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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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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "**Analysis and Design of Algorithms**" carried out by **Aisha Taffazul Chesti (1BM21CS010),** 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 May-2023 to July-2023. The Lab report has been approved as it satisfies the academic requirements in respect of an **Analysis and Design of Algorithms (22CS4PCADA)** work prescribed for the said degree.

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Course Outcome

CO1	Analyze time complexity of Recursive and Non-recursive algorithms using asymptotic notations.
CO2	Apply various design techniques for the given problem.
CO3	Apply the knowledge of complexity classes P, NP, and NP-Complete and prove certain problems are NP-Complete
CO4	Design efficient algorithms and conduct practical experiments to solve problems.

1.Write program to do the following:

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

Solution:

Code:

```
#include<stdio.h>

#define MAX_VERTICES 20

int a[MAX_VERTICES][MAX_VERTICES], q[MAX_VERTICES], visited[MAX_VERTICES];
int n, f, r;

void bfs(int v) {
   int i;
   for (i = 1; i <= n; i++) {
      if (a[v][i] && !visited[i]) {
         q[++r] = i;
         visited[i] = 1;
      }
   }
   if (f <= r) {
      bfs(q[f++]);
   }
}

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

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

   for (i = 1; i <= n; i++) {
      q[i] = 0;
      visited[i] = 0;
   }
```

```
    printf("Enter 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);

    f = 0;
    r = -1;
    visited[v] = 1;
    bfs(v);

    printf("The nodes that are reachable are:\n");

    int allNodesReachable = 1;
    for (i = 1; i <= n; i++) {
        if (visited[i]) {
            printf("%d\t", i);
        } else {
            printf("\nBFS is not possible. Not all nodes are reachable.\n");
            allNodesReachable = 0;
            break;
        }
    }

    if (allNodesReachable) {
        printf("\n");
    }

    return 0;
}
```

Output:

```
Enter the number of vertices: 7
Enter graph data in matrix form:
0 1 1 0 0 0 0
0 0 0 1 1 0 0
0 0 0 0 0 1 1
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
Enter the starting vertex: 1
The nodes that are reachable are:
1       2       3       4       5       6       7

Process returned 0 (0x0)   execution time : 177.319 s
Press any key to continue.
```

```
Enter the number of vertices: 5
Enter graph data in matrix form:
1 0 0 0 0
0 0 0 1 0
0 1 0 1 0
0 1 1 0 0
0 0 0 1 0
Enter the starting vertex: 1
The nodes that are reachable are:
1
BFS is not possible. Not all nodes are reachable.

Process returned 0 (0x0)   execution time : 44.208 s
Press any key to continue.
```

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

Solution:

Code:

```
#include<stdio.h>
#include<conio.h>
int graph[20][20];
void DFS(int i,int vis[],int n)
{
   int j;
   printf("%d ",i);
   vis[i]=1;
   for(j=0;j<n;j++)
   {
      if(graph[i][j]==1 && vis[j]==0)
      {
         DFS(j,vis,n);
      }
   }
}
int main()
{
   int n,i,j,top=-1;
   printf("Enter the number of vertices:\n");
   scanf("%d",&n);
   printf("Enter the adjacency matrix representing the graph:\n");

   int vis[n],st[n];
   for(int i=0;i<n;i++)
   {
      for(int j=0;j<n;j++)
      {
         scanf("%d",&graph[i][j]);
      }
   }
   for(int i=0;i<n;i++)
   {
      vis[i]=0;
   }
```

```
    DFS(0,vis,n);
    return 0;
}
```

Output:

```
Enter the number of vertices:
4
Enter the adjacency matrix representing the graph:
0 1 0 0
0 0 1 0
0 1 0 1
1 1 0 0
0 1 2 3
Process returned 0 (0x0)   execution time : 38.994 s
Press any key to continue.
```

```
Enter the number of vertices:
5
Enter the adjacency matrix representing the graph:
0 1 0 1 0
1 0 0 0 0
1 1 0 0 0
0 1 0 0 1
1 1 0 0 0
0 1 3 4
Process returned 0 (0x0)   execution time : 32.151 s
Press any key to continue.
```

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

Solution:

Code:

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

#define MAX_VERTICES 100

typedef struct Node {
   int data;
   struct Node* next;
} Node;

typedef struct Graph {
   Node* adjList[MAX_VERTICES];
   int numVertices;
} Graph;

Node* createNode(int data) {
   Node* newNode = (Node*)malloc(sizeof(Node));
   newNode->data = data;
   newNode->next = NULL;
   return newNode;
}

Graph* createGraph(int numVertices) {
   Graph* graph = (Graph*)malloc(sizeof(Graph));
```

```
    graph->numVertices = numVertices;

    for (int i = 0; i < numVertices; i++) {
        graph->adjList[i] = NULL;
    }

    return graph;
}

void addEdge(Graph* graph, int src, int dest) {
    Node* newNode = createNode(dest);
    newNode->next = graph->adjList[src];
    graph->adjList[src] = newNode;
}

void topologicalSortUtil(Graph* graph, int v, int visited[], int* stackIndex, int stack[]) {
    visited[v] = 1;

    Node* node = graph->adjList[v];
    while (node != NULL) {
        int adjVertex = node->data;
        if (!visited[adjVertex]) {
            topologicalSortUtil(graph, adjVertex, visited, stackIndex, stack);
        }
        node = node->next;
    }

    stack[(*stackIndex)] = v;
    (*stackIndex)++;
```

```
}

void topologicalSort(Graph* graph) {
    int visited[MAX_VERTICES] = {0};
    int stack[MAX_VERTICES];
    int stackIndex = 0;

    for (int i = 0; i < graph->numVertices; i++) {
        if (!visited[i]) {
            topologicalSortUtil(graph, i, visited, &stackIndex, stack);
        }
    }

    printf("Topological Sort: ");
    for (int i = stackIndex - 1; i >= 0; i--) {
        printf("%d ", stack[i]);
    }
}

int main() {
    int numVertices = 6;
    Graph* graph = createGraph(numVertices);

    addEdge(graph, 5, 2);
    addEdge(graph, 5, 0);
    addEdge(graph, 4, 0);
    addEdge(graph, 4, 1);
    addEdge(graph, 2, 3);
    addEdge(graph, 3, 1);
```

```
    topologicalSort(graph);

    return 0;
}
```

Output:

```
Topological Sort: 5 4 2 3 1 0
Process returned 0 (0x0)   execution time : 0.030 s
Press any key to continue.
```

```
Topological Sort: 5 2 0 3 4 1
Process returned 0 (0x0)   execution time : 0.111 s
Press any key to continue.
```

3. Implement Johnson Trotter algorithm to generate permutations.

Solution:

Code:

```
#include <stdio.h>
void swap(int *a, int *b)
{
   int temp = *a;
   *a = *b;
   *b = temp;
}

void display(int *array, int n) {
   for (int i = 0; i < n; i++) {
      printf("%d ", array[i]);
   }
   printf("\n");
}

void johnsonT(int *array, int *directions, int n) {
   display(array, n);

   int mobileElement, mobileIndex;

   while (1) {
      mobileElement = 0;
      mobileIndex = 0;

      for (int i = 0; i < n; i++) {
         if ((i == 0 && directions[i] == -1) ||
            (i == n - 1 && directions[i] == 1)) {
            continue;
         }

         if ((array[i] > array[i + directions[i]]) &&
            (array[i] > mobileElement)) {
```

```
            mobileElement = array[i];
            mobileIndex = i;
         }
      }

      if (mobileElement == 0) {
         break;
      }

      int neighborIndex = mobileIndex + directions[mobileIndex];
      swap(&array[mobileIndex], &array[neighborIndex]);
      swap(&directions[mobileIndex], &directions[neighborIndex]);

      for (int i = 0; i < n; i++) {
         if (array[i] > mobileElement) {
            directions[i] = -directions[i];
         }
      }

      display(array, n);
   }
}

int main() {
   int n;

   printf("Enter the n of the array: ");
   scanf("%d", &n);

   int array[n];
   int directions[n];

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

   johnsonT(array, directions, n);

   return 0;
```

}

Output:

```
Enter the n of the array: 3
1 2 3
1 3 2
3 1 2
3 2 1
2 3 1
2 1 3

Process returned 0 (0x0)   execution time : 7.598 s
Press any key to continue.
```

```
Enter the n of the array: 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 : 1.656 s
Press any key to continue.
```

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

Solution:

Code:

```
#include <stdio.h>

void merge(int arr[], int left[], int left_size, int right[], int right_size) {
   int i = 0, j = 0, k = 0;

   while (i < left_size && j < right_size) {
      if (left[i] < right[j])
         arr[k++] = left[i++];
      else
         arr[k++] = right[j++];
   }

   while (i < left_size)
      arr[k++] = left[i++];

   while (j < right_size)
      arr[k++] = right[j++];
}

void merge_sort(int arr[], int size) {
   if (size <= 1)
      return;

   int mid = size / 2;
   int left[mid];
   int right[size - mid];

   for (int i = 0; i < mid; i++)
      left[i] = arr[i];

   for (int i = mid; i < size; i++)
      right[i - mid] = arr[i];
```

```
    merge_sort(left, mid);
    merge_sort(right, size - mid);
    merge(arr, left, mid, right, size - mid);
}

int main() {
    int arr[] = {13, 11, 13, 5, 6, 7};
    int size = sizeof(arr) / sizeof(arr[0]);

    merge_sort(arr, size);

    printf("Sorted array: ");
    for (int i = 0; i < size; i++)
        printf("%d ", arr[i]);

    return 0;
}
```

Output:

```
Merge Sort
Sorted array: 5 6 7 11 13 13
Process returned 0 (0x0)   execution time : 0.068 s
Press any key to continue.
```

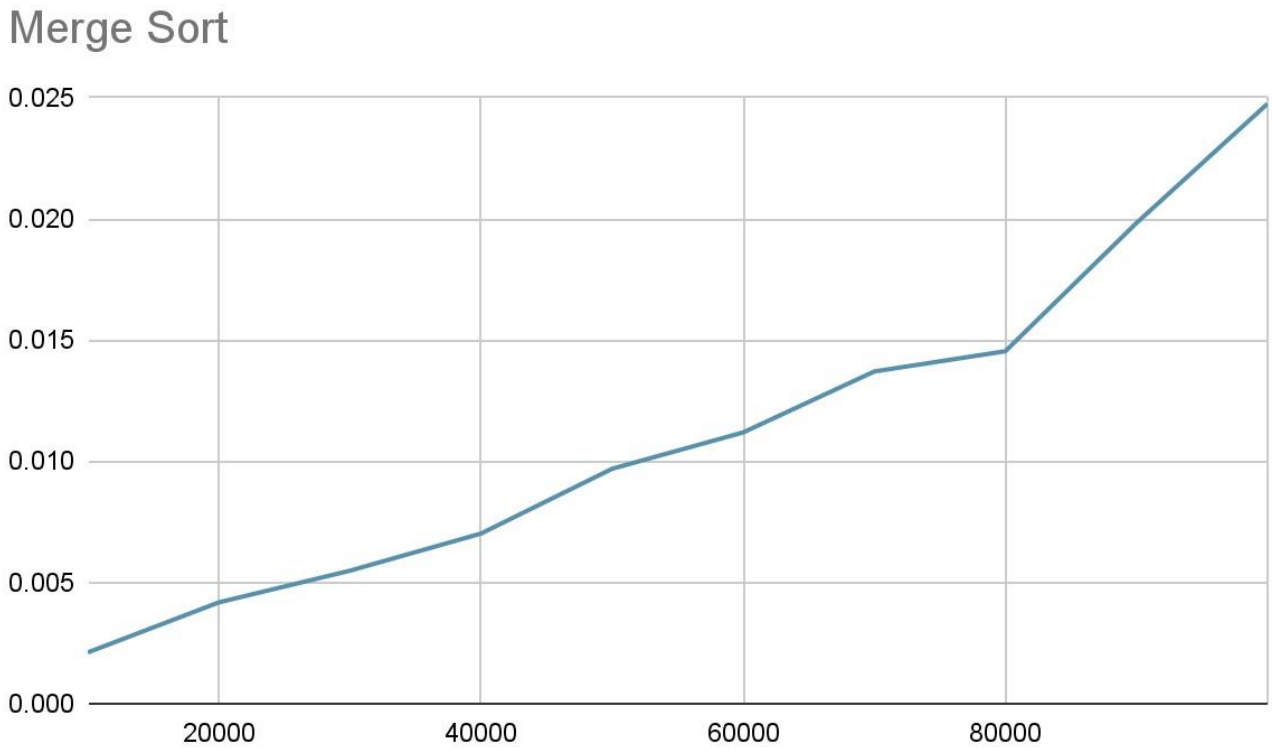
```
Merge Sort
Sorted array: 1 23 24 25 65 345 556
Process returned 0 (0x0)   execution time : 0.073 s
Press any key to continue.
```

Table of values:

Input size(n)	Time taken
10000	0.002114
20000	0.00418

30000	0.005486
40000	0.007019
50000	0.00969
60000	0.011191
70000	0.013704
80000	0.014539
90000	0.019828
100000	0.024749

Graph:



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

Solution:

Code:

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

int partition(int low, int high, int* a) {
   int i = low;
   int j = high + 1;
   int pivot = a[low];
   int temp;

   while (1) {
      do {
         i = i + 1;
      } while (pivot >= a[i]);

      do {
         j = j - 1;
      } while (pivot < a[j]);

      if (i >= j)
         break;

      temp = a[i];
      a[i] = a[j];
      a[j] = temp;
   }

   temp = a[low];
   a[low] = a[j];
   a[j] = temp;
```

```
    return j;
}

void Quicksort(int low, int high, int* a) {
    int j;

    if (low < high) {
        j = partition(low, high, a);
        Quicksort(low, j - 1, a);
        Quicksort(j + 1, high, a);
    }
}

int main() {
    int arr[20], n;
    printf("Enter the number of elements: ");
    scanf("%d", &n);
    printf("Enter the elements: ");
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }

    Quicksort(0, n - 1, arr);

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

    return 0;
}
```

Output:

```
Enter the number of elements: 5
Enter the elements: 23 434 2 53 25
Sorted array: 2 23 25 53 434

Process returned 0 (0x0)   execution time : 20.820 s
Press any key to continue.
```

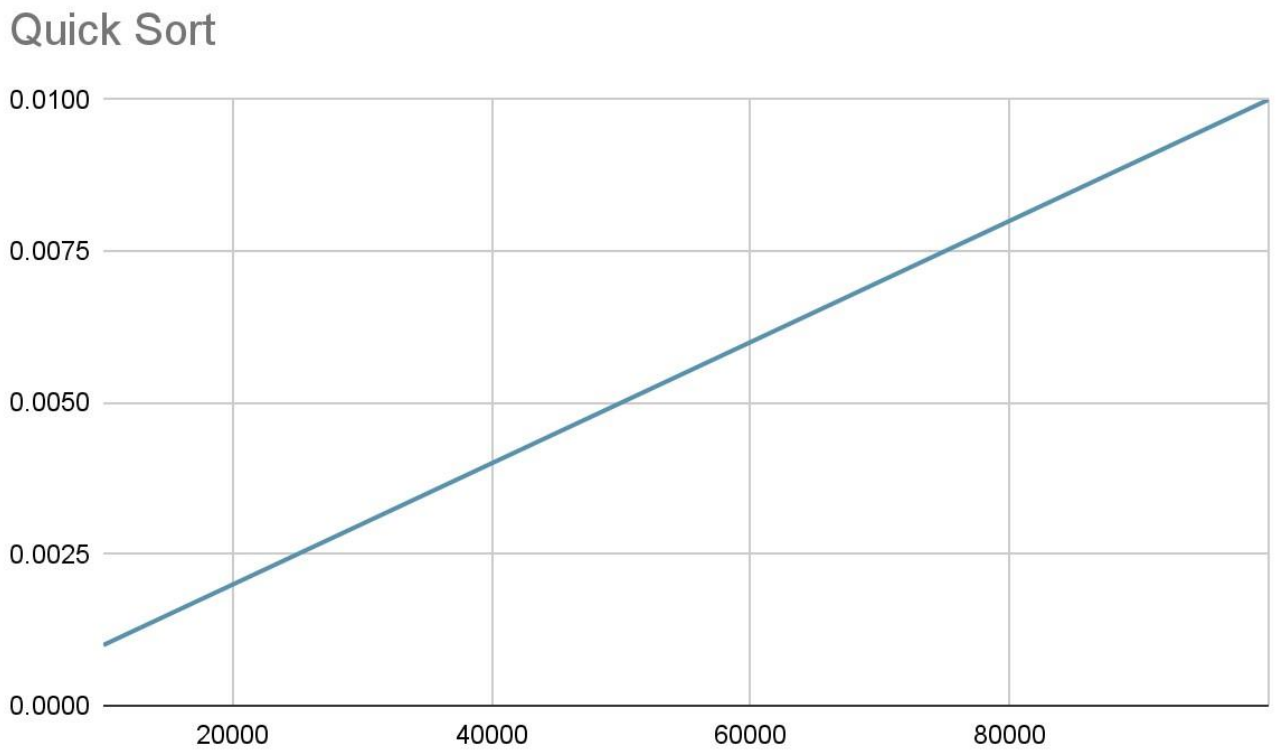
```
Enter the number of elements: 9
Enter the elements: 2 4 6 1 8 5 73 23 98
Sorted array: 1 2 4 5 6 8 23 73 98

Process returned 0 (0x0)   execution time : 17.828 s
Press any key to continue.
```

Table of values:

Input size(n)	Time taken
10000	0.001
20000	0.002
30000	0.003
40000	0.004
50000	0.005
60000	0.006
70000	0.007

80000	0.008
90000	0.009
100000	0.010

Graph:



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

Solution:

Code:

```
#include<stdio.h>

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

   // Extract elements from the heap one by one
   for (int i = n - 1; i > 0; i--)
   {
      // Move the current root (maximum value) to the end
      swap(&arr[0], &arr[i]);
      // Call max heapify on the reduced heap
      heapify(i, arr, 0);
   }
}

void heapify(int n, int arr[], 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], &arr[largest]);
```

```
      heapify(n, arr, largest);
   }
}

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

void main()
{
   int n;
   printf("HEAP SORT \n ");
   printf("\nEnter the number of elements to be sorted: ");
   scanf("%d", &n);
   int arr[n];
   printf("\nEnter the elements: ");
   for (int i = 0; i < n; i++)
      scanf("%d", &arr[i]);

   heapsort(n, arr);

   printf("\nSorted array in ascending order:\n ");
   for (int i = 0; i < n; i++)
      printf("%d ", arr[i]);
}
```

Output:

```
HEAP SORT

Enter the number of elements to be sorted: 5

Enter the elements: 6 23 7 523 8

Sorted array in ascending order:
 6 7 8 23 523
Process returned 5 (0x5)   execution time : 11.386 s
Press any key to continue.
```

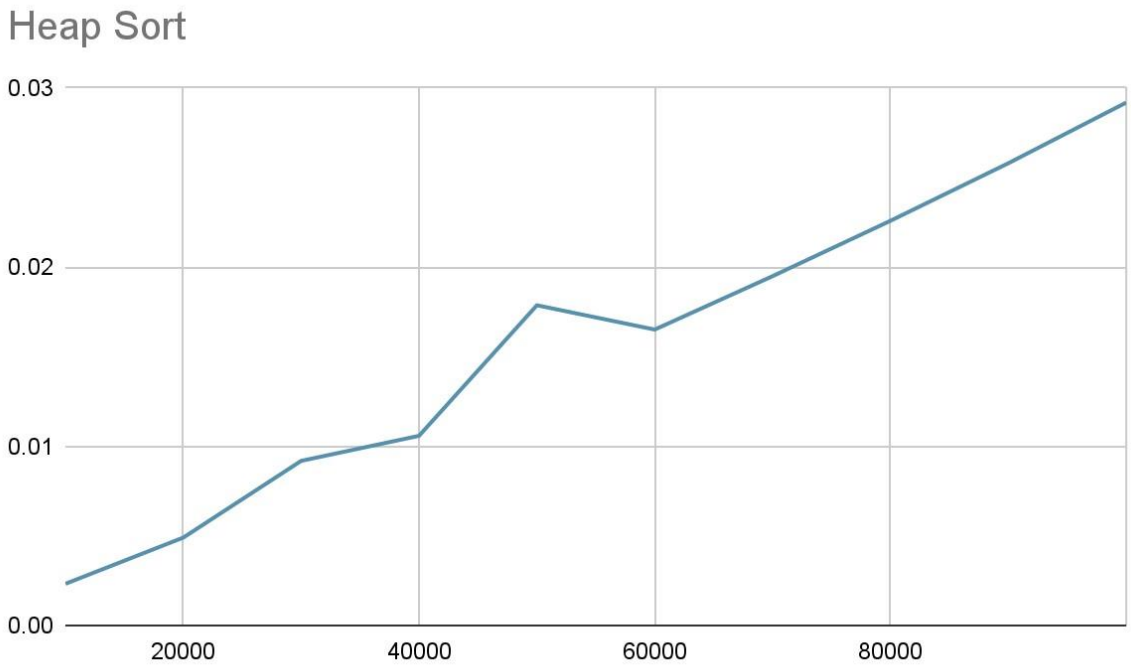
```
HEAP SORT

Enter the number of elements to be sorted: 8

Enter the elements: 5 26 18 32 43 243 54 24

Sorted array in ascending order:
 5 18 24 26 32 43 54 243
Process returned 8 (0x8)   execution time : 20.375 s
Press any key to continue.
```

Table of values:

Input size(n)	Time taken
10000	0.002324
20000	0.004903
30000	0.009185
40000	0.010584
50000	0.017871
60000	0.016515

70000	0.019496
80000	0.022587
90000	0.025799
100000	0.029185

Graph:



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

Solution:

Code:

```
#include<stdio.h>
int max(int a, int b) {
   return (a > b) ? a : b;
}
int knapsack(int W,int weights[],int values[],int n)
{
   int matrix[n+1][W+1];
   int i,j;
   for(i=0; i<n+1; i++)
   {
      for(j=0; j<W+1; j++)
      {
         if(i==0 || j==0) matrix[i][j]=0;
         else if(weights[i]>j) matrix[i][j]=matrix[i-1][j];
         else {
            matrix[i][j]= max(matrix[i-1][j], matrix[i-1][j-weights[i]]+values[i]);
         }
      }
   }
   return matrix[n][W];
}

int main() {
   int W, n;

   printf("Enter the capacity of the knapsack: ");
   scanf("%d", &W);

   printf("Enter the number of items: ");
   scanf("%d", &n);

   int weights[n];
   int values[n];
```

```
    printf("Enter the weight and value of each item:\n");
    for (int i = 0; i < n; i++) {
        scanf("%d %d", &weights[i], &values[i]);
    }

    int max_value = knapsack(W, weights, values, n);
    printf("Maximum value in the knapsack: %d\n", max_value);

    return 0;
}
```

Output:

```
Enter the capacity of the knapsack: 5
Enter the number of items: 4
Enter the weight and value of each item:
2 12
1
10
3 20
2 15
Maximum value in the knapsack: 35

Process returned 0 (0x0)   execution time : 31.309 s
Press any key to continue.
```

```
Enter the capacity of the knapsack: 7
Enter the number of items: 4
Enter the weight and value of each item:
1 8
2 6
3 12
4 20
Maximum value in the knapsack: 32

Process returned 0 (0x0)   execution time : 30.041 s
Press any key to continue.
```

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

Solution:

Code:

```
#include <stdio.h>

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

   printf("Floyd's algorithm\n");
   printf("Enter the number of vertices\n");
   scanf("%d", &n);

   printf("Enter the distance matrix for %d vertices\n", n);
   for (i = 0; i < n; i++) {
      for (j = 0; j < n; j++) {
         scanf("%d", &adj[i][j]);
         result[i][j] = adj[i][j];
      }
   }

   for (k = 0; k < n; k++) {
      for (j = 0; j < n; j++) {
         for (i = 0; i < n; i++) {
            result[i][j] = result[i][j] < (result[i][k] + result[k][j]) ? result[i][j] : (result[i][k] + result[k][j]);
         }
      }
   }

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

```
  }
}
```

Output:

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

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

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

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

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

Prim's algorithm:

Code:

```
#include <limits.h>
#include <stdbool.h>
#include <stdio.h>
#define V 5

int minKey(int key[], bool mstSet[])
{
int min = INT_MAX, min_index;

for (int v = 0; v < V; v++)
if (mstSet[v] == false && key[v] < min)
min = key[v], min_index = v;

return min_index;
}
int printMST(int parent[], int graph[V][V])
{
printf("Edge \tWeight\n");
for (int i = 1; i < V; i++)
printf("%d - %d \t%d \n", parent[i], i,
graph[i][parent[i]]);
}

void primMST(int graph[V][V])
{
int parent[V];
int key[V];
bool mstSet[V];
for (int i = 0; i < V; i++)
key[i] = INT_MAX, mstSet[i] = false;
key[0] = 0;
parent[0] = -1;
for (int count = 0; count < V - 1; count++) {
int u = minKey(key, mstSet);
mstSet[u] = true;
```

```
for (int v = 0; v < V; v++)
if (graph[u][v] && mstSet[v] == false
&& graph[u][v] < key[v])
parent[v] = u, key[v] = graph[u][v];
}
printMST(parent, graph);
}


int main()
{
   int v;
   printf("enter the no of vertices :");
   scanf("%d",&v);
   int graph[V][V];
   printf("enter the adjacency matrix\n");
   for(int i=0;i<v;i++)
      for(int j=0;j<v;j++)
         scanf("%d",&graph[i][j]);
primMST(graph);

return 0;
}
```

Output:

```
enter the no of vertices :5
enter the adjacency matrix
0 2 0 6 0
2 0 3 8 5
0 3 0 0 7
6 8 0 0 9
0 5 7 9 0
Edge    Weight
0 - 1   2
1 - 2   3
0 - 3   6
1 - 4   5

Process returned 0 (0x0)   execution time : 61.191 s
Press any key to continue.
```

```
enter the no of vertices :5
enter the adjacency matrix
0 1 0 4 0
1 0 3 0 2
0 3 0 5 0
4 0 5 0 6
0 2 0 6 0
Edge    Weight
0 - 1   1
1 - 2   3
0 - 3   4
1 - 4   2

Process returned 0 (0x0)   execution time : 12.989 s
Press any key to continue.
```

Kruskal's algorithm:

Code:

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

int find(int v, int parent[10]) {
   while (parent[v] != v) {
      v = parent[v];
   }
   return v;
}

void union1(int i, int j, int parent[10]) {
   if (i < j)
      parent[j] = i;
   else
      parent[i] = j;
}

void kruskal(int n, int a[10][10]) {
   int count, k, min, sum, i, j, t[10][10], u, v, parent[10];
   count = 0;
   k = 0;
   sum = 0;

   for (i = 0; i < n; i++)
      parent[i] = i;

   while (count != n - 1) {
      min = 999;
      for (i = 0; i < n; i++) {
         for (j = 0; j < n; j++) {
            if (a[i][j] < min && a[i][j] != 0) {
               min = a[i][j];
               u = i;
               v = j;
            }
         }
      }

      i = find(u, parent);
```

```
      j = find(v, parent);

      if (i != j) {
         union1(i, j, parent);
         t[k][0] = u;
         t[k][1] = v;
         k++;
         count++;
         sum = sum + a[u][v];
      }
      a[u][v] = a[v][u] = 999;
   }

   if (count == n - 1) {
      printf("Spanning tree\n");
      for (i = 0; i < n - 1; i++) {
         printf("%d %d\n", t[i][0], t[i][1]);
      }
      printf("Cost of spanning tree = %d\n", sum);
   } else {
      printf("Spanning tree does not exist\n");
   }
}

void main() {
   int n, i, j, a[10][10];
   clrscr();

   printf("Enter the number of nodes\n");
   scanf("%d", &n);

   printf("Enter the adjacency matrix\n");
   for (i = 0; i < n; i++)
      for (j = 0; j < n; j++)
         scanf("%d", &a[i][j]);

   kruskal(n, a);
   getch();
}
```

Output:

```
enter the number of nodes
5
enter the adjacency matrix
0 1 5 2 999
1 0 999 999 999
5 999 0 3 999
2 999 3 0 2
999 999 999 2 0
spanning tree
0 1
0 3
3 4
2 3
cost of spanning tree=8
```

```
enter the number of nodes
5
enter the adjacency matrix
0 1 5 2 999
1 0 999 999 999
5 999 0 3 999
2 999 3 0 2
999 999 999 2 0
spanning tree
0 1
0 3
3 4
2 3
```

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

Solution:

Code:

```
#include <stdio.h>

#define INFINITY 9999

#define MAX 10



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

int main() {

   int G[MAX][MAX], i, j, n, u;

   printf("Enter the number of vertices:");

   scanf("%d", &n);

   printf("\nEnter the adjacency matrix:\n");

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

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

         scanf("%d", &G[i][j]);

   printf("\nEnter the starting node:");

   scanf("%d", &u);

   dijkstra(G, n, u);

   return 0;
```

```
}
void dijkstra(int G[MAX][MAX], int n, int startnode) {
   int cost[MAX][MAX], distance[MAX], pred[MAX];
   int visited[MAX], count, mindistance, nextnode, i, j;
   for (i = 0; i < n; i++)
      for (j = 0; j < n; j++)
         cost[i][j] = (G[i][j] == 0) ? INFINITY : G[i][j];
   for (i = 0; i < n; i++) {
      distance[i] = cost[startnode][i];
      pred[i] = startnode;
      visited[i] = 0;
   }
   distance[startnode] = 0;
   visited[startnode] = 1;
   count = 1;
   while (count < n - 1) {
      mindistance = INFINITY;


      for (i = 0; i < n; i++) {
         if (distance[i] < mindistance && !visited[i]) {
            mindistance = distance[i];
```

```
            nextnode = i;
        }
    }
    visited[nextnode] = 1;
    for (i = 0; i < n; i++) {
        if (!visited[i] && mindistance + cost[nextnode][i] < distance[i]) {
            distance[i] = mindistance + cost[nextnode][i];
            pred[i] = nextnode;
        }
    }
    count++;
}
for (i = 0; i < n; i++) {
    if (i != startnode) {
        printf("\nDistance of node %d = %d", i, distance[i]);
        printf("\nPath = %d", i);
        j = i;
        do {
            j = pred[j];
            printf("<-%d", j);
        } while (j != startnode);
```

```
    }
  }
}
```

Output:

```
Enter no. of vertices:6

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

Enter the starting node:0

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

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

Solution:

Code:

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

int board[20], count = 0;
void print(int n);
int place(int row, int column);
void queen(int row, int n);
int main() {
   int n, i, j;
   printf(" - N Queens Problem Using Backtracking -");
   while (1) {
      printf("\n\nEnter number of Queens:");
      count = 0;
      scanf("%d", &n);
      if (n <= 3) {
         printf("No solution\n");
      } else {
         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:

```
Enter number of Queens:4

Solution 1:
        1       2       3       4
1       -       Q       -       -
2       -       -       -       Q
3       Q       -       -       -
4       -       -       Q       -
Solution 2:
        1       2       3       4
1       -       -       Q       -
2       Q       -       -       -
3       -       -       -       Q
4       -       Q       -       -
```

```
Enter number of Queens:6

Solution 1:
        1       2       3       4       5       6
1       -       Q       -       -       -       -
2       -       -       -       Q       -       -
3       -       -       -       -       -       Q
4       Q       -       -       -       -       -
5       -       -       Q       -       -       -
6       -       -       -       -       Q       -
Solution 2:
        1       2       3       4       5       6
1       -       -       Q       -       -       -
2       -       -       -       -       -       Q
3       -       Q       -       -       -       -
4       -       -       -       -       Q       -
5       Q       -       -       -       -       -
6       -       -       -       Q       -       -
Solution 3:
        1       2       3       4       5       6
1       -       -       -       Q       -       -
2       Q       -       -       -       -       -
3       -       -       -       -       Q       -
4       -       Q       -       -       -       -
5       -       -       -       -       -       Q
6       -       -       Q       -       -       -
Solution 4:
        1       2       3       4       5       6
1       -       -       -       -       Q       -
2       -       -       Q       -       -       -
3       Q       -       -       -       -       -
4       -       -       -       -       -       Q
5       -       -       -       Q       -       -
6       -       Q       -       -       -       -
```