Day 9 and 10:

Task 1: Dijkstra's Shortest Path Finder
Code Dijkstra's algorithm to find the shortest path from a start node to every other node in a weighted graph with positive weights.

```
package com.dsassignment.day9;

import java.util.ArrayList;
import java.util.HashMap;
import java.util.Map;
import java.util.PriorityQueue;

public class dijsktra {
	private HashMap<String, HashMap<String, Integer>> adjList = new HashMap<>();

	private HashMap<String, String> previous = new HashMap<>();

	public static void main(String[] args) {
		dijsktra myGraph = new dijsktra();
		myGraph.addVertex("A");
		myGraph.addVertex("B");
		myGraph.addVertex("C");
		myGraph.addVertex("D");
		myGraph.addVertex("E");
		myGraph.addVertex("F");

		myGraph.addEdge("A", "B", 2);
		myGraph.addEdge("A", "D", 8);
		myGraph.addEdge("B", "E", 6);
		myGraph.addEdge("B", "D", 5);
		myGraph.addEdge("E", "D", 3);
		myGraph.addEdge("E", "F", 1);
		myGraph.addEdge("E", "C", 9);
		myGraph.addEdge("D", "F", 2);
		myGraph.addEdge("F", "C", 3);

		myGraph.printGraph();

		myGraph.dijkstra("A");

		ArrayList<String> shortestPathToC = myGraph.getShortestPathTo("C");
		System.out.println("Shortest path from A to C: " + shortestPathToC);
	}

	private void addVertex(String vertex) {
		if (!adjList.containsKey(vertex)) {
			adjList.put(vertex, new HashMap<>());
		}
	}
```

```
	public boolean addEdge(String vertex1, String vertex2, int weight) {

		if (adjList.containsKey(vertex1) && adjList.containsKey(vertex2)) {

			adjList.get(vertex1).put(vertex2, weight);
			adjList.get(vertex2).put(vertex1, weight);
			return true;
		}
		return false;
	}

	private void printGraph() {
		System.out.println("Graph:");
		for (Map.Entry<String, HashMap<String, Integer>> entry :
adjList.entrySet()) {
			System.out.println(entry.getKey() + " -> " + entry.getValue());
		}

	}

	private void dijkstra(String start) {
		HashMap<String, Integer> distance = new HashMap<>();
		PriorityQueue<VertexDistancePair> pq = new PriorityQueue<>(
				(pair1, pair2) -> Integer.compare(pair1.distance,
pair2.distance));

		for (String vertex : adjList.keySet()) {
			distance.put(vertex, Integer.MAX_VALUE);
			previous.put(vertex, null);
		}

		distance.put(start, 0);
		pq.offer(new VertexDistancePair(start, 0));

		while (!pq.isEmpty()) {
			VertexDistancePair currentPair = pq.poll();
			String current = currentPair.vertex;

			for (Map.Entry<String, Integer> neighborEntry :
adjList.get(current).entrySet()) {
				String neighbor = neighborEntry.getKey();
				int weight = neighborEntry.getValue();
				int newDistance = distance.get(current) + weight;

				if (newDistance < distance.get(neighbor)) {
					distance.put(neighbor, newDistance);
					previous.put(neighbor, current);
					pq.offer(new VertexDistancePair(neighbor,
newDistance));
				}
			}
```

```
            }
        }

        private ArrayList<String> getShortestPathTo(String destination) {
            ArrayList<String> path = new ArrayList<>();
            String current = destination;
            while (current != null) {
                path.add(0, current);
                current = previous.get(current);
            }
            return path;
        }

        private static class VertexDistancePair {
            String vertex;
            int distance;

            VertexDistancePair(String vertex, int distance) {
                this.vertex = vertex;
                this.distance = distance;
            }
        }

}
```

Output:

```
<terminated> dijsktra (1) [Java Application] C:\Program Files\Java\jdk-17\bin\javaw.exe  (02-Jun-2024, 12:41:55 pm – 12:41:55 pm) [pid: 9652]
Graph:
A -> {B=2, D=8}
B -> {A=2, D=5, E=6}
C -> {E=9, F=3}
D -> {A=8, B=5, E=3, F=2}
E -> {B=6, C=9, D=3, F=1}
F -> {C=3, D=2, E=1}
Shortest path from A to C: [A, B, D, F, C]
```

Task 2: Kruskal's Algorithm for MST
Implement Kruskal's algorithm to find the minimum spanning tree of a given connected, undirected graph with non-negative edge weights.

```
package com.dsassignment.day9;

import java.util.*;

class Edge implements Comparable<Edge> {
    int src, dest, weight;
```

```
    Edge(int src, int dest, int weight) {
        this.src = src;
        this.dest = dest;
        this.weight = weight;
    }

    public int compareTo(Edge compareEdge) {
        return this.weight - compareEdge.weight;
    }
}

class DisjointSet {
    int[] parent, rank;

    DisjointSet(int n) {
        parent = new int[n];
        rank = new int[n];
        for (int i = 0; i < n; i++) {
            parent[i] = i;
            rank[i] = 0;
        }
    }

    int find(int x) {
        if (parent[x] != x)
            parent[x] = find(parent[x]);
        return parent[x];
    }

    void union(int x, int y) {
        int xRoot = find(x);
        int yRoot = find(y);

        if (xRoot == yRoot)
            return;

        if (rank[xRoot] < rank[yRoot])
            parent[xRoot] = yRoot;
        else if (rank[xRoot] > rank[yRoot])
            parent[yRoot] = xRoot;
        else {
            parent[yRoot] = xRoot;
```

```
            rank[xRoot]++;
        }
    }
}

public class KruskalMST {
    private int V, E;
    private Edge[] edges;

    KruskalMST(int v, int e) {
        V = v;
        E = e;
        edges = new Edge[E];
        for (int i = 0; i < e; ++i)
            edges[i] = new Edge(0, 0, 0);
    }

    void addEdge(int e, int src, int dest, int weight) {
        edges[e].src = src;
        edges[e].dest = dest;
        edges[e].weight = weight;
    }

    void kruskalMST() {
        Edge result[] = new Edge[V];
        int e = 0;
        int i = 0;
        for (i = 0; i < V; ++i)
            result[i] = new Edge(0, 0, 0);

        Arrays.sort(edges);

        DisjointSet ds = new DisjointSet(V);

        i = 0;

        while (e < V - 1) {
            Edge nextEdge = edges[i++];

            int x = ds.find(nextEdge.src);
            int y = ds.find(nextEdge.dest);

            if (x != y) {
```

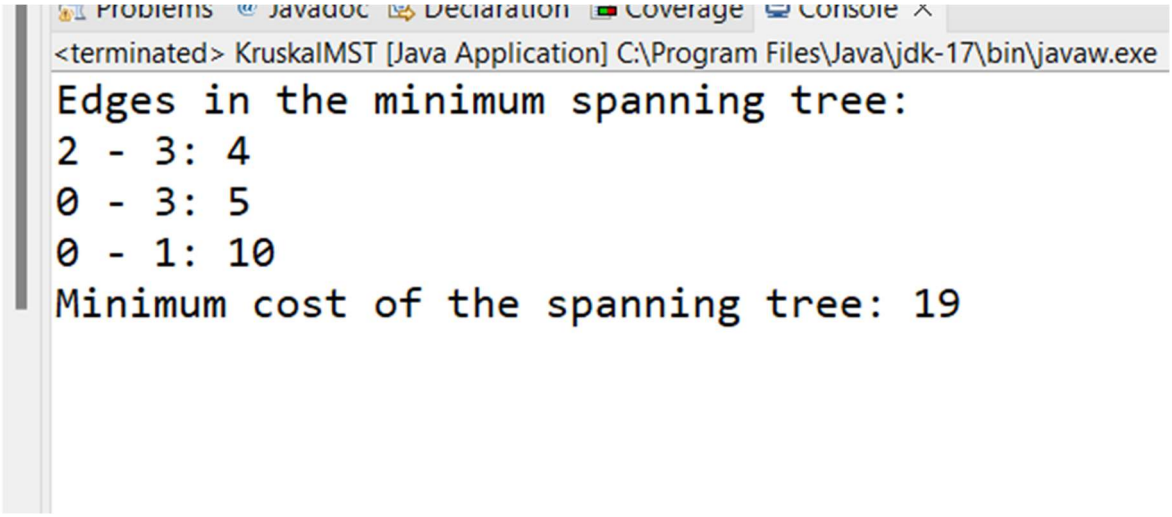
```
                result[e++] = nextEdge;
                ds.union(x, y);
            }
        }

        System.out.println("Edges in the minimum spanning
tree:");
        int minimumCost = 0;
        for (i = 0; i < e; ++i) {
            System.out.println(result[i].src + " - " +
result[i].dest + ": " + result[i].weight);
            minimumCost += result[i].weight;
        }
        System.out.println("Minimum cost of the spanning
tree: " + minimumCost);
    }

    public static void main(String[] args) {
        int V = 4;
        int E = 5;
        KruskalMST graph = new KruskalMST(V, E);

        graph.addEdge(0, 0, 1, 10);
        graph.addEdge(1, 0, 2, 6);
        graph.addEdge(2, 0, 3, 5);
        graph.addEdge(3, 1, 3, 15);
        graph.addEdge(4, 2, 3, 4);

        graph.kruskalMST();
    }
}
```



Task 3: Union-Find for Cycle Detection
Write a Union-Find data structure with path compression. Use this data structure to detect a cycle in an undirected graph.

```
package com.dsassignment.day9;

import java.util.Arrays;

class UnionFind {
	int[] parent;
	int[] rank;

	UnionFind(int n) {
		parent = new int[n];
		rank = new int[n];
		Arrays.fill(rank, 1);
		for(int i=0; i<n ;i++) {
			parent[i] =i;
		}

	}

	int find(int i) {
		if (parent[i] != i) {
			parent[i] = find(parent[i]);
		}
		return parent[i];
	}
```

```
    void union(int x, int y) {
        int rootX = find(x);
        int rootY = find(y);

        if (rootX != rootY) {
            if (rank[rootX] < rank[rootY]) { // 1<2
                parent[rootX] = rootY;
            } else if (rank[rootX] > rank[rootY]) {
                parent[rootY] = rootX;
            } else {
                parent[rootY] = rootX;
                rank[rootX]++;

            }

        }

    }

}

class Graph {
    int V, E;
    Edge[] edges;

    class Edge {
        int src, dest;
    }

    Graph(int v, int e) {
        this.V = v;
        this.E = e;
        this.edges = new Edge[E];
        for (int i = 0; i < e; i++) {
            edges[i] = new Edge();
            System.out.println(edges[i].src + "  -- " +
edges[i].dest);
        }
    }

    public boolean isCycleFound(Graph graph) {
        UnionFind uf = new UnionFind(V);
```

```
            for(int i=0; i< E ; ++i) {
                int x = find(uf, graph.edges[i].src);
                int y = find(uf, graph.edges[i].dest);

                if(x==y) {
                    return true;
                }
                uf.union(x, y);
            }
            return false;
        }

        private int find(UnionFind uf, int i) {

            return uf.find(i);
        }

}

public class CycleDetect {
    public static void main(String[] args) {
        //int V = 3, E = 3;
        int V = 3, E = 2;
        Graph graph = new Graph(V, E);

        graph.edges[0].src = 0;
        graph.edges[0].dest = 1;

        graph.edges[1].src = 1;
        graph.edges[1].dest = 2;

        //graph.edges[2].src = 0;
        //graph.edges[2].dest = 2;

        System.out.println(graph.V + " -- " + graph.E);
        for (int i = 0; i < E; i++) {

            System.out.println(graph.edges[i].src + "
-- " + graph.edges[i].dest);
        }


        if(graph.isCycleFound(graph)) {
```

```
                System.out.println("Cycle Found");
            }else {
                System.out.println("Cycle Not Found...");
            }

        }
}
```

Output: