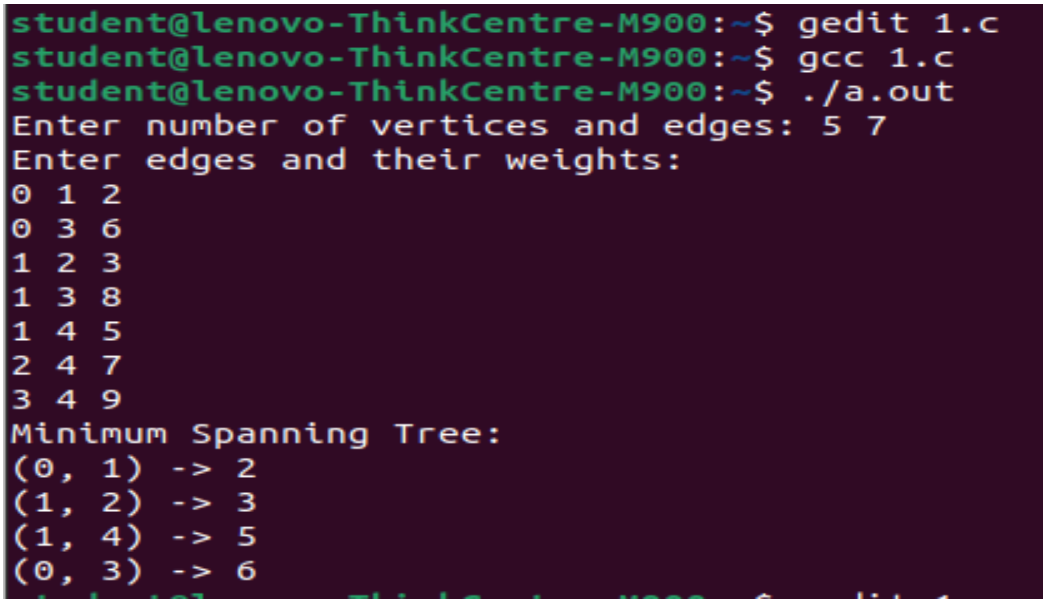
1.Design and implement C Program to find Minimum Cost Spanning Tree of a given connected undirected graph using Kruskal's algorithm

PROGRAM:

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

#define MAX_EDGES 1000

typedef struct Edge {
    int src, dest, weight;
} Edge;

typedef struct Graph {
    int V, E;
    Edge edges[MAX_EDGES];
} Graph;

typedef struct Subset {
    int parent, rank;
} Subset;

Graph* createGraph(int V, int E) {
    Graph* graph = (Graph*) malloc(sizeof(Graph));
    graph->V = V;
    graph->E = E;
    return graph;
}

int find(Subset subsets[], int i) {
    if (subsets[i].parent != i) {
        subsets[i].parent = find(subsets, subsets[i].parent);
    }
    return subsets[i].parent;
}

void Union(Subset subsets[], int x, int y) {
    int xroot = find(subsets, x);
    int yroot = find(subsets, y);

    if (subsets[xroot].rank < subsets[yroot].rank) {
        subsets[xroot].parent = yroot;
    } else if (subsets[xroot].rank > subsets[yroot].rank) {
        subsets[yroot].parent = xroot;
    } else {
        subsets[yroot].parent = xroot;
        subsets[xroot].rank++;
    }
}

int compare(const void* a, const void* b) {
```

```
    Edge* a_edge = (Edge*) a;
    Edge* b_edge = (Edge*) b;
    return a_edge->weight - b_edge->weight;
}

void kruskalMST(Graph* graph) {
    Edge mst[graph->V];
    int e = 0, i = 0;

    qsort(graph->edges, graph->E, sizeof(Edge), compare);

    Subset* subsets = (Subset*) malloc(graph->V * sizeof(Subset));
    for (int v = 0; v < graph->V; ++v) {
        subsets[v].parent = v;
        subsets[v].rank = 0;
    }

    while (e < graph->V - 1 && i < graph->E) {
        Edge next_edge = graph->edges[i++];

        int x = find(subsets, next_edge.src);
        int y = find(subsets, next_edge.dest);

        if (x != y) {
            mst[e++] = next_edge;
            Union(subsets, x, y);
        }
    }

    printf("Minimum Spanning Tree:\n");
    for (i = 0; i < e; ++i) {
        printf("(%d, %d) -> %d\n", mst[i].src, mst[i].dest, mst[i].weight);
    }
}

int main() {
    int V, E;
    printf("Enter number of vertices and edges: ");
    scanf("%d %d", &V, &E);

    Graph* graph = createGraph(V, E);

    printf("Enter edges and their weights:\n");
    for (int i = 0; i < E; ++i) {
        scanf("%d %d %d", &graph->edges[i].src, &graph->edges[i].dest, &graph-
>edges[i].weight);
    }

    kruskalMST(graph);

    return 0;
}
```

OUTPUT:


student@lenovo-ThinkCentre-M900:~$ gedit 1.c
student@lenovo-ThinkCentre-M900:~$ gcc 1.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter number of vertices and edges: 5 7
Enter edges and their weights:
0 1 2
0 3 6
1 2 3
1 3 8
1 4 5
2 4 7
3 4 9
Minimum Spanning Tree:
(0, 1) -> 2
(1, 2) -> 3
(1, 4) -> 5
(0, 3) -> 6

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

PROGRAM:

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

#define V_MAX 100 // Maximum number of vertices

// Function to find the vertex with the minimum key value, from the set of vertices not yet included in the MST
int minKey(int key[], int mstSet[], int V) {
    int min = INT_MAX, min_index;

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

    return min_index;
}

// Function to print the constructed MST stored in parent[]
void printMST(int parent[], int n, int graph[V_MAX][V_MAX], int V) {
    printf("Edge   Weight\n");
    for (int i = 1; i < V; i++)
        printf("%d - %d    %d \n", parent[i], i, graph[i][parent[i]]);
}

// Function to construct and print MST for a graph represented using adjacency matrix representation
void primMST(int graph[][V_MAX], int V) {
    int parent[V_MAX]; // Array to store constructed MST
    int key[V_MAX]; // Key values used to pick minimum weight edge in cut
    int mstSet[V_MAX]; // To represent set of vertices not yet included in MST

    // Initialize all keys as INFINITE, mstSet[] as 0
    for (int i = 0; i < V; i++)
        key[i] = INT_MAX, mstSet[i] = 0;

    // Always include first 1st vertex in MST. Make key 0 so that this vertex is picked as the first vertex
    key[0] = 0;
    parent[0] = -1; // First node is always the root of MST

    // The MST will have V vertices
    for (int count = 0; count < V - 1; count++) {
        // Pick the minimum key vertex from the set of vertices not yet included in MST
        int u = minKey(key, mstSet, V);

        // Add the picked vertex to the MST set
```

```
        mstSet[u] = 1;

        // Update key value and parent index of the adjacent vertices of the picked vertex
        // Consider only those vertices which are not yet included in the MST
        for (int v = 0; v < V; v++)
            if (graph[u][v] && mstSet[v] == 0 && graph[u][v] < key[v])
                parent[v] = u, key[v] = graph[u][v];
    }

    // Print the constructed MST
    printMST(parent, V, graph, V);
}

int main() {
    int V, E;
    printf("Enter the number of vertices and edges: ");
    scanf("%d %d", &V, &E);

    // Create the graph as an adjacency matrix
    int graph[V_MAX][V_MAX];
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            graph[i][j] = 0; // Initialize the graph with 0s
        }
    }

    // Prompt the user to enter the source vertex, destination vertex, and weight for each edge
    printf("Enter the source vertex, destination vertex, and weight for each edge:\n");
    for (int i = 0; i < E; i++) {
        int source, dest, weight;
        scanf("%d %d %d", &source, &dest, &weight);
        graph[source][dest] = weight;
        graph[dest][source] = weight; // Since the graph is undirected
    }

    // Print the MST using Prim's algorithm
    primMST(graph, V);

    return 0;
}
```

OUTPUT:

```
student@lenovo-ThinkCentre-M900:~$ gedit 2.c
student@lenovo-ThinkCentre-M900:~$ gcc 2.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of vertices and edges: 5
7
Enter the source vertex, destination vertex, and weight for each edge:
0 1 2
0 3 6
1 2 3
1 3 8
1 4 5
2 4 7
3 4 9
Edge   Weight
0 - 1    2
1 - 2    3
0 - 3    6
1 - 4    5
```

3.a. Design and implement C Program to solve All-Pairs Shortest Paths problem using Floyd's algorithm.

PROGRAM:

```
#include<stdio.h>

int min(int,int);
void floyds(int p[10][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++)
            if(i==j)
             p[i][j]=0; else
             p[i][j]=min(p[i][j],p[i][k]+p[k][j]);
}
int min(int a,int b) {
        if(a<b)
          return(a); else
          return(b);
}
void main() {
        int p[10][10],w,n,e,u,v,i,j;

        printf("\n Enter the number of vertices:");
        scanf("%d",&n);
        printf("\n Enter the number of edges:\n");
        scanf("%d",&e);
        for (i=1;i<=n;i++) {
                for (j=1;j<=n;j++)
                   p[i][j]=999;
        }
        for (i=1;i<=e;i++) {
                printf("\n Enter the end vertices of edge%d with its weight \n",i);
                scanf("%d%d%d",&u,&v,&w);
                p[u][v]=w;
        }
        printf("\n Matrix of input data:\n");
        for (i=1;i<=n;i++) {
                for (j=1;j<=n;j++)
                   printf("%d \t",p[i][j]);
                printf("\n");
        }
        floyds(p,n);
        printf("\n Transitive closure:\n");
        for (i=1;i<=n;i++) {
                for (j=1;j<=n;j++)
                   printf("%d \t",p[i][j]);
```

```
                printf("\n");
        }
        printf("\n The shortest paths are:\n");
        for (i=1;i<=n;i++)
          for (j=1;j<=n;j++) {
                if(i!=j)
                   printf("\n <%d,%d>=%d",i,j,p[i][j]);
        }

   }
```

OUTPUT:

```
student@lenovo-ThinkCentre-M900:~$ gcc 3a.c
student@lenovo-ThinkCentre-M900:~$ ./a.out

 Enter the number of vertices:4

 Enter the number of edges:
5

 Enter the end vertices of edge1 with its weight
1 3 3

 Enter the end vertices of edge2 with its weight
2 1 2

 Enter the end vertices of edge3 with its weight
3 2 7

 Enter the end vertices of edge4 with its weight
3 4 1

 Enter the end vertices of edge5 with its weight
4 1 6

 Matrix of input data:
999     999     3       999
2       999     999     999
999     7       999     1
6       999     999     999

 Transitive closure:
0       10      3       4
2       0       5       6
7       7       0       1
6       16      9       0

 The shortest paths are:

 <1,2>=10
```

<1,3>=3
<1,4>=4
<2,1>=2
<2,3>=5
<2,4>=6
<3,1>=7
<3,2>=7
<3,4>=1
<4,1>=6
<4,2>=16

3b.Design and implement C Program to find the transitive closure using Warshal's algorithm.

PROGRAM:

```
#include<stdio.h>
#include<math.h>
int max(int, int);
void warshal(int p[10][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] = max(p[i][j], p[i][k] && p[k][j]);
}
int max(int a, int b) {
    ;
    if (a > b)
        return (a);
    else
        return (b);
}
void main() {
    int p[10][10] = { 0 }, n, e, u, v, i, j;
    printf("\n Enter the number of vertices:");
    scanf("%d", &n);
    printf("\n Enter the number of edges:");
```

```
    scanf("%d", &e);
    for (i = 1; i <= e; i++) {
        printf("\n Enter the end vertices of edge %d:", i);
        scanf("%d%d", &u, &v);
        p[u][v] = 1;
    }
    printf("\n Matrix of input data: \n");
    for (i = 1; i <= n; i++) {
        for (j = 1; j <= n; j++)
            printf("%d\t", p[i][j]);
        printf("\n");
    }
    warshal(p, n);
    printf("\n Transitive closure: \n");
    for (i = 1; i <= n; i++) {
        for (j = 1; j <= n; j++)
            printf("%d\t", p[i][j]);
        printf("\n");
    }

}
```

OUTPUT:

```
student@lenovo-ThinkCentre-M900:~$ gedit 3b.c
student@lenovo-ThinkCentre-M900:~$ gcc 3b.c
student@lenovo-ThinkCentre-M900:~$ ./a.out

 Enter the number of vertices:5

 Enter the number of edges:11

 Enter the end vertices of edge 1:1 1
```

```
Enter the end vertices of edge 2:1 4

Enter the end vertices of edge 3:3 2

Enter the end vertices of edge 4:3 3

Enter the end vertices of edge 5:3 4

Enter the end vertices of edge 6:4 2

Enter the end vertices of edge 7:4 4

Enter the end vertices of edge 8:5 2

Enter the end vertices of edge 9:5 3

Enter the end vertices of edge 10:5 4

Enter the end vertices of edge 11:5 5

 Matrix of input data:
1       0       0       1       0
0       0       0       0       0
0       1       1       1       0
0       1       0       1       0
0       1       1       1       1

 Transitive closure:
1       1       0       1       0
0       0       0       0       0
0       1       1       1       0
0       1       0       1       0
0       1       1       1       1
```

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

PROGRAM:

```
  #include <stdio.h>
#include <stdbool.h>
#include <limits.h>

#define MAX_VERTICES 10  // Maximum number of vertices
#define INF INT_MAX

// A function to find the vertex with the minimum distance value, from the set of vertices not yet included in the shortest path tree
int minDistance(int dist[], bool sptSet[], int V) {
   int min = INF, min_index;

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

   return min_index;
}

// A utility function to print the constructed distance array
void printSolution(int dist[], int V) {
   printf("Vertex \t\t Distance from Source\n");
   for (int i = 0; i < V; i++)
      printf("%d \t\t %d\n", i, dist[i]);
}

// Dijkstra's algorithm for adjacency matrix representation of the graph
void dijkstra(int graph[MAX_VERTICES][MAX_VERTICES], int src, int V) {
   int dist[MAX_VERTICES];  // The output array. dist[i] will hold the shortest distance from src to i
   bool sptSet[MAX_VERTICES];  // sptSet[i] will be true if vertex i is included in the shortest path tree

   // Initialize all distances as INFINITE and sptSet[] as false
   for (int i = 0; i < V; i++)
      dist[i] = INF, sptSet[i] = false;

   dist[src] = 0;

   // Find shortest path for all vertices
   for (int count = 0; count < V - 1; count++) {
      int u = minDistance(dist, sptSet, V);
      sptSet[u] = true;
      for (int v = 0; v < V; v++)
         if (!sptSet[v] && graph[u][v] && dist[u] != INF && dist[u] + graph[u][v] < dist[v])
            dist[v] = dist[u] + graph[u][v];
```

```
    }

    printSolution(dist, V);
}

// Driver code
int main() {
    int V, E;
    printf("Enter the number of vertices: ");
    scanf("%d", &V);
    printf("Enter the number of edges: ");
    scanf("%d", &E);

    int graph[MAX_VERTICES][MAX_VERTICES] = {{0}};

    printf("Enter the source vertex, destination vertex, and weight for each edge:\n");
    for (int i = 0; i < E; i++) {
        int source, dest, weight;
        scanf("%d %d %d", &source, &dest, &weight);
        graph[source][dest] = weight;
        graph[dest][source] = weight; // Assuming undirected graph
    }

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

OUTPUT:

```
student@lenovo-ThinkCentre-M900:~$ gedit 4.c
student@lenovo-ThinkCentre-M900:~$ gcc 4.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of vertices: 5
Enter the number of edges: 7
Enter the source vertex, destination vertex, and weight for each edge:
0 1 2
0 3 6
1 2 3
1 3 8
1 4 5
2 4 7
3 4 9
Vertex          Distance from Source
0               0
1               2
2               5
3               6
4               7
```

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

PROGRAM:

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

#define MAX_VERTICES 100

// Structure to represent a graph
typedef struct {
    int V;
    int** adjMatrix;
} Graph;

// Function to create a new graph
Graph* createGraph(int V) {
    Graph* graph = (Graph*)malloc(sizeof(Graph));
    graph->V = V;
    graph->adjMatrix = (int**)calloc(V, sizeof(int*));
    for (int i = 0; i < V; i++) graph->adjMatrix[i] = (int*)calloc(V, sizeof(int));
    return graph;
}

// Function to add an edge to the graph
void addEdge(Graph* graph, int src, int dest) {
    graph->adjMatrix[src][dest] = 1;
}

// Function to perform topological sorting
void topologicalSort(Graph* graph) {
    int V = graph->V, inDegree[MAX_VERTICES] = {0}, queue[MAX_VERTICES], front = 0,
rear = -1;

    for (int i = 0; i < V; i++)
        for (int j = 0; j < V; j++)
            if (graph->adjMatrix[i][j] == 1) inDegree[j]++;

    for (int i = 0; i < V; i++) if (inDegree[i] == 0) queue[++rear] = i;

    printf("Topological ordering of vertices: ");
    while (front <= rear) {
        int vertex = queue[front++];
        printf("%d ", vertex);
        for (int i = 0; i < V; i++) if (graph->adjMatrix[vertex][i] == 1 && --inDegree[i] == 0)
queue[++rear] = i;
    }
    printf("\n");
}
```

```
// Driver code
int main() {
    int V, E;
    printf("Enter the number of vertices: ");
    scanf("%d", &V);
    Graph* graph = createGraph(V);
    printf("Enter the number of edges: ");
    scanf("%d", &E);
    printf("Enter the edges (source vertex, destination vertex):\n");
    for (int i = 0, src, dest; i < E; i++) {
        scanf("%d %d", &src, &dest);
        addEdge(graph, src, dest);
    }
    topologicalSort(graph);
    return 0;
}
```

OUTPUT:

```
student@lenovo-ThinkCentre-M900:~$ gcc 5.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of vertices: 7
Enter the number of edges: 8
Enter the edges (source vertex, destination vertex):
0 1
0 2
1 3
2 3
3 4
3 5
4 6
5 6
Topological ordering of vertices: 0 1 2 3 4 5 6
```

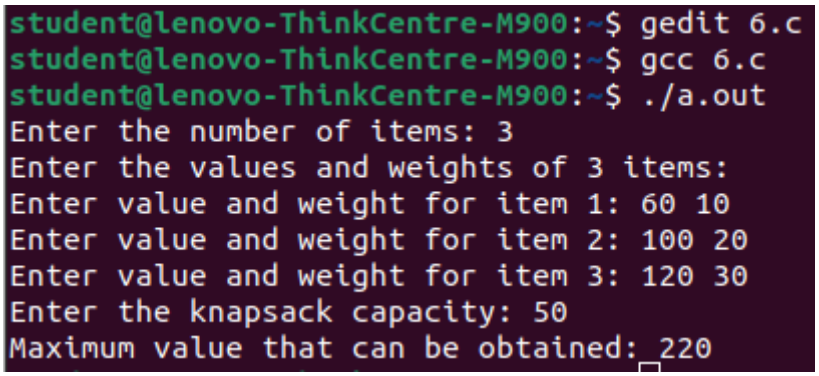
6.Design and implement C Program to solve 0/1 Knapsack problem using Dynamic Programming method.

PROGRAM:

```
#include <stdio.h>

// Function to find maximum of two integers
int max(int a, int b) {
   return (a > b) ? a : b;
}

// Function to solve 0/1 Knapsack problem
int knapsack(int W, int wt[], int val[], int n) {
   int i, w;
   int K[n + 1][W + 1];

   // Build table K[][] in bottom-up manner
   for (i = 0; i <= n; i++) {
      for (w = 0; w <= W; w++) {
         if (i == 0 || w == 0)
            K[i][w] = 0;
         else if (wt[i - 1] <= w)
            K[i][w] = max(val[i - 1] + K[i - 1][w - wt[i - 1]], K[i - 1][w]);
         else
            K[i][w] = K[i - 1][w];
      }
   }

   // K[n][W] contains the maximum value that can be put in a knapsack of capacity W
   return K[n][W];
}

int main() {
   int val[100], wt[100]; // Arrays to store values and weights
   int W, n; // Knapsack capacity and number of items
   printf("Enter the number of items: ");
   scanf("%d", &n);

   printf("Enter the values and weights of %d items:\n", n);
   for (int i = 0; i < n; i++) {
      printf("Enter value and weight for item %d: ", i + 1);
      scanf("%d %d", &val[i], &wt[i]);
   }

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

   printf("Maximum value that can be obtained: %d\n", knapsack(W, wt, val, n));

   return 0;
```

}

OUTPUT:


student@lenovo-ThinkCentre-M900:~$ gedit 6.c
student@lenovo-ThinkCentre-M900:~$ gcc 6.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of items: 3
Enter the values and weights of 3 items:
Enter value and weight for item 1: 60 10
Enter value and weight for item 2: 100 20
Enter value and weight for item 3: 120 30
Enter the knapsack capacity: 50
Maximum value that can be obtained: 220

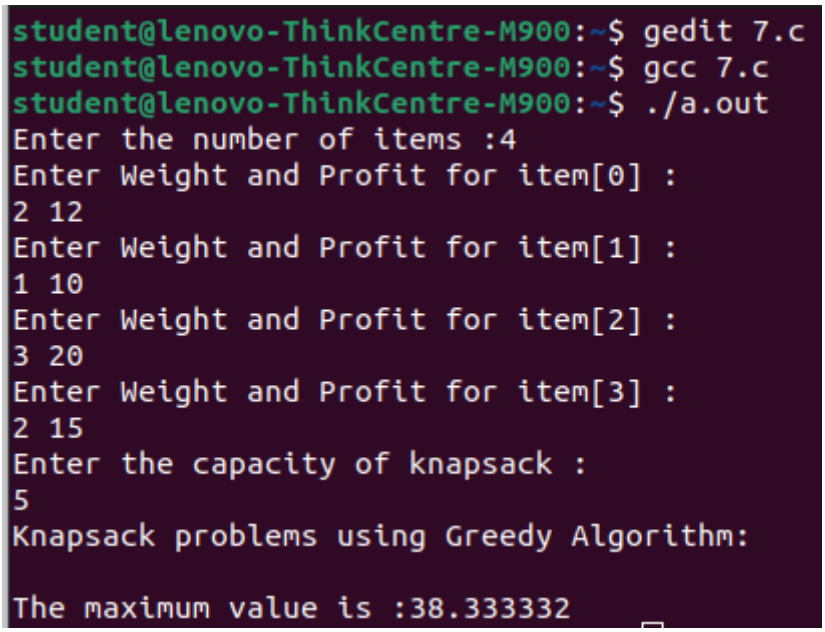
7.Design and implement C Program to solve discrete Knapsack and continuous Knapsack problems using greedy approximation method.

PROGRAM:

```
#include<stdio.h>
int main()
{
    float weight[50],profit[50],ratio[50],Totalvalue,temp,capacity,amount;
    int n,i,j;
    printf("Enter the number of items :");
    scanf("%d",&n);
   for (i = 0; i < n; i++)
   {
      printf("Enter Weight and Profit for item[%d] :\n",i);
      scanf("%f %f", &weight[i], &profit[i]);
   }
   printf("Enter the capacity of knapsack :\n");
   scanf("%f",&capacity);

    for(i=0;i<n;i++)
        ratio[i]=profit[i]/weight[i];

   for (i = 0; i < n; i++)
     for (j = i + 1; j < n; j++)
        if (ratio[i] < ratio[j])
       {
          temp = ratio[j];
          ratio[j] = ratio[i];
          ratio[i] = temp;

          temp = weight[j];
          weight[j] = weight[i];
          weight[i] = temp;

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

    printf("Knapsack problems using Greedy Algorithm:\n");
    for (i = 0; i < n; i++)
    {
     if (weight[i] > capacity)
        break;
      else
     {
        Totalvalue = Totalvalue + profit[i];
        capacity = capacity - weight[i];
      }
    }
      if (i < n)
```

```
    Totalvalue = Totalvalue + (ratio[i]*capacity);
  printf("\nThe maximum value is :%f\n",Totalvalue);
  return 0;
}
```

OUTPUT:



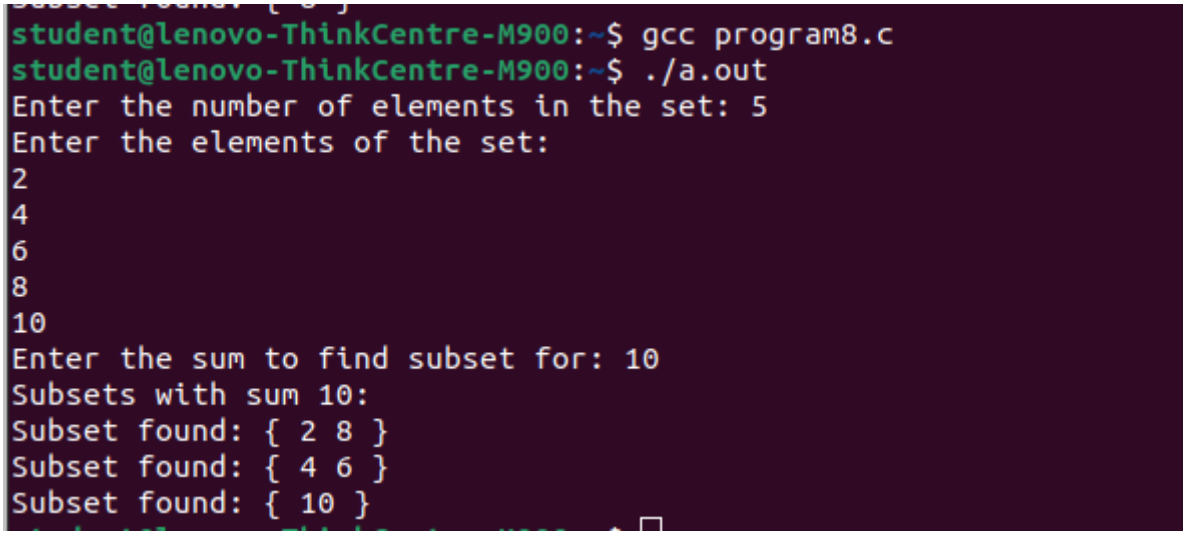
8.Design and implement C Program to find a subset of a given set S = {sl , s2,.....,sn} of n positive integers whose sum is equal to a given positive integer d.

PROGRAM:

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

#define MAX_SIZE 100

// Function to find subset with given sum
void subsetSum(int set[], int subset[], int n, int subSize, int total, int nodeCount, int sum) {
    if (total == sum) {
        // Print the subset
        printf("Subset found: { ");
        for (int i = 0; i < subSize; i++) {
            printf("%d ", subset[i]);
        }
        printf("}\n");
        return;
    } else {
        // Check the sum of the remaining elements
        for (int i = nodeCount; i < n; i++) {
            subset[subSize] = set[i];
            subsetSum(set, subset, n, subSize + 1, total + set[i], i + 1, sum);
        }
    }
}

int main() {
    int set[MAX_SIZE];
    int subset[MAX_SIZE];
    int n, sum;

    // Input the number of elements in the set
    printf("Enter the number of elements in the set: ");
    scanf("%d", &n);

    // Input the elements of the set
    printf("Enter the elements of the set:\n");
    for (int i = 0; i < n; i++) {
        scanf("%d", &set[i]);
    }

    // Input the target sum
    printf("Enter the sum to find subset for: ");
    scanf("%d", &sum);

    printf("Subsets with sum %d:\n", sum);
    subsetSum(set, subset, n, 0, 0, 0, sum);

    return 0;
```

}

OUTPUT:


student@lenovo-ThinkCentre-M900:~$ gcc program8.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of elements in the set: 5
Enter the elements of the set:
2
4
6
8
10
Enter the sum to find subset for: 10
Subsets with sum 10:
Subset found: { 2 8 }
Subset found: { 4 6 }
Subset found: { 10 }

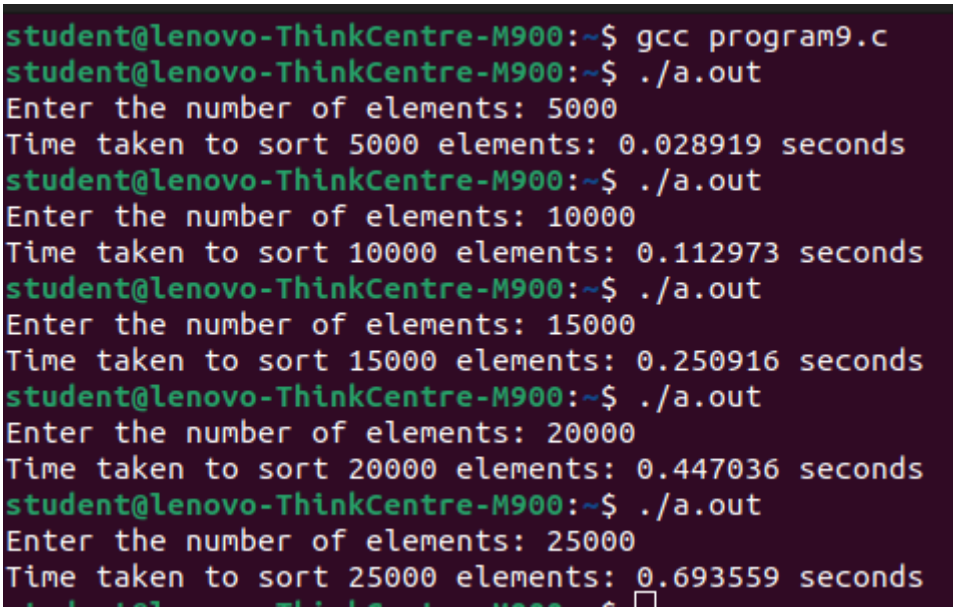
9.Design and implement C Program to sort a given set of n integer elements using Selection Sort method and compute its time complexity. Run the program for varied values of n> 5000 and record the time taken to sort. Plot a graph of the time taken versus n. The elements can be read from a file or can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

PROGRAM:

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

// Function to swap two integers
void swap(int *a, int *b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

// Function to perform Selection Sort
void selectionSort(int arr[], int n) {
    int i, j, min_idx;

    for (i = 0; i < n-1; i++) {
        min_idx = i;
        for (j = i+1; j < n; j++) {
            if (arr[j] < arr[min_idx])
                min_idx = j;
        }
        swap(&arr[min_idx], &arr[i]);
    }
}

int main() {
    int n;
    printf("Enter the number of elements: ");
    scanf("%d", &n);

    int arr[n];
    srand(time(0)); // Seed for random number generation

    // Generating random numbers for elements
    for (int i = 0; i < n; i++) {
        arr[i] = rand() % 10000; // Generating random numbers between 0 and 9999
    }

    clock_t start, end;
    double cpu_time_used;

    start = clock();
    selectionSort(arr, n);
```

```
    end = clock();

    cpu_time_used = ((double) (end - start)) / CLOCKS_PER_SEC;
    printf("Time taken to sort %d elements: %f seconds\n", n, cpu_time_used);

    return 0;
}
```

OUTPUT:



10.Design and implement 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.

PROGRAM:

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

// Function to swap two integers
void swap(int* a, int* b) {
    int temp = *a;
    *a = *b;
    *b = temp;
}

// Function to partition the array and return the pivot index
int partition(int arr[], int low, int high) {
    int pivot = arr[high];
    int i = low - 1;

    for (int j = low; j <= high - 1; j++) {
        if (arr[j] < pivot) {
            i++;
            swap(&arr[i], &arr[j]);
        }
    }
    swap(&arr[i + 1], &arr[high]);
    return i + 1;
}

// Function to implement Quick Sort
void quickSort(int arr[], int low, int high) {
    if (low < high) {
        int pi = partition(arr, low, high);

        quickSort(arr, low, pi - 1);
        quickSort(arr, pi + 1, high);
    }
}

int main() {
    FILE *fp;
    fp = fopen("numbers.txt", "w");

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

```
    srand(time(NULL));
    for (int i = 0; i < n; i++) {
        int num = rand() % 10000;
        fprintf(fp, "%d ", num);
    }
    fclose(fp);

    int arr[n];
    fp = fopen("numbers.txt", "r");
    for (int i = 0; i < n; i++) {
        fscanf(fp, "%d", &arr[i]);
    }
    fclose(fp);

    clock_t start, end;
    double cpu_time_used;

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

    cpu_time_used = ((double)(end - start)) / CLOCKS_PER_SEC;
    printf("Time taken to sort %d elements: %f seconds\n", n, cpu_time_used);

    return 0;
}
```

OUTPUT:

```
student@lenovo-ThinkCentre-M900:~$ gcc 10.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of elements: 5000
Time taken to sort 5000 elements: 0.000557 seconds
student@lenovo-ThinkCentre-M900:~$ gcc 10.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of elements: 10000
Time taken to sort 10000 elements: 0.001171 seconds
student@lenovo-ThinkCentre-M900:~$ gcc 10.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of elements: 15000
Time taken to sort 15000 elements: 0.001912 seconds
student@lenovo-ThinkCentre-M900:~$ gcc 10.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of elements: 20000
Time taken to sort 20000 elements: 0.002697 seconds
student@lenovo-ThinkCentre-M900:~$ gcc 10.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
Enter the number of elements: 25000
Time taken to sort 25000 elements: 0.003862 seconds
```

OR

Program:

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

void fnGenRandInput(int [], int);
void fnDispArray( int [], int);
int fnPartition(int [], int , int);
void fnQuickSort(int [], int , int);
void fnSwap(int*, int*);

void fnSwap(int *a, int *b)
{
        int t = *a; *a = *b; *b = t;
}

int main( int argc, char **argv)
{
        FILE *fp;
        struct timeval tv;
        double dStart,dEnd;
        int iaArr[500000],iNum,i,iChoice;

   for(;;)
   {
      printf("\n1.Plot the Graph\n2.QuickSort\n3.Exit");
      printf("\nEnter your choice\n");
      scanf("%d",&iChoice);
      switch(iChoice)
      {
         case 1:
            fp = fopen("QuickPlot.dat","w");

            for(i=100;i<100000;i+=100)
            {
               fnGenRandInput(iaArr,i);
               gettimeofday(&tv,NULL);
               dStart = tv.tv_sec + (tv.tv_usec/1000000.0);
               fnQuickSort(iaArr,0,i-1);
               gettimeofday(&tv,NULL);
               dEnd = tv.tv_sec + (tv.tv_usec/1000000.0);
               fprintf(fp,"%d\t%lf\n",i,dEnd-dStart);
            }
            fclose(fp);
            printf("\nData File generated and stored in file < QuickPlot.dat >.\n Use a plotting
utility\n");
        break;
```

```
        case 2:
           printf("\nEnter the number of elements to sort\n");
           scanf("%d",&iNum);
           printf("\nUnsorted Array\n");
           fnGenRandInput(iaArr,iNum);
           fnDispArray(iaArr,iNum);
           fnQuickSort(iaArr,0,iNum-1);
           printf("\nSorted Array\n");
           fnDispArray(iaArr,iNum);
        break;

        case 3:
           exit(0);
     }
   }
        return 0;
}


int fnPartition(int a[], int l, int r)
{
        int i,j;
        int p;
        p = a[l];
        i = l;
        j = r+1;
        do
        {
                do { i++; } while (a[i] < p);
                do { j--; } while (a[j] > p);
                fnSwap(&a[i], &a[j]);
        }while (i<j);
        fnSwap(&a[i], &a[j]);
        fnSwap(&a[l], &a[j]);
        return j;
}


void fnQuickSort(int a[], int l, int r)
{
        int s;
        if (l < r)
        {
                s = fnPartition(a, l, r);
                fnQuickSort(a, l, s-1);
                fnQuickSort(a, s+1, r);
        }
}


void fnGenRandInput(int X[], int n)
{
```

```
        srand(time(NULL));
        for(int i=0;i<n;i++)
        {
                X[i] = rand()%10000;
        }
}


void fnDispArray( int X[], int n)
{
        for(int i=0;i<n;i++)
                printf(" %5d \n",X[i]);
}
```

OUTPUT:

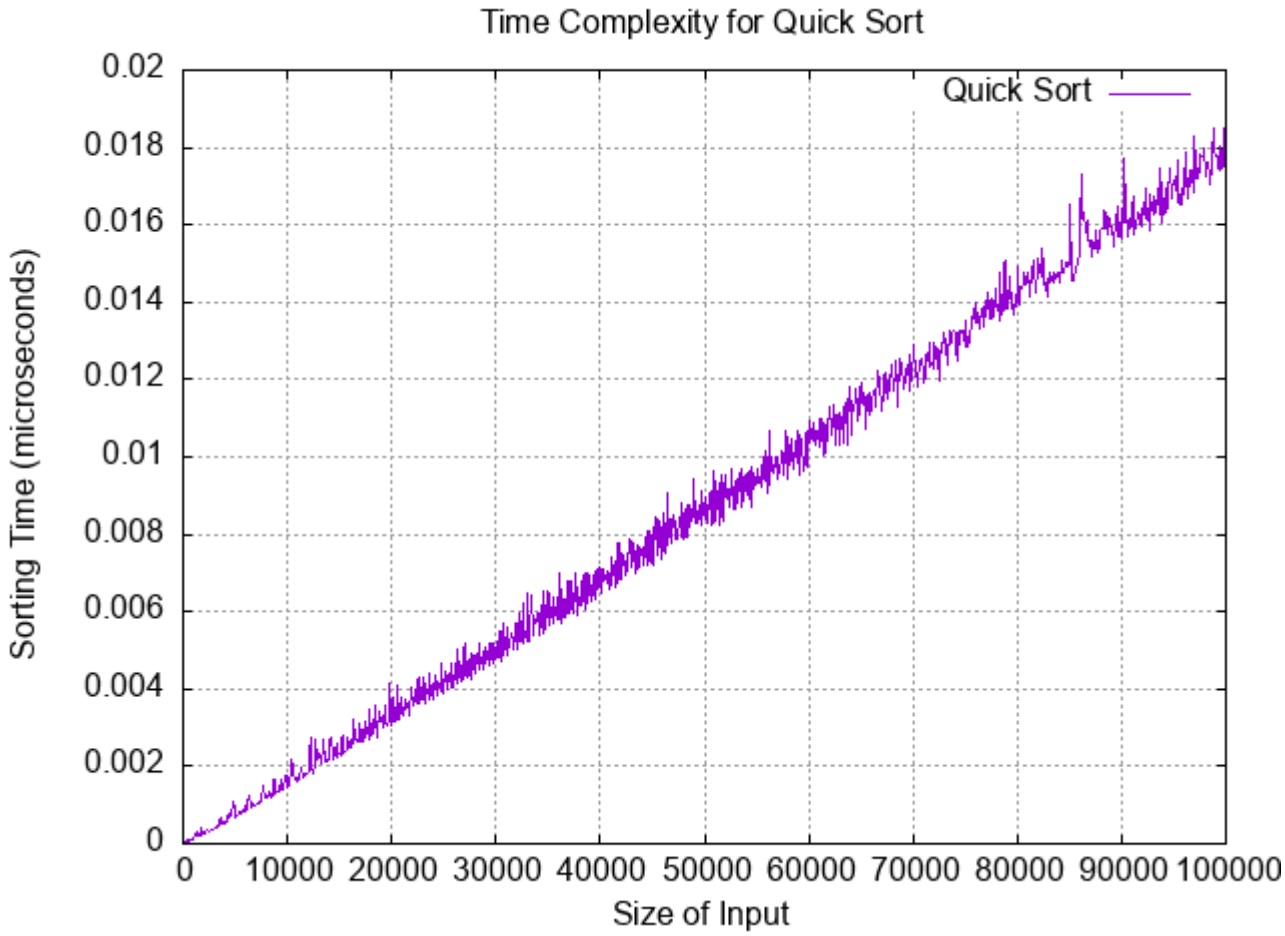
```
1.MergeSort
2.Plot the Graph
3.Exit
Enter your choice
1

Enter number of elements to sort : 6

Unsorted Array
   4680
   2144
    465
   5406
   8471
   3602

Sorted Array
    465
   2144
   3602
   4680
   5406
   8471

1.MergeSort
2.Plot the Graph
3.Exit
Enter your choice
2

Data File generated and stored in file < MergePlot.dat >.
 Use a plotting utility

1.MergeSort
2.Plot the Graph
```

3.Exit
Enter your choice
3

To execute the Gnuplot script you have to give the following command:

```
# Gnuplot script file for plotting data in file "QuickPlot.dat"
# This file is called       10QuickPlot.gpl
set terminal png font arial
set title "Time Complexity for Quick Sort"
set autoscale
set xlabel "Size of Input"
set ylabel "Sorting Time (microseconds)"
set grid
set output "QuickPlot.png"
plot "QuickPlot.dat" t 'Quick Sort' with lines
```

$ gnuplot 03QuickPlot.gpl



11.Design and implement 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.

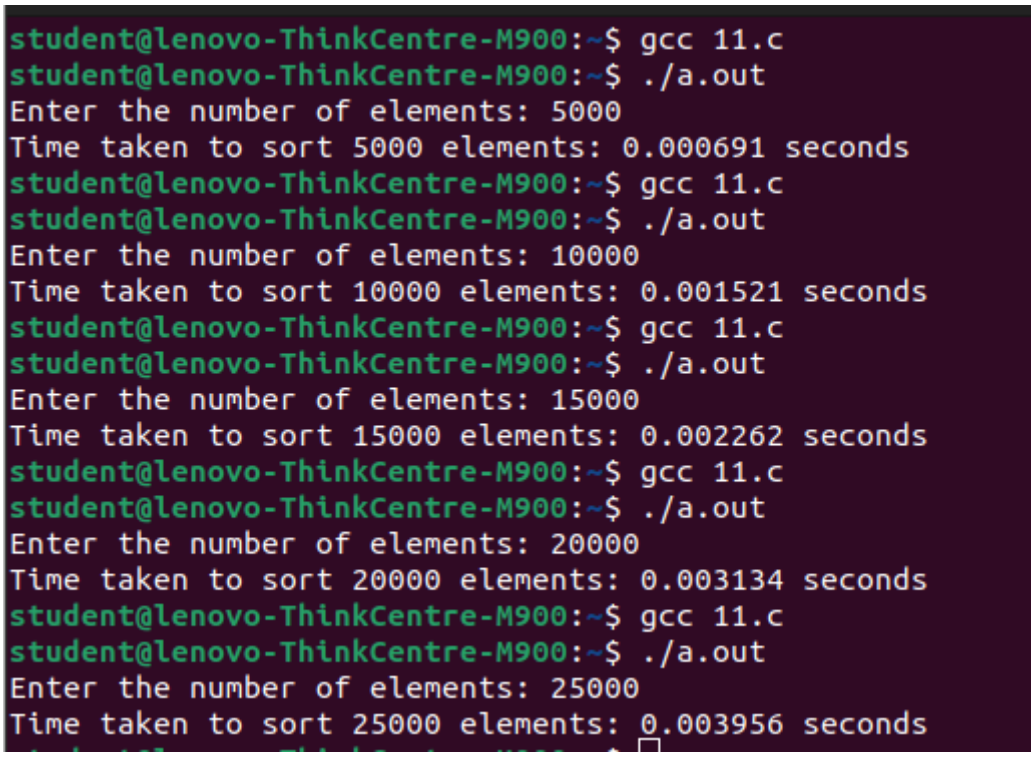
PROGRAM:

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

// Function to merge two subarrays arr[l..m] and arr[m+1..r]
void merge(int arr[], int l, int m, int r) {
    int i, j, k;
    int n1 = m - l + 1;
    int n2 = r - m;

    // Create temporary arrays
    int L[n1], R[n2];

    // Copy data to temporary arrays L[] and R[]
    for (i = 0; i < n1; i++)
        L[i] = arr[l + i];
    for (j = 0; j < n2; j++)
        R[j] = arr[m + 1 + j];

    // Merge the temporary arrays back into arr[l..r]
    i = 0; // Initial index of first subarray
    j = 0; // Initial index of second subarray
    k = l; // Initial index of merged subarray
    while (i < n1 && j < n2) {
        if (L[i] <= R[j]) {
            arr[k] = L[i];
            i++;
        } else {
            arr[k] = R[j];
            j++;
        }
        k++;
    }

    // Copy the remaining elements of L[], if any
    while (i < n1) {
        arr[k] = L[i];
        i++;
        k++;
    }

    // Copy the remaining elements of R[], if any
    while (j < n2) {
```

```
        arr[k] = R[j];
        j++;
        k++;
    }
}

// Merge Sort function
void mergeSort(int arr[], int l, int r) {
    if (l < r) {
        // Same as (l+r)/2, but avoids overflow for large l and r
        int m = l + (r - l) / 2;

        // Sort first and second halves
        mergeSort(arr, l, m);
        mergeSort(arr, m + 1, r);

        // Merge the sorted halves
        merge(arr, l, m, r);
    }
}

int main() {
    FILE *fp;
    fp = fopen("numbers.txt", "w");

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

    srand(time(NULL));
    for (int i = 0; i < n; i++) {
        int num = rand() % 10000;
        fprintf(fp, "%d ", num);
    }
    fclose(fp);

    int arr[n];
    fp = fopen("numbers.txt", "r");
    for (int i = 0; i < n; i++) {
        fscanf(fp, "%d", &arr[i]);
    }
    fclose(fp);

    clock_t start, end;
    double cpu_time_used;

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

    cpu_time_used = ((double)(end - start)) / CLOCKS_PER_SEC;
    printf("Time taken to sort %d elements: %f seconds\n", n, cpu_time_used);
```

```
    return 0;
}
```

OUTPUT:



OR

Program:

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


void fnGenRandInput(int [], int);
void fnDispArray( int [], int);
void fnMerge(int [], int ,int ,int);
void fnMergeSort(int [], int , int);



int main( int argc, char **argv)
{

        FILE *fp;
        struct timeval tv;
        double dStart,dEnd;
        int iaArr[500000],iNum,i,iChoice;

   for(;;)
   {
      printf("\n1.Plot the Graph\n2.MergeSort\n3.Exit");
      printf("\nEnter your choice\n");
      scanf("%d",&iChoice);

      switch(iChoice)
      {
         case 1:
            fp = fopen("MergePlot.dat","w");

            for(i=100;i<100000;i+=100)
            {
               fnGenRandInput(iaArr,i);

               gettimeofday(&tv,NULL);
               dStart = tv.tv_sec + (tv.tv_usec/1000000.0);

               fnMergeSort(iaArr,0,i-1);

               gettimeofday(&tv,NULL);
               dEnd = tv.tv_sec + (tv.tv_usec/1000000.0);

               fprintf(fp,"%d\t%lf\n",i,dEnd-dStart);

            }
            fclose(fp);
```

```
            printf("\nData File generated and stored in file < MergePlot.dat >.\n Use a plotting
utility\n");
        break;

        case 2:
            printf("\nEnter the number of elements to sort\n");
            scanf("%d",&iNum);
            printf("\nUnsorted Array\n");
            fnGenRandInput(iaArr,iNum);
            fnDispArray(iaArr,iNum);
            fnMergeSort(iaArr,0,iNum-1);
            printf("\nSorted Array\n");
            fnDispArray(iaArr,iNum);
        break;

        case 3:
            exit(0);
      }
   }

        return 0;
}


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 fnGenRandInput(int X[], int n)
{
        int i;

        srand(time(NULL));
        for(i=0;i<n;i++)
        {
                X[i] = rand()%10000;
        }

}


void fnDispArray( int X[], int n)
{
        int i;

        for(i=0;i<n;i++)
                printf(" %5d \n",X[i]);

}
```

OUTPUT:

1.MergeSort
2.Plot the Graph
3.Exit
Enter your choice
1

Enter number of elements to sort : 6

Unsorted Array
4680
2144
465
5406
8471
3602

Sorted Array
465
2144
3602

4680
5406
8471

1.MergeSort
2.Plot the Graph
3.Exit
Enter your choice
2

Data File generated and stored in file < MergePlot.dat >.
Use a plotting utility

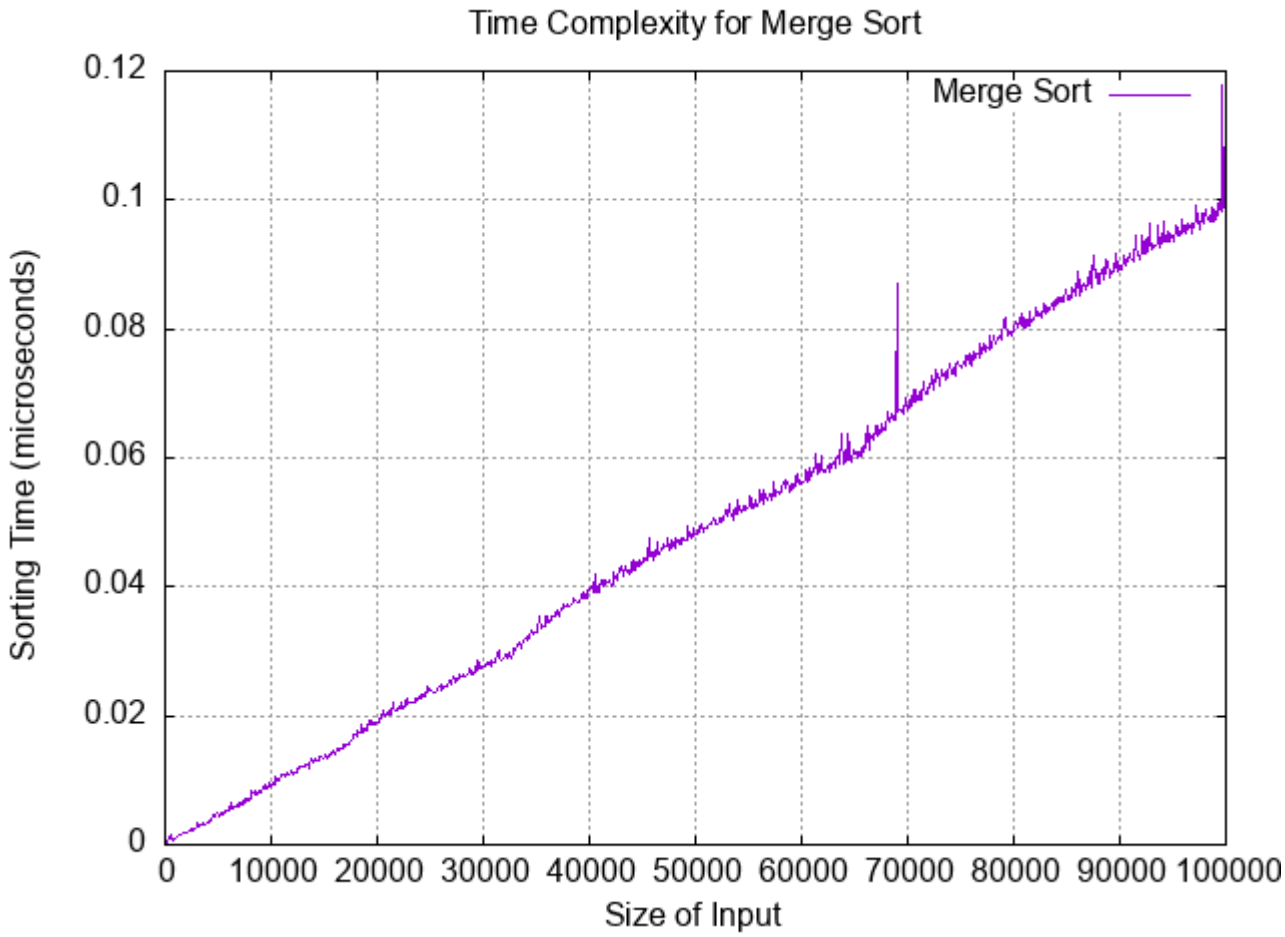
1.MergeSort
2.Plot the Graph
3.Exit
Enter your choice
3

To plot the graph use following steps

```
# Gnuplot script file for plotting data in file "MergePlot.dat"
# This file is called       MergePlot.gpl
set terminal png font arial
set title "Time Complexity for Merge Sort"
set autoscale
set xlabel "Size of Input"
set ylabel "Sorting Time (microseconds)"
set grid
set output "MergePlot.png"
plot "MergePlot.dat" t 'Merge Sort' with lines
```

To execute the Gnuplot script you have to give the following command:

```
$ gnuplot 03MergePlot.gpl
```


Time Complexity for Merge Sort
Merge Sort
Sorting Time (microseconds)
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
Size of Input

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

PROGRAM:

```
#include<stdio.h>
#include<math.h>
#include<stdlib.h>
int board[20],count;

int main()
{
int n,i,j;
void queen(int row,int n);

printf(" - N Queens Problem Using Backtracking -");
printf("\n\nEnter number of Queens:");
scanf("%d",&n);
queen(1,n);
return 0;
}

//function for printing the solution
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) //for nxn board
  {
   if(board[i]==j)
    printf("\tQ"); //queen at i,j position
   else
    printf("\t-"); //empty slot
  }
}
}

/*funtion to check conflicts
If no conflict for desired postion returns 1 otherwise returns 0*/
int place(int row,int column)
{
int i;
for(i=1;i<=row-1;++i)
{
  //checking column and digonal conflicts
```

```
  if(board[i]==column)
   return 0;
  else
   if(abs(board[i]-column)==abs(i-row))
    return 0;
}

return 1; //no conflicts
}

//function to check for proper positioning of queen
void queen(int row,int n)
{
int column;
for(column=1;column<=n;++column)
{
  if(place(row,column))
  {
   board[row]=column; //no conflicts so place queen
   if(row==n) //dead end
    print(n); //printing the board configuration
   else //try queen with next position
    queen(row+1,n);
  }
}
}
```

OUTPUT:

```
student@lenovo-ThinkCentre-M900:~$ gedit 12.c
student@lenovo-ThinkCentre-M900:~$ gcc 12.c
student@lenovo-ThinkCentre-M900:~$ ./a.out
 - N Queens Problem Using Backtracking -

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       -       -student@lenov
```