

VISVESVARAYA TECHNOLOGICAL UNIVERSITY
JNANA SANGAMA, BELGAVI-590018, KARNATAKA



LABORATORY MANUAL

ANALYSIS AND DESIGN OF ALGORITHMS LAB
BCSL404

Semester: IV (CBCS SCHEME)

NAME:

USN:

SECTION/BATCH:

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C BYREGOWDA INSTITUTE OF TECHNOLOGY

Department of Computer Science and Engineering

Department of Computer Engineering

An ISO 9001: 2015 Certified Institute,

Accredited by NAAC First cycle with B++.

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C BYRE GOWDA INSTITUTE OF TECHNOLOGY

Department of Computer Science and Engineering

VISION

- Prepare competent professionals embedded with human values to meet the challenges in the field of Computer Science & Engineering.

MISSION

MD1	To empower the students with the fundamentals for a successful career in the field of Computer Science & Engineering.
MD2	To impart Quality technical education and training to the students to make them Competent Engineers and thereby contribute to research and scientific development.
MD3	To create technical manpower for meeting the current and future demands of Industry

Course objectives:

- To design and implement various algorithms in C/C++ programming using suitable development to address different computational challenges.
- To apply diverse design strategies for effective problem-solving.
- To Measure and compare the performance of different algorithms to determine their efficiency and for specific tasks.

Course outcomes:

On the completion of this laboratory course, the students will be able to:

- Develop programs to solve computational problems using suitable algorithm design strategy
- Compare algorithm design strategies by developing equivalent programs and observing running times for analysis (Empirical).
- Make use of suitable integrated development tools to develop programs.
- Choose appropriate algorithm design techniques to develop solution to the computational and complex problems.
- Demonstrate and present the development of program, its execution and running time(s) and record the results/inferences..

Conduction of Practical Examination:

- Experiment distribution
 - For laboratories having only one part: Students are allowed to pick one experiment from the lot with equal opportunity.
 - For laboratories having PART A and PART B: Students are allowed to pick one experiment from PART A and one experiment from PART B, with equal opportunity.
- Change of experiment is allowed only once and marks allotted for procedure to be made zero of the changed part only.
- Marks Distribution (Need to change in accordance with university regulations)
 - ✓ For laboratories having only one part – Procedure + Execution + Viva-Voce: $20+60+20 = 100$ Marks
 - ✓ For laboratories having PART A and PART B
 - i. Part A – Procedure + Execution + Viva = $6 + 28 + 6 = 40$ Marks
 - ii. Part B – Procedure + Execution + Viva = $9 + 42 + 9 = 60$ Marks

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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.	28-30
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.	31-33
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1. Design and implement C/C++ Program to find Minimum Cost Spanning Tree of a given connected undirected graph using Kruskal's algorithm.

Aim : To apply Kruskal's Algorithm for computing the minimum spanning tree is directly based on the generic MST algorithm. It builds the MST in forest.

Definition: Kruskal's algorithm is an algorithm in graph theory that finds a minimum spanning tree for a connected weighted graph. This means it finds a subset of the edges that forms a tree that includes every vertex, where the total weight of all the edges in the tree is minimized. If the graph is not connected, then it finds a minimum spanning forest. It is an example of a greedy algorithm.

Efficiency: With an efficient sorting algorithm, the time efficiency of Kruskal's algorithm will be in $O(|E| \log |E|)$

Algorithm

Start with an empty set A , and select at every stage the shortest edge that has not been chosen or rejected, regardless of where this edge is situated in graph.

- Initially, each vertex is in its own tree in forest.
- Then, algorithm considers each edge in turn, order by increasing weight.
- If an edge (u, v) connects two different trees, then (u, v) is added to the set of edges of the MST, and two trees connected by an edge (u, v) are merged into a single tree.
- On the other hand, if an edge (u, v) connects two vertices in the same tree, then edge (u, v) is discarded.

Kruskal's algorithm can be implemented using **disjoint set** data structure or **priority queue** data structure.

I Kruskal's algorithm implemented with disjoint-sets data structure.

MST_KRUSKAL (G, w)

- $A \leftarrow \{\}$ // A will ultimately contain the edges of the MST
- for each vertex v in $V[G]$
- do Make_Set (v)
- Sort edge of E by nondecreasing weights w
- for each edge (u, v) in E
- do if FIND_SET (u) \neq FIND_SET (v)
- then $A = A \cup \{(u, v)\}$
- UNION (u, v)
- Return A

Program:

```
#include<stdio.h>
#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 ata:\n");
    for(i=1;i<=n;i++)
        for(j=1;j<=n;j++)
            scanf("%d",&c[i][j]);
    kruskal(n);
    return 0;
}
```

Input/Output:

Enter the n value:5
Enter the graph data:
0 10 15 9 999
10 0 999 17 15
15 999 0 20 999
9 17 20 0 18
999 15 999 18 0
Cost of spanning tree is=49

Edges of spanning tree are:

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

Program 2 : Design and implement C/C++ Program to find Minimum Cost Spanning Tree of a given connected undirected graph using Prim's algorithm.

Aim:To find minimum spanning tree of a given graph using prim's algorithm

Definition: Prim's is an algorithm that finds a minimum spanning tree for a connected weighted undirected graph. This means it finds a subset of the edges that forms a tree that includes every vertex, where the total weight of all edges in the tree is minimized. Prim's algorithm is an example of a greedy algorithm.

Algorithm

MST_PRIM (G, w, v)

1. $Q \leftarrow V[G]$
2. for each u in Q do
3. $\text{key}[u] \leftarrow \infty$
4. $\text{key}[r] \leftarrow 0$
5. $\pi[r] \leftarrow \text{NIL}$
6. while queue is not empty do
7. $u \leftarrow \text{EXTRACT_MIN}(Q)$
8. for each v in $\text{Adj}[u]$ do
9. if v is in Q and $w(u, v) < \text{key}[v]$
10. then $\pi[v] \leftarrow w(u, v)$
11. $\text{key}[v] \leftarrow w(u, v)$

Analysis

The performance of Prim's algorithm depends on how we choose to implement the priority queue Q .

Program:

```
#include<stdio.h>
// #include<conio.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++)
    {
```



```
        v[s]=1;;
        ver[i]=s;
        d[i]=c[s][i];
        v[i]=0;

    }
    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);

}
```

Input/output:

Enter n value:3

Enter the graph data:

0 10 1

10 0 6

1 6 0

Enter the source node:1

1 -> 3 sum=1

3 -> 2 sum=7

Cost=7



Program 3:

- a. Design and implement C/C++ Program to solve All-Pairs Shortest Paths problem using Floyd's algorithm.**
- b. Design and implement C/C++ Program to find the transitive closure using Warshal's algorithm.**

Definition: The **Floyd algorithm** is a graph analysis algorithm for finding shortest paths in a weighted graph (with positive or negative edge weights). A single execution of the algorithm will find the lengths (summed weights) of the shortest paths between *all* pairs of vertices though it does not return details of the paths themselves. The algorithm is an example of dynamic programming

Algorithm:

Floyd's Algorithm

Accept no .of vertices

Call graph function to read weighted graph // w(i,j)

Set D[] <- weighted graph matrix // get D {d(i,j)}

for k=0 // If there is a cycle in graph, abort. How to find? Repeat for k = 1 to n

Repeat for i = 1 to n Repeat for j = 1 to n

$D[i,j] = \min \{D[i,j], D[i,k] + D[k,j]\}$

Print D

Program A:

```
#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]);
```

```
}
```

```
void 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")
}
```

Input/Output:

Enter the n value:4

Enter the graph data:

0 999 3 999

2 0 999 999

999 7 0 1

6 999 999 0

Shortest path

0 10 3 4

2 0 5 6

7 7 0 1

6 16 9 0



Definition: The Warshall algorithm is a graph analysis algorithm for finding shortest paths in a weighted graph. A single execution of the algorithm will find the lengths of the shortest path between all pairs of vertices though it does not return details of the paths themselves. The algorithm is an example of Dynamic programming.

Algorithm

```
//Input: Adjacency matrix of digraph
//Output: R, transitive closure of digraph
Accept no. of vertices
Call graph function to read directed graph
Set R[ ] <- digraph matrix // get R {r(i,j)}
for k=0 Print digraph
Repeat for k = 1 to n
    Repeat for i = 1 to n
        Repeat for j = 1 to n
            R(i,j) = 1
            if {rij(k-1) = 1 OR rik(k-1) = 1 and r (k-1) = 1}
Print R
```

Program:

```
#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;
}
```

Input/Output:

Enter the n value:4

Enter the graph data:

0 1 0 0

0 0 0 1

0 0 0 0

1 0 1 0

Resultant path matrix

1 1 1 1

1 1 1 1

0 0 0 0

1 1 1 1



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.**Aim: To find shortest path using Dijkstra's algorithm.****Definition:** Dijkstra's algorithm -For a given source vertex(node) in the graph, the algorithm finds the path with lowest cost between that vertex and every other vertex. It can also be used for finding cost of shortest paths from a single vertex to a single destination vertex by stopping the algorithm once the shortest path to the destination vertex has been determined.

Efficiency: 1) $\theta(|V|^2)$ -graph represented by weighted matrix and priority queue as unordered array
2) $O(|E| \log |V|)$ -graph represented by adjacency lists and priority queue as min-heap

Algorithm: Dijkstra(G,s)

```
//Dijkstra's algorithm for single source shortest path
//input:A weighted connected graph with non negative weights and its vertex s
//output:The length  $d_v$  of a shortest path from s to v and penultimate vertex  $p_v$ 
for every vertex v in V
Initialize(Q)
for every vertex v in V do
 $d_v \leftarrow -\infty$ ;  $P_v \leftarrow \text{null}$  Insert(Q,v, $d_v$ )
 $D_s \leftarrow 0$ ; Decrease(Q,s, $d_s$ );  $V_T \leftarrow \emptyset$ 
for i<- 0 to  $|V| - 1$  do
 $u^* \leftarrow \text{DeleteMin}(Q)$ 
 $V_T \leftarrow V_T \cup \{u^*\}$ 
For every vertex u in  $V - V_T$  that is adjacent to  $u^*$  do
If  $d_{u^*} + w(u^*,u) < d_u$ 
 $d_u \leftarrow d_{u^*} + w(u^*,u)$ ;
 $p_u \leftarrow u^*$  Decrease(Q,u, $d_u$ )
```

Program:

```
#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;
}
```

Input/Output

Enter n value:6

Enter the graph data:

0 15 10 999 45 999

999 0 15 999 20 999

20 999 0 20 999 999

999 10 999 0 35 999

999 999 999 30 0 999

999 999 999 4 999 0

Enter the souce node:2

Shortest distance from 2 to 1 is 35

Shortest distance from 2 to 2 is 0

Shortest distance from 2 to 3 is 15

Shortest distance from 2 to 4 is 35
 Shortest distance from 2 to 5 is 20
 Shortest distance from 2 to 6 is 999

Output:

enter the no. of nodes:

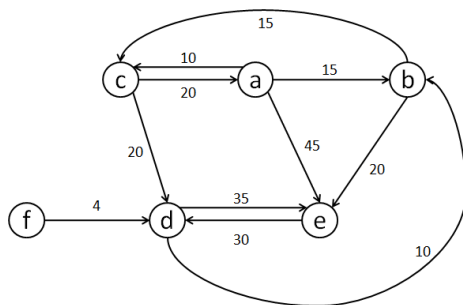
6

enter the cost adjacency matrix, '9999' for no direct path

0	15	10	9999	45	9999
9999	10	9999	0	35	9999
9999	9999	9999	30	0	9999
9999	9999	9999	4	9999	0
9999	0	15	9999	20	9999
20	9999	0	20	9999	9999

enter the starting vertex:

6



Shortest path from starting vertex to other vertices are

6->1=49

6->2=14

6->3=29

6->4=4

6->5=34

6->6=0

Program 5 : Design and implement C/C++ Program to obtain the Topological ordering of vertices in a given digraph.

Aim: To find topological ordering of given graph

Definition: Topological ordering that for every edge in the graph, the vertex where the edge starts is listed before the edge where the edge ends.

Algorithm:

1. repeatedly identify in a remaining digraph a source which is a vertex with no incoming edges and delete it along with all edges outgoing from it.
2. The order in which the vertices are deleted yields a solution to the topological sorting.

```
#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;
        }
    }
}
void 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]);
}
}
```

Input/output:

Enter the n value:6

Enter the graph data:

001100

000110

000101

000001

000001

000000

Topological ordering is:1 2 3 4 5 6



Program 6 :Design and implement C/C++ Program to solve 0/1 Knapsack problem using Dynamic Programming method.

Aim: To implement 0/1 Knapsack problem using Dynamic programming

Definition: using **Dynamic programming**

It gives us a way to design custom algorithms which systematically search all possibilities (thus guaranteeing correctness) while storing results to avoid recomputing (thus providing efficiency).

We are given a set of n items from which we are to select some number of items to be carried in a knapsack(BAG). Each item has both a *weight* and a *profit*. The objective is to choose the set of items that fits in the knapsack and maximizes the profit.

Given a knapsack with maximum capacity W , and a set S consisting of n items, Each item i has some weight w_i and benefit value b_i (all w_i , b_i and W are integer values)

Problem: How to pack the knapsack to achieve maximum total value of packed items?

ALGORITHM

//(n items, W weight of sack) Input: n , w_i , v_i and W – all integers

//Output: $V(n,W)$

// Initialization of first column and first row elements Repeat

for $i = 0$ to n

set $V(i,0) = 0$

Repeat for $j = 0$ to W

Set $V(0,j) = 0$ //complete remaining entries row by row

Repeat for $i = 1$ to n

repeat for $j = 1$ to W

if ($w_i \leq j$)

$V(i,j) = \max \{ V(i-1,j), V(i-1,j-w_i) + v_i \}$

if ($w_i > j$) $V(i,j) = V(i-1,j)$

Print $V(n,W)$

PROGRAM:

```
#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;
}
```

Input/Output:

Enter the no. of objects:4

Enter the knapsack capacity:6

Enter profit followed by weight:

78 2

45 3

92 4

71 5

Max profit=170

Program 7 :Design and implement C/C++ Program to solve discrete Knapsack and continuous Knapsack problems using greedy approximation method.

This program first calculates the profit-to-weight ratio for each item, then sorts the items based on this ratio in non-increasing order. It then fills the knapsack greedily by selecting items with the highest ratio until the knapsack is full. If there's space left in the knapsack after selecting whole items, it adds fractional parts of the next item. Finally, it prints the optimal solution and the solution vector.

Here's a simplified version of the C program to solve discrete Knapsack and continuous Knapsack problems using the greedy approximation method:

```
#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;
}
```

Input/Output:

Enter the number of objects: 4

Enter the objects' weights: 5

6

7

9

Enter the objects' profits: 10

20

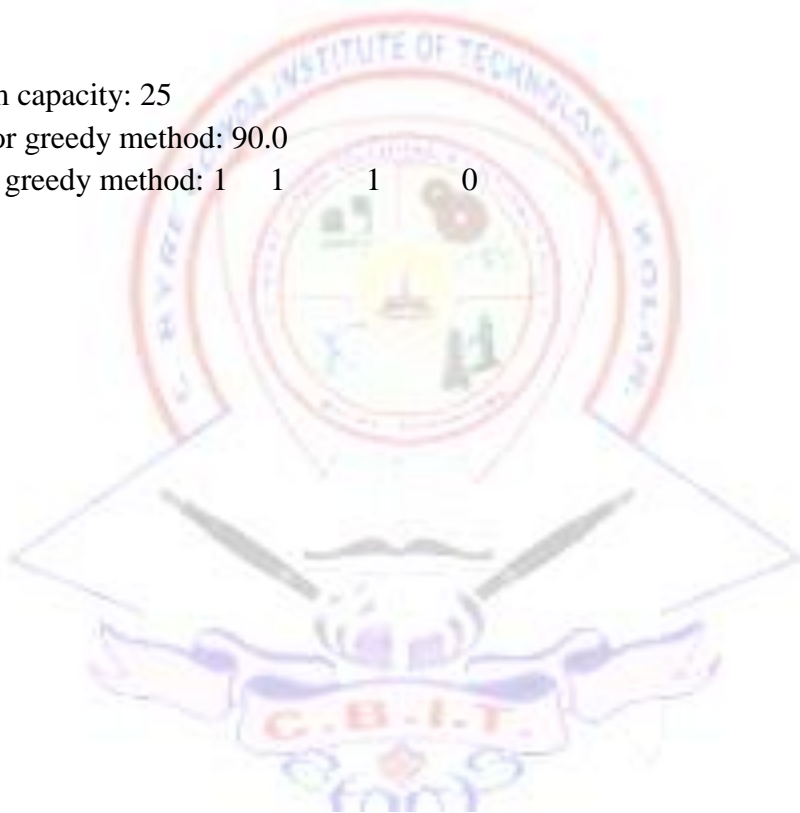
30

40

Enter the maximum capacity: 25

Optimal solution for greedy method: 90.0

Solution vector for greedy method: 1 1 1 0



Program 8 :Design and implement C/C++ Program to 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 .

AIM: An instance of the Subset Sum problem is a pair (S, t) , where $S = \{x_1, x_2, \dots, x_n\}$ is a set of positive integers and t (the target) is a positive integer. The decision problem asks for a subset of S whose sum is as large as possible, but not larger than t .

Algorithm: SumOfSub (s, k, r)

//Values of $x[j]$, $1 \leq j \leq k$, have been determined

//Node creation at level k taking place: also call for creation at level $K+1$ if possible

// s = sum of 1 to $k-1$ elements and r is sum of k to n elements

//generating left child that means including k in solution

Set $x[k] = 1$

If $(s + s[k] = d)$ then subset found, print solution

If $(s + s[k] + s[k+1] \leq d)$

 then SumOfSub ($s + s[k]$, $k+1$, $r - s[k]$)

//Generate right child i.e. element k absent

If $(s + r - s[k] \geq d)$ AND $(s + s[k+1]) \leq d$

THEN

$x[k]=0$;

SumOfSub(s , $k+1$, $r - s[k]$)

PROGRAM:

```
#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;
}
```

Input/output:

Enter the n value:9

Enter the set in increasing order:1 2 3 4 5 6 7 8 9

Enter the max subset value:9

1 2 6

1 3 5

1 8

2 3 4

2 7

3 6

4 5

9

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> 5000and 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.

Aim: Sort a given set of elements using Selection sort and determine the time required to sort elements. Repeat the experiment for different values of n, the number of elements in the list to be sorted and plot a graph of the time taken versus n.

Definition: selection sort is a sorting routine that scans a list of items repeatedly and, on each pass, selects the item with the lowest value and places it in its final position. It is based on brute force approach. Sequential search is a $\Theta(n^2)$ algorithm on all inputs.

Algorithm:

```
SelectionSort(A[0...n-1])
//sort a given array by select5ion sort
//input:A[0...n-1]of orderable elements Output:Array a[0...n-1] Sorted in ascending order
for i<- 0 to n-2 do
  min<-i
  for j<-i+1 to n-1 do
    if A[j]<A[min] min<-j
  swap A[i] and A[min]
```

PROGRAM:

```
#include<stdio.h>
#include<time.h>
#include<stdlib.h>
void selsort(int a[],int n)
{
  int i,j,small,pos,temp; for(i=0;i<n-1;i++)
  {
    small=a[i];
    pos=i;
    for(j=i+1;j<n;j++)
    {
      if(a[j]<small)
      {
        small=a[j];
        pos=j;
      }
    }
    temp=a[i]; a[i]=small; a[pos]=temp;
  }
}
```

```
void main()
{
    int a[50000],i,n;
    clock_t start,end;
    float dura;

    printf("\nEnter the n value:");
    scanf("%d",&n);
    printf("\nEnter the array:");
    for(i=0;i<n;i++)
    {
        a[i]=rand( )% 10000;
        printf("%d\t",a[i]);
    }
    start=clock();
    selsort(a,n);
    end=clock();
    dura=(end-start)
    dura=dura/CLOCKS_PER_SEC;
    printf("\nTime taken is:%f seconds",dura);
    printf("\nSorted array is:");
    for(i=0;i<n;i++)
    printf("%d\t ",a[i]);
}
```

Input /output:

1.Enter the n value:5

Enter the array:9383 886 2777 6915 7793

Time taken is:0.000002 seconds

Sorted array is:886 2777 6915 7793 9383

2. Enter the n value:6000

Enter the array:9383 886 2777 6915 7793 8335 5386 492 6649.....

Time taken is:0.041081 seconds

Sorted array is:0 1 1 3 5 8 10

3. Enter the n value:7000

Enter the array:9383 886 2777 6915 7793 8335 5386 492 6649.....

Time taken is:0.051081 seconds

Sorted array is: 0 1 1 3 5 8 10

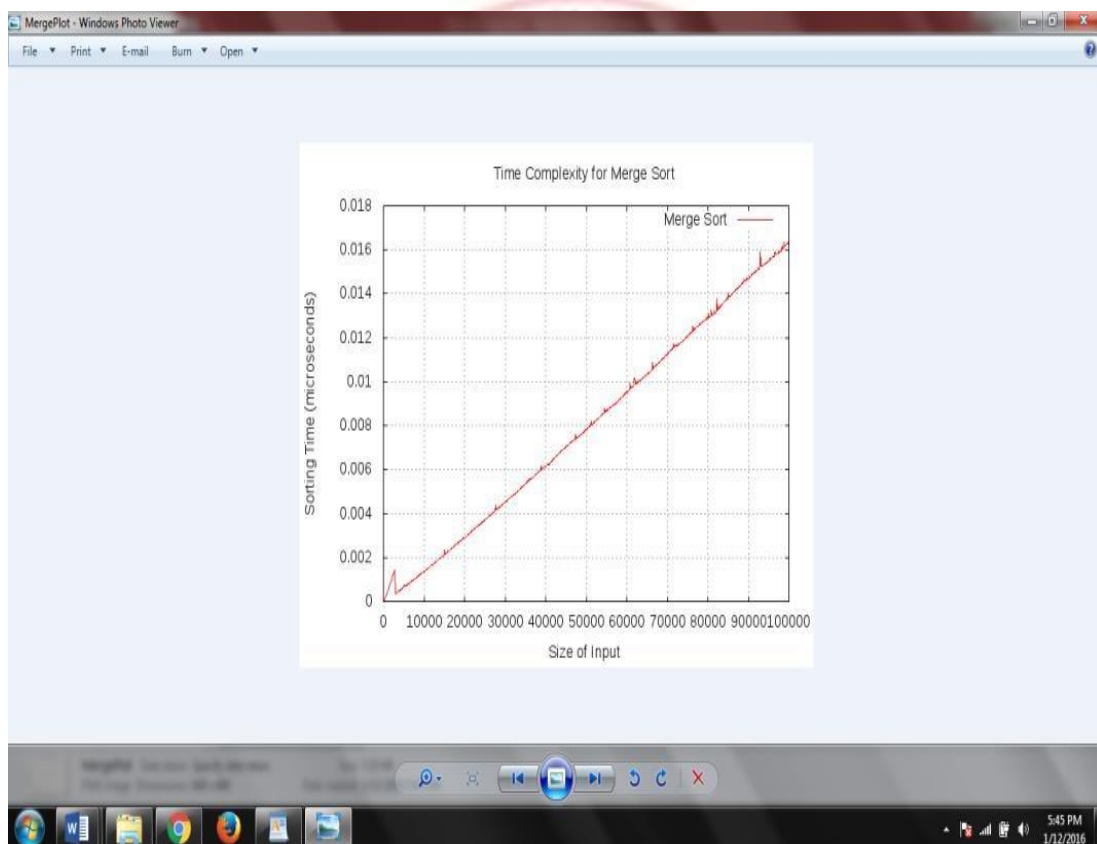
4. Enter the n value: 6000

Enter the array: 9383 886 2777 6915 7793 8335 5386 492 6649.....

Time taken is: 0.061081 seconds

Sorted array is: 0 1 1 3 5 8 10

Plot a graph **Time** versus **no. of elements**



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.

Aim:

The aim of this program is to sort 'n' randomly generated elements using Quick sort and Plotting the graph of the time taken to sort n elements versus n.

Definition: Quick sort is based on the Divide and conquer approach. Quick sort divides array according to their value. Partition is the situation where all the elements before some position s are smaller than or equal to A[s] and all the elements after position s are greater than or equal to A[s].

Efficiency: $C_{best}(n) \in \Theta(n \log_2 n)$, $C_{worst}(n) \in \Theta(n^2)$, $C_{avg}(n) \in 1.38n \log_2 n$

ALGORITHM: Quick sort (A[l...r])

// Sorts a sub array by quick sort

// Input : A sub array A[l..r] of A[0..n-1], defined by its left and right indices l and r

// Output : The sub array A[l..r] sorted in non decreasing order

if $l < r$

 s = Partition (A[l..r]) //s is a split position

 Quick sort (A[l ...s-1])

 Quick sort (A[s+1...r])

ALGORITHM Partition (A[l...r])

//Partition a sub array by using its first element as a pivot

// Input : A sub array A[l...r] of A[0...n-1] defined by its left and right indices l and r ($l < r$)

// Output : A partition of A[l...r], with the split position returned as this function's value

p=A[l]

i=l;

j=r+1;

repeat

 delay(500);

 repeat i= i+1 until A[i] >= p repeat j=j-1 until A[j] <= p

 Swap (A[i],A[j])

 until i >= j

 Swap (A[i],A[j]) // Undo last Swap when i >= j

 Swap (A[l],A[j])

Return j

PROGRAM:

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

int partition( int a[], int low, int high)
{
    int i, j, temp, key ;
    key = a[low];
    i= low+1;
    j= high;
    while(1)
    {
        while ( i< high && key >=a[i] )
            i++;
        while ( key < a[j] )
            j--;
        if (i<j)
        {
            temp = a[i];
            a[i]= a[j];
            a[j]=temp;
        }
        else
        {
            temp = a[low];
            a[low]= a[j];
            a[j]=temp;
            return j;
        }
    }
}

void quick( int a[], int low, int high)
{
    int j;
    if( low< high)
    {
        j=partition (a,low,high);
        quick (a,low,j-1);
        quick (a,j+1, high);
    }
}
```

```
void main( )
{
    int n, i, a[50000] ;
    clock_t start, end;
    printf( " Enter the array size \n");
    scanf("%d", &n);
    printf( "system inputs %d elements \n",n);
    for (i=0; i<n; i++)
    {
        a[i]=rand( )% 1000;
        printf ( "%d\t", a[i] );
    }
    start = clock ( );
    quick( a, 0, n-1 );
    end =clock ( );
    dura=end-start;
    dura=dura/CLOCKS_PER_SEC;
    printf( " The sorted array is \n");
    for (i=0; i< n; i++)
        printf ( " %d\t", a[i] );
    printf (" Time taken to sort is  %f seconds \n",dura);
}
```

Input and Output:

1.Enter the n value:5
Enter the array:9383 886 2777 6915 7793
Time taken is:0.000002 seconds
Sorted array is:886 2777 6915 7793 9383

Note:Plot a graph **Time** versus **no. of elements** for atleast 5 readings (Refer 9th Lab Program)

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.

Aim:

The aim of this program is to sort 'n' randomly generated elements using Merge sort and Plotting the graph of the time taken to sort n elements versus n.

Definition: Merge sort is a sort algorithm based on divide and conquer technique. It divides the array element based on the position in the array. The concept is that we first break the list into two smaller lists of roughly the same size, and then use merge sort recursively on the subproblems, until they cannot subdivide anymore. Then, we can merge by stepping through the lists in linear time. Its time efficiency is $\Theta(n \log n)$.

Algorithm: Merge sort ($A[0 \dots n-1]$)

```
// Sorts array A[0..n-1] by Recursive merge sort
// Input : An array A[0..n-1] elements
// Output : Array A[0..n-1] sorted in non decreasing order
If  $n > 1$ 
    Copy  $A[0 \dots (n/2)-1]$  to  $B[0 \dots (n/2)-1]$ 
    Copy  $A[(n/2) \dots n-1]$  to  $C[0 \dots (n/2)-1]$ 
    Mergesort ( $B[0 \dots (n/2)-1]$ )
    Mergesort ( $C[0 \dots (n/2)-1]$ )
    Merge( $B, C, A$ )
```

ALGORITHM :Merge ($B[0 \dots p-1], C[0 \dots q-1], A[0 \dots p+q-1]$)

```
// merges two sorted arrays into one sorted array
// Input : Arrays  $B[0 \dots p-1]$  and  $C[0 \dots q-1]$  both sorted
// Output : Sorted array  $A[0 \dots p+q-1]$  of the elements of B and C
i = 0;
j = 0;
k = 0;
While  $i < p$  and  $j < q$  do
    If  $B[i] \leq C[j]$ 
         $A[k] = B[i]; i = i + 1;$ 
    else
         $A[k] = C[j]; j = j + 1; k = k + 1;$ 
If  $i = p$ 
    Copy  $C[j \dots q-1]$  to  $A[k \dots p+q-1]$ 
If  $j = q$ 
    Copy  $B[i \dots p-1]$  to  $A[k \dots p+q-1]$ 
```

PROGRAM:

```
#include<stdio.h>
#include<stdlib.h>
#include<time.h>
void fnMerge(int a[], int low,int mid,int high)
{
    int i,k,j,b[500000];
    i=k=low;
    j=mid+1;
    while(i<=mid && j<=high)
    {
        if(a[i]<a[j])
            b[k++]=a[i++];
        else
            b[k++]=a[j++];
    }
    while(i<=mid)
        b[k++]=a[i++];
    while(j<=high)
        b[k++]=a[j++];
    for(i=low;i<k;i++)
        a[i]=b[i];
}

void fnMergeSort(int a[],int low,int high)
{
    int mid; if(low<high)
    {
        mid=(low+high)/2;
        fnMergeSort(a,low,mid);
        fnMergeSort(a,mid+1,high);
        fnMerge(a,low,mid,high);
    }
}

void main( )
{
    int i,n,a[500000];
    clock_t start,end;
    float dura;
    printf("enter the size of the array");
    scanf("%d",&n);
    printf("enter the array elements");
```

```
for(i=0;i<n;i++)
{
a[i]=rand()%10000;
printf("%d\t",a[i]);
}
start=clock();
fnMergeSort(a,0,n-1);
end=clock();
dura=(end-start)
dura=dura/CLOCKS_PER_SEC;
printf("\nTime taken is:%f seconds",dura);
printf("the sorted elements are");
for(i=0;i<n;i++)
printf("%d\t",a[i]);
}
```

Input and Output:

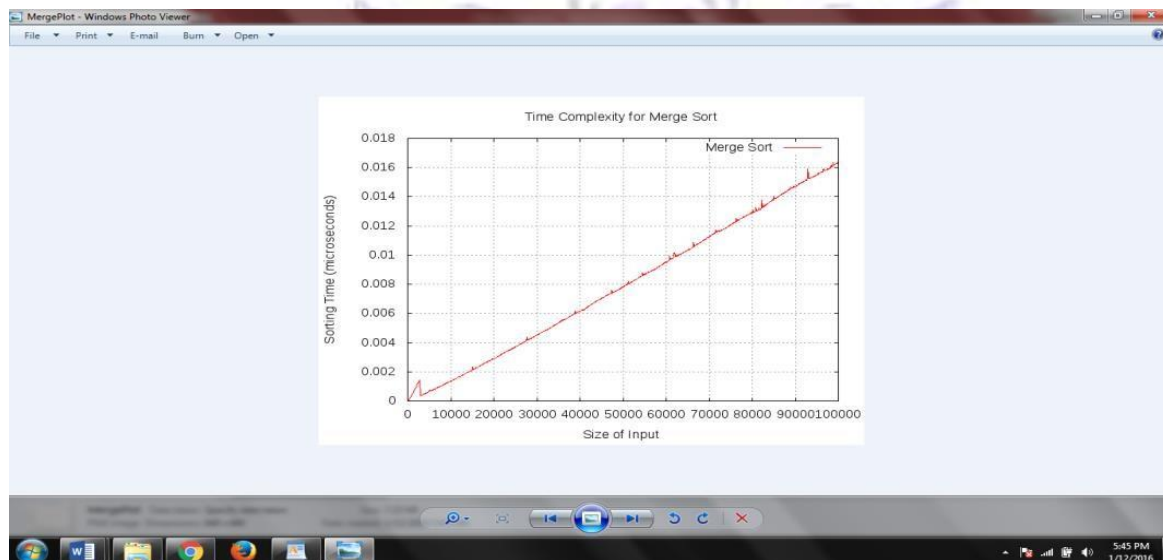
1.Enter the n value:5

Enter the array:9383 886 2777 6915 7793

Time taken is:0.000002 seconds

Sorted array is:886 2777 6915 7793 9383

Note:Plot a graph **Time** versus **no. of elements** for atleast 5 readings (Refer 9th Lab Program)



Program 12: Design and implement C/C++ Program for N Queen's problem using Backtracking.
Aim: To implement N Queens Problem using Back Tracking**Definition:**

The object is to place queens on a chess board in such a way as no queen can capture another one in a single move

Recall that a queen can move horz, vert, or diagonally an infinite distance This implies that no two queens can be on the same row, col, or diagonal We usually want to know how many different placements there are **Using Backtracking Techniques**

Algorithm:

```
/* outputs all possible acceptable positions of n queens on n x n chessboard */
// Initialize x [ ] to zero
// Set k = 1 start with first queen
Repeat for i = 1 to n // try all columns one by one for kth queen
  if Place (k, i) true then
    {
      x(k) = i // place kth queen in column i
      if (k==n)
        all queens placed and hence print output (x[ ])
      else
        NQueens(K+1,n) //try for next queen
    }
  Place (k,i)
/* finds if kth queen in kth row can be placed in column i or not; returns true if queen can be placed */
// x[1,2, . . . k-1] have been defined
//queens at (p, q) & (r, s) attack
if |p-r| = |q-s|
  Repeat for j = 1 to (k-1)
    if any earlier jth queen is in ith column ( x[j]= i) or in same diagonal ( abs(x[ j] - i) = abs( j - k) )
      then kth queen cannot be placed (return false)
  return true (as all positions checked and no objection)
```

Program:

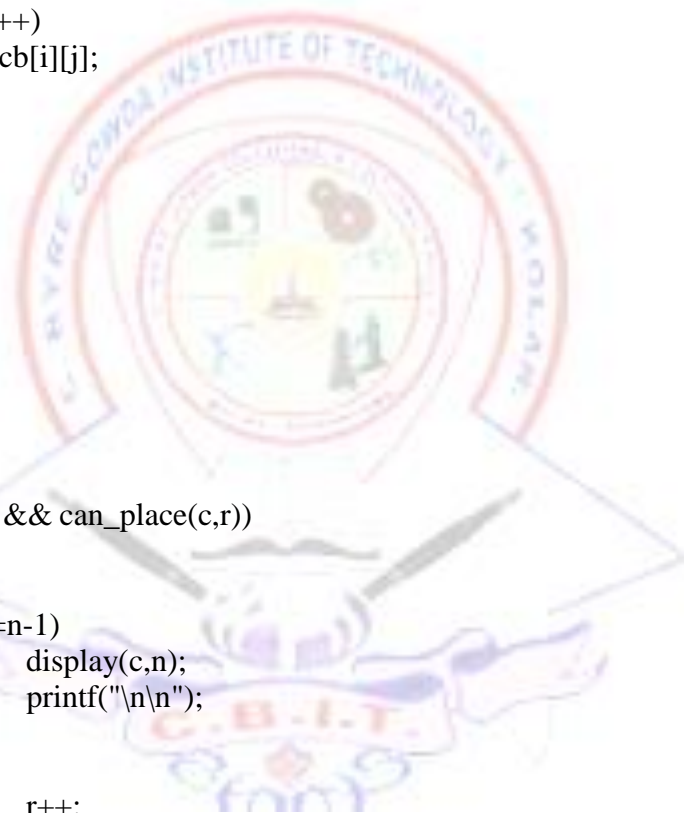
```
#include<stdio.h>
#include<stdlib.h>
#define MAX 50

int can_place(int c[],int r)
{
  int i;
  for(i=0;i<r;i++)
    if(c[i]==c[r] || (abs(c[i]-c[r])==abs(i-r)))
      return 0;
  return 1;
}
```

```
}

void display(int c[],int n)
{
    int i,j;
    char cb[10][10];
    for(i=0;i<n;i++)
    for(j=0;j<n;j++)
    cb[i][j]='-';
    for(i=0;i<n;i++)
    cb[i][c[i]]='Q';
    for(i=0;i<n;i++)
    {
        for(j=0;j<n;j++)
        printf("%c",cb[i][j]);
        printf("\n");
    }
}

void n_queens(int n)
{
    int r;
    int c[MAX];
    c[0]=-1;
    r=0;
    while(r>=0)
    {
        c[r]++;
        while(c[r]<n && can_place(c,r))
        c[r]++;
        if(c[r]<n)
        {
            if(r==n-1)
            {
                display(c,n);
                printf("\n\n");
            }
            else
            {
                r++;
                c[r]=-1;
            }
        }
        else
        r--;
    }
}
```



```
void main()
{
    int n;
    clrscr();
    printf("\nEnter the no. of queens:");
    scanf("%d",&n);
    n_queens(n);
}
```

Input/Output:

Enter the no. of queens:4

1.

```
—  Q  —  —
—  —  —  Q
Q  —  —  —
—  —  Q  —
```

2.

```
—  —  Q  —
Q  —  —  —
—  —  —  Q
—  Q  —  —
```



II) Sample Viva Questions and Answers

1) Explain what is an algorithm in computing?

An algorithm is a well-defined computational procedure that take some value as input and generatesome value as output. In simple words, it's a sequence of computational steps that converts input into the output.

2) Explain what is time complexity of Algorithm?

Time complexity of an algorithm indicates the total time needed by the program to run to completion. It is usually expressed by using the **big O notation**.

3) The main measure for efficiency algorithm are-Time and space

4. The time complexity of following code: `int a = 0;`

```
for (i = 0; i < N; i++)
```

```
{
```

```
for (j = N; j > i; j--)
```

```
{
```

```
    a = a + i + j;
```

```
}
```

```
} Ans  $O(n*n)$ 
```

5) What does the algorithmic analysis count?

The number of arithmetic and the operations that are required to run the program

6) Examples of $O(1)$ algorithms are _____

A Multiplying two numbers.
B assigning some value to a variable C displaying some integer on console

7) Examples of $O(n^2)$ algorithms are _____

A Adding of two Matrices
B Initializing all elements of matrix by zero

8) The complexity of three algorithms is given as: $O(n)$, $O(n^2)$ and $O(n^3)$. Which should execute slowest for large value of n ?

All will execute in same time.

9) In quick sort, the number of partitions into which the file of size n is divided by a selected record is 2.

The three factors contributing to the sort efficiency considerations are the efficiency in coding, machine run time and the space requirement for running the procedure.

10) How many passes are required to sort a file of size n by bubble sort method?

A. $N-1$

11) How many number of comparisons are required in insertion sort to sort a file if the file is sorted in reverse order?

A. N^2

12) How many number of comparisons are required in insertion sort to sort a file if the file is already sorted?

N-1

13) In quick sort, the number of partitions into which the file of size n is divided by a selected record is

2

14) The worst-case time complexity of Quick Sort is _____. 16) The worst-case time complexity of Bubble Sort is _____.

17) The worst-case time complexity of Merge Sort is _____.

18) The algorithm like Quick sort does not require extra memory for carrying out the sorting procedure. This technique is called _____.

19) Which of the following sorting procedures is the slowest?

- A. Quick sort
- B. Heap sort
- C. Shell sort
- D. Bubble sort

20) The time factor when determining the efficiency of algorithm is measured by Counting the number of key operations

21) The concept of order Big O is important because

A. It can be used to decide the best algorithm that solves a given problem

22) The running time of insertion sort is _____.

23) A sort which compares adjacent elements in a list and switches where necessary is _____.

A. insertion sort

24) The correct order of the efficiency of the following sorting algorithms according to their overall running time comparison is

bubble > selection > insertion

25) The total number of comparisons made in quick sort for sorting a file of size n, is

A. $O(n \log n)$

26) Quick sort efficiency can be improved by adopting

A. non-recursive method

27) For the improvement of efficiency of quick sort the pivot can be_____.

“the mean element”

28) What is the time complexity of linear search?

$\Theta(n)$

29) What is the time complexity of binary search?

$\Theta(\log_2 n)$

30) What is the major requirement for binary search?

The given list should be sorted.

31) What are important problem types? (or) Enumerate some important types of problems.

1. Sorting 2. Searching
3. Numerical problems 4. Geometric problems
5. Combinatorial Problems 6. Graph Problems
7. String processing Problems

32). Name some basic Efficiency classes

1. Constant 2. Logarithmic 3. Linear 4. $n \log n$
5. Quadratic 6. Cubic 7. Exponential 8. Factorial

33) What are algorithm design techniques?

Algorithm design techniques (or strategies or paradigms) are general approaches to solving problems algorithmically, applicable to a variety of problems from different areas of computing. General design techniques are: (i) Brute force

(ii) divide and conquer

(iii) decrease and conquer (iv) transform and conquer

(v) greedy technique (vi) dynamic programming

(vii) backtracking (viii) branch and bound

34). How is an algorithm's time efficiency measured?

Time efficiency indicates how fast the algorithm runs. An algorithm's time efficiency is

Measured as a function of its input size by counting the number of times its basic operation (running time) is executed.

Basic operation is the most time consuming operation in the algorithm's inner most loop.

35) Explain the greedy method.

Greedy method is the most important design technique, which makes a choice that looks best at that moment. A given 'n' inputs are required us to obtain a subset that satisfies some constraints that is the feasible solution. A greedy method suggests that one can device an algorithm that works in stages considering one input at a time.

36) Define feasible and optimal solution.

Given n inputs and we are required to form a subset such that it satisfies some given constraints then such a subset is called feasible solution. A feasible solution either maximizes or minimizes the given objective function is called as optimal solution.

37). What are the constraints of knapsack problem?

To maximize $\sum p_i x_i$ The constraint is: $\sum w_i x_i \leq m$ and $0 \leq x_i \leq 1 \ 1 \leq i \leq n$

where m is the bag capacity, n is the number of objects and for each object i w_i and p_i are the weight and profit of object respectively.

38). Specify the algorithms used for constructing Minimum cost spanning tree.

- a) Prim's Algorithm
- b) Kruskal's Algorithm

39). State single source shortest path algorithm (Dijkstra's algorithm).

For a given vertex called the source in a weighted connected graph, find shortest paths to all its other vertices. Dijkstra's algorithm applies to graph with non-negative weights only.

40). State efficiency of prim's algorithm.

$O(V^2)$ (WEIGHT MATRIX AND PRIORITY QUEUE AS UNORDERED ARRAY) $O(E \log V)$ (ADJACENCY LIST AND PRIORITY QUEUE AS MIN-HEAP)

41) State Kruskal Algorithm.

The algorithm looks at a MST for a weighted connected graph as an acyclic sub graph with $|V|-1$ edges for which the sum of edge weights is the smallest.

42) State efficiency of Dijkstra's algorithm.

$O(V^2)$ (WEIGHT MATRIX AND PRIORITY QUEUE AS UNORDERED ARRAY)