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SUB:DAA

Ass no:9

Title of assignment: Dynamic Programming

Q1. From a given vertex in a weighted connected graph, Implement shortest path finding

Bellman-Ford algorithm.

- Algorithm: (Pseudocode)

  ……………………………………………………..

STEP 1 : distance[] , previous[] , V->vertex , G->Graph

STEP 2 : for each vertex V in G

distance[V] <- infinite

previous[V] <- NULL

STEP 3 : distance[S] <- 0

STEP 4 : for each vertex V in G

for each edge (U,V) in G

tempDistance <- distance[U] + edge_weight(U, V)

if tempDistance < distance[V]

distance[V] <- tempDistance

previous[V] <- U

STEP 5 : for each edge (U,V) in G

If distance[U] + edge_weight(U, V) < distance[V}

return Negative Cycle Exists

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return distance[], previous[].

- **Code snapshots of implementation**

```
#include <bits/stdc++.h>
using namespace std;
#define pii pair<int, int>
const int N = 1000005;
int n, m;

struct node
{
    int u;
    int v;
    int wt;
    node(int first, int second, int weight)
    {
        u = first;
        v = second;
        wt = weight;
    }
};

signed main()
{
    ios_base::sync_with_stdio(false);
    cin.tie(NULL);

#ifndef ONLINE_JUDGE
    freopen("C:\\Users\\Teknath\\Desktop\\code\\input.txt", "r", stdin);
    freopen("C:\\Users\\Teknath\\Desktop\\code\\output.txt", "w", stdout);
#endif
    vector<node> edges;
    vector<int> dis(N, INT_MAX);
    cin >> n >> m;
    for (int i = 1; i <= m; i++)
    {
        int u, v, wt;
```

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```
            cin >> u >> v >> wt;
            edges.push_back(node(u, v, wt));
        }
        for(int i=1;i<=n;i++)
            dis[i]=INT_MAX;

        //let source is 1
        dis[1] = 0;

        //traverse for n-1 time
        for (int i = 1; i <= n - 1; i++)
        {
            for (auto it : edges)
            {
                if (dis[it.u] + it.wt < dis[it.v])
                    dis[it.v] = dis[it.u] + it.wt;
            }
        }

        int fl = 0;
        for (auto it : edges)
        {
            if (dis[it.u] + it.wt < dis[it.v])
            {
                cout << "Negative Cycle is here \n";
                fl = 1;
            }
        }

        if (fl == 0)
        {
            cout << "No negative Cycle \n";
            for (int i = 1; i <= n; i++)
            {
                cout << i << " -> " << dis[i] << '\n';
            }
        }
    }
```

……………………………………………………………

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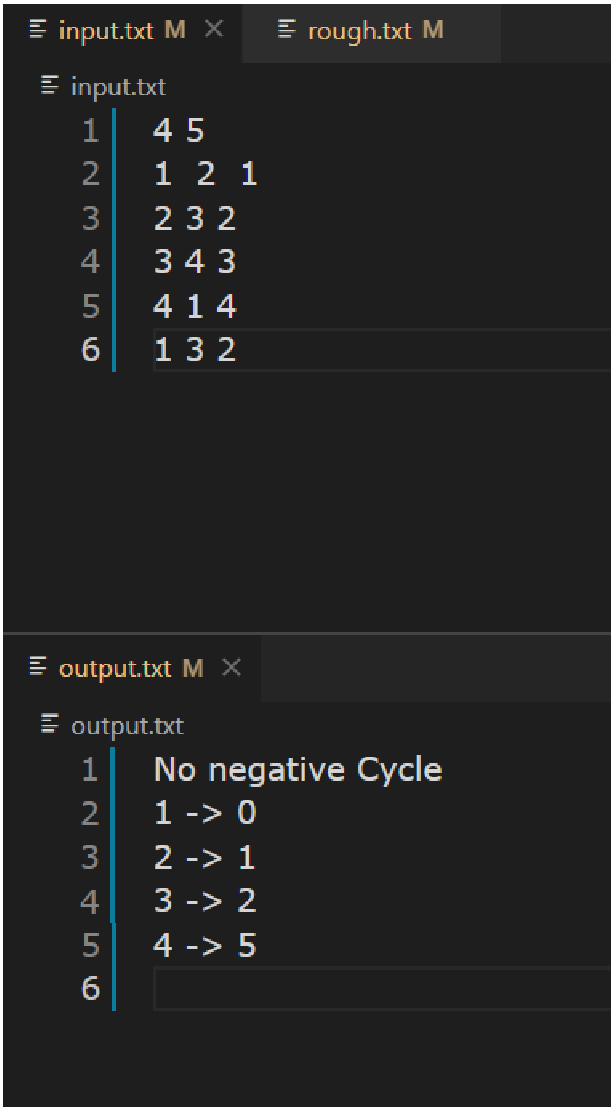
OUTPUTS :



input.txt M × rough.txt M

input.txt

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

output.txt M ×

output.txt

```
No negative Cycle
1 -> 0
2 -> 1
3 -> 2
4 -> 5
```

………………………………………………………

- **Complexity of proposed algorithm (Time & Space)**

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<u>Space Complexity :</u>

As here I have used minimum priority queue so fetching is done in logV time and we are doing for all Edges E so time complexity is O(V)

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Time Complexity :

Only distance array is extra space for all vertex So space complexity is O(VE)

……………………………………………………

- **Your comment (How your solution is optimal?)**

……………………………………………………

In this algorithm as we have relax n-1 time each node so at nth relaxation we got our result , thus it optimal than Dijkistra algorithm.

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Q) Show that Dijkstra's algorithm doesn't work for above graph

Ans-> As applying Dijkistra algorithm we end up with a infinity while loop as shown in pic

Because priority queue never gets empty

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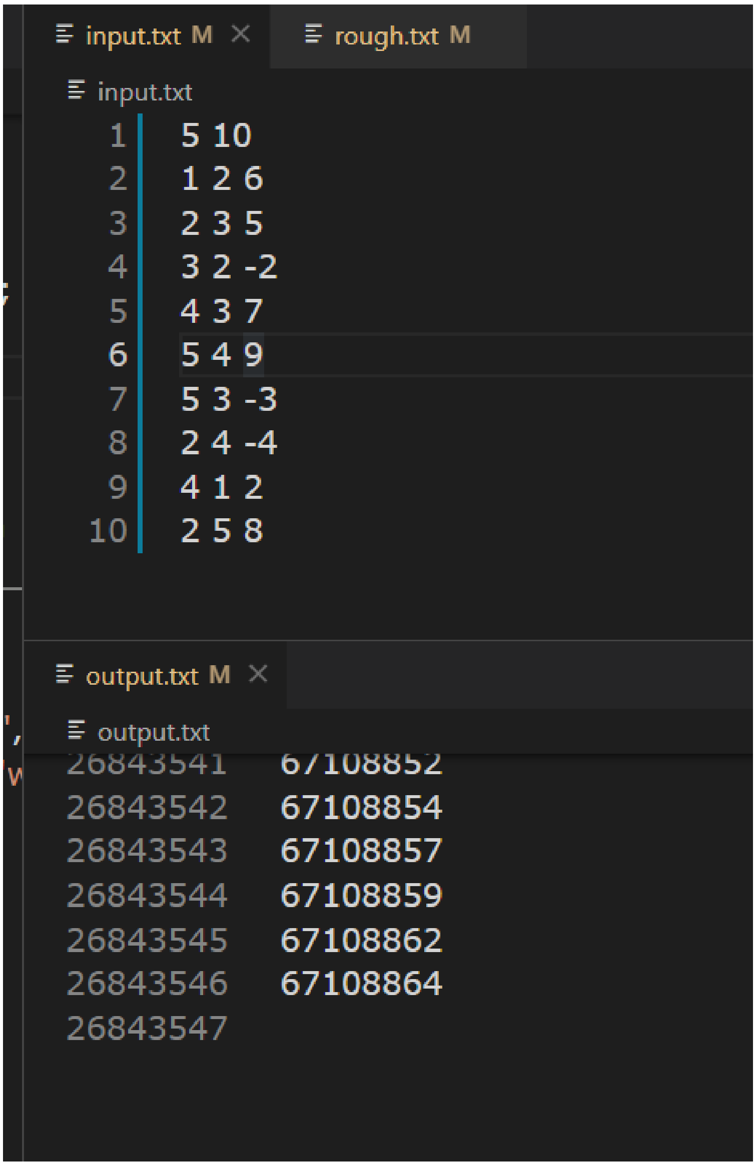

Given a weighted, directed graph $G = (V, E)$ with no negative-weight cycles, let m be the maximum over all vertices $v \in V$ of the minimum number of edges in a shortest path from the source s to v. (Here, the shortest path is by weight, not the number of edges.) Suggest a simple change to the Bellman-Ford algorithm that allows it to terminate in $m + 1$ passes, even if m is not known in advance.

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ANS ->

We can simply implement this optimization of BELLMAN-FORD algorithm by remebering if v was relaxed or not.

If v is relaxed then we wait to see if v was udpated (which means being relaxed again).

If v was not updated, then we would stop

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