Ramanujan College

Delhi University

Practical File

Design And Analysis of Algorithms

(Core)

Semester-IV

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1.

i. Implement Insertion Sort (The program should report the number of comparisons)

ii. Implement Merge Sort (The program should report the number of comparisons)

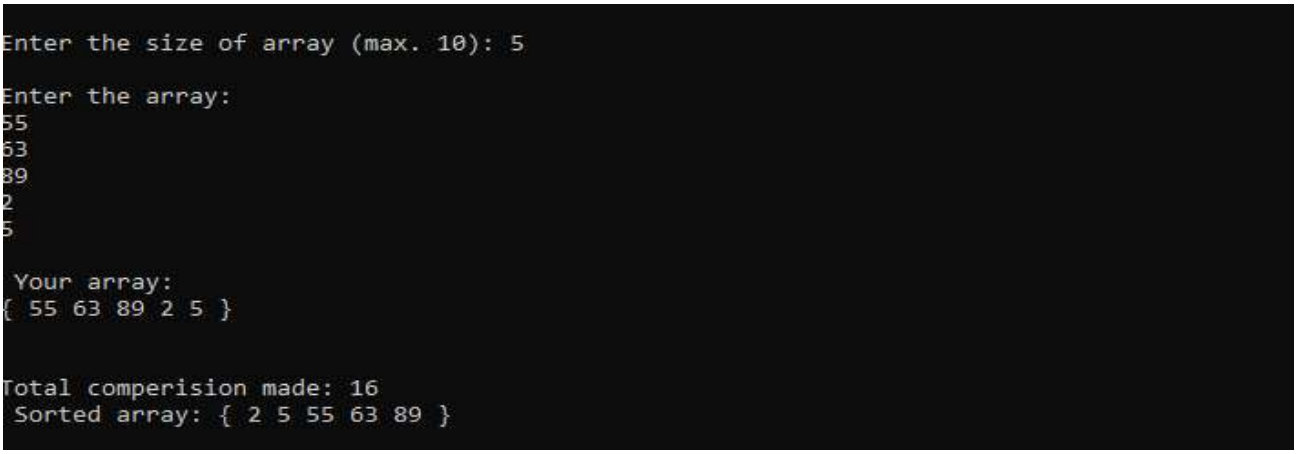
Answer:

i.

```
#include<iostream.h>
#include<conio.h>
using namespace std;
void display(int *a, int size) {
   cout<<"{ ";
   for(int i=0; i<size; i++ )
cout<<a[i]<<' ';
   cout<<"}"<<endl;
}

int insertionSort(int *a, int n)
{
  int i, j, k, comparison = 0;
  for(i=1; i<n; i++)
  {
    comparison++;
    k = a[i];
    for(j=i-1; (a[j]>k) && (j>=0); j--)
    {
```

```
        comparison += 2;
        a[j+1] = a[j];
    }
    a[j+1] = k;
  }
  return comparison;
}
int main()
{
int size, i, *arr;
cout<<"\nEnter the size of array (max. 10): ";
cin>>size;
arr = new int[size];
cout<<"\nEnter the array: \n";
for(i=0; i<size; i++)
   cin>>arr[i];
cout<<"\n Your array: \n";
display(arr, size);
getch();
cout<<"\n\nTotal comperision made: "<<insertionSort(arr, size);
cout<<"\n Sorted array: ";
display(arr, size);
getch();
return 0;
}
```

Output:



ii.

```
pace std;
int comparison = 0;
void display(int *a, int size) {
   cout<<"{ ";
   for(int i=0; i<size; i++ )
cout<<a[i]<<' ';
   cout<<"}"<<endl;
}

void merge(int *a, int beg, int mid, int end)
{
  int size = end - beg + 1;
  int *temp = new int[size];
  int i=beg, j=mid+1, k=0;

  //arranging in order
  while (i <= mid && j<=end){
   temp[k++] = (a[i]<a[j]) ? a[i++] : a[j++];
```

```
   comparison += 3;
  }
  while(i<=mid){
   comparison++;
   temp[k++] = a[i++];
  }
  while(j<end){
   comparison++;
   temp[k++] = a[j++];
  }

  for(i=0; i<k; i++)
  {
   a[i+beg] = temp[i];
  }
}

void mergeSort(int* a,int beg, int end)
{
   if (beg < end) {
comparison++;
       int mid = (beg+end)/2;
       mergeSort(a, beg, mid);
       mergeSort(a, mid+1, end);
       merge(a, beg, mid, end);
   }
}
```

```
int main()
{
int size, i, *arr;
cout<<"\nEnter the size of array (max. 10): ";
cin>>size;
arr = new int[size];
cout<<"\nEnter the array: \n";
for(i=0; i<size; i++)
  cin>>arr[i];
cout<<"\n Your array: \n";
display(arr, size);

getch();
mergeSort(arr, 0, size-1);
cout<<"\n\nTotal comperision made: "<<comparison;

cout<<"\n Sorted array: \n";
display(arr, size);

getch();
}
```

Output:

2. Implement Heap Sort(The program should report the number of comparisons)

Answer:

```
#include <iostream>
#include <conio.h>
using namespace std;
int comparison = 0;

void display(int *a, int size) {
   cout<<"{ ";
   for(int i=0; i<size; i++ )
cout<<a[i]<<' ';
   cout<<"}"<<endl;
}

void swap(int *a, int x, int y){
  int temp = a[y];
  a[y] = a[x];
  a[x] = temp;
}
```

```
void maxHeapify(int *a, int index, int heapSize)
{
  int left = index*2 + 1;
  int right = index*2 + 2;
  int largest = index;

  if(left < heapSize && a[left] > a[largest]){
    largest = left;
  comparison+=2;
  }
  if(right < heapSize && a[right] > a[largest]){
    largest = right;
  comparison+=2;
  }

  if(largest != index){
    comparison++;
    swap(a, largest, index);
    maxHeapify(a, largest, heapSize);
  }
}

void buildMaxHeap(int *a, int n)
{
  for (int i = (n/2) - 1; i >= 0; i--) {
    maxHeapify(a, i, n);
    comparison++;
  }
```

```
}

void heapSort(int *a, int size)
{
  buildMaxHeap(a, size);
  int heapSize = size, i;
  for(i=size-1; i>=0; i--) {
            swap(a, 0, i);
            heapSize--;
            comparison++;
            maxHeapify(a,0,heapSize);
  }
}

int main()
{
int size, i, *arr;
cout<<"\nEnter the size of array (max. 10): ";
cin>>size;
arr = new int[size];
cout<<"\nEnter the array: \n";
for(i=0; i<size; i++)
   cin>>arr[i];
cout<<"\n Your array: \n";
display(arr, size);
getch();
heapSort(arr, size);
cout<<"\n\nTotal comperision made: "<<comparison;
cout<<"\n Sorted array: \n";
```

```
display(arr, size);

getch();

return 0;

}
```

Output:

3. Implement Randomized Quick sort (The program should report the number of comparisons)

Answer:

```
#include <conio.h>

#include <iostream>

#include <stdlib.h>

#include <stdio.h>

using namespace std;

int comparison = 0;


void display(int *a, int size) {

   cout<<"{ ";

   for(int i=0; i<size; i++ )
```

```
cout<<a[i]<<' ';
    cout<<"}"<<endl;
}

void swap(int *a, int x, int y){
  int temp = a[y];
  a[y] = a[x];
  a[x] = temp;
}

int partition(int *a, int p, int r)
{
  int i = p-1, j, x;
  for (j = p; j<r; j++)
    if(a[j] <= a[r]){
      comparison+=2;
      i++;
      swap(a, j, i);
    }
  swap(a, i+1, r);

  return i+1;
}

int randomizedPartition(int *a, int beg, int end)
{
  int t = (rand()%(end-beg)) + beg;
  swap(a, end, t);
  return partition(a, beg, end);
```

```
}

void randomizedQuickSort(int *a, int p, int r)
{
  if (p<r) {
    comparison++;
    int q = randomizedPartition(a, p, r);
    randomizedQuickSort(a, p, q-1);
    randomizedQuickSort(a, q+1, r);
  }
}

int main()
{
int size, i, *arr;
cout<<"\nEnter the size of array (max. 10): ";
cin>>size;
arr = new int[size];

cout<<"\nEnter the array: \n";
for(i=0; i<size; i++)
   cin>>arr[i];
cout<<"\n Your array: \n";
display(arr, size);
getch();
randomizedQuickSort(arr, 0, size-1);
cout<<"\n\nTotal comperision made: "<<comparison;
cout<<"\n Sorted array: \n";
display(arr, size);
```

```
getch();
}
```

Output:

4. Implement Radix Sort

Answer:

```
#include <iostream>
#include <conio.h>
#include <math.h>
using namespace std;
void countSort(int arr[], int size, int num) {
   int x[10];
for(int c=0; c<10; c++)
  x[c] = 0;

   int *disp = new int[size];
   for(int i=0; i<size; i++)
      x[int(arr[i]/num)%10]++;
   for(int i=1; i<10; i++) {
      x[i] += x[i-1];
```

```
    }
    for(int j=0; j<size; j++) {
        disp[x[int(arr[j]/num)%10] - 1] = arr[j];
        x[int(arr[j]/num)%10]--;
    }
    for(int k=0; k<size; k++) {
        arr[k] = disp[k];
    }
}

void radixSort(int arr[], int size) {
    int max = arr[0];

    for(int i=1; i<size; i++)
        if(max<arr[i])
            max = arr[i];

    for(int p=1; max/p>0; p*=10)
        countSort(arr, size, p);
}

int main()
{
int arr[10], size, largest, i;
cout<<"\nEnter the size of array (max. 10): ";
cin>>size;
cout<<"\nEnter positive elements in the array: \n";
for(i=0; i<size; i++)
cin>>arr[i];
```

```
cout<<"\n Your array: \n";
for(i=0; i<size; i++)
{
cout<<arr[i]<<" ";
}

getch();
radixSort(arr, size);
cout<<"\n Sorted array: ";
for(i=0; i<size; i++)
{
cout<<arr[i]<<" ";
}
getch();
}
```

Output:

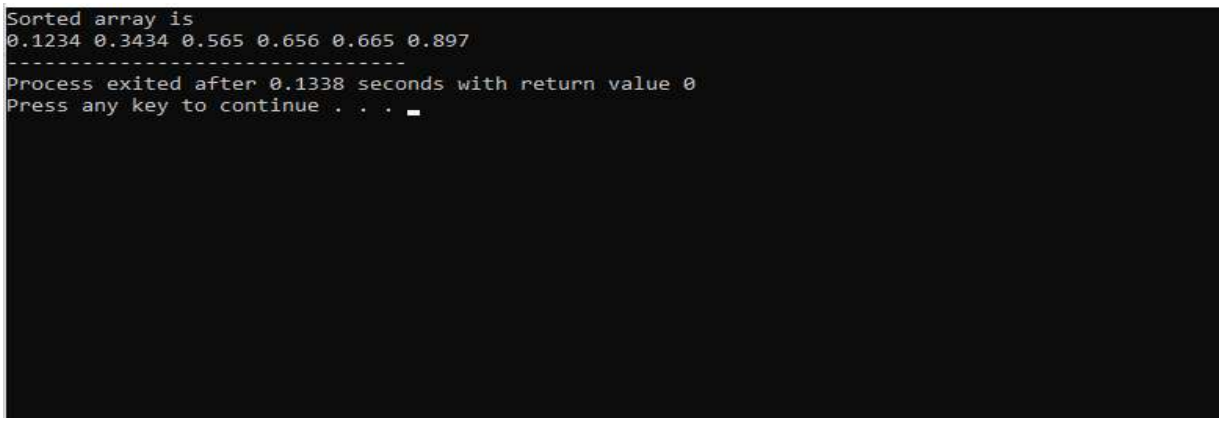
5. Implement Bucket Sort

Answer:

```
#include <algorithm>
#include <iostream>
#include <vector>
using namespace std;

// Function to sort arr[] of
// size n using bucket sort
void bucketSort(float arr[], int n)
{

    // 1) Create n empty buckets
    vector<float> b[n];

    // 2) Put array elements
    // in different buckets
    for (int i = 0; i < n; i++) {
        int bi = n * arr[i]; // Index in bucket
        b[bi].push_back(arr[i]);
    }

    // 3) Sort individual buckets
    for (int i = 0; i < n; i++)
        sort(b[i].begin(), b[i].end());

    // 4) Concatenate all buckets into arr[]
    int index = 0;
```

```
    for (int i = 0; i < n; i++)
        for (int j = 0; j < b[i].size(); j++)
            arr[index++] = b[i][j];
}


int main()
{
    float arr[]
        = { 0.897, 0.565, 0.656, 0.1234, 0.665, 0.3434 };
    int n = sizeof(arr) / sizeof(arr[0]);
    bucketSort(arr, n);

    cout << "Sorted array is \n";
    for (int i = 0; i < n; i++)
        cout << arr[i] << " ";
    return 0;
}
```

Output:



6. Implement Randomized Select

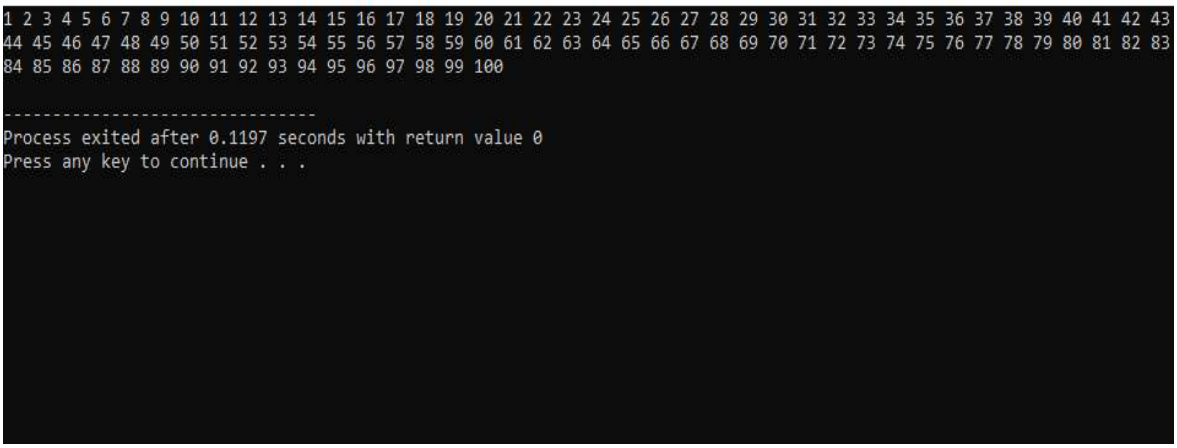
Answer:

```
#include<iostream>
#include<cstdlib>
#include<ctime>
#define MAX 100
using namespace std;
void random_shuffle(int arr[]) {
  //function to shuffle the array elements into random positions
  srand(time(NULL));
  for (int i = MAX - 1; i > 0; i--) {
    int j = rand()%(i + 1);
    int temp = arr[i];
    arr[i] = arr[j];
    arr[j] = temp;
  }
}
// Partitioning the array on the basis of values at high as pivot value.
int Partition(int a[], int low, int high) {
  int pivot, index, i;
  index = low;
  pivot = high;
  for(i=low; i < high; i++) {
    // finding index of pivot.
    if(a[i] < a[pivot]) {
      swap(a[i], a[index]);
      index++;
```

```
    }
  }
  swap(a[pivot], a[index]);
  return index;
}
int RandomPivotPartition(int a[], int low, int high){
  // Random selection of pivot.
  int pvt, n, temp;
  n = rand();
  pvt = low + n%(high-low+1); // Randomizing the pivot value from sub-array.
  swap(a[high], a[pvt]);
  return Partition(a, low, high);
}
void quick_sort(int arr[], int p, int q) {
  //recursively sort the list
  int pindex;
  if(p < q) {
    pindex = RandomPivotPartition(arr, p, q); //randomly choose pivot
    // Recursively implementing QuickSort.
    quick_sort(arr, p, pindex-1);
   quick_sort(arr, pindex+1, q);
}
}
int main() {
int i;
int arr[MAX];
for (i = 0;i < MAX; i++)
arr[i] = i + 1;
random_shuffle(arr); //To randomize the array
```

```
quick_sort(arr, 0, MAX - 1); //sort the elements of array

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

cout << arr[i] << " ";

cout << endl;

return 0;

}
```

Output:



7. Implement Breadth-First Search in a graph

Answer:

```
#include<iostream>

using namespace std;

#include<conio.h>

Using namespace std;


int graph[20][2], rows=-1, index = 0;



////////////////////////////////

/////     QUEUE           /////
```

```
//////////////////////////////////

class node
{
  public:
int info;
node *next;

    node(int data, node *ptr = 0)
{
  info = data;
  next = ptr;
}
};

class queue
{
node *head, *tail;

  public:
  queue()
 {
    head = 0;
    tail = 0;
 }

  int giveHead()
  {
    return head->info;
```

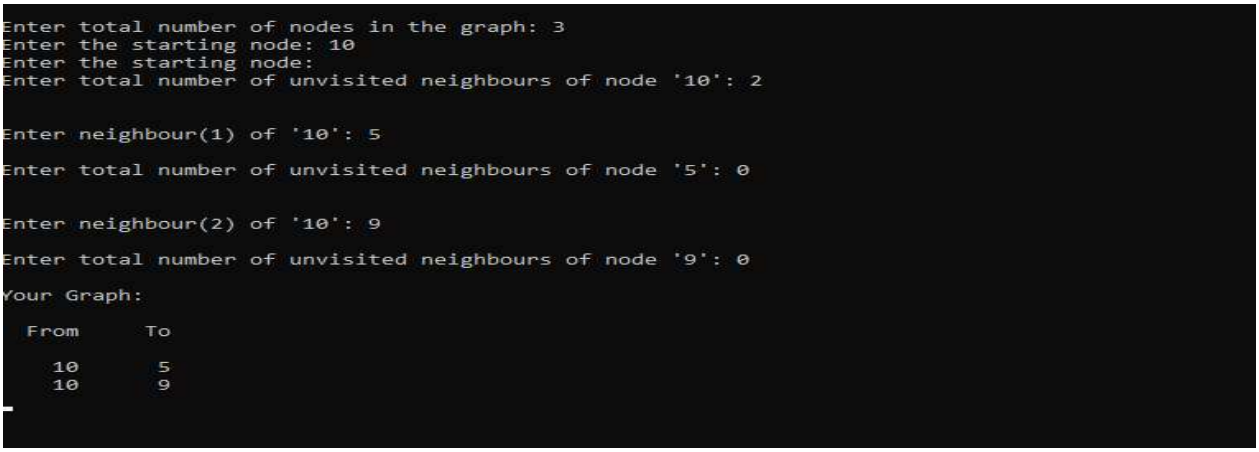
```
  }
void enqueue(int val)
  {
    if(head != 0)
    {
      tail->next = new node(val);
      tail = tail->next;
    }
    else
      head = tail = new node(val);
  }

int dequeue()
  {
    int temp;
    if(head != 0)
    {
       temp = head->info;
     head = head->next;
       return temp;
    }
    else
     return -1;
  }
} Q;

////////////////////////////////

void printGraph()
```

```
{


cout<<"\nYour Graph: ";
cout<<"\n\n  From    To\n\n";
  for(int i = 0; i < rows; i++) {
    for (int j = 0; j < 2; j++) {
      cout<<"   "<<graph[i][j]<<"\t";
    }
    cout<<endl;
  }
}

int checkPeresence(int a, int row, int col)
{
   for(int i=0; i<row; i++)
     if(graph[i][col] == a)
       return 1;
   return 0;
}

void drawGraph(int x, int i,  int limit)
{
    int n;

    cout<<"\nEnter total number of unvisited neighbours of node \'"<<x<<"\': ";
    cin>>n;
    rows += n;

    if(n>0)
```

```
    {
      for (int j = i; j < i+n; j++) {
       graph[j][0] = x;
      }

      for (int j = i; j < i+n; j++) {
cout<<"\n\nEnter neighbour("<<j-i+1<<") of \'"<<x<<"\': ";
cin>>graph[j][1];

if(checkPeresence(graph[j][1], rows, 0) == 0)
  drawGraph(graph[j][1], rows, limit);
      }
    }
}

////////////////////////////////////////////////////////////
void fill(int x)
{
  cout<<x<<"  ";
  Q.enqueue(x);
}

void BFS()
{
  while ((index < rows) && (Q.giveHead() == graph[index][0])) {
    if(checkPeresence(graph[index][1], index, 1) == 0)
      fill(graph[index][1]);
    index++;
  }
```

```
  if(index < rows)
  {
    do {
        if (Q.dequeue() == -1)
        return;
    } while(Q.giveHead() != graph[index][0]);

    BFS();
  }
  return;
}

int main()
{

    int t, start;
    rows = 0;

    cout<<"\nEnter total number of nodes in the graph: ";
    cin>>t;
    cout<<"Enter the starting node: ";
    cin>>start;


    cout<<"Enter the starting node: ";
    drawGraph(start, 0, t-1);
    printGraph();

    getch();
```

```
  cout<<"------------------\n\n"
   <<"Output of Breadth First Search (BFS) for this graph:"
   <<"\n\n";
  fill(start);
  BFS();

 getch();
}
```



8. Implement Depth-First Search in a graph

Answer:

```
#include<iostream>
using namespace std;
#include<conio.h>

int graph[20][3], rows=-1;
int vFlag[20][2], tNodes, index = 0;

////////////////////////////////
/////  STACK          /////
////////////////////////////////
```

```
class node
{
  public:
int info;
node *next;

  node(int data, node *ptr = 0)
{
  info = data;
  next = ptr;
}
};

class stack
{
node *top;

  public:
  stack()
{ top = 0; }

  int givetop()
  {  return top->info;  }

  void push(int val)
  {
    if(top != 0)
      top = new node(val, top);
```

```
    else
      top = new node(val);
  }

  void pop()
  {
    if(top != 0)
    top = top->next;
    else
    return;
  }

};

////////////////////////////////

int getFirstIndex(int n)
{
  for (int c = 0; c < rows; c++)
    if(graph[c][0] == n)
      return c;
  return -1;
}

void printGraph()
{

cout<<"\nYour Graph: ";
cout<<"\n\n  From    To\n\n";
```

```
  for(int i = 0; i < rows; i++) {
    for (int j = 0; j < 2; j++) {
      cout<<"    "<<graph[i][j]<<"\t";
    }
    cout<<endl;
  }
}

int checkPeresence(int a, int row, int col)
{
   for(int i=0; i<row; i++)
     if(graph[i][col] == a)
       return 1;
   return 0;
}

void drawGraph(int x, int i,  int limit)
{
    int n;

    cout<<"\nEnter total number of unvisited neighbours of node \'"<<x<<"\': ";
    cin>>n;
    rows += n;

    if(n>0)
    {
      for (int j = i; j < i+n; j++) {
       graph[j][0] = x;
      }
```

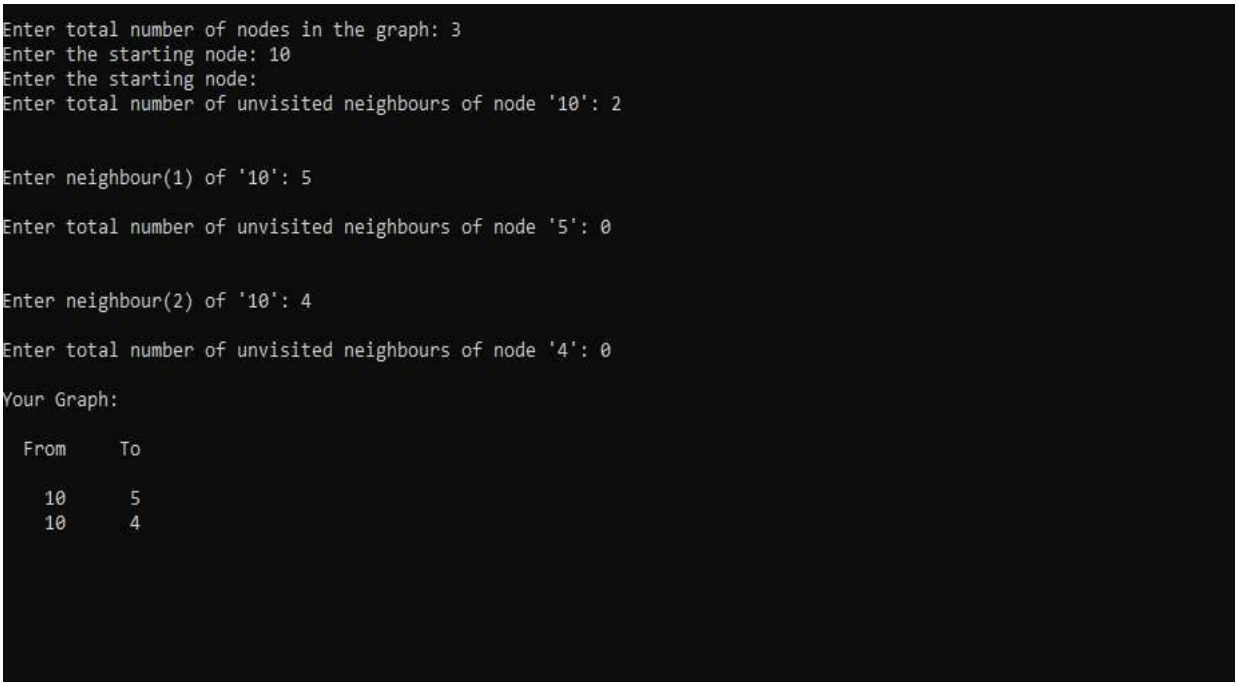
```
    for (int j = i; j < i+n; j++) {
            cout<<"\n\nEnter neighbour("<<j-i+1<<") of \'"<<x<<"\': ";
            cin>>graph[j][1];

      for(int c=0; (c<index) && (graph[j][1] != vFlag[c][0]); c++);
            if(int c = index)
             vFlag[index++][0] = graph[j][1];

            if(checkPeresence(graph[j][1], rows, 0) == 0)
             drawGraph(graph[j][1], rows, limit);
    }
   }
}

////////////////////////////////////////////////////////
void markVisited(int val) {
  for(int i=0; i<tNodes; i++)
   if(vFlag[i][0] == val)
   {
    vFlag[i][1] = 1;
    return;
   }
}

int isVisited(int x){
  for (int i = 0; i < tNodes; i++)
   if (vFlag[i][0] == x){
    return (vFlag[i][1] == 1) ? 0 : -1;
```

```
    }
  return -1;
}

void fill(int x)
{
  cout<<x<<"  ";
  markVisited(x);
  S.push(x);
}

void DFS(int v, int i)
{
  int j, temp;
  if(isVisited(v == -1))
    fill(v);

  while((S.givetop() == graph[i][0])&&(i<rows)){
    if(isVisited(graph[i][1]) == -1){
      j = getFirstIndex(graph[i][1]);
      if(j != -1){
      DFS(graph[i][1], j);
      }
      else{
      fill(graph[i][1]);
      S.pop();
      }
    }
    i++;
```

```
  }
  S.pop();
}

int main()
{

    int start, t=0;
    rows = 0;

    cout<<"\nEnter total number of nodes in the graph: ";
    cin>>tNodes;
    cout<<"Enter the starting node: ";
    cin>>start;
    vFlag[index++][0] = start;



    cout<<"Enter the starting node: ";
    drawGraph(start, 0, tNodes-1);
    printGraph();

    for (int c = 0; c < tNodes; c++) {
     vFlag[c][1] = 0;
    }

    getch();

    cout<<"------------------\n\n"
      <<"Output of Depth First Search (DFS) for this graph:"
```

```
    <<"\n\n";


   DFS(start, 0);


  getch();
}
```

Output:



9. Write a program to determine the minimum spanning tree of a graph using both Prims and Kruskals algorithm.

Answer:

```
#include <iostream>

#include <climits>

using namespace std;


#define v 5
```

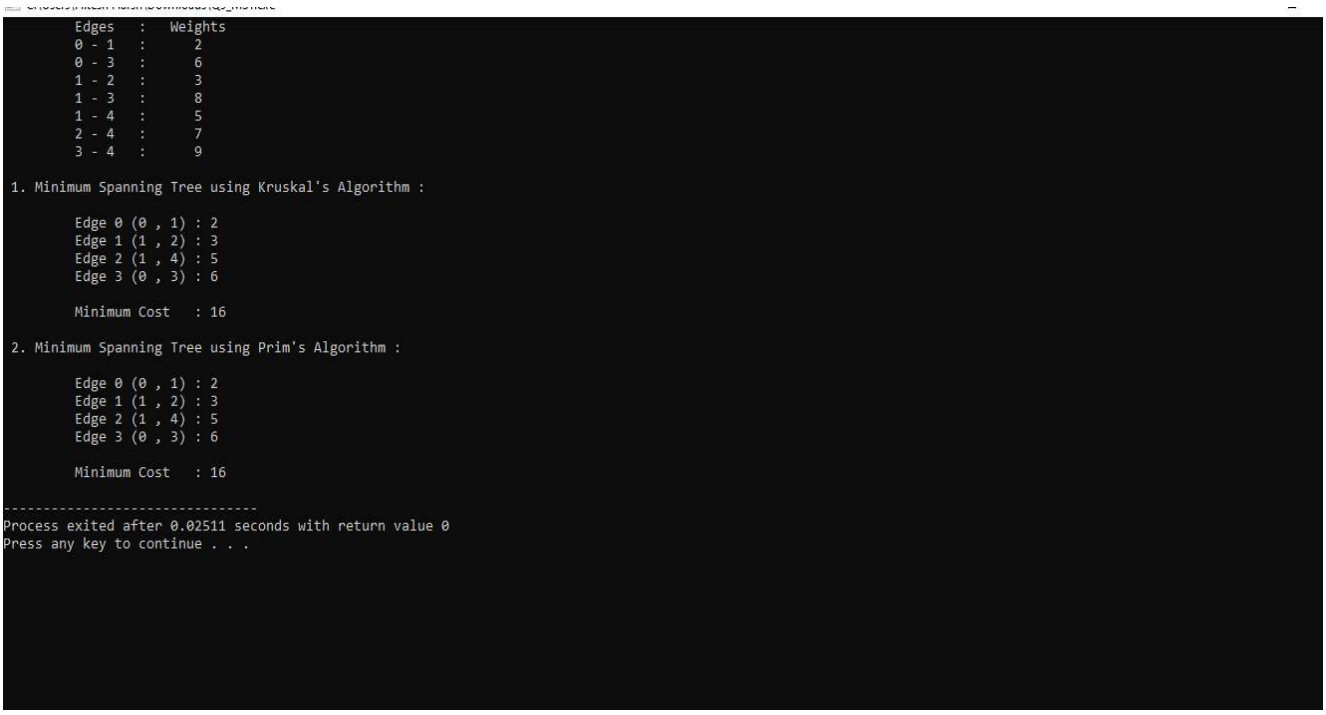
```
int parent[v];

bool visited[v] = {0};

/******      Kruskal's Algorithm       *******/

// Find set of vertex i
int find(int i)
{
   while (parent[i] != i)
      i = parent[i];
   return i;
}

void union1(int i, int j)
{
   int a = find(i);
   int b = find(j);
   parent[a] = b;
}

int kruskal_mst(int cost[][v])
{
   int mincost = 0;
   int edge_count = 0;

   for (int i = 0; i < v; i++)
      parent[i] = i;
```

```
   while (edge_count < v - 1)
   {
      int min = INT_MAX, a = -1, b = -1;
      for (int i = 0; i < v; i++)
         for (int j = 0; j < v; j++)
            if (find(i) != find(j) &&
               cost[i][j] < min)
            {
               min = cost[i][j];
               a = i;
               b = j;
            }

      union1(a, b);
      mincost += min;
      cout << "\n\t Edge " << edge_count++ << " ("
         << a << " , " << b << ") : " << min;
   }
   return mincost;
}

/******      Prim's Algorithm      *******/

bool validEdge(int a, int b)
{
   if (a == b || visited[a] == visited[b])
      return false;
   return true;
}
```

```
int prim_mst(int cost[][v])
{
   int mincost = 0, edge_count = 0;
   fill(visited, visited + v, false);
   visited[0] = true;

   while (edge_count < v - 1)
   {
      int min = INT_MAX, a = -1, b = -1;
      for (int i = 0; i < v; i++)
         for (int j = 0; j < v; j++)
            if (cost[i][j] < min &&
               validEdge(i, j))
            {
               min = cost[i][j];
               a = i;
               b = j;
            }

      visited[a] = visited[b] = true;
      mincost += min;
      cout << "\n\t Edge " << edge_count++ << " ("
         << a << " , " << b << ") : " << min;
   }
   return mincost;
}

/*************************************/
```

```
int main()
{
   int Graph[][v] = {
      {INT_MAX, 2, INT_MAX, 6, INT_MAX},
      {2, INT_MAX, 3, 8, 5},
      {INT_MAX, 3, INT_MAX, INT_MAX, 7},
      {6, 8, INT_MAX, INT_MAX, 9},
      {INT_MAX, 5, 7, 9, INT_MAX},
   };

   cout << "\n\t\t  Practical 9\n\tMinimum Spanning Tree Algorithms\n\t\t Kruskal & Prim\n";

   cout << "\n\n Given Graph is :\n\n\t Edges   :   Weights\n";
   for (int i = 0; i < v; i++)
      for (int j = 0; j < v; j++)
         if (Graph[i][j] != INT_MAX && !(visited[j]))
         {
            visited[i] = true;
            cout << "\t " << i << " - " << j << "   :\t" << Graph[i][j] << endl;
         }

   cout << "\n 1. Minimum Spanning Tree using Kruskal's Algorithm : \n";
   int k = kruskal_mst(Graph);
   cout << "\n\n\t Minimum Cost\t: " << k << endl;

   cout << "\n 2. Minimum Spanning Tree using Prim's Algorithm : \n";
   k = prim_mst(Graph);
   cout << "\n\n\t Minimum Cost\t: " << k << endl;
```

Output:



10. Write a program to solve the weighted interval scheduling problem.

Answer:

```
#include <iostream>

#include <algorithm>


using namespace std;


struct job

{

   int start, finish, profit;


   job(const int &s = 0, const int &f = 0, const int &p = 0)

   {
```

```
        start = s;
        finish = f;
        profit = p;
    }

    friend ostream &operator<<(ostream &out, const job &j)
    {
        out << '(' << j.start << ',' << j.finish << ',' << j.profit << ')' << endl;
        return out;
    }
};

bool cmp(const job &a, const job &b)
{
    return a.finish < b.finish;
}

int check_Overloop(const job *j, const int &n)
{
    for (int i = n - 2; i > -1; i--)
        if (j[n - 1].start >= j[i].finish)
            return i;
    return -1;
}

int wi_sch(const job *j, const int &n)
{
    if (n == 0)
        return j[0].profit;
```

```
    else
    {
        int i = check_Overloop(j, n);
        int incl = j[n - 1].profit;

        if (i != -1)
            incl += wi_sch(j, i + 1);

        int excl = wi_sch(j, n - 1);
        return (incl > excl ? incl : excl);
    }
}

int max_profit(job *j, const int &n)
{
    sort(j, j + n, cmp);
    cout << "\n\nSorted jobs according to respective finish time are :\n\n"
         << "S.N.\t  Start-time\t  Finish-time\t\tProfit\n";
    for (int i = 0; i < n; i++)
        cout << "\n " << i + 1 << "\t\t" << j[i].start << "\t\t" << j[i].finish << "\t\t" << j[i].profit;
    return wi_sch(j, n);
}

int main()
{
    job j[] = {{3, 10, 20}, {1, 24, 50}, {6, 19, 100}, {2, 100, 20}};
    int n = sizeof(j) / sizeof(j[0]);
```

```
    cout << "\n\t\t Practical 10 \n\t Weighted Interval Schedueling \n";


    cout << "\nGiven jobs are :\n\nS.N.\t  Start-time\t  Finish-time\t\tProfit\n";
    for (int i = 0; i < n; i++)
        cout << "\n " << i + 1 << "\t\t" << j[i].start << "\t\t" << j[i].finish << "\t\t" << j[i].profit;


    int mx = max_profit(j, n);
    cout << "\n\nThe Maximum Optimal Profit is : " << mx << endl;
}
```

Output:

```
                Practical 10
         Weighted Interval Schedueling

Given jobs are :

S.N.       Start-time      Finish-time          Profit

 1              3               10              20
 2              1               24              50
 3              6               19              100
 4              2               100             20

Sorted jobs according to respective finish time are :

S.N.       Start-time      Finish-time          Profit

 1              3               10              20
 2              6               19              100
 3              1               24              50
 4              2               100             20

The Maximum Optimal Profit is : 100

--------------------------------
Process exited after 0.1241 seconds with return value 0
Press any key to continue . . .
```

11. Write a program to solve the 0-1 knapsack problem

Answer:

```
#include <bits/stdc++.h>

using namespace std;


// A utility function that returns

// maximum of two integers
```

```
int max(int a, int b) { return (a > b) ? a : b; }

// Returns the maximum value that
// can be put in a knapsack of capacity W
int knapSack(int W, int wt[], int val[], int n)
{

    // Base Case
    if (n == 0 || W == 0)
        return 0;

    // If weight of the nth item is more
    // than Knapsack capacity W, then
    // this item cannot be included
    // in the optimal solution
    if (wt[n - 1] > W)
        return knapSack(W, wt, val, n - 1);

    // Return the maximum of two cases:
    // (1) nth item included
    // (2) not included
    else
        return max(
            val[n - 1]
                + knapSack(W - wt[n - 1],
                           wt, val, n - 1),
            knapSack(W, wt, val, n - 1));
}
```

```
// Driver code
int main()
{
    int val[] = { 60, 100, 120 };
    int wt[] = { 10, 20, 30 };
    int W = 50;
    int n = sizeof(val) / sizeof(val[0]);
    cout << knapSack(W, wt, val, n);
    return 0;
}
```

Output: