and determine the time required to search an element. Repeat the experiment for different values of N and plot a graph of the time taken versus N.

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

void delay(){
  for (int i = 0; i < 5000000; ++i)
  {
    int d=i/33;
  }
}

int binarySearch(int arr[], int k, int si, int ei){
  if(si>ei){
    return -1;
  }
  delay();
  int mid=(si+ei)/2;
  if(arr[mid]==k){
    return mid;
  }
  else if(arr[mid]>k){
    return binarySearch(arr,k,si,mid-1);
  }
  else{
    return binarySearch(arr,k,mid+1,ei);
  }
}

void swap(int arr[], int i, int j){
  if(i==j){
    return;
  }
  int temp=arr[i];
  arr[i]=arr[j];
  arr[j]=temp;
}

void bubbleSort(int arr[], int n){
  for(int i=n-1;i>=0;i--){
    for(int j=0;j<i;j++){
      if(arr[j]>arr[j+1]){
        swap(arr,j,j+1);
      }
    }
  }
}

int main(){
  int arr[5000],n;
  printf("Enter the number of elements in the Array :");
  scanf("%d",&n);
```

```c
  for(int i=0;i<n;i++){
    arr[i]=(rand() % (1 - 5000 + 1)) + 1;
  }
  bubbleSort(arr,n);
  clock_t start=clock();
  int j=binarySearch(arr,-1,0,n-1);
  clock_t end=clock();

  printf("Time taken by Binary Search is %f",(double)(end-start)/CLOCKS_PER_SEC);
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % ./BinarySearch
Enter the number of elements in the Array :100
Time taken by Binary Search is 0.047197%
akashm@Akashs-MacBook-Pro ADAPrograms % ./BinarySearch
Enter the number of elements in the Array :200
Time taken by Binary Search is 0.053674%
akashm@Akashs-MacBook-Pro ADAPrograms % ./BinarySearch
Enter the number of elements in the Array :300
Time taken by Binary Search is 0.055753%
akashm@Akashs-MacBook-Pro ADAPrograms % ./BinarySearch
Enter the number of elements in the Array :400
Time taken by Binary Search is 0.058912%
```

Graph:

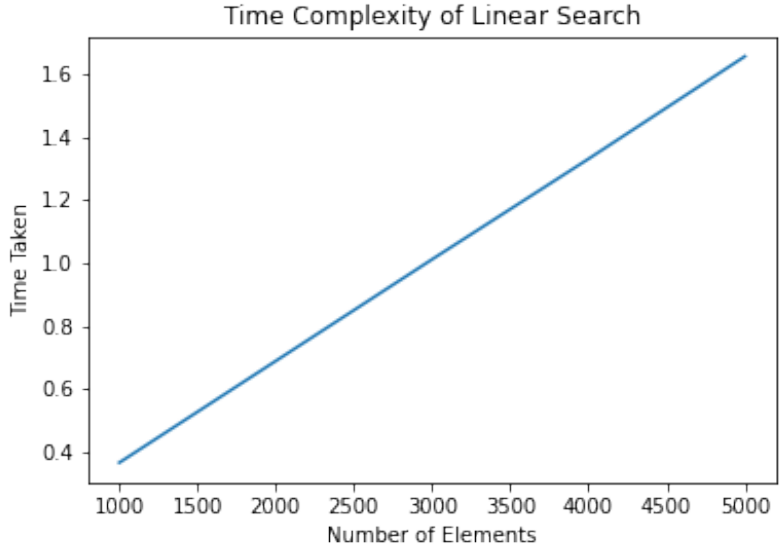


```c
//2.b. Implement Recursive Linear search and determine the time required to search an element. Repeat the experiment for different values of N and plot a graph of the time taken versus N.

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

void delay(){
  for (int i = 0; i < 500000; ++i)
  {
    int d=i/33;
  }
}


int linearSearch(int arr[], int k,int si,int ei){
  if(si>ei){
    return -1;
  }
  if(arr[si]==k){
    return si;
  }
  delay();
  return linearSearch(arr,k,si+1,ei);
}


int main(){
  int arr[5000],n;
  printf("Enter the number of elements in the Array :");
  scanf("%d",&n);
  for(int i=0;i<n;i++){
    arr[i]=(rand() % (1 - 5000 + 1)) + 1;
  }
  clock_t start=clock();
  int i=linearSearch(arr,-1,0,n-1);
  clock_t end=clock();

  printf("Time taken by Linear Search is %f",(double)(end-start)/CLOCKS_PER_SEC);
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % make Lin
cc     LinearSearch.c   -o LinearSearch
akashm@Akashs-MacBook-Pro ADAPrograms % ./Linear
Enter the number of elements in the Array :1000
Time taken by Linear Search is 0.364711%
akashm@Akashs-MacBook-Pro ADAPrograms % ./Linear
Enter the number of elements in the Array :2000
Time taken by Linear Search is 0.687920%
akashm@Akashs-MacBook-Pro ADAPrograms % ./Linear
Enter the number of elements in the Array :3000
Time taken by Linear Search is 1.011175%
akashm@Akashs-MacBook-Pro ADAPrograms % ./Linear
Enter the number of elements in the Array :4000
Time taken by Linear Search is 1.330706%
akashm@Akashs-MacBook-Pro ADAPrograms % ./Linear
Enter the number of elements in the Array :5000
Time taken by Linear Search is 1.656666%
akashm@Akashs-MacBook-Pro ADAPrograms %
```

Graph:

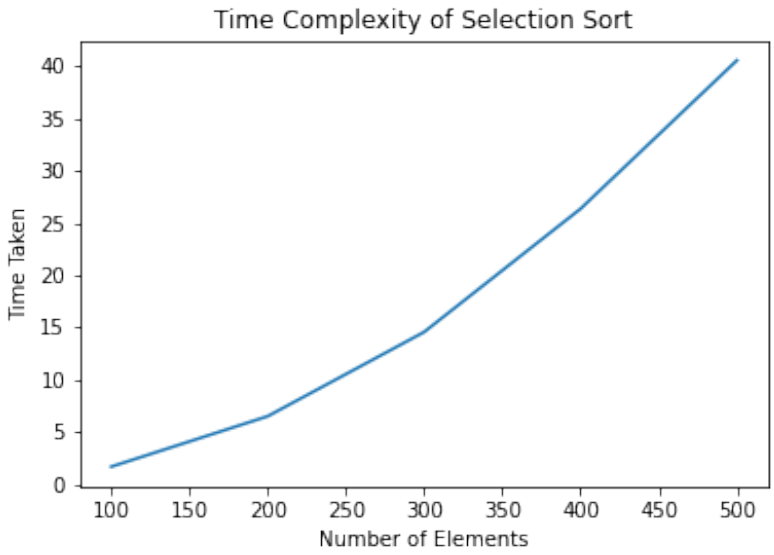


```c
//3.Sort a given set of N integer elements using Selection Sort technique and compute its time taken. Run the program for different values of N and record the time taken to sort.

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

void delay(){
  for (int i = 0; i < 500000; ++i)
  {
    int d=i/33;
  }
}

void swap(int arr[],int i,int j){
  if(i==j){
    return;
  }
  int temp=arr[i];
  arr[i]=arr[j];
  arr[j]=temp;
}

void selectionSort(int arr[],int n){
  for(int i=n-1;i>0;i--){
    int max=-999;
    int maxInd=0;
    for (int j = 0; j <= i; ++j)
    {
      delay();
      if(arr[j] > max){
        max=arr[j];
        maxInd=j;
      }
    }
    swap(arr,maxInd,i);
  }
}

int main(){
  int arr[5000],n;
  printf("Enter the number of elements in the Array :");
  scanf("%d",&n);
  for(int i=0;i<n;i++){
    arr[i]=(rand() % (1 - 5000 + 1)) + 1;
  }
  clock_t start=clock();
  selectionSort(arr,n);
  clock_t end=clock();

  printf("Time taken by Selection Sort is %f",(double)(end-start)/CLOCKS_PER_SEC);
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % ./SelectionSort
Enter the number of elements in the Array :100
Time taken by Selection Sort is 1.663294%
akashm@Akashs-MacBook-Pro ADAPrograms % ./SelectionSort
Enter the number of elements in the Array :200
Time taken by Selection Sort is 6.492463%
akashm@Akashs-MacBook-Pro ADAPrograms % ./SelectionSort
Enter the number of elements in the Array :300
Time taken by Selection Sort is 14.554929%
akashm@Akashs-MacBook-Pro ADAPrograms % ./SelectionSort
Enter the number of elements in the Array :400
Time taken by Selection Sort is 26.356178%
akashm@Akashs-MacBook-Pro ADAPrograms % ./SelectionSort
Enter the number of elements in the Array :500
Time taken by Selection Sort is 40.571646%
akashm@Akashs-MacBook-Pro ADAPrograms %
```

Graph:



```c
//4.Write program to do the following:
  //.Print all the nodes reachable from a given starting node in a digraph using BFS method.

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

int q[30];
int f=-1,r=-1;


bool isEmpty(){
  if(f==-1 && r==-1){
    return true;
  }
  return false;
}

void enQueue(int i){
  if(f==-1 && r==-1){
    f=0;
  }
  q[++r]=i;
  return;
}

int deQueue(){
  if(isEmpty()){
    return -1;
  }
  if(f==r){
    int temp=q[f];
    f=-1;
    r=-1;
    return temp;
  }
  int temp=q[f];
  f++;
  return temp;

}

void bfs(int arr[10][10], int start, int visited[], int n, int *flag){
  visited[start]=1;
  enQueue(start);

  while(!isEmpty()){
    int pending=deQueue();
    printf("%d ",pending);
    for(int i=0;i<n;i++){
      if(arr[pending][i]==1 && visited[i]==0){
        enQueue(i);
        visited[i]=1;
        *flag=1;
```

```
        *flag = 1;
      }
    }
  }
}

int main(){
  int arr[10][10];
  int n,m;
  int visited[10];
  printf("Enter number of Vertices :");
  scanf("%d",&n);
  printf("Enter number of Edges :");
  scanf("%d",&m);
  for(int i = 0; i < n; ++i){
    for (int j = 0; j < n; ++j)
    {
      arr[i][j]=0;
    }
  }
  for (int i = 0; i < m; ++i)
  {
    int a,b;
    printf("Enter the Edge %d :",(i+1));
    scanf("%d %d",&a,&b);
    arr[a][b]=1;
    arr[b][a]=1;
  }
  for (int i = 0; i < n; ++i)
  {
    visited[i]=0;
  }
  int start;
  int flag=0;
  printf("Enter the starting vertex :");
  scanf("%d",&start);

  bfs(arr,start,visited,n,&flag);

  if(flag==0){
    printf("\nNo Path Found\n");
  }
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % ./BFS
Enter number of Vertices :5
Enter number of Edges :6
Enter the Edge 1 :1 2
Enter the Edge 2 :2 3
Enter the Edge 3 :3 4
Enter the Edge 4 :1 3
Enter the Edge 5 :0 4
Enter the Edge 6 :0 1
Enter the starting vertex :0
0 1 4 2 3 %
akashm@Akashs-MacBook-Pro ADAPrograms % ./BFS
Enter number of Vertices :5
Enter number of Edges :4
Enter the Edge 1 :1 2
Enter the Edge 2 :2 3
Enter the Edge 3 :3 4
Enter the Edge 4 :1 3
Enter the starting vertex :0
0
No Path Found
```

```c
//4.Write program to do the following:
  //b. Check whether a given graph is connectedor not using DFS method.
#include<stdio.h>
#include<stdlib.h>

void dfs(int arr[10][10],int start,int visited[], int n){
  visited[start]=1;
  // printf("%d ",start);
  for(int i=0;i<n;i++){
    if(arr[start][i]==1 && visited[i]==0){
      dfs(arr,i,visited,n);
    }
  }
}

int main(){
  int arr[10][10];
  int n,m;
  int visited[10];
  printf("Enter number of Vertices :");
  scanf("%d",&n);
  printf("Enter number of Edges :");
  scanf("%d",&m);
  for(int i = 0; i < n; ++i){
    for (int j = 0; j < n; ++j)
    {
      arr[i][j]=0;
    }
  }
  for (int i = 0; i < m; ++i)
  {
    int a,b;
    printf("Enter the Edge %d :",(i+1));
    scanf("%d %d",&a,&b);
    arr[a][b]=1;
    arr[b][a]=1;
  }
  for (int i = 0; i < n; ++i)
  {
    visited[i]=0;
  }

  for (int i = 0; i < n; ++i)
  {
    if(i!=0 && visited[i]==0){
      printf("\nDisconnected Graph\n");
      return 0;
    }
    if(visited[i]==0)
      dfs(arr,i,visited,n);
  }
  printf("\nConnected Graph\n");
}
```

Output:

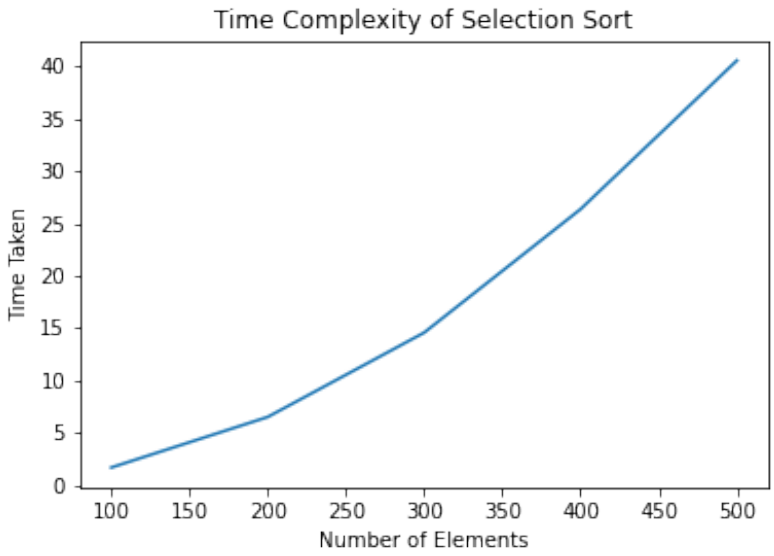
```
akashm@Akashs-MacBook-Pro ADAPrograms % ./DFS
Enter number of Vertices :5
Enter number of Edges :3
Enter the Edge 1 :0 4
Enter the Edge 2 :3 4
Enter the Edge 3 :2 3

Disconnected Graph
akashm@Akashs-MacBook-Pro ADAPrograms % ./DFS
Enter number of Vertices :5
Enter number of Edges :6
Enter the Edge 1 :0 1
Enter the Edge 2 :0 4
Enter the Edge 3 :1 2
Enter the Edge 4 :2 3
Enter the Edge 5 :3 4
Enter the Edge 6 :1 3

Connected Graph
```

```c
//5. Sort a given set of N integer elements using Insertion Sort technique and compute its time taken.

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


void delay(){
  for (int i = 0; i < 500000; ++i)
  {
    int d=i/33;
  }
}

void insertionSort(int arr[],int n){
  for (int i = 1; i < n ; ++i)
  {
    int temp=arr[i];
    int j;
    for(j=i-1;j>=0 && temp<arr[j]; j--){
      delay();
      arr[j+1]=arr[j];
    }
    arr[j+1]=temp;
  }
}

int main(){
  int arr[5000],n;
  printf("Enter the number of elements in the Array :");
  scanf("%d",&n);
  for(int i=0;i<n;i++){
    arr[i]=(rand() % (1 - 5000 + 1)) + 1;
  }

  clock_t start=clock();
  insertionSort(arr,n);
  clock_t end=clock();

  printf("Time taken by Insertion Sort is %f",(double)(end-start)/CLOCKS_PER_SEC);
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % ./InsertionSort
Enter the number of elements in the Array :100
Time taken by Insertion Sort is 0.896186%
akashm@Akashs-MacBook-Pro ADAPrograms % ./InsertionSort
Enter the number of elements in the Array :200
Time taken by Insertion Sort is 3.658319%
akashm@Akashs-MacBook-Pro ADAPrograms % ./InsertionSort
Enter the number of elements in the Array :300
Time taken by Insertion Sort is 8.061177%
akashm@Akashs-MacBook-Pro ADAPrograms % ./InsertionSort
Enter the number of elements in the Array :400
Time taken by Insertion Sort is 13.283337%
akashm@Akashs-MacBook-Pro ADAPrograms % ./InsertionSort
Enter the number of elements in the Array :500
Time taken by Insertion Sort is 20.731952%
```

Graph:



```c
//6. Write program to obtain the Topological ordering of vertices in a given digraph.

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

int q[30];
int f=-1,r=-1;

bool isEmpty(){
  if(f==-1 && r==-1){
    return true;
  }
  return false;
}

void enQueue(int i){
  if(f==-1 && r==-1){
    f=0;
  }
  q[++r]=i;
  return;
}

int deQueue(){
  if(isEmpty()){
    return -1;
  }
  if(f==r){
    int temp=q[f];
    f=-1;
    r=-1;
    return temp;
  }
  int temp=q[f];
  f++;
  return temp;

}

void topoLogicalSorting(int arr[10][10],int n){
  int sorted[10];
  int k=0;
  int indegrees[10];
  for (int i = 0; i < n; ++i)
  {
    indegrees[i]=0;
  }
  for(int i=0;i<n;i++){
    for(int j=0;j<n;j++){
      if(arr[i][j]==1)
        indegrees[j]++;
    }
```

```c
    }
  }
  for (int i = 0; i < n; ++i)
  {
    if(indegrees[i]==0){
      enQueue(i);
    }
  }
  int visitedNodes=0;
  while(!isEmpty()){
    int snode=deQueue();
    sorted[k++]=snode;
    for(int i=0;i<n;i++){
      if(arr[snode][i]==1){
        if(--indegrees[i]==0){
          enQueue(i);
        }
      }
    }
    visitedNodes++;
  }
  if(visitedNodes!=n){
    printf("\nError!! Graph has a cycle\n");
    return;
  }

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

int main(){
  int arr[10][10];
  int n,m;
  int visited[10];
  printf("Enter number of Vertices :");
  scanf("%d",&n);
  printf("Enter number of Edges :");
  scanf("%d",&m);
  for(int i = 0; i < n; ++i){
    for (int j = 0; j < n; ++j)
    {
      arr[i][j]=0;
    }
  }
  for (int i = 0; i < m; ++i)
  {
    int a,b;
    printf("Enter the Edge %d :",(i+1));
    scanf("%d %d",&a,&b);
    arr[a][b]=1;
  }
  topoLogicalSorting(arr,n);
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % ./TopoLogicalSort
Enter number of Vertices :4
Enter number of Edges :4
Enter the Edge 1 :2 0
Enter the Edge 2 :2 1
Enter the Edge 3 :1 0
Enter the Edge 4 :1 3
2 1 0 3 %
akashm@Akashs-MacBook-Pro ADAPrograms % ./TopoLogicalSort
Enter number of Vertices :4
Enter number of Edges :5
Enter the Edge 1 :2 0
Enter the Edge 2 :2 1
Enter the Edge 3 :1 0
Enter the Edge 4 :1 3
Enter the Edge 5 :3 0
2 1 3 0 %
akashm@Akashs-MacBook-Pro ADAPrograms % ./TopoLogicalSort
Enter number of Vertices :4
Enter number of Edges :5
Enter the Edge 1 :0 2
Enter the Edge 2 :2 1
Enter the Edge 3 :1 3
Enter the Edge 4 :1 0
Enter the Edge 5 :3 0

Error!! Graph has a cycle
```

```c
//7. Implement Johnson Trotter algorithm to generate permutations

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


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

int fact(int n){
  if(n==0 || n==1){
    return 1;
  }
  return n*fact(n-1);
}

int mobileSearch(int arr[], int n, int dir[]){
  int mobile=0, mobile_prev=0;
  for(int i=0;i<n;i++){
    if(dir[arr[i]-1]==0 && i!=0){
      if(arr[i]>arr[i-1] && arr[i]>mobile_prev){
        mobile=arr[i];
        mobile_prev=mobile;
      }
    }
  }

  for(int i = 0; i < n;i++){
    if(dir[arr[i]-1]==1 && i!=n-1){
      if(arr[i]>arr[i+1] && arr[i]>mobile_prev){
        mobile=arr[i];
        mobile_prev=mobile;
      }
    }
  }

  if(mobile != 0)
    return mobile;
  else
    return 0;
}

void permutationPrint(int arr[], int n, int dir[]){
  int mobile=mobileSearch(arr,n,dir);
  int getPos=searchArray(arr,n,mobile);

  if(dir[arr[getPos-1]-1]==0){
    int temp=arr[getPos-1];
    arr[getPos-1]=arr[getPos-2];
```

```
    arr[getPos-2]=temp;
  }
  if(dir[arr[getPos-1]-1]==1){
    int temp=arr[getPos-1];
    arr[getPos-1]=arr[getPos];
    arr[getPos]=temp;
  }


  for (int i = 0; i < n; ++i)
  {
    if(arr[i]>mobile && dir[arr[i]-1]==0){
      dir[arr[i]-1]=1;
    }

    else if(arr[i]>mobile && dir[arr[i]-1]==1){
      dir[arr[i]-1]=0;
    }
  }

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

  printf(" ");
}

void johnsonTrotter(int n){
  int dir[300];
  int arr[300];
  for(int i=0;i<n;i++){
    arr[i]=i+1;
  }

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

  printf(" ");

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

  for (int i = 1; i < fact(n); ++i)
  {
    permutationPrint(arr, n, dir);
  }

}
```

```c
int main(){
  int n;
  printf("Enter the value of N : ");
  scanf("%d",&n);
  printf("Permutations of 5 digit number is \n");
  johnsonTrotter(n);
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % ./Johnsc
Enter the value of N : 4
Permutations of 5 digit number is
1234 1243 1423 4123 4132 1432 1342 1324 3124 314
2134 %
akashm@Akashs-MacBook-Pro ADAPrograms % ./Johnsc
Enter the value of N : 5
Permutations of 5 digit number is
12345 12354 12534 15234 51234 51243 15243 12543
1235 41325 41352 41532 45132 51432 51342 15342 1
252 31225 32125 32152 32512 35212 52312 52132 25
54 21245 21425 21452 21542 25142 52142 52412 254
2 24152 24125 21425 21452 21524 25124 52124 2512
 24152 24125 42125 42152 42512 45212 54212 52412
21254 21245 21425 21452 21542 %
```

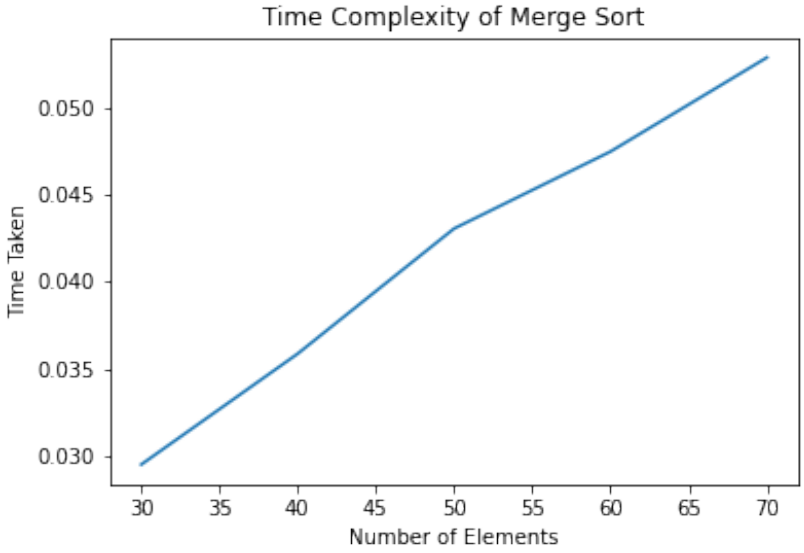
```c
//8. Sort a given set of N integer elements using Merge Sort technique and compute its time taken. Run the program for different values of N and record the time taken to sort.

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


void delay(){
  for (int i = 0; i < 500000; ++i)
  {
    int d=i/33;
  }
}

void merge(int arr[],int si,int ei,int mid){
  int i=si,j=mid+1,k=si;
  int res[ei+1];
  while(i<=mid && j<=ei){
    if(arr[i]<arr[j]){
      res[k]=arr[i];
      k++;
      i++;
    }
    else if(arr[i]>arr[j]){
      res[k]=arr[j];
      k++;
      j++;
    }
  }
  while(i<=mid){
    res[k]=arr[i];
    i++;
    k++;
  }
  while(j<=ei){
    res[k]=arr[j];
    j++;
    k++;
  }
  for(int i=si;i<=ei;i++){
    arr[i]=res[i];
  }
}

void mergeSort(int arr[],int si,int ei){
  if(si>=ei){
    return;
  }
  delay();
  int mid=(si+ei)/2;

  mergeSort(arr,si,mid);
  mergeSort(arr,mid+1,ei);
```

```
  mergeSort(arr,mid+1,ei);

  merge(arr,si,ei,mid);

}

int main(){
  int arr[5000],n;
  printf("Enter the number of elements in the Array :");
  scanf("%d",&n);
  for(int i=0;i<n;i++){
    arr[i]=(rand() % (1 - 5000 + 1)) + 1;
  }
  clock_t start=clock();
  mergeSort(arr,0,n-1);
  clock_t end=clock();

  printf("Time taken by Merge Sort is %f",(double)(end-start)/CLOCKS_PER_SEC);
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % ./mergeSort
Enter the number of elements in the Array :30
Time taken by Merge Sort is 0.029481%
akashm@Akashs-MacBook-Pro ADAPrograms % ./mergeSort
Enter the number of elements in the Array :40
Time taken by Merge Sort is 0.035862%
akashm@Akashs-MacBook-Pro ADAPrograms % ./mergeSort
Enter the number of elements in the Array :50
Time taken by Merge Sort is 0.043071%
akashm@Akashs-MacBook-Pro ADAPrograms % ./mergeSort
Enter the number of elements in the Array :60
Time taken by Merge Sort is 0.047507%
akashm@Akashs-MacBook-Pro ADAPrograms % ./mergeSort
Enter the number of elements in the Array :70
Time taken by Merge Sort is 0.052922%
```

Graph:



```c
//9. Sort a given set of N integer elements using Quick Sort technique and compute its time taken

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

void swap(int arr[],int i,int j){
  if(i==j){
    return;
  }
  int temp = arr[i];
  arr[i] = arr[j];
  arr[j] = temp;

}

int partition(int arr[],int si,int ei){
  int temp=arr[si];
  int count=0;
  for (int i = si+1; i <= ei; ++i)
  {
    if(temp>arr[i]){
      count++;
    }
  }
  swap(arr,si,si+count);

  int i=si, j=ei;

  while(i<j){
    if(arr[i]<temp){
      i++;
    }
    else if(arr[j]>=temp){
      j--;
    }
    else{
      swap(arr,i,j);
      i++;
      j--;
    }
  }
  return si+count;

}


void quickSort(int arr[],int si,int ei){
  if(si>=ei){
    return;
  }

  int i=partition(arr,si,ei);
  quickSort(arr,si,i-1);
```

```c
  quickSort(arr,i+1,ei);
}


int main(){
  int arr[5000],n;
  printf("Enter the number of elements in the Array :");
  scanf("%d",&n);
  for(int i=0;i<n;i++){
    arr[i]=(rand() % (1 - 5000 + 1)) + 1;
  }

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

  printf("Time taken by Quick Sort is %f",(double)(end-start)/CLOCKS_PER_SEC);
}
```

Output:

```
akashm@Akashs-MacBook-Pro ADAPrograms % ./QuickSort
Enter the number of elements in the Array :1000
Time taken by Quick Sort is 0.000348%
akashm@Akashs-MacBook-Pro ADAPrograms % ./QuickSort
Enter the number of elements in the Array :1500
Time taken by Quick Sort is 0.000720%
akashm@Akashs-MacBook-Pro ADAPrograms % ./QuickSort
Enter the number of elements in the Array :2000
Time taken by Quick Sort is 0.000978%
akashm@Akashs-MacBook-Pro ADAPrograms % ./QuickSort
Enter the number of elements in the Array :2500
Time taken by Quick Sort is 0.001283%
akashm@Akashs-MacBook-Pro ADAPrograms % ./QuickSort
Enter the number of elements in the Array :3000
Time taken by Quick Sort is 0.001402%
akashm@Akashs-MacBook-Pro ADAPrograms % ./QuickSort
Enter the number of elements in the Array :3500
Time taken by Quick Sort is 0.001820%
```

Graph: