DELHI TECHNOLOGICAL UNIVERSITY

GRAPH THEORY
MC-405

Practical File

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INDEX

PRACTICAL – 1

AIM: To write a program to find the number of vertices, even vertices, odd vertices and number of edges in a graph.

CODE:

```
#include <bits/stdc++.h>
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)
        {
            adj[u].push_back(v);
            adj[v].push_back(u);
        }

        int noOfVertices() { return this->V; }

        int countEdges()
        {
            int sum = 0;
            for (int i = 0; i < V; i++)
                sum += adj[i].size();
            return sum / 2;
        }

        int evenVertices()
        {
            int count = 0;
            for (int i = 0; i < this->V; i++)
            {
                if (adj[i].size() % 2 == 0)
                    count++;
            }
            return count;
        }
```

```cpp
        int oddVertices()
        {
            return this->V - evenVertices();
        }
};

int main()
{
    int V = 5;
    Graph g(V);

    g.addEdge(0, 1);
    g.addEdge(3, 2);
    g.addEdge(0, 3);
    g.addEdge(1, 3);
    g.addEdge(2, 4);
    g.addEdge(1, 4);

    cout << "Number of Vertices: " << g.noOfVertices() << endl;
    cout << "Number of Even Vertices: " << g.evenVertices() << endl;
    cout << "Number of Odd Vertices: " << g.oddVertices() << endl;
    cout << "Number of Edges: " << g.countEdges() << endl;

    return 0;
}
```

OUTPUT:

```
Number of Vertices: 5
Number of Even Vertices: 3
Number of Odd Vertices: 2
Number of Edges: 6

Process returned 0 (0x0)   execution time : 0.638 s
Press any key to continue.
```

PRACTICAL – 2

AIM: To write a program to find union, intersection and ring-sum of two graphs.

CODE:

UNION

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

int V1[] = {0, 1};
int V2[] = {0, 1, 2};
int E1[2][2], E2[3][3], E3[5][5];

void Union(int arr1[], int arr2[], int m, int n)
{
    cout << "\nSet of vertices in union of the graphs G1 and G2 is:\n";

    int i = 0, j = 0;
    while (i < m && j < n)
    {
        if (arr1[i] < arr2[j])
            cout << arr1[i++]<<" ";
        else if (arr2[j] < arr1[i])
            cout << arr2[j++]<<" ";
        else
        {
            cout << arr2[j++]<<" ";
            i++;
        }
    }
    while (i < m)
        cout << arr1[i++]<<" ";
    while (j < n)
        cout << arr2[j++]<<" ";

    cout << "\n";
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < n; j++)
        {
            if (i < m && j < m && E1[i][j] > E2[i][j])
                E3[i][j] = E1[i][j];
            else if (i < m && j < m && E1[i][j] < E2[i][j])
                E3[i][j] = E2[i][j];
            else
                E3[i][j] = E2[i][j];
        }
```

```
    }

    cout << "\nAdjacency matrix of union of graphs G1 and G2 is:\n";
    for (i = 0; i < n; i++)
    {
        cout << "\t" << i;
    }
    cout << "\n\t";
    for (i = 0; i < n; i++)
    {
        cout << " ";
    }
    for (i = 0; i < n; i++)
    {
        cout << "\n"
             << i << "|\t";
        for (j = 0; j < n; j++)
        {
            cout << E3[i][j] << "\t";
        }
    }
    cout << "\n";
}

int main()
{

    int m = sizeof(V1) / sizeof(V1[0]);
    int n = sizeof(V2) / sizeof(V2[0]);

    int i, j, k;
    cout << "Enter the adjacency matrix(symmetric) for graph 1:" << endl;
    for (i = 0; i < m; i++)
    {
        for (j = 0; j < m; j++)
            cin >> E1[i][j];

    }

    cout << "\nEnter the adjacency matrix(symmetric) for graph 2"<<endl;
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < n; j++)
            cin >> E2[i][j];
    }

    Union(V1, V2, m, n);

    return 0;
}
```

Output

```
Enter the adjacency matrix(symmetric) for graph 1:
0 1
1 0

Enter the adjacency matrix(symmetric) for graph 2
0 0 1
0 0 1
1 1 0

Set of vertices in union of the graphs G1 and G2 is:
0 1 2

Adjacency matrix of union of graphs G1 and G2 is:
        0       1       2

0|      0       1       1
1|      1       0       1
2|      1       1       0

Process returned 0 (0x0)   execution time : 16.061 s
Press any key to continue.
```

INTERSECTION

```
void intersection(int arr1[], int arr2[], int m, int n)
{
    cout << "\nSet of vertices in intersection of the graphs G1 and G2
is:\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
        {
            cout << arr2[j++]<<" ";
            i++;
        }
    }

    cout << "\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] = 0;
        }

    cout << "\nAdjacency matrix of intersection of graphs G1 and G2 is:\n\t";

    for (i = 0; i < m; i++)
        cout << i << "\t";
    cout << "\n\t";
    for (i = 0; i < m; i++)
        cout << " ";
    for (i = 0; i < m; i++)
    {
        cout << "\n"
             << i << "|\t";
        for (j = 0; j < m; j++)
        {
            cout << E3[i][j] << "\t";
        }
    }
    cout << endl;
}
```

Output

```
Enter the adjacency matrix(symmetric) for graph 1:
0 1
1 0

Enter the adjacency matrix(symmetric) for graph 2:
0 1 1
1 0 0
1 0 0

Set of vertices in intersection of the graphs G1 and G2 is:
0 1

Adjacency matrix of intersection of graphs G1 and G2 is:
        0       1

0|      0       1
1|      1       0

Process returned 0 (0x0)   execution time : 12.935 s
Press any key to continue.
```

RING SUM

```
void ring_sum(int arr1[], int arr2[], int m, int n)
{
    cout << "\nSet of vertices in ring sum of the graphs G1 and G2 are:\n";
    int i = 0, j = 0;
    while (i < m && j < n)
    {
        if (arr1[i] < arr2[j])
            cout << arr1[i++]<<" ";
        else if (arr2[j] < arr1[i])
            cout << arr2[j++]<<" ";
        else
        {
            cout << arr2[j++]<<" ";
            i++;
        }
    }
    while (i < m)
        cout << arr1[i++];
    while (j < n)
        cout << arr2[j++];

    cout << "\n";
    for (i = 0; i < n; i++){
        for (j = 0; j < n; j++)
        {
            if (i<m && j<m && E1[i][j] == E2[i][j])
                E3[i][j] = 0;
            else if (i<m && j<m && E1[i][j]>E2[i][j])
                E3[i][j] = E1[i][j];
            else
                E3[i][j] = E2[i][j];
        }
    }

    cout << "\nAdjacency matrix of ring sum of graphs G1 and G2 is:\n\t";
    for (i = 0; i < n; i++)
        cout << i << "\t";
    cout << "\n\t";

    for (i = 0; i < n; i++)
        cout << " ";
    for (i = 0; i < n; i++)
    {
        cout << "\n"
             << i << "|\t";
        for (j = 0; j < n; j++)
        {
            cout << E3[i][j] << "\t";
        }
    }
}
```

Output

```
Enter the adjacency matrix(symmetric) for graph G1:
0 1 1
1 0 0
1 0 0

Enter the adjacency matrix(symmetric) for graph G2:
0 1 0
1 0 1
0 1 0

Set of vertices in ring sum of the graphs G1 and G2 are:
0 1 2

Adjacency matrix of ring sum of graphs G1 and G2 is:
        0       1       2

0|      0       0       1
1|      0       0       1
2|      1       1       0

Process returned 0 (0x0)   execution time : 26.033 s
Press any key to continue.
```

PRACTICAL – 3

AIM: To write a program to find the minimum spanning tree of a graph using Prim's Algorithm.

CODE:

```
#include <bits/stdc++.h>
using namespace std;

#define V 5

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

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

    return min_index;
}

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])
{
    int parent[V];

    int key[V];

    bool mstSet[V];

    for (int i = 0; i < V; i++)
        key[i] = INT_MAX, mstSet[i] = false;

    key[0] = 0;
    parent[0] = -1;

    for (int count = 0; count < V - 1; count++)
    {
        int u = minKey(key, mstSet);
        mstSet[u] = true;
```

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

    printMST(parent, graph);
}

int main()
{
    int 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 } };

    primMST(graph);

    return 0;
}
```

OUTPUT:

"C:\Users\aiman\Desktop\Semester 7\GT\Practicals\Programs\2K18_MC_008_GT_Practical_3.exe"

```
Edge    Weight
0 - 1   2
1 - 2   3
0 - 3   6
1 - 4   5

Process returned 0 (0x0)   execution time : 13.949 s
Press any key to continue.
```

PRACTICAL – 4

AIM: To write a program to find the minimum spanning tree of a graph using Kruskal's Algorithm.

CODE:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.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 = (struct Graph*)(malloc(sizeof(struct Graph)));
    graph->V = V;
    graph->E = E;

    graph->edge = (struct Edge*)malloc(sizeof( struct Edge)*E);

    return graph;
}

struct subset {
    int parent;
    int rank;
};

int find(struct subset subsets[], int i)
{
    if (subsets[i].parent != i)
        subsets[i].parent
            = find(subsets, subsets[i].parent);

    return subsets[i].parent;
}

void Union(struct subset subsets[], int x, int y)
{
    int xroot = find(subsets, x);
```

```c
    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 myComp(const void* a, const void* b)
{
    struct Edge* a1 = (struct Edge*)a;
    struct Edge* b1 = (struct Edge*)b;
    return a1->weight > b1->weight;
}

void KruskalMST(struct Graph* graph)
{
    int V = graph->V;
    struct Edge
        result[V];
    int e = 0;
    int i = 0;

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

    struct subset* subsets
        = (struct subset*)malloc(V * sizeof(struct subset));

    for (int v = 0; v < V; ++v) {
        subsets[v].parent = v;
        subsets[v].rank = 0;
    }

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

        struct Edge next_edge = graph->edge[i++];

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

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

```
    printf(
        "Following are the edges in the constructed MST\n");
    int minimumCost = 0;
    for (i = 0; i < e; ++i)
    {
        printf("%d -- %d == %d\n", result[i].src,
            result[i].dest, result[i].weight);
        minimumCost += result[i].weight;
    }
    printf("\nMinimum Cost Spanning tree : %d",minimumCost);
    return;
}

int main()
{
    int V = 4;
    int E = 5;
    struct Graph* graph = createGraph(V, E);

    graph->edge[0].src = 0;
    graph->edge[0].dest = 1;
    graph->edge[0].weight = 10;

    graph->edge[1].src = 0;
    graph->edge[1].dest = 2;
    graph->edge[1].weight = 6;

    graph->edge[2].src = 0;
    graph->edge[2].dest = 3;
    graph->edge[2].weight = 5;

    graph->edge[3].src = 1;
    graph->edge[3].dest = 3;
    graph->edge[3].weight = 15;

    graph->edge[4].src = 2;
    graph->edge[4].dest = 3;
    graph->edge[4].weight = 4;

    KruskalMST(graph);

    return 0;
}
```

OUTPUT:

```
"C:\Users\aiman\Desktop\Semester 7\GT\Practicals\Programs\2K18_MC_008_Practical_4.exe"
Following are the edges in the constructed MST
2 -- 3 == 4
0 -- 3 == 5
0 -- 1 == 10

Minimum Cost Spanning tree : 19
Process returned 0 (0x0)   execution time : 7.147 s
Press any key to continue.
```

PRACTICAL – 5

AIM: To write a program to find the shortest path between two vertices in a graph using Dijkstra's Algorithm.

CODE:

```
#include <bits/stdc++.h>
using namespace std;

#define V 8

int minDistance(int dist[], bool sptSet[])
{
    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;
}

void dijkstra(int graph[V][V], int src)
{
    int dist[V];

    bool sptSet[V];

    for (int i = 0; i < V; i++)
        dist[i] = INT_MAX, sptSet[i] = false;

    dist[src] = 0;

    for (int count = 0; count < V - 1; count++) {
        int u = minDistance(dist, sptSet);

        sptSet[u] = true;

        for (int v = 0; v < V; 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];
    }

    for (int i = 0; i < V; i++)
        cout <<"Distance of vertex " << i << " from source is "<<dist[i]<<
endl;
}
```

```
int main()
{
    int graph[V][V] = { { 0, 8, 0, 0, 0, 0, 0, 4},
                        { 8, 0, 4, 0, 0, 0, 0, 1},
                        { 0, 7, 0, 4, 0, 8, 0, 0},
                        { 0, 0, 7, 0, 9, 4, 0, 0},
                        { 0, 0, 0, 9, 0, 10, 0, 0},
                        { 0, 0, 4, 11, 10, 0, 2, 0},
                        { 0, 0, 0, 0, 0, 2, 0, 1},
                        { 8, 6, 0, 0, 0, 0, 11, 0}};

    dijkstra(graph, 0);

    return 0;
}
```

OUTPUT:

"C:\Users\aiman\Desktop\Semester 7\GT\Practicals\Programs\5.exe"

```
Distance of vertex 0 from source is 0
Distance of vertex 1 from source is 8
Distance of vertex 2 from source is 12
Distance of vertex 3 from source is 16
Distance of vertex 4 from source is 25
Distance of vertex 5 from source is 17
Distance of vertex 6 from source is 15
Distance of vertex 7 from source is 4

Process returned 0 (0x0)   execution time : 1.071 s
Press any key to continue.
```

PRACTICAL – 6

AIM: To write a program to find the shortest path between every pair of vertices in a graph using Floyd-Warshall's Algorithm.

CODE:

```
#include<bits/stdc++.h>
using namespace std;

#define N 4
#define INF 100000

void floydWarshall(int g[][N])
{
    int dist[N][N], i, j, k;

    for (i = 0; i < N; i++)
        for (j = 0; j < N; j++)
            dist[i][j] = g[i][j];

    for (k = 0; k < N; k++) {
        for (i = 0; i < N; i++) {
            for (j = 0; j < N; j++) {
                if (dist[i][j] > (dist[i][k] + dist[k][j])
                    && (dist[k][j] != INF
                        && dist[i][k] != INF))
                    dist[i][j] = dist[i][k] + dist[k][j];
            }
        }
    }

    for (int i = 0; i < N; i++) {
        for (int j = 0; j < N; j++) {
            if (dist[i][j] == INF)
                cout << "INF"
                     << " ";
            else
                cout << dist[i][j] << " ";
        }
        cout << endl;
    }
}
```

```
int main(){

    int g[4][4] = {{0 ,5,INF,2},
                   {INF,2,4,1},
                   {INF,INF,0,1},
                   {INF,INF,INF,0}};

    floydWarshall(g);

    return 0;
}
```

OUTPUT:

"C:\Users\aiman\Desktop\Semester 7\GT\Practicals\Programs\2k18_MC_008_Practical_6.exe"

```
0 5 9 2
INF 2 4 1
INF INF 0 1
INF INF INF 0

Process returned 0 (0x0)   execution time : 6.743 s
Press any key to continue.
```

PRACTICAL – 7

AIM: To write a program to find the shortest path between two vertices in a graph using Bellaman Ford's Algorithm.

CODE:

```
#include<bits/stdc++.h>
using namespace std;

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;
}

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++) {
```

```c
        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;
        }
    }

    printf("Vertex Distance from Source\n");
    for (int i = 0; i < V; ++i)
        printf("%d \t\t %d\n", i, dist[i]);

}

int main()
{
    int V = 5;
    int E = 8;
    struct Graph* graph = createGraph(V, E);

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

    graph->edge[1].src = 0;
    graph->edge[1].dest = 2;
    graph->edge[1].weight = 4;

    graph->edge[2].src = 1;
    graph->edge[2].dest = 2;
    graph->edge[2].weight = 3;

    graph->edge[3].src = 1;
    graph->edge[3].dest = 3;
    graph->edge[3].weight = 2;

    graph->edge[4].src = 1;
    graph->edge[4].dest = 4;
    graph->edge[4].weight = 2;

    graph->edge[5].src = 3;
    graph->edge[5].dest = 2;
    graph->edge[5].weight = 5;

    graph->edge[6].src = 3;
    graph->edge[6].dest = 1;
    graph->edge[6].weight = 1;

    graph->edge[7].src = 4;
    graph->edge[7].dest = 3;
    graph->edge[7].weight = -3;
```

```
    BellmanFord(graph, 0);

    return 0;
}
```

OUTPUT:

"C:\Users\aiman\Desktop\Semester 7\GT\Practicals\Programs\2K18_MC_008_GT_Practical_7.exe"

```
Vertex Distance from Source
0               0
1               -1
2               2
3               -2
4               1

Process returned 0 (0x0)   execution time : 7.268 s
Press any key to continue.
```

PRACTICAL – 8

AIM: To write a program to find maximum matching in bipartite graph.

CODE:

```
#include <bits/stdc++.h>
using namespace std;

int n, k;
vector<vector<int>> g;
vector<int> mt;
vector<bool> used;

bool try_kuhn(int v) {
    if (used[v])
        return false;

    used[v] = true;

    for (int to : g[v]) {
        if (mt[to] == -1 || try_kuhn(mt[to])) {
            mt[to] = v;
            return true;
        }
    }

    return false;
}

int main(){

    cin>>n>>k;

    int m;
    cin>>m;

    g.assign(n, vector<int>());

    for(int i =0; i<m; i++){
        int a, b;
        cin>>a>>b;
        g[--a].push_back(--b);
    }

    mt.assign(k, -1);

    for (int v = 0; v < n; ++v) {
        used.assign(n, false);
```

```
            try_kuhn(v);
        }

        int count = 0;

        for (int i = 0; i < k; ++i)
            if (mt[i] != -1)
                count++;

        cout<<"\nMaximum matching in given bipartite graph : \n"<<count<<"\n";
        cout<<"\nIncluded Edges: \n";

        for (int i = 0; i < k; ++i)
            if (mt[i] != -1)
                printf("%d %d\n", mt[i] + 1, i + 1);

        return 0;
}
```

OUTPUT:

"C:\Users\aiman\Desktop\Semester 7\GT\Practicals\Programs\2K18_MC_008_GT_Practical_8.exe"

```
5 4
8
1 1
1 2
2 1
2 2
3 1
3 4
4 3
5 2

Maximum matching in given bipartite graph :
4

Included Edges:
2 1
1 2
4 3
3 4
```

PRACTICAL – 9

AIM: To write a program to find maximum matching in a general graph.

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;
    cin>>V>>E;
```

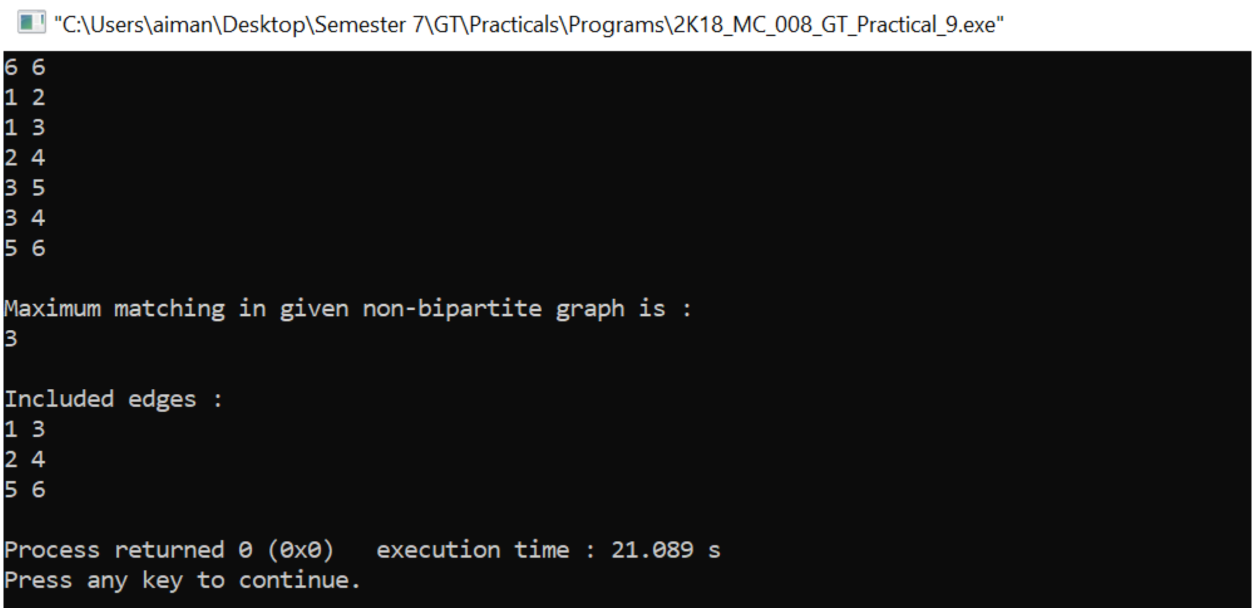
```
    while(E--){
        cin>>u>>v;

        if (!ed[u-1][v-1]){
            add_edge(u-1,v-1);
            ed[u-1][v-1]=ed[v-1][u-1]=true;
        }
    }

      cout<<"\nMaximum matching in given non-bipartite graph is :\n";
      cout<<edmonds()<<endl;
    cout<<"\nIncluded edges :\n";

    for (int i=0;i<V;i++)
        if (i<match[i])
            cout<<i+1<<" "<<match[i]+1<<endl;
}
```

OUTPUT:



```
"C:\Users\aiman\Desktop\Semester 7\GT\Practicals\Programs\2K18_MC_008_GT_Practical_9.exe"
6 6
1 2
1 3
2 4
3 5
3 4
5 6

Maximum matching in given non-bipartite graph is :
3

Included edges :
1 3
2 4
5 6

Process returned 0 (0x0)   execution time : 21.089 s
Press any key to continue.
```

PRACTICAL – 10

AIM: To write a program to find the maximum flow from source node to sink node using Ford-Fulkerson Algorithm.

CODE:

```
#include<bits/stdc++.h>
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) {
                if (v == t) {
                    parent[v] = u;
                    return true;
                }
                q.push(v);
                parent[v] = u;
                visited[v] = true;
            }
        }
    }
    return false;
}

int fordFulkerson(int graph[V][V], int s, int t)
{
    int u, v;

    int rGraph[V][V];

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

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

    int parent[V];

    int max_flow = 0;

    while (bfs(rGraph, s, t, parent)) {
        int path_flow = INT_MAX;
        for (v = t; v != s; v = parent[v]) {
            u = parent[v];
            path_flow = min(path_flow, rGraph[u][v]);
        }

        for (v = t; v != s; v = parent[v]) {
            u = parent[v];
            rGraph[u][v] -= path_flow;
            rGraph[v][u] += path_flow;
        }

        max_flow += path_flow;
    }

    return max_flow;
}

int main()
{
    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 from source to sink is "
         << fordFulkerson(graph, 0, 5);

    return 0;
}
```

OUTPUT:

"C:\Users\aiman\Desktop\Semester 7\GT\Practicals\Programs\2K18_MC_008_GT_Practical_10..exe"

```
The maximum possible flow from source to sink is 23
Process returned 0 (0x0)   execution time : 9.471 s
Press any key to continue.
```