Analysis of Algorithm

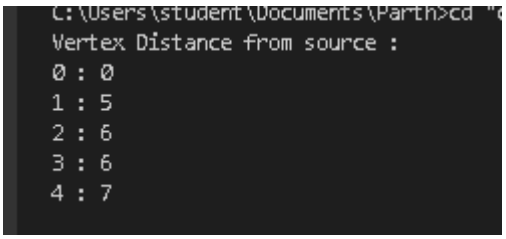
Practical no 8 : Bellman Ford Algorithm

Code :

```
import java.util.Arrays;
class bFord2 {
  static int[] bellmanFord(int V, int[][] edges, int src) {
    int[] dist = new int[V];
    Arrays.fill(dist, Integer.MAX_VALUE);
    dist[src] = 0;
    for (int i = 0; i < V; i++) {
      for (int[] edge : edges) {
        int u = edge[0];
        int v = edge[1];
        int wt = edge[2];
        if (dist[u] != Integer.MAX_VALUE && dist[u] + wt < dist[v]) {
          if (i == V - 1)
            return new int[]{-1};
          dist[v] = dist[u] + wt;
        }
      }
    }
    return dist;
  }
  public static void main(String[] args) {
    int V = 5;
    int[][] edges = new int[][] {
      {1, 3, 2},
```

```
        {4, 3, -1},
        {2, 4, 1},
        {1, 2, 1},
        {0, 1, 5}
    };
    int src = 0;
    int[] ans = bellmanFord(V, edges, src);
    System.out.println("Vertex Distance from source : ");
    for(int i = 0; i < V; i++) {
        if(ans[i] == Integer.MAX_VALUE)
            System.out.println(i + " : INF");
        else
            System.out.println(i + " : " + ans[i]);
    }
  }
}
```

Output :



Analysis :

1. Function: bellmanFord

- **Inputs**:
  - V: The number of vertices in the graph.
  - edges: A 2D array representing the edges of the graph, where each edge is defined by a 3-element array [u, v, wt] indicating an edge from vertex u to vertex v with weight wt.
  - src: The source vertex from which the shortest paths will be computed.
- **Outputs**:
  - An array dist[] that holds the shortest distance from the source to every vertex. If a vertex is unreachable, its distance will be set to Integer.MAX_VALUE.

Steps:

- **Step 1: Initialization**:
  - The dist[] array is initialized with Integer.MAX_VALUE to represent "infinity," meaning initially all vertices are unreachable from the source except the source itself, which has a distance of 0.
- **Step 2: Relaxation**:
  - The main part of the algorithm involves relaxing all edges V - 1 times. During each relaxation, for each edge (u, v, wt), if the current distance to vertex u is not infinity and the distance through u is shorter than the current distance to vertex v, we update the distance to vertex v.
- **Step 3: Negative Weight Cycle Detection**:
  - After V - 1 relaxations, the algorithm performs an additional relaxation. If any distance can still be reduced, it indicates the presence of a negative weight cycle, and the function returns {-1} to indicate the cycle.

2. Function: main

- **Graph Representation**:
  - A graph with 5 vertices and 5 edges is represented by the 2D array edges. Each row defines an edge from vertex u to vertex v with a given weight wt.
- **Calling the Bellman-Ford Algorithm**:

    - The algorithm is executed starting from vertex 0 and the resulting shortest distances are printed.

- **Output**:
    - The distances from the source vertex (src = 0) to all other vertices are displayed. If a vertex is unreachable, it will be displayed as "INF".

Summary of Time and Space Complexities

- **Time Complexity**:
    - **Best Case**: O(V * E)
    - **Average Case**: O(V * E)
    - **Worst Case**: O(V * E)
- **Space Complexity**:
    - **Best Case**: O(V + E)
    - **Average Case**: O(V + E)
    - **Worst Case**: O(V + E)