

**Graph Theory**

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**Submitted to:**

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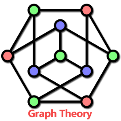
professional behaviours for a harmonious and prosperous society.

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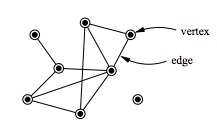
scientific and technological age.

Content 

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| --- | --- | --- | --- |
| **SNo.** | **Practical Name / Description** | **Date** | **Remarks** |
| 1) | Write a program to find the number of vertices , even vertices , odd vertices and the number of edges in a graph |  |  |
| 2) | Write a program to find UNION, INTERSECTION and RING SUM of two graphs. |  |  |
| 3) | Write a program to find minimum spannin tree of a graph using Prim’s Algorithm. |  |  |
| 4) | Write a program to find minimum spanning tree of a graph using Kruskal’s Algorithm. |  |  |
| 5) | between 2 vertices in a graph using Disjkstra’s Algorithm. |  |  |
| 6) | between every pair of vertices in a graph using Floyd Warshall’s algorithm. |  |  |
| 7) | Write a program to find shortest path between every pair of vertices in a graph using Bellman Ford’s algorithm. |  |  |
| 8) | Write a program to find maximum matching in a bipartite graph. |  |  |
| 9) | Write a program to find maximum matching for general graph. |  |  |
| 10) | Write a program to find max flow from source node to sink using Ford- Fulkerson algorithm. |  |  |

Practical 1:

**Aim:** Write a program to find the number of vertices, even vertices, odd vertices and the number of edges in a graph.



**URL to Code**: <https://ide.geeksforgeeks.org/XlvtxaYHHN>

**Code**:

#include<bits/stdc++.h>

#include<iostream>

#include<string>

#include<algorithm>

using namespace std;

class Graph

{

int V;

list < int >\* adj;

public:

Graph(int V)

{

this->V = V;

adj = new list<int>[V];

}

void addEdge(int u, int v);

int countEdges();

void count\_evenOdd();

};

void Graph::addEdge(int u, int v)

{

adj[u].push\_back(v);

adj[v].push\_back(u);

}

int Graph::countEdges()

{

int sum = 0;

for (int i = 0; i < V; i++)

sum += adj[i].size();

return sum / 2;

}

void Graph::count\_evenOdd() {

int even\_degree = 0, odd\_degree = 0;

for (int i = 0; i < V; i++) {

int degree = adj[i].size();

if (degree % 2 == 0)

even\_degree++;

else

odd\_degree++;

}

cout << "No. of even vertices:" << even\_degree << endl;

cout << "No. of odd vertices:" << odd\_degree << endl;

}

int main()

{

int V, E, u, v, w;

// cout<<"No. of Vertices:";

cin >> V;

// cout<<"No. of Edges:";

cin >> E;

Graph g(V);

for (int i = 0; i < E; i++) {

cin >> u;

cin >> v;

g.addEdge(u, v);

}

cout << "No.of vertices : " << V << endl;

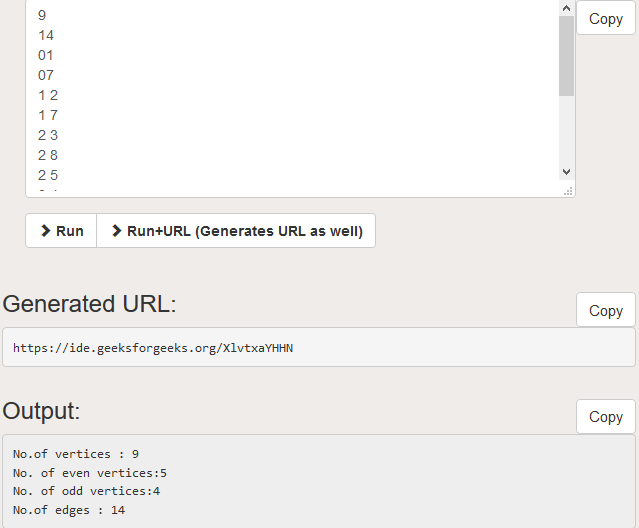
g.count\_evenOdd();

cout << "No.of edges : " << g.countEdges() << endl;

return 0;

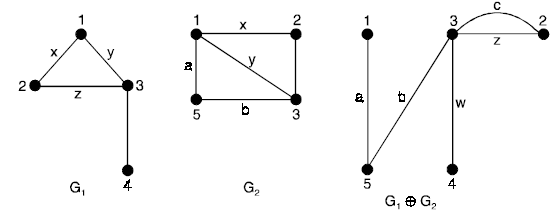
}

**Output:**



Practical 2:

**Aim:** Write a program to find UNION, INTERSECTION and RING SUM of two graphs.



**URL to Code**: <https://ide.geeksforgeeks.org/L1GNIw3tuu>

**Code**:

#include<iostream>

#include<stdio.h>

using namespace std;

int unionPrint(int arr1[], int arr2[], int m, int n)

{

int i = 0, j = 0;

while (i < m && j < n)

{

if (arr1[i] < arr2[j])

printf(" %d ", arr1[i++]);

else if (arr2[j] < arr1[i])

printf(" %d ", arr2[j++]);

else

{

printf(" %d ", arr2[j++]);

i++;

}

}

while (i < m)

printf(" %d ", arr1[i++]);

while (j < n)

printf(" %d ", arr2[j++]);

}

int intersectionPrint(int arr1[], int arr2[], int m, int n)

{

int i = 0, j = 0;

while (i < m && j < n)

{

if (arr1[i] < arr2[j])

i++;

else if (arr2[j] < arr1[i])

j++;

else

{

printf(" %d ", arr2[j++]);

i++;

}

}

}

int main()

{

int m, n, i, j, k;

cout << "Enter the number of vertices in G1 & G2 : ";

cin >> m >> n;

int V1[m], V2[n];

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

{

V1[i] = i;

}

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

V2[i] = i;

}

int E1[m][m], E2[n][n], E3[m + n][m + n];

printf("Enter the adjacency matrix(symmetric) for graph G1:\n");

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

{

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

{

printf("E1[%d][%d]=", i, j);

scanf("%d", &E1[i][j]);

}

}

printf("Enter the adjacency matrix(symmetric) for graph G2:\n");

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

{

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

{

printf("E2[%d][%d]=", i, j);

scanf("%d", &E2[i][j]);

}

}

printf("\nSet of vertices in union of the graphs G1 and G2 is:\n");

unionPrint(V1, V2, m, n);

printf("\n");

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

{

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

{

if (E1[i][j] > E2[i][j] && i < m && j < m)

E3[i][j] = E1[i][j];

else if (E1[i][j] < E2[i][j] && i < m && j < m)

E3[i][j] = E2[i][j];

else

E3[i][j] = E2[i][j];

}

}

printf("Adjacency matrix of union of graphs G1 and G2 is:\n\t");

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

{

Cout<<"%d\t"<< i;

}

printf("\n\t");

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

{

printf("\_\_\_\_\_\_\_");

}

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

{

printf("\n%d|\t", i);

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

{

printf("%d\t", E3[i][j]);

}

}

printf("\nSet of vertices in intersection of the graphs G1 and G2 is:\n");

intersectionPrint(V1, V2, m, n);

printf("\n");

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

{

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

{

if (E1[i][j] > E2[i][j])

E3[i][j] = E1[i][j];

else

E3[i][j] = E2[i][j];

}

}

printf("Adjacency matrix of intersection of graphs G1 and G2 is:\n\t");

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

{

printf("%d\t", i);

}

printf("\n\t");

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

{

printf("\_\_\_\_\_\_\_");

}

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

{

printf("\n%d|\t", i);

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

{

printf("%d\t", E3[i][j]);

}

}

printf("\nSet of vertices in ring sum of the graphs G1 and G2 is:\n");

printUnion(V1, V2, m, n);

printf("\n");

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

{

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

{

if (E1[i][j] == E2[i][j] && i < m && j < m)

E3[i][j] = 0;

else if (E1[i][j] < E2[i][j] && i < m && j < m)

E3[i][j] = E2[i][j];

if (E1[i][j] < E2[i][j] && i < m && j < m)

E3[i][j] = E1[i][j];

else

E3[i][j] = E2[i][j];

}

}

printf("Adjacency matrix of ring sum of graphs G1 and G2 is:\n\t");

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

{

printf("%d\t", i);

}

printf("\n\t");

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

{

printf("\_\_\_\_\_\_\_");

}

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

{

Cout<<"\n%d|\t"<<i

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

{

Cout<<"%d\t"<< E3[i][j];

}

}

return 0;

}

**Output:**



Practical 3:

**Aim:** Write a program to find minimum spanning tree of a graph using Prim’s Algorithm.

**URL to Code**: <https://ide.geeksforgeeks.org/ZXR5ROSvDa>

**Code**:

#include <bits/stdc++.h>

using namespace std;

// Number of vertices in the graph

#define V 5

int minKey(int key[], bool mstSet[])

{

// Initialize min value

int min = INT\_MAX, min\_index;

for (int v = 0; v < V; v++)

if (mstSet[v] == false && key[v] < min)

min = key[v], min\_index = v;

return min\_index;

}

void printMST(int parent[], int graph[V][V])

{

cout << "Edge \tWeight\n";

for (int i = 1; i < V; i++)

cout << parent[i] << " - " << i << " \t" << graph[i][parent[i]] << " \n";

}

void primMST(int graph[V][V])

{

// Array to store constructed MST

int parent[V];

// Key values used to pick minimum weight edge in cut

int key[V];

// To represent set of vertices not yet included in MST

bool mstSet[V];

// Initialize all keys as INFINITE

for (int i = 0; i < V; i++)

key[i] = INT\_MAX, mstSet[i] = false;

// Always include first 1st vertex in MST.

// Make key 0 so that this vertex is picked as first vertex.

key[0] = 0;

parent[0] = -1; // First node is always 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);

// Add the picked vertex to the MST Set

mstSet[u] = true;

// Update key value and parent index of

// the adjacent vertices of the picked vertex.

// Consider only those vertices which are not

// yet included in MST

for (int v = 0; v < V; v++)

// graph[u][v] is non zero only for adjacent vertices of m

// mstSet[v] is false for vertices not yet included in MST

// Update the key only if graph[u][v] is smaller than key[v]

if (graph[u][v] && mstSet[v] == false && graph[u][v] < key[v])

parent[v] = u, key[v] = graph[u][v];

}

// print the constructed MST

printMST(parent, graph);

}

// Driver code

int main()

{

int graph[V][V] = { { 0, 2, 0, 6, 0 },

{ 2, 0, 3, 8, 5 },

{ 0, 3, 0, 0, 7 },

{ 6, 8, 0, 0, 9 },

{ 0, 5, 7, 9, 0 } };

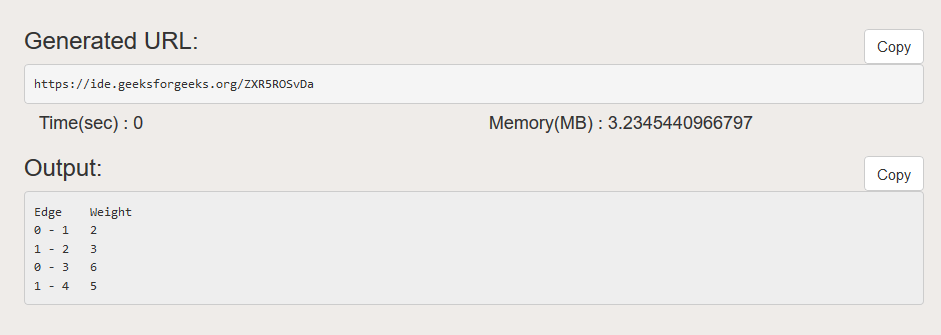
// Print the solution

primMST(graph);

return 0;

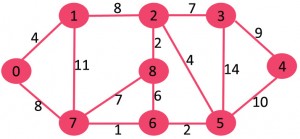
}

**Output:**



Practical 4:

**Aim:** Write a program to find minimum spanning tree of a graph using Kruskal’s Algorithm.



**URL to Code**: <https://ide.geeksforgeeks.org/TvR0AjbQIR>

**Code**:

#include <bits/stdc++.h>

using namespace std;

// a structure to represent a weighted edge in graph

class Edge

{

public:

int src, dest, weight;

};

// a structure to represent a connected, undirected

// and weighted graph

class Graph

{

public:

// V-> Number of vertices, E-> Number of edges

int V, E;

Edge\* edge;

};

// Creates a graph with V vertices and E edges

Graph\* createGraph(int V, int E)

{

Graph\* graph = new Graph;

graph->V = V;

graph->E = E;

graph->edge = new Edge[E];

return graph;

}

// A structure to represent a subset for union-find

class subset

{

public:

int parent;

int rank;

};

// A utility function to find set of an element i

// (uses path compression technique)

int find(subset subsets[], int i)

{

// find root and make root as parent of i

// (path compression)

if (subsets[i].parent != i)

subsets[i].parent = find(subsets, subsets[i].parent);

return subsets[i].parent;

}

// A function that does union of two sets of x and y

// (uses union by rank)

void Union(subset subsets[], int x, int y)

{

int xroot = find(subsets, x);

int yroot = find(subsets, y);

// Attach smaller rank tree under root of high

// rank tree (Union by Rank)

if (subsets[xroot].rank < subsets[yroot].rank)

subsets[xroot].parent = yroot;

else if (subsets[xroot].rank > subsets[yroot].rank)

subsets[yroot].parent = xroot;

// If ranks are same, then make one as root and

// increment its rank by one

else

{

subsets[yroot].parent = xroot;

subsets[xroot].rank++;

}

}

// Compare two edges according to their weights.

// Used in qsort() for sorting an array of edges

int myComp(const void\* a, const void\* b)

{

Edge\* a1 = (Edge\*)a;

Edge\* b1 = (Edge\*)b;

return a1->weight > b1->weight;

}

// The main function to construct MST using Kruskal's algorithm

void KruskalMST(Graph\* graph)

{

int V = graph->V;

Edge result[V]; // Tnis will store the resultant MST

int e = 0; // An index variable, used for result[]

int i = 0; // An index variable, used for sorted edges

// Step 1: Sort all the edges in non-decreasing order

qsort(graph->edge, graph->E, sizeof(graph->edge[0]), myComp);

// Allocate memory for creating V ssubsets

subset\* subsets = new subset[(V \* sizeof(subset))];

// Create V subsets with single elements

for (int v = 0; v < V; ++v)

{

subsets[v].parent = v;

subsets[v].rank = 0;

}

// Number of edges to be taken is equal to V-1

while (e < V - 1 && i < graph->E)

{

// Step 2: Pick the smallest edge. And increment

// the index for next iteration

Edge next\_edge = graph->edge[i++];

int x = find(subsets, next\_edge.src);

int y = find(subsets, next\_edge.dest);

// If including this edge does't cause cycle,

// include it in result and increment the index

// of result for next edge

if (x != y)

{

result[e++] = next\_edge;

Union(subsets, x, y);

}

// Else discard the next\_edge

}

// print the contents of result[] to display the

// built MST

cout << "Following are the edges in the constructed MST\n";

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

cout << result[i].src << " -- " << result[i].dest << " == " << result[i].weight << endl;

return;

}

// Driver code

int main()

{

int V = 4; // Number of vertices in graph

int E = 5; // Number of edges in graph

Graph\* graph = createGraph(V, E);

// add edge 0-1

graph->edge[0].src = 0;

graph->edge[0].dest = 1;

graph->edge[0].weight = 10;

// add edge 0-2

graph->edge[1].src = 0;

graph->edge[1].dest = 2;

graph->edge[1].weight = 6;

// add edge 0-3

graph->edge[2].src = 0;

graph->edge[2].dest = 3;

graph->edge[2].weight = 5;

// add edge 1-3

graph->edge[3].src = 1;

graph->edge[3].dest = 3;

graph->edge[3].weight = 15;

// add edge 2-3

graph->edge[4].src = 2;

graph->edge[4].dest = 3;

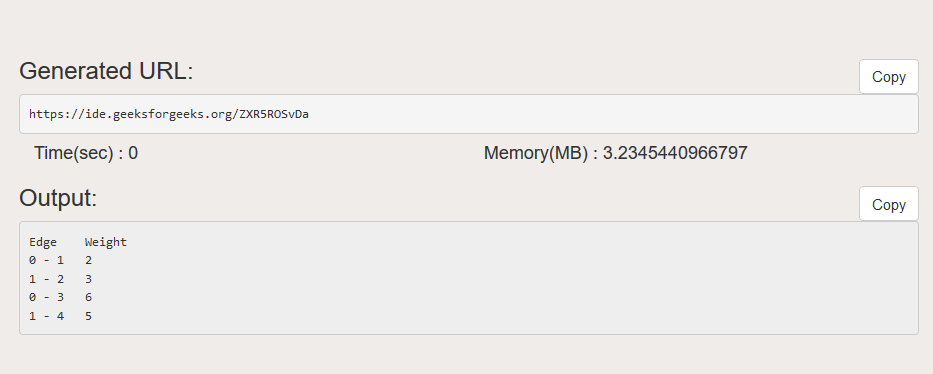
graph->edge[4].weight = 4;

KruskalMST(graph);

return 0;

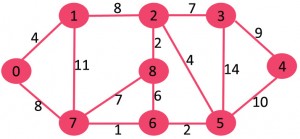
}

**Output:**



Practical 5:

**Aim:** Write a program to find shortest path between 2 vertices in a graph using Dijkstra’s Algorithm.





**URL to Code**: <https://ide.geeksforgeeks.org/TvR0AjbQIR>

**Code**:

#include <limits.h>

#include <stdio.h>

#define V 9

int minDistance(int dist[], bool sptSet[])

{

// Initialize min value

int min = INT\_MAX, 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;

}

int printSolution(int dist[])

{

printf("Vertex \t\t Distance from Source\n");

for (int i = 0; i < V; i++)

printf("%d \t\t %d\n", i, dist[i]);

}

void dijkstra(int graph[V][V], int src)

{

int dist[V]; // The output array. dist[i] will hold the shortest

// distance from src to i

bool sptSet[V]; // sptSet[i] will be true if vertex i is included in shortest

// path tree or shortest distance from src to i is finalized

// Initialize all distances as INFINITE and stpSet[] as false

for (int i = 0; i < V; i++)

dist[i] = INT\_MAX, sptSet[i] = false;

// Distance of source vertex from itself is always 0

dist[src] = 0;

// Find shortest path for all vertices

for (int count = 0; count < V - 1; count++) {

// Pick the minimum distance vertex from the set of vertices not

// yet processed. u is always equal to src in the first iteration.

int u = minDistance(dist, sptSet);

// Mark the picked vertex as processed

sptSet[u] = true;

// Update dist value of the adjacent vertices of the picked vertex.

for (int v = 0; v < V; v++)

// Update dist[v] only if is not in sptSet, there is an edge from

// u to v, and total weight of path from src to v through u is

// smaller than current value of dist[v]

if (!sptSet[v] && graph[u][v] && dist[u] != INT\_MAX

&& dist[u] + graph[u][v] < dist[v])

dist[v] = dist[u] + graph[u][v];

}

// print the constructed distance array

printSolution(dist);

}

// driver program to test above function

int main()

{

int graph[V][V] = { { 0, 4, 0, 0, 0, 0, 0, 8, 0 },

{ 4, 0, 8, 0, 0, 0, 0, 11, 0 },

{ 0, 8, 0, 7, 0, 4, 0, 0, 2 },

{ 0, 0, 7, 0, 9, 14, 0, 0, 0 },

{ 0, 0, 0, 9, 0, 10, 0, 0, 0 },

{ 0, 0, 4, 14, 10, 0, 2, 0, 0 },

{ 0, 0, 0, 0, 0, 2, 0, 1, 6 },

{ 8, 11, 0, 0, 0, 0, 1, 0, 7 },

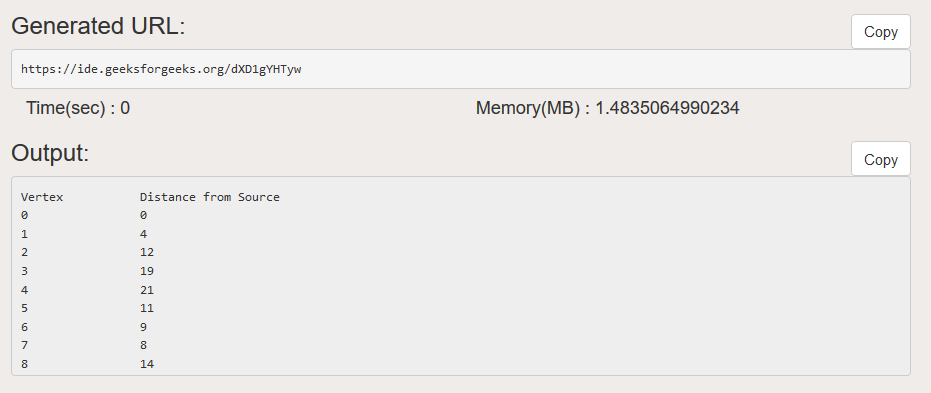
{ 0, 0, 2, 0, 0, 0, 6, 7, 0 } };

dijkstra(graph, 0);

return 0;

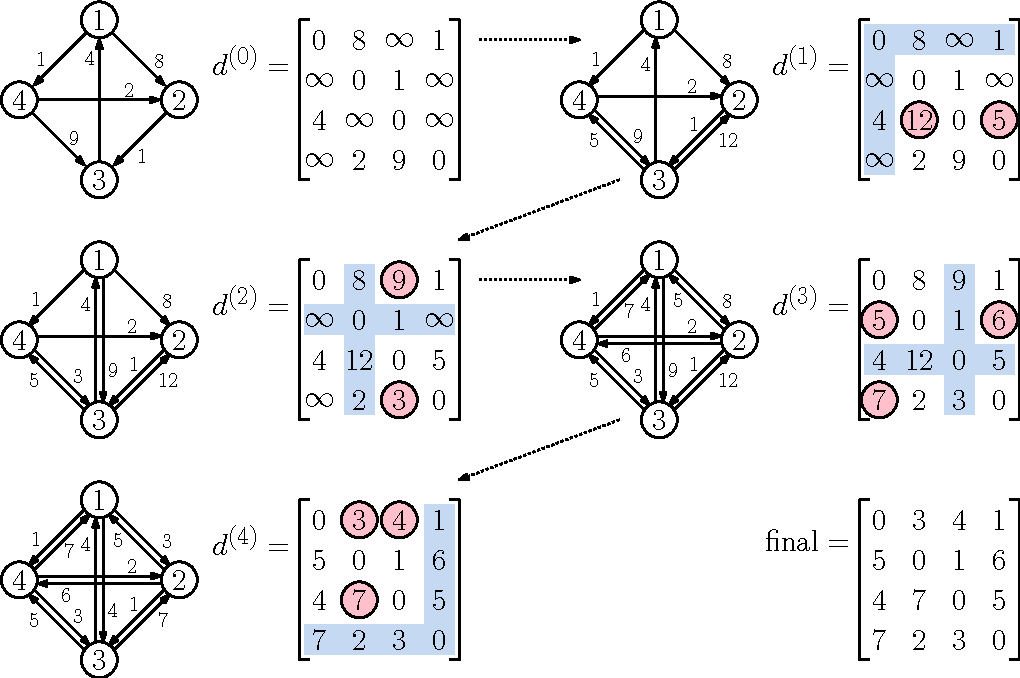
}

**Output:**



Practical 6:

**Aim:** Write a program to find shortest path between every pair of vertices in a graph using Floyd Warshall’s algorithm.



**URL to Code**: https://ide.geeksforgeeks.org/LJBGuaqtQm

**Code**:

#include <bits/stdc++.h>

using namespace std;

// Number of vertices in the graph

#define V 4

#define INF 99999

void printSolution(int dist[][V]);

void floydWarshall(int graph[][V])

{

int dist[V][V], i, j, k;

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

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

dist[i][j] = graph[i][j];

for (k = 0; k < V; k++)

{

// Pick all vertices as source one by one

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

{

// Pick all vertices as destination for the

// above picked source

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

{

// If vertex k is on the shortest path from

// i to j, then update the value of dist[i][j]

if (dist[i][k] + dist[k][j] < dist[i][j])

dist[i][j] = dist[i][k] + dist[k][j];

}

}

}

// Print the shortest distance matrix

printSolution(dist);

}

/\* A utility function to print solution \*/

void printSolution(int dist[][V])

{

cout << "The following matrix shows the shortest distances"

" between every pair of vertices \n";

for (int i = 0; i < V; i++)

{

for (int j = 0; j < V; j++)

{

if (dist[i][j] == INF)

cout << "INF" << " ";

else

cout << dist[i][j] << " ";

}

cout << endl;

}

}

// Driver code

int main()

{

int graph[V][V] = { {0, 5, INF, 10},

{INF, 0, 3, INF},

{INF, INF, 0, 1},

{INF, INF, INF, 0}

};

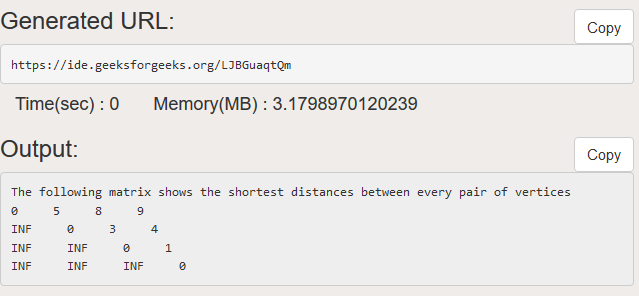
// Print the solution

floydWarshall(graph);

return 0;

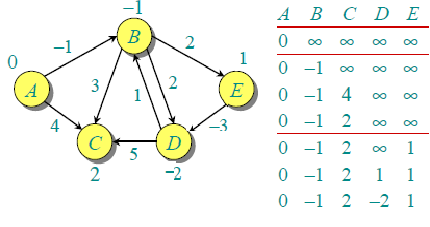
}

**Output:**



Practical 7:

**Aim:** Write a program to find shortest path between every pair of vertices in a graph using Bellman Ford’s algorithm.



**URL to Code**: https://ide.geeksforgeeks.org/qNjvnG5y5i

**Code**:

#include <bits/stdc++.h>

struct Edge {

int src, dest, weight;

};

struct Graph {

int V, E;

struct Edge\* edge;

};

struct Graph\* createGraph(int V, int E)

{

struct Graph\* graph = new Graph;

graph->V = V;

graph->E = E;

graph->edge = new Edge[E];

return graph;

}

// A utility function used to print the solution

void printArr(int dist[], int n)

{

printf("Vertex Distance from Source\n");

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

printf("%d \t\t %d\n", i, dist[i]);

}

void BellmanFord(struct Graph\* graph, int src)

{

int V = graph->V;

int E = graph->E;

int dist[V];

for (int i = 0; i < V; i++)

dist[i] = INT\_MAX;

dist[src] = 0;

for (int i = 1; i <= V - 1; i++) {

for (int j = 0; j < E; j++) {

int u = graph->edge[j].src;

int v = graph->edge[j].dest;

int weight = graph->edge[j].weight;

if (dist[u] != INT\_MAX && dist[u] + weight < dist[v])

dist[v] = dist[u] + weight;

}

}

for (int i = 0; i < E; i++) {

int u = graph->edge[i].src;

int v = graph->edge[i].dest;

int weight = graph->edge[i].weight;

if (dist[u] != INT\_MAX && dist[u] + weight < dist[v]) {

printf("Graph contains negative weight cycle");

return; // If negative cycle is detected, simply return

}

}

printArr(dist, V);

return;

}

// Driver program to test above functions

int main()

{

int V = 5; // Number of vertices in graph

int E = 8; // Number of edges in graph

struct Graph\* graph = createGraph(V, E);

// add edge 0-1 (or A-B in above figure)

graph->edge[0].src = 0;

graph->edge[0].dest = 1;

graph->edge[0].weight = -1;

// add edge 0-2 (or A-C in above figure)

graph->edge[1].src = 0;

graph->edge[1].dest = 2;

graph->edge[1].weight = 4;

// add edge 1-2 (or B-C in above figure)

graph->edge[2].src = 1;

graph->edge[2].dest = 2;

graph->edge[2].weight = 3;

// add edge 1-3 (or B-D in above figure)

graph->edge[3].src = 1;

graph->edge[3].dest = 3;

graph->edge[3].weight = 2;

// add edge 1-4 (or A-E in above figure)

graph->edge[4].src = 1;

graph->edge[4].dest = 4;

graph->edge[4].weight = 2;

// add edge 3-2 (or D-C in above figure)

graph->edge[5].src = 3;

graph->edge[5].dest = 2;

graph->edge[5].weight = 5;

// add edge 3-1 (or D-B in above figure)

graph->edge[6].src = 3;

graph->edge[6].dest = 1;

graph->edge[6].weight = 1;

// add edge 4-3 (or E-D in above figure)

graph->edge[7].src = 4;

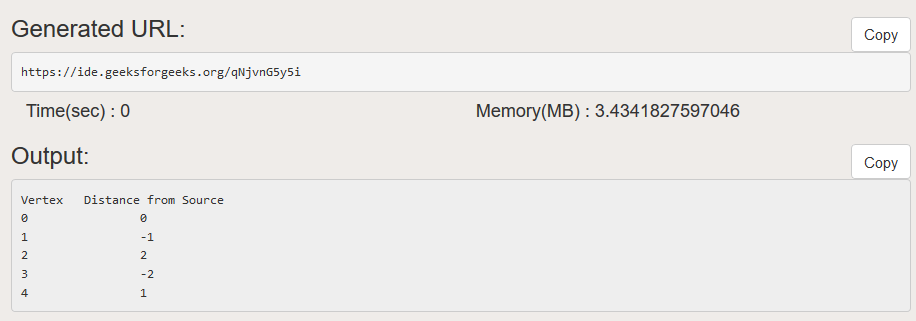
graph->edge[7].dest = 3;

graph->edge[7].weight = -3;

BellmanFord(graph, 0);

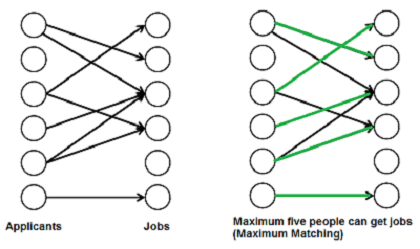
return 0;

}**Output:**



Practical 8:

**Aim:** Write a program to find maximum matching in a bipartite graph.



**URL to Code**: https://ide.geeksforgeeks.org/JHnbrDtIFH

**Code**:

#include <iostream>

#include <string.h>

using namespace std;

#define M 6

#define N 6

bool bpm(bool bpGraph[M][N], int u,

bool seen[], int matchR[])

{

for (int v = 0; v < N; v++)

{

if (bpGraph[u][v] && !seen[v])

{

// Mark v as visited

seen[v] = true;

if (matchR[v] < 0 || bpm(bpGraph, matchR[v],

seen, matchR))

{

matchR[v] = u;

return true;

}

}

}

return false;

}

int maxBPM(bool bpGraph[M][N])

{

int matchR[N];

// Initially all jobs are available

memset(matchR, -1, sizeof(matchR));

// Count of jobs assigned to applicants

int result = 0;

for (int u = 0; u < M; u++)

{

bool seen[N];

memset(seen, 0, sizeof(seen));

// Find if the applicant 'u' can get a job

if (bpm(bpGraph, u, seen, matchR))

result++;

}

return result;

}

int main()

{

bool bpGraph[M][N] = { {0, 1, 1, 0, 0, 0},

{1, 0, 0, 1, 0, 0},

{0, 0, 1, 0, 0, 0},

{0, 0, 1, 1, 0, 0},

{0, 0, 0, 0, 0, 0},

{0, 0, 0, 0, 0, 1} };

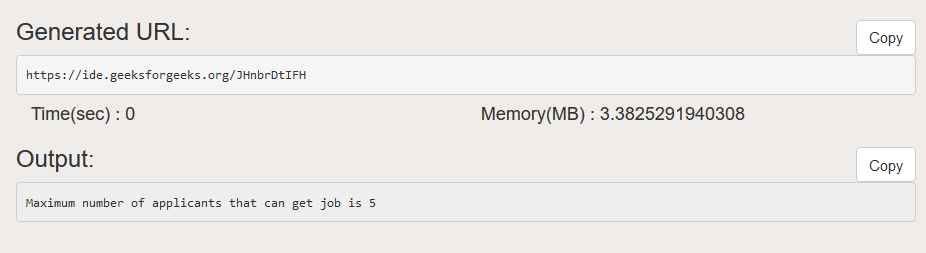
cout << "Maximum number of applicants that can get job is "

<< maxBPM(bpGraph);

return 0;

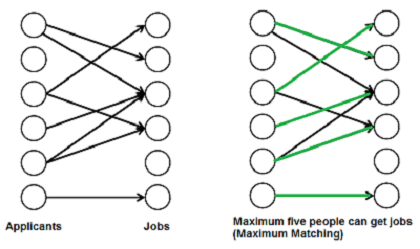
}

**Output:**



Practical 9:

**Aim:** Write a program to find maximum matching for a general graph.



**URL to Code**: https://ide.geeksforgeeks.org/ZoQagFGJIk

**Code**:

#include <bits/stdc++.h>

using namespace std;

const int M = 500;

struct struct\_edge { int v; struct\_edge\* n; };

typedef struct\_edge\* edge;

struct\_edge pool[M \* M \* 2];

edge top = pool, adj[M];

int V, E, match[M], qh, qt, q[M], father[M], base[M];

bool inq[M], inb[M], ed[M][M];

void add\_edge(int u, int v)

{

top->v = v, top->n = adj[u], adj[u] = top++;

top->v = u, top->n = adj[v], adj[v] = top++;

}

int LCA(int root, int u, int v)

{

static bool inp[M];

memset(inp, 0, sizeof(inp));

while (1)

{

inp[u = base[u]] = true;

if (u == root) break;

u = father[match[u]];

}

while (1)

{

if (inp[v = base[v]]) return v;

else v = father[match[v]];

}

}

void mark\_blossom(int lca, int u)

{

while (base[u] != lca)

{

int v = match[u];

inb[base[u]] = inb[base[v]] = true;

u = father[v];

if (base[u] != lca) father[u] = v;

}

}

void blossom\_contraction(int s, int u, int v)

{

int lca = LCA(s, u, v);

memset(inb, 0, sizeof(inb));

mark\_blossom(lca, u);

mark\_blossom(lca, v);

if (base[u] != lca)

father[u] = v;

if (base[v] != lca)

father[v] = u;

for (int u = 0; u < V; u++)

if (inb[base[u]])

{

base[u] = lca;

if (!inq[u])

inq[q[++qt] = u] = true;

}

}

int find\_augmenting\_path(int s)

{

memset(inq, 0, sizeof(inq));

memset(father, -1, sizeof(father));

for (int i = 0; i < V; i++) base[i] = i;

inq[q[qh = qt = 0] = s] = true;

while (qh <= qt)

{

int u = q[qh++];

for (edge e = adj[u]; e; e = e->n)

{

int v = e->v;

if (base[u] != base[v] && match[u] != v)

if ((v == s) || (match[v] != -1 && father[match[v]] != -1))

blossom\_contraction(s, u, v);

else if (father[v] == -1)

{

father[v] = u;

if (match[v] == -1)

return v;

else if (!inq[match[v]])

inq[q[++qt] = match[v]] = true;

}

}

}

return -1;

}

int augment\_path(int s, int t)

{

int u = t, v, w;

while (u != -1)

{

v = father[u];

w = match[v];

match[v] = u;

match[u] = v;

u = w;

}

return t != -1;

}

int edmonds()

{

int matchc = 0;

memset(match, -1, sizeof(match));

for (int u = 0; u < V; u++)

if (match[u] == -1)

matchc += augment\_path(u, find\_augmenting\_path(u));

return matchc;

}

int main()

{

int u, v;

cout << "Enter the number of vertices and edges : ";

cin >> V >> E;

cout << "Enter the edges : \n";

while (E--)

{

cin >> u >> v;

if (!ed[u - 1][v - 1])

{

add\_edge(u - 1, v - 1);

ed[u - 1][v - 1] = ed[v - 1][u - 1] = true;

}

}

cout << "Number of matches : " << edmonds() << endl;

cout << "The matches are : \n";

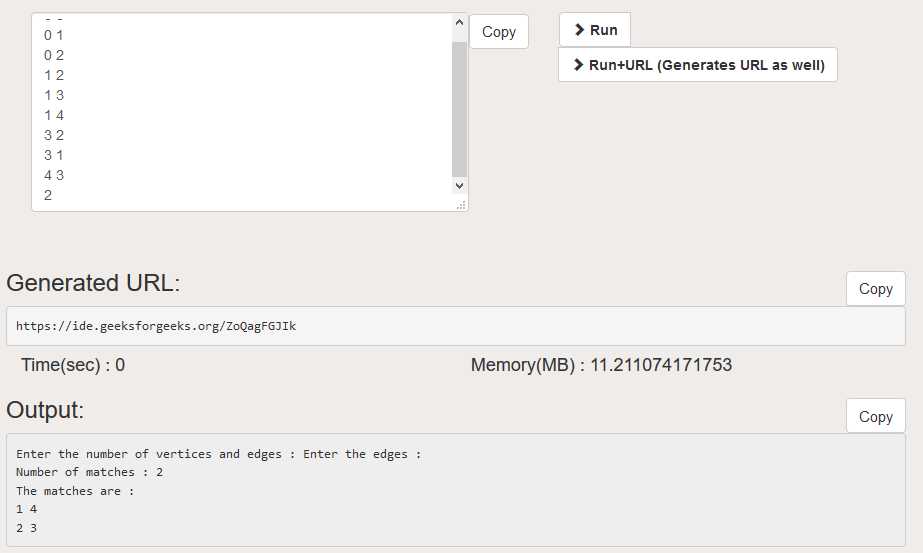
for (int i = 0; i < V; i++)

if (i < match[i])

cout << i + 1 << " " << match[i] + 1 << endl;

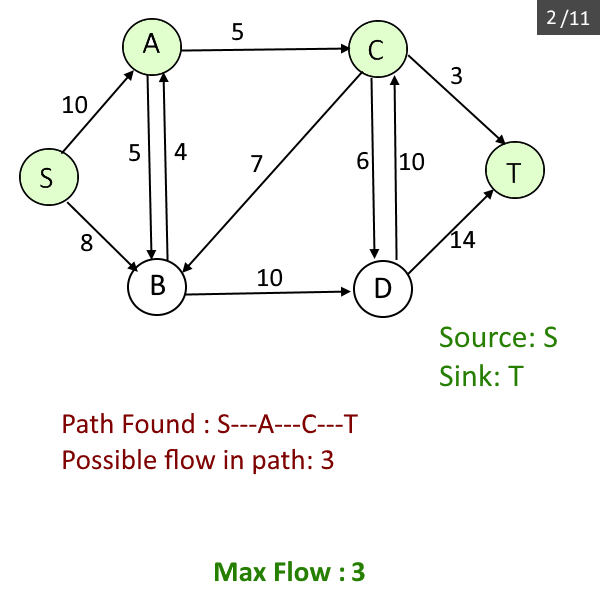
}

**Output:**



Practical 10:

**Aim:** Write a program to find maximum matching for a general graph.



**URL to Code**: https://ide.geeksforgeeks.org/ZoQagFGJIk

**Code**:

#include <iostream>

#include <limits.h>

#include <string.h>

#include <queue>

using namespace std;

#define V 6

bool bfs(int rGraph[V][V], int s, int t, int parent[])

{

bool visited[V];

memset(visited, 0, sizeof(visited));

queue <int> q;

q.push(s);

visited[s] = true;

parent[s] = -1;

while (!q.empty())

{

int u = q.front();

q.pop();

for (int v = 0; v < V; v++)

{

if (visited[v] == false && rGraph[u][v] > 0)

{

q.push(v);

parent[v] = u;

visited[v] = true;

}

}

}

return (visited[t] == true);

}

int fordFulkerson(int graph[V][V], int s, int t)

{

int u, v;

int rGraph[V][V]; // Residual graph where rGraph[i][j] indicates

// residual capacity of edge from i to j (if there

// is an edge. If rGraph[i][j] is 0, then there is not)

for (u = 0; u < V; u++)

for (v = 0; v < V; v++)

rGraph[u][v] = graph[u][v];

int parent[V]; // This array is filled by BFS and to store path

int max\_flow = 0; // There is no flow initially

// Augment the flow while tere is path from source to sink

while (bfs(rGraph, s, t, parent))

{

// Find minimum residual capacity of the edges along the

// path filled by BFS. Or we can say find the maximum flow

// through the path found.

int path\_flow = INT\_MAX;

for (v = t; v != s; v = parent[v])

{

u = parent[v];

path\_flow = min(path\_flow, rGraph[u][v]);

}

// update residual capacities of the edges and reverse edges

// along the path

for (v = t; v != s; v = parent[v])

{

u = parent[v];

rGraph[u][v] -= path\_flow;

rGraph[v][u] += path\_flow;

}

// Add path flow to overall flow

max\_flow += path\_flow;

}

// Return the overall flow

return max\_flow;

}

// Driver program to test above functions

int main()

{

// Let us create a graph shown in the above example

int graph[V][V] = { {0, 16, 13, 0, 0, 0},

{0, 0, 10, 12, 0, 0},

{0, 4, 0, 0, 14, 0},

{0, 0, 9, 0, 0, 20},

{0, 0, 0, 7, 0, 4},

{0, 0, 0, 0, 0, 0}

};

cout << "The maximum possible flow is " << fordFulkerson(graph, 0, 5);

return 0;

}

**Output:**

