VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI, KARNATAKA-590018

Department of Computer Science and Engineering

Laboratory Report on

"Analysis & Design of Algorithms Lab"

A Laboratory report submitted to Visvesvaraya Technological University in partial fulfillment of requirements for the award of the Degree.

BACHELOR OF TECHNOLOGY

In

"Computer Science and Business Systems"

Submitted By

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CERTIFICATE

This is to certify that **Mr/Ms.** **GYANARANJAN MAHANTA** bearing USN **2VX22CB017** studying in IV semester **B.Tech ("Computer Science and Business Systems")** has presented and successfully completed the Laboratory Report titled **"Analysis & Design of Algorithms Lab"** in the presence of the undersigned examiners for the partial fulfillment of the award of B.Tech. degree VTU, Belagavi, for the academic year 2023-24.

Staff In Charge	Course Coordinator
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Examiner-1	**Examiner-2**
Name:	Name:
Signature with Date:	Signature with Date:

PROGRAM 1

Design and implement C/C++ Program to find Minimum Cost Spanning Tree of a given connected undirected graph using Kruskal's algorithm.

CODE:

```
#define INF 999
#define MAX 100
int p[MAX], c[MAX][MAX], t[MAX][2];
int find(int v)
{
   while (p[v])
      v = p[v];
   return v;
}
void union1(int i, int j)
{
   p[j] = i;
}
void kruskal(int n)
{
   int i, j, k, u, v, min, res1, res2, sum = 0;
   for (k = 1; k < n; k++)
   {
      min = INF;
      for (i = 1; i < n - 1; i++)
      {
         for (j = 1; j <= n; j++)
         {
            if (i == j) continue;
            if (c[i][j] < min)
            {
               u = find(i);
               v = find(j);
               if (u != v)
               {
                  res1 = i;
                  res2 = j;
                  min = c[i][j];
               }
            }
         }
```

```
        }
      union1(res1, find(res2));
      t[k][1] = res1;
      t[k][2] = res2;
      sum = sum + min;
   }
   printf("\nCost of spanning tree is=%d", sum);
   printf("\nEdgesof spanning tree are:\n");
   for (i = 1; i < n; i++)
      printf("%d -> %d\n", t[i][1], t[i][2]);
}
int main()
{
   int i, j, n;
   printf("\nEnter the n value:");
   scanf("%d", & n);
   for (i = 1; i <= n; i++)
      p[i] = 0;
   printf("\nEnter the graph data:\n");
   for (i = 1; i <= n; i++)
      for (j = 1; j <= n; j++)
         scanf("%d", & c[i][j]);
   kruskal(n);
    return 0;
}
```

OUTPUT:

```
Enter the n value:3
Enter the graph data:
 5   25  10
15  12  35
18  45  35
Cost of spanning tree is=35
Edgesof spanning tree are:
1 -> 3
1 -> 2
```

PROGRAM 2

Design and implement C/C++ Program to find Minimum Cost Spanning Tree of a given connected undirected graph using Prim's algorithm.

CODE:

```
#include<stdio.h>
#define INF 999
int prim(int c[10][10],int n,int s)
{
   int v[10],i,j,sum=0,ver[10],d[10],min,u;
   for(i=1; i<=n; i++)
   {
      ver[i]=s;
      d[i]=c[s][i];
      v[i]=0;
   }
   v[s]=1;
   for(i=1; i<=n-1; i++)
   {
      min=INF;
      for(j=1; j<=n; j++)
         if(v[j]==0 && d[j]<min)
         {
            min=d[j];
            u=j;
         }
      v[u]=1;
      sum=sum+d[u];
      printf("\n%d -> %d sum=%d",ver[u],u,sum);
      for(j=1; j<=n; j++)
         if(v[j]==0 && c[u][j]<d[j])
         {
            d[j]=c[u][j];
            ver[j]=u;
         }
   }
   return sum;
}
void main()
{
   int c[10][10],i,j,res,s,n;
```

```
    printf("\nEnter n value:");
    scanf("%d",&n);
    printf("\nEnter the graph data:\n");
    for(i=1; i<=n; i++)
        for(j=1; j<=n; j++)
            scanf("%d",&c[i][j]);
    printf("\nEnter the souce node:");
    scanf("%d",&s);
    res=prim(c,n,s);
    printf("\nCost=%d",res);
    getch();
}
```

OUTPUT:

```
Enter n value:4

Enter the graph data:
3 2 5 1
6 4 5 7
8 5 4 7
4 5 3 7

Enter the souce node:3
3 -> 2 sum=5
2 -> 1 sum=11
1 -> 4 sum=12
Cost=12
```

PROGRAM 3

(A) Design and implement C/C++ Program to solve All-Pairs Shortest Paths problem using Floyd's algorithm.

CODE:

```
#include<stdio.h>
#define INF 999
int min(int a,int b)
{
   return(a<b)?a:b;
}
void floyd(int p[][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++)
            p[i][j]=min(p[i][j],p[i][k]+p[k][j]);
}
int main()
{
   int a[10][10],n,i,j;
   printf("\nEnter the n value:");
   scanf("%d",&n);
   printf("\nEnter the graph data:\n");
   for(i=1; i<=n; i++)
      for(j=1; j<=n; j++)
         scanf("%d",&a[i][j]);
   floyd(a,n);
   printf("\nShortest path matrix\n");
   for(i=1; i<=n; i++)
   {
      for(j=1; j<=n; j++)
         printf("%d ",a[i][j]);
      printf("\n");
   }
   return 0;
}
```

OUTPUT:

```
Enter the n value:4
```

Enter the graph data:
0 222 3 54
31 0 56 272
7 155 0 342
65 2 44 0

Shortest path matrix
0 56 3 54
31 0 34 85
7 63 0 61
33 2 36 0

(B)Design and implement C/C++ Program to find the transitive closure using Warshal's algorithm.

CODE:

```
#include<stdio.h>
void warsh(int p[][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++)
            p[i][j]=p[i][j] || p[i][k] && p[k][j];
}
int main()
{
   int a[10][10],n,i,j;
   printf("\nEnter the n value:");
   scanf("%d",&n);
   printf("\nEnter the graph data:\n");
   for(i=1; i<=n; i++)
      for(j=1; j<=n; j++)
         scanf("%d",&a[i][j]);
   warsh(a,n);
   printf("\nResultant path matrix\n");
   for(i=1; i<=n; i++)
   {
      for(j=1; j<=n; j++)
         printf("%d ",a[i][j]);
      printf("\n");
   }
   return 0;
}
```

OUTPUT:

```
Enter the n value:4
Enter the graph data:
0 0 1 0
1 0 0 0
0 1 0 0
0 0 0 0
```

Resultant path matrix
1 1 1 0
1 1 1 0
1 1 1 0
0 0 0 0

PROGRAM 4

Design and implement C/C++ Program to find shortest paths from a given vertex in a weighted connected graph to other vertices using Dijkstra's algorithm.

CODE:

```
#include<stdio.h>
#define INF 999
void dijkstra(int c[10][10],int n,int s,int d[10])
{
   int v[10],min,u,i,j;
   for(i=1; i<=n; i++)
   {
      d[i]=c[s][i];
      v[i]=0;
   }
   v[s]=1;
   for(i=1; i<=n; i++)
   {
      min=INF;
      for(j=1; j<=n; j++)
         if(v[j]==0 && d[j]<min)
         {
            min=d[j];
            u=j;
         }
      v[u]=1;
      for(j=1; j<=n; j++)
         if(v[j]==0 && (d[u]+c[u][j])<d[j])
            d[j]=d[u]+c[u][j];
   }
}
int main()
{
   int c[10][10],d[10],i,j,s,sum,n;
   printf("\nEnter n value:");
   scanf("%d",&n);
   printf("\nEnter the graph data:\n");
   for(i=1; i<=n; i++)
      for(j=1; j<=n; j++)
         scanf("%d",&c[i][j]);
```

```
    printf("\nEnter the souce node:");
    scanf("%d",&s);
    dijkstra(c,n,s,d);
    for(i=1; i<=n; i++)
        printf("\nShortest distance from %d to %d is %d",s,i,d[i]);
    return 0;
}
```

OUTPUT:

```
Enter n value:4
Enter the graph data:
12  28  108  0
16  32   7    2
2    32  28   0
3    5    43   1
Enter the souce node:2
Shortest distance from 2 to 1 is 5
Shortest distance from 2 to 2 is 32
Shortest distance from 2 to 3 is 7
Shortest distance from 2 to 4 is 2
```

PROGRAM 5

Design and implement C/C++ Program to obtain the Topological ordering of vertices in a given digraph.

CODE:

```
#include<stdio.h>
int temp[10],k=0;
void sort(int a[][10],int id[],int n)
{
   int i,j;
   for(i=1; i<=n; i++)
   {
      if(id[i]==0)
      {
         id[i]=-1;
         temp[++k]=i;
         for(j=1; j<=n; j++)
         {
            if(a[i][j]==1 && id[j]!=-1)
               id[j]--;
         }
         i=0;
      }
   }
}
int main()
{
   int a[10][10],id[10],n,i,j;
   printf("\nEnter the n value:");
   scanf("%d",&n);
   for(i=1; i<=n; i++)
      id[i]=0;
   printf("\nEnter the graph data:\n");
   for(i=1; i<=n; i++)
      for(j=1; j<=n; j++)
      {
         scanf("%d",&a[i][j]);
         if(a[i][j]==1)
            id[j]++;
      }
   sort(a,id,n);
```

```
    if(k!=n)
        printf("\nTopological ordering not possible");
    else
    {
        printf("\nTopological ordering is:");
        for(i=1; i<=k; i++)
            printf("%d ",temp[i]);
    }

}
```

OUTPUT:

1)Enter the n value:6
Enter the graph data:
0 0 1 1 0 0
0 0 0 1 1 0
0 0 0 1 0 1
0 0 0 0 0 1
0 0 0 0 0 1
0 0 0 0 0 0
Topological ordering is: 1 2 3 4 5 6

2) Enter the n value:4
Enter the graph data:
0 0 1 1 0 0
0 0 0 1 1 0
0 0 0 1 0 1
0 0 0 0 1 1
0 0 1 0 0 1
Topological ordering not possible

PROGRAM 6

Design and implement C/C++ Program to solve 0/1 Knapsack problem using Dynamic Programming method.

CODE:

```
#include<stdio.h>
int w[10],p[10],n;
int max(int a,int b)
{
   return a>b?a:b;
}
int knap(int i,int m)
{
   if(i==n) return w[i]>m?0:p[i];
   if(w[i]>m) return knap(i+1,m);
   return max(knap(i+1,m),knap(i+1,m-w[i])+p[i]);
}
int main()
{
   int m,i,max_profit;
   printf("\nEnter the no. of objects:");
   scanf("%d",&n);
   printf("\nEnter the knapsack capacity:");
   scanf("%d",&m);
   printf("\nEnter profit followed by weight:\n");
   for(i=1; i<=n; i++)
      scanf("%d %d",&p[i],&w[i]);
   max_profit=knap(1,m);
   printf("\nMax profit=%d",max_profit);
   return 0;
}
```

OUTPUT:

```
Enter the no. of objects:4
Enter the knapsack capacity:5
Enter profit followed by weight:
46 5
24 7
20 4
22 7
Max profit=46
```

PROGRAM 7

Design and implement C/C++ Program to solve discrete Knapsack and continuous Knapsack problems using greedy approximation method.

CODE:

```
#include <stdio.h>
#define MAX 50
int p[MAX], w[MAX], x[MAX];
double maxprofit;
int n, m, i;
void greedyKnapsack(int n, int w[], int p[], int m)
{
   double ratio[MAX];
// Calculate the ratio of profit to weight for each item
   for (i = 0; i < n; i++)
   {
      ratio[i] = (double)p[i] / w[i];
   }
// Sort items based on the ratio in non-increasing order
   for (i = 0; i < n - 1; i++)
   {
      for (int j = i + 1; j < n; j++)
      {
         if (ratio[i] < ratio[j])
         {
            double temp = ratio[i];
            ratio[i] = ratio[j];
            ratio[j] = temp;

            int temp2 = w[i];
            w[i] = w[j];
            w[j] = temp2;

            temp2 = p[i];
            p[i] = p[j];
            p[j] = temp2;
         }
      }
   }
   int currentWeight = 0;
   maxprofit = 0.0;
```

```
// Fill the knapsack with items
    for (i = 0; i < n; i++)
    {
        if (currentWeight + w[i] <= m)
        {
            x[i] = 1; // Item i is selected
            currentWeight += w[i];
            maxprofit += p[i];
        }
        else
        {
// Fractional part of item i is selected
            x[i] = (m - currentWeight) / (double)w[i];
            maxprofit += x[i] * p[i];
            break;
        }
    }
    printf("Optimal solution for greedy method: %.1f\n", maxprofit);
    printf("Solution vector for greedy method: ");
    for (i = 0; i < n; i++)
        printf("%d\t", x[i]);
}
int main()
{
    printf("Enter the number of objects: ");
    scanf("%d", &n);
    printf("Enter the objects' weights: ");
    for (i = 0; i < n; i++)
        scanf("%d", &w[i]);
    printf("Enter the objects' profits: ");
    for (i = 0; i < n; i++)
        scanf("%d", &p[i]);
    printf("Enter the maximum capacity: ");
    scanf("%d", &m);
    greedyKnapsack(n, w, p, m);
    return 0;
}
```

OUTPUT:

```
Enter the number of objects: 5
Enter the objects' weights: 90 120 85 40 27
Enter the objects' profits: 160 180 120 100 200
Enter the maximum capacity: 400
Optimal solution for greedy method: 760.0
Solution vector for greedy method: 1   1   1   1   1
```

PROGRAM 8

Design and implement C/C++ Program to find a subset of a given set S = {sl , s2,…..,sn} of n positive integers whose sum is equal to a given positive integer d.

CODE:

```
#include<stdio.h>
#define MAX 10
int s[MAX],x[MAX],d;
void sumofsub(int p,int k,int r)
{
   int i;
   x[k]=1;
   if((p+s[k])==d)
   {
      for(i=1; i<=k; i++)
         if(x[i]==1)
            printf("%d ",s[i]);
      printf("\n");
   }
   else if(p+s[k]+s[k+1]<=d)
      sumofsub(p+s[k],k+1,r
            -s[k]);
   if((p+r
         -s[k]>=d) && (p+s[k+1]<=d))
   {
      x[k]=0;
      sumofsub(p,k+1,r
            -s[k]);
   }
}
int main()
{
   int i,n,sum=0;
   printf("\nEnter the n value:");
   scanf("%d",&n);
   printf("\nEnter the set in increasing order:");
   for(i=1; i<=n; i++)
      scanf("%d",&s[i]);
   printf("\nEnter the max subset value:");
   scanf("%d",&d);
   for(i=1; i<=n; i++)
```

```
    sum=sum+s[i];
  if(sum<d || s[1]>d)
    printf("\nNo subset possible");
  else
    sumofsub(0,1,sum);
  return 0;
}
```

OUTPUT:

```
Enter the n value:7
Enter the set in increasing order:2 3 4 6 7 8 9
Enter the max subset value:11
2 3 6
2 9
3 8
4 7
```

PROGRAM 9

Design and implement C/C++ Program to sort a given set of n integer elements using Selection Sort method and compute its time complexity. Run the program for varied values of n> 5000 and record the time taken to sort. Plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.

CODE:

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
// Function to perform selection sort on an array
void selectionSort(int arr[], int n)
{
   int i, j, min_idx;
   for (i = 0; i < n-1; i++)
   {
      min_idx = i;  // Assume the current element is the minimum
      for (j = i+1; j < n; j++)
      {
         if (arr[j] < arr[min_idx])
         {
            min_idx = j;  // Update min_idx if a smaller element is found
         }
      }
      // Swap the found minimum element with the current element
      int temp = arr[min_idx];
      arr[min_idx] = arr[i];
      arr[i] = temp;
   }
}
// Function to generate an array of random numbers
void generateRandomNumbers(int arr[], int n)
{
   for (int i = 0; i < n; i++)
   {
      arr[i] = rand() % 10000;  // Generate random numbers between 0 and 9999
   }
}
int main()
{
   int n;
   printf("Enter number of elements: ");
   scanf("%d", &n);  // Read the number of elements from the user
```

```
    if (n <= 5000)
    {
        printf("Please enter a value greater than 5000\n");
        return 1;  // Exit if the number of elements is not greater than 5000
    }
    // Allocate memory for the array
    int *arr = (int *)malloc(n * sizeof(int));
    if (arr == NULL)
    {
        printf("Memory allocation failed\n");
        return 1;  // Exit if memory allocation fails
    }
    // Generate random numbers and store them in the array
    generateRandomNumbers(arr, n);
    // Measure the time taken to sort the array
    clock_t start = clock();
    selectionSort(arr, n);
    clock_t end = clock();
    // Calculate and print the time taken to sort the array
    double time_taken = ((double)(end - start)) / CLOCKS_PER_SEC;
    printf("Time taken to sort %d elements: %f seconds\n", n, time_taken);
    // Free the allocated memory
    free(arr);
    return 0;
}
```

PYTHON CODE:

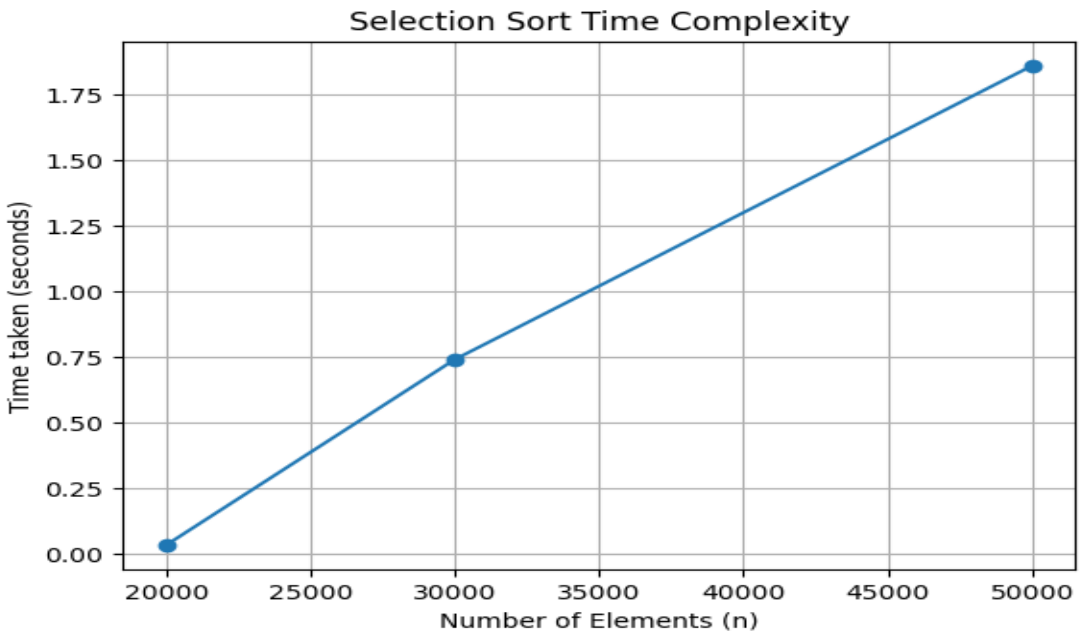
```
import matplotlib.pyplot as plt
n_values = [20000, 30000, 50000]
time_taken = [ 0.0334753, 0.740417, 1.858939]
plt.plot(n_values, time_taken, marker='o')
plt.title('Selection Sort Time Complexity')
plt.xlabel('Number of Elements (n)')
plt.ylabel('Time taken (seconds)')
plt.grid(True)
plt.show()
```

OUTPUT:

Enter number of elements: 20000
Time taken to sort 20000 elements: 0.0334753 seconds

Enter number of elements: 30000
Time taken to sort 30000 elements: 0.740417 seconds

Enter number of elements: 50000
Time taken to sort 50000 elements: 1.858939 seconds



PROGRAM 10

Design and implement C/C++ Program to sort a given set of n integer elements using Quick Sort method and compute its time complexity. Run the program for varied values of n> 5000 and record the time taken to sort. Plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.

CODE:

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
// Function to swap two elements
void swap(int* a, int* b)
{
   int t = *a;
   *a = *b;
   *b = t;
}
// Partition function for Quick Sort
int partition(int arr[], int low, int high)
{
   int pivot = arr[high]; // Pivot element
   int i = (low - 1); // Index of smaller element
   for (int j = low; j <= high - 1; j++)
   {
      if (arr[j] < pivot)
      {
         i++; // Increment index of smaller element
         swap(&arr[i], &arr[j]);
      }
   }
   swap(&arr[i + 1], &arr[high]);
   return (i + 1);
}
// Quick Sort function
void quickSort(int arr[], int low, int high)
{
   if (low < high)
   {
      int pi = partition(arr, low, high);
      // Recursively sort elements before and after partition
      quickSort(arr, low, pi - 1);
      quickSort(arr, pi + 1, high);
   }
```

```
}
// Function to generate random numbers
void generateRandomNumbers(int arr[], int n)
{
    for (int i = 0; i < n; i++)
    {
        arr[i] = rand() % 100000; // Generate random numbers between 0 and 99999
    }
}
int main()
{
    int n;
    printf("Enter number of elements: ");
    scanf("%d", &n); // Read the number of elements from the user
    if (n <= 5000)
    {
        printf("Please enter a value greater than 5000\n");
        return 1; // Exit if the number of elements is not greater than 5000
    }
    // Allocate memory for the array
    int *arr = (int *)malloc(n * sizeof(int));
    if (arr == NULL)
    {
        printf("Memory allocation failed\n");
        return 1; // Exit if memory allocation fails
    }
    // Generate random numbers and store them in the array
    generateRandomNumbers(arr, n);

    // Measure the time taken to sort the array
    clock_t start = clock();
    quickSort(arr, 0, n - 1);
    clock_t end = clock();

    // Calculate and print the time taken to sort the array
    double time_taken = ((double)(end - start)) / CLOCKS_PER_SEC;
    printf("Time taken to sort %d elements: %f seconds\n", n, time_taken);
```

```
    // Free the allocated memory
    free(arr);
    return 0;
}
```

PYTHON CODE:

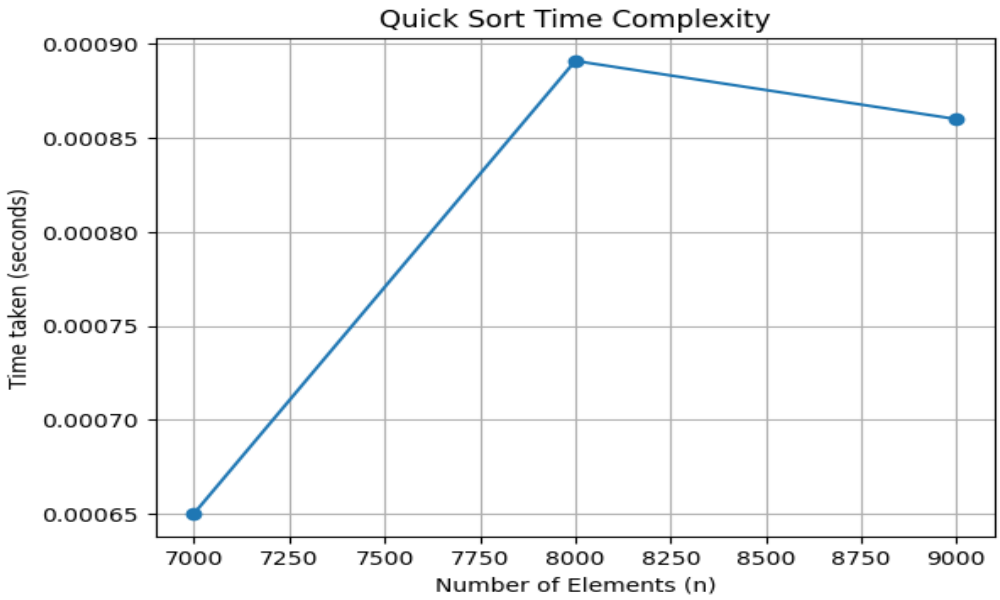
```
import matplotlib.pyplot as plt
n_values = [ 7000, 8000, 9000]
time_taken = [0.000650, 0.000891, 0.000860]
plt.plot(n_values, time_taken, marker='o')
plt.title('Quick Sort Time Complexity')
plt.xlabel('Number of Elements (n)')
plt.ylabel('Time taken (seconds)')
plt.grid(True)
plt.show()
```

OUTPUT:

```
Enter number of elements: 7000
Time taken to sort 7000 elements: 0.000650 seconds

Enter number of elements: 8000
Time taken to sort 8000
 elements: 0.000891 seconds

Enter number of elements: 9000
Time taken to sort 9000
elements: 0.000860seconds
```


Quick Sort Time Complexity
0.00090
0.00085
0.00080
0.00075
0.00070
0.00065
Time taken (seconds)
7000
7250
7500
7750
8000
8250
8500
8750
9000
Number of Elements (n)

PROGRAM 11

Design and implement C/C++ Program to sort a given set of n integer elements using Merge Sort method and compute its time complexity. Run the program for varied values of n> 5000, and record the time taken to sort. Plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.

CODE:

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
void merge(int arr[], int left, int mid, int right)
{
   int i, j, k;
   int n1 = mid - left + 1;
   int n2 = right - mid;
   int *L = (int *)malloc(n1 * sizeof(int));
   int *R = (int *)malloc(n2 * sizeof(int));
   for (i = 0; i < n1; i++)
      L[i] = arr[left + i];
   for (j = 0; j < n2; j++)
      R[j] = arr[mid + 1 + j];
   i = 0;
   j = 0;
   k = left;
   while (i < n1 && j < n2)
   {
      if (L[i] <= R[j])
      {
         arr[k] = L[i];
         i++;
      }
      else
      {
         arr[k] = R[j];
         j++;
      }
      k++;
   }
   while (i < n1)
   {
      arr[k] = L[i];
      i++;
      k++;
```

```
    }
    while (j < n2)
    {
        arr[k] = R[j];
        j++;
        k++;
    }
    free(L);
    free(R);
}
// Function to implement Merge Sort
void mergeSort(int arr[], int left, int right)
{
    if (left < right)
    {
        int mid = left + (right - left) / 2;
        mergeSort(arr, left, mid);
        mergeSort(arr, mid + 1, right);
        merge(arr, left, mid, right);
    }
}
// Function to generate random integers
void generateRandomArray(int arr[], int n)
{
    for (int i = 0; i < n; i++)
        arr[i] = rand() % 100000; // Generate random integers between 0 and 99999
}
int main()
{
    int n;
    printf("Enter the number of elements: ");
    scanf("%d", &n);
    if (n <= 5000)
    {
        printf("Please enter a value greater than 5000\n");
        return 1; // Exit if the number of elements is not greater than 5000
    }
```

```
    int *arr = (int *)malloc(n * sizeof(int));
    if (arr == NULL)
    {
        printf("Memory allocation failed\n");
        return 1; // Exit if memory allocation fails
    }
    generateRandomArray(arr, n);
    // Repeat the sorting process multiple times to increase duration for timing
    clock_t start = clock();
    for (int i = 0; i < 1000; i++)
    {
        mergeSort(arr, 0, n - 1);
    }
    clock_t end = clock();
    // Calculate the time taken for one iteration
    double time_taken = ((double)(end - start)) / CLOCKS_PER_SEC / 1000.0;
    printf("Time taken to sort %d elements: %f seconds\n", n, time_taken);
    free(arr);
    return 0;
}
```

PYTHON CODE:

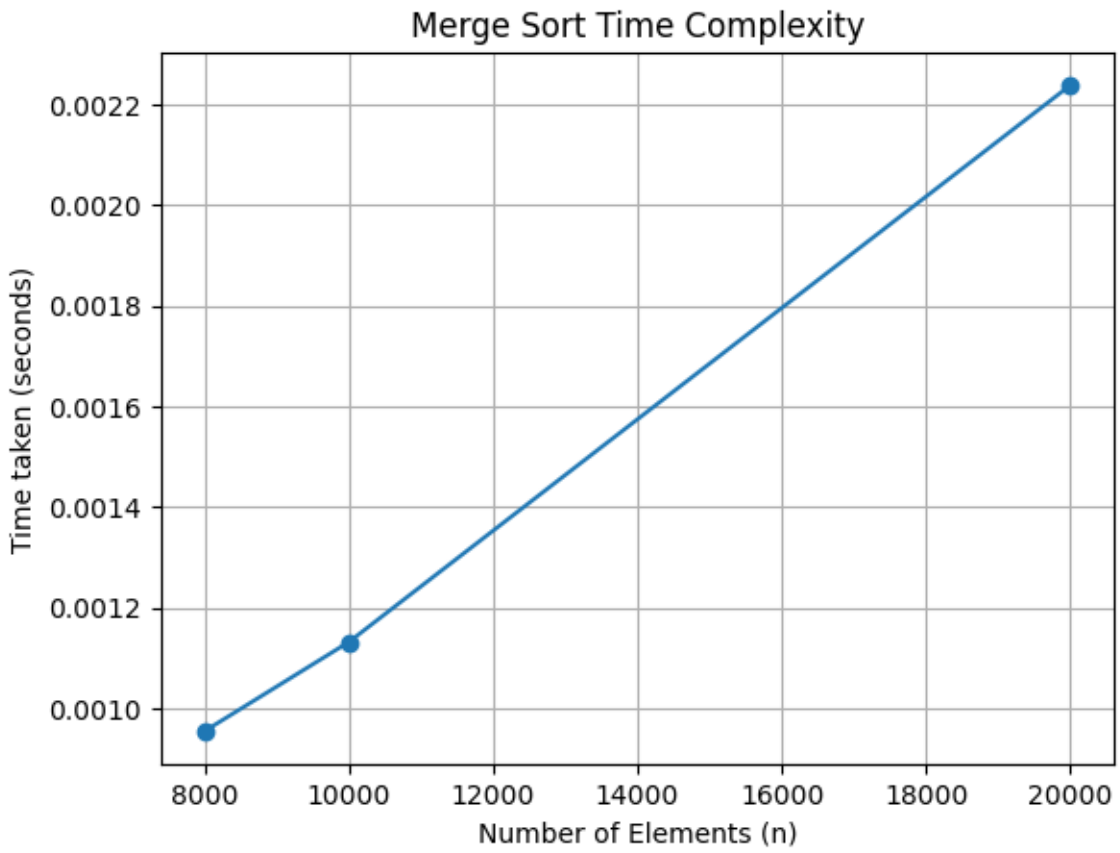
```
import matplotlib.pyplot as plt
n_values = [8000,10000,20000]
time_taken = [0.000955,0.001132,0.002238]
plt.plot(n_values, time_taken, marker='o')
plt.title('Merge Sort Time Complexity')
plt.xlabel('Number of Elements (n)')
plt.ylabel('Time taken (seconds)')
plt.grid(True)
plt.show()
```

OUTPUT:

```
Enter number of elements: 8000
Time taken to sort 8000 elements: 0.000955 seconds
```

Enter number of elements: 10000
Time taken to sort 10000 elements: 0.001132 seconds

Enter number of elements: 20000
Time taken to sort 20000 elements: 0.002238 seconds



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PROGRAM 12

Design and implement C/C++ Program for N Queen's problem using Backtracking.

CODE:

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>
// Function to print the solution
void printSolution(int **board, int N)
{
    for (int i = 0; i < N; i++)
    {
        for (int j = 0; j < N; j++)
        {
            printf("%s ", board[i][j] ? "Q" : "#");
        }
        printf("\n");
    }
}
// Function to check if a queen can be placed on board[row][col]
bool isSafe(int **board, int N, int row, int col)
{
    int i, j;

    // Check this row on left side
    for (i = 0; i < col; i++)
    {
        if (board[row][i])
        {
            return false;
        }
    }
    // Check upper diagonal on left side
    for (i = row, j = col; i >= 0 && j >= 0; i--, j--)
    {
        if (board[i][j])
        {
            return false;
        }
    }
```

```
    // Check lower diagonal on left side
    for (i = row, j = col; j >= 0 && i < N; i++, j--)
    {
        if (board[i][j])
        {
            return false;
        }
    }
    return true;
}
// A recursive utility function to solve N Queen problem
bool solveNQUtil(int **board, int N, int col)
{
    // If all queens are placed, then return true
    if (col >= N)
    {
        return true;
    }
    // Consider this column and try placing this queen in all rows one by one
    for (int i = 0; i < N; i++)
    {
        if (isSafe(board, N, i, col))
        {
            // Place this queen in board[i][col]
            board[i][col] = 1;

            // Recur to place rest of the queens
            if (solveNQUtil(board, N, col + 1))
            {
                return true;
            }
            // If placing queen in board[i][col] doesn't lead to a solution,
            // then remove queen from board[i][col]
            board[i][col] = 0; // BACKTRACK
        }
    }
    // If the queen cannot be placed in any row in this column col, then return false
```

```
    return false;
}
// This function solves the N Queen problem using Backtracking
// It mainly uses solveNQUtil() to solve the problem
// It returns false if queens cannot be placed, otherwise, return true and prints the
placement of queens
bool solveNQ(int N)
{
    int **board = (int **)malloc(N * sizeof(int *));
    for (int i = 0; i < N; i++)
    {
        board[i] = (int *)malloc(N * sizeof(int));
        for (int j = 0; j < N; j++)
        {
            board[i][j] = 0;
        }
    }
    if (!solveNQUtil(board, N, 0))
    {
        printf("Solution does not exist\n");
        for (int i = 0; i < N; i++)
        {
            free(board[i]);
        }
        free(board);
        return false;
    }
    printSolution(board, N);
    for (int i = 0; i < N; i++)
    {
        free(board[i]);
    }
    free(board);
    return true;
}
int main()
{
```

```
    int N;
    printf("Enter the number of queens: ");
    scanf("%d", &N);
    solveNQ(N);
    return 0;
}
```

OUTPUT:

1) Enter the number of queens: 4
   # # Q #
   Q # # #
   # # # Q
   # Q # #

2) Enter the number of queens: 3
   Solution does not exist