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Lab Assignment 5

1. **Write a program to Eulerian path and circuit, given an undirected/directed graph.**

```
#include<iostream>
#include <list>
using namespace std;
class Graph
{
int V;
list<int> *adj;
public:Graph(int V) {this->V = V; adj = new list<int>[V]; }
~Graph() { delete [] adj; }
void addEdge(int v, int w);
int isEulerian();

bool isConnected();
void DFSUtil(int v, bool visited[]);
};

void Graph::addEdge(int v, int w)
{
adj[v].push_back(w);
adj[w].push_back(v);
}

void Graph::DFSUtil(int v, bool visited[])
{
visited[v] = true;
list<int>::iterator i;
for (i = adj[v].begin(); i != adj[v].end(); ++i)
        if (!visited[*i])
                DFSUtil(*i, visited);
}
bool Graph::isConnected()
{
bool visited[V];
int i;
for (i = 0; i < V; i++)
        visited[i] = false;
for (i = 0; i < V; i++)
        if (adj[i].size() != 0)
                break;
if (i == V)
        return true;
DFSUtil(i, visited);

for (i = 0; i < V; i++)
if (visited[i] == false && adj[i].size() > 0)
                return false;

return true;
}
```

```
/* The function returns one of the following values
0 If graph is not Eulerian
1 If graph has an Euler path (Semi-Eulerian)
2 If graph has an Euler Circuit (Eulerian) */
int Graph::isEulerian()
{
if (isConnected() == false)
        return 0;

// Count vertices with odd degree
int odd = 0;
for (int i = 0; i < V; i++)
        if (adj[i].size() & 1)
                odd++;

// If count is more than 2, then graph is not Eulerian
if (odd > 2)
        return 0;
return (odd)? 1 : 2;
}

void test(Graph &g)
{
int res = g.isEulerian();
if (res == 0)
        cout << "graph is not Eulerian\n";
else if (res == 1)
        cout << "graph has a Euler path\n";
else
        cout << "graph has a Euler cycle\n";
}
int main()
{
Graph g1(5);
g1.addEdge(1, 0);
g1.addEdge(0, 2);
g1.addEdge(2, 1);
g1.addEdge(0, 3);
g1.addEdge(3, 4);
test(g1);

Graph g2(5);
g2.addEdge(1, 0);
g2.addEdge(0, 2);
g2.addEdge(2, 1);
g2.addEdge(0, 3);
g2.addEdge(3, 4);
g2.addEdge(4, 0);
test(g2);

Graph g3(5);
g3.addEdge(1, 0);
g3.addEdge(0, 2);
g3.addEdge(2, 1);
g3.addEdge(0, 3);
```

```
g3.addEdge(3, 4);
g3.addEdge(1, 3);
test(g3);

Graph g4(3);
g4.addEdge(0, 1);
g4.addEdge(1, 2);
g4.addEdge(2, 0);
test(g4);

Graph g5(3);
test(g5);

return 0;
}
```

```
C:\DAA program sem4\euleri
graph has a Euler path
graph has a Euler cycle
graph is not Eulerian
graph has a Euler cycle
graph has a Euler cycle

--------------------------------
Process exited after 0.08495 seconds with return value 0
Press any key to continue . . .
```

2. **Given an adjacency matrix representation of an undirected graph consisting of N vertices, write a program to find whether the graph contains a Hamiltonian Path or not. If found to be true, then print "Yes".**
   Otherwise, print "No".

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

const int MAXN = 10;
bool isSafe(int node, int graph[MAXN][MAXN], int path[], int pos) {
  if (graph[path[pos - 1]][node] == 0) {
    return false;
  }
  for (int i = 0; i < pos; i++) {
    if (path[i] == node) {
      return false;
    }
  }
  return true;
}

bool hamiltonianPathHelper(int graph[MAXN][MAXN], int path[], int pos, int n) {
  if (pos == n) {
    return true;
  }
  for (int node = 1; node < n; node++) {
```

```
        if (isSafe(node, graph, path, pos)) {
            path[pos] = node;
            if (hamiltonianPathHelper(graph, path, pos + 1, n)) {
                return true;
            }

            path[pos] = -1;
        }
    }
    return false;
}
bool hasHamiltonianPath(int graph[MAXN][MAXN], int n) {
    int path[MAXN];
    memset(path, -1, sizeof(path));

    for (int start = 0; start < n; start++) {
        path[0] = start;
        if (hamiltonianPathHelper(graph, path, 1, n)) {
            return true;
        }
    }

    return false;
}

int main() {
    int graph[MAXN][MAXN] = {
        {0, 1, 1, 0, 0},
        {1, 0, 1, 1, 0},
        {1, 1, 0, 1, 1},
        {0, 1, 1, 0, 1},
        {0, 0, 1, 1, 0}
    };

    int n = 5;

    if (hasHamiltonianPath(graph, n)) {
        cout << "Yes" <<endl;
    } else {
        cout << "No" <<endl;
    }

    return 0;
}
```

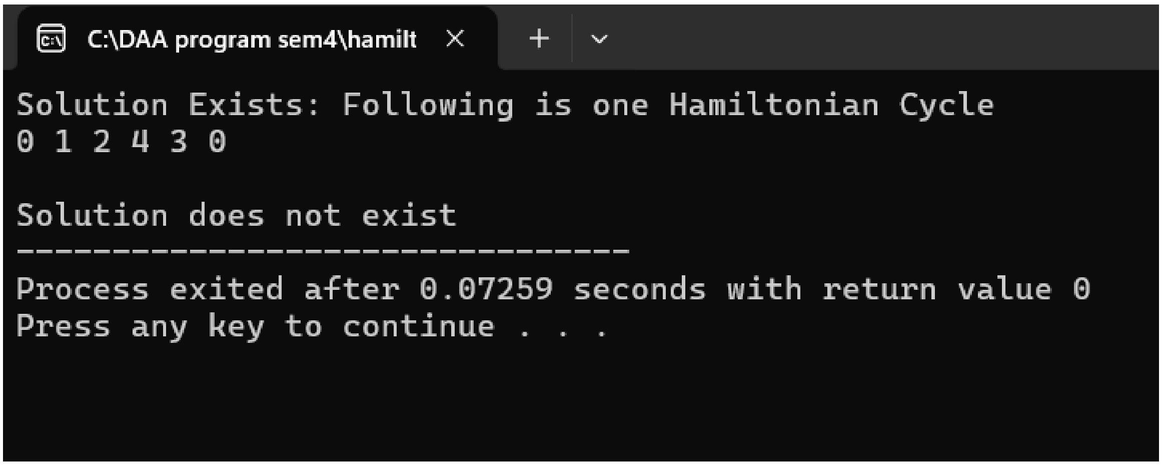
```
C:\DAA program sem4\hamilt

Yes

--------------------------------
Process exited after 0.07799 seconds with return value 0
Press any key to continue . . .
```

3. Write a program for finding the Hamiltonian Cycle or Hamiltonian Circuit in a graph using backtracking

```
#include <bits/stdc++.h>
using namespace std;
#define V 5

void printSolution(int path[]);

bool isSafe(int v, bool graph[V][V],
                        int path[], int pos)
{

    if (graph [path[pos - 1]][ v ] == 0)
        return false;


     for (int i = 0; i < pos; i++)
         if (path[i] == v)
            return false;
    return true;
}

bool hamCycleUtil(bool graph[V][V],
                            int path[], int pos)
{

    if (pos == V)
    {
        if (graph[path[pos - 1]][path[0]] == 1)
            return true;
        else
            return false;
    }
    for (int v = 1; v < V; v++)
    {
        if (isSafe(v, graph, path, pos))
        {
            path[pos] = v;
```

```
                    if (hamCycleUtil (graph, path, pos + 1) == true)
                        return true;
                    path[pos] = -1;
                }
            }

            return false;
}

bool hamCycle(bool graph[V][V])
{
            int *path = new int[V];
            for (int i = 0; i < V; i++)
                path[i] = -1;



            path[0] = 0;
            if (hamCycleUtil(graph, path, 1) == false )
            {
                cout << "\nSolution does not exist";
                return false;
            }

            printSolution(path);
            return true;
}
void printSolution(int path[])
{
            cout << "Solution Exists:"
                    " Following is one Hamiltonian Cycle \n";
            for (int i = 0; i < V; i++)
                cout << path[i] << " ";

            cout << path[0] << " ";
            cout << endl;
```

```
}

int main()
{

    bool graph1[V][V] = {{0, 1, 0, 1, 0},
                         {1, 0, 1, 1, 1},
                         {0, 1, 0, 0, 1},
                         {1, 1, 0, 0, 1},
                         {0, 1, 1, 1, 0}};

    hamCycle(graph1);

    bool graph2[V][V] = {{0, 1, 0, 1, 0},
                         {1, 0, 1, 1, 1},
                         {0, 1, 0, 0, 1},
                         {1, 1, 0, 0, 0},
                         {0, 1, 1, 0, 0}};
    hamCycle(graph2);

    return 0;
}
```



4. **Topological sort using Kahn algo and**

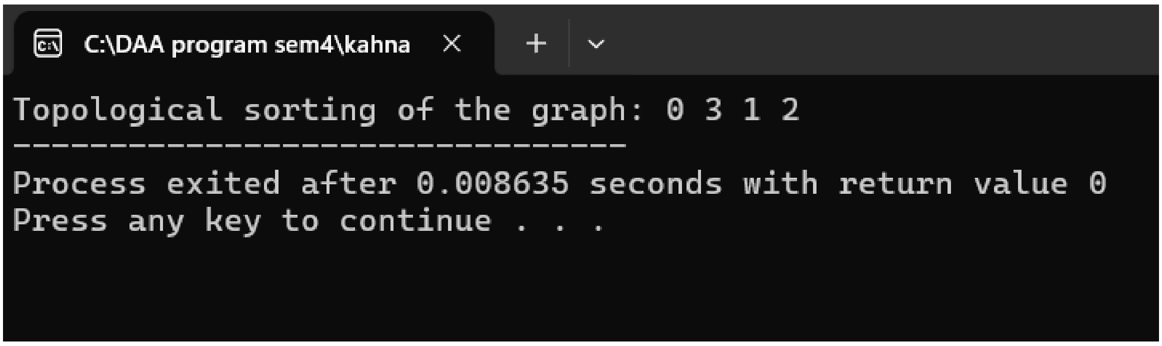
DFS #include <bits/stdc++.h>

using namespace std;

vector<int> topologicalSort(vector<vector<int> >& adj,

```
                                                                int V)
{
        vector<int> indegree(V);
        for (int i = 0; i < V; i++) {
                for (auto it : adj[i]) {
                        indegree[it]++;
                }
        }
        queue<int> q;
        for (int i = 0; i < V; i++) {
                if (indegree[i] == 0) {
                        q.push(i);
                }
        }
        vector<int> result;
        while (!q.empty()) {
                int node = q.front();
                q.pop();
                result.push_back(node);
                for (auto it : adj[node]) {
                        indegree[it]--;
                        if (indegree[it] == 0)
                                q.push(it);
                }
        }
        if (result.size() != V) {
                cout << "Graph contains cycle!" << endl;
                return {};
        }

        return result;
}

int main()
{
        int n = 4;
```

```
        vector<vector<int> > edges
                = { { 0, 1 }, { 1, 2 }, { 3, 1 }, { 3, 2 } };
        vector<vector<int> > adj(n);
        for (auto i : edges) {
                adj[i[0]].push_back(i[1]);
        }
        cout << "Topological sorting of the graph: ";
        vector<int> result = topologicalSort(adj, n);
        for (auto i : result) {
                cout << i << " ";
        }
        return 0;
}
```



5. **Write a program to implement Ford-Fulkerson algorithm for Maximum Flow**

```
Problem #include <iostream>
#include <queue>
#include <cstring>
using namespace std;
const int MAXN = 10;
bool bfs(int graph[MAXN][MAXN], int n, int source, int sink, int parent[]) {
  bool visited[MAXN];
  memset(visited, false, sizeof(visited));
  queue<int> q;
  q.push(source);
  visited[source] = true;
  parent[source] = -1;
  while (!q.empty()) {
    int current = q.front();
```

```
        q.pop();
        for (int i = 0; i < n; i++) {
            if (!visited[i] && graph[current][i] > 0) {
                q.push(i);
                visited[i] = true;
                parent[i] = current;
                if (i == sink) {
                    return true;
                }
            }
        }
    }
    return false;
}
int fordFulkerson(int graph[MAXN][MAXN], int n, int source, int sink) {
    int residual[MAXN][MAXN];
    memcpy(residual, graph, sizeof(residual));
    int parent[MAXN];
    int max_flow = 0;
    while (bfs(residual, n, source, sink, parent)) {
        int path_flow = INT_MAX;
        for (int v = sink; v != source; v = parent[v]) {
            int u = parent[v];
            path_flow = min(path_flow, residual[u][v]);
        }
        for (int v = sink; v != source; v = parent[v]) {
            int u = parent[v];
            residual[u][v] -= path_flow;
            residual[v][u] += path_flow;
        }
        max_flow += path_flow;
    }
    return max_flow;
}
int main() {
    int graph[MAXN][MAXN] = {
```

```
        {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}

    };

    int n = 6;

    int source = 0;

    int sink = 5;

    int max_flow = fordFulkerson(graph, n, source, sink);

    cout << "Maximum flow: " << max_flow << endl;

    return 0;

}
```