Worksheet 2.1

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Subject Name: Advance Programming Lab
Subject Code: 20CSP-334

1. Aim/Overview of the practical:

a) From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.
b) Compute the transitive closure of a given directed graph using Warshall's algorithm.

2. Task to be done:

a) From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.
b) Compute the transitive closure of a given directed graph using Warshall's algorithm.

3. Algorithm/Flowchart (For programming-based labs):

a) Dijkstra's algorithm

- Create a set **sptSet** (shortest path tree set) that keeps track of vertices included in the shortest-path tree, i.e., whose minimum distance from the source is calculated and finalized. Initially, this set is empty.
- Assign a distance value to all vertices in the input graph. Initialize all distance values as **INFINITE**. Assign the distance value as 0 for the source vertex so that it is picked first.
- While **sptSet** doesn't include all vertices
    - Pick a vertex **u** which is not there in **sptSet** and has a minimum distance value.
    - Include u to **sptSet**.
    - Then update distance value of all adjacent vertices of u.
        - To update the distance values, iterate through all adjacent vertices.
        - For every adjacent vertex v, if the sum of the distance value of u (from source) and weight of edge u-v, is less than the distance value of v, then update the distance value of v.

b) Floyd Warshall:

- For the first step, the solution matrix is initialized with the input adjacent matrix of the graph. Let's name it as reach.
- Next we need to iterate over the number of nodes from {0,1,.....n} one by one by considering them strating vertex. Similarly, another iteration is performed over the nodes {1,2,....,n} by considering ending vertex one by one.

- For the shortest path, we need to form another iteration which ranges from {1,2,...,k-1}, where vertex k has been picked up as an intermediate vertex.
- For every pair (i, j) of the starting and ending vertices respectively, there are two possible cases.
- if k is an intermediate vertex in the shortest path from i to j, then we check the condition reach[i][j] > reach[i][k] + reach[k][j] and update reach[i][j] accordingly.
- Otherwise, if k is not an intermediate vertex, we don't update anything and continue the loop.

Transitive Closure condition:

Only one difference of the condition to be checked when there is an intermediate vertex k exits between the starting vertex and the ending vertex. We need to check two conditions and check if any of them is true,

- Is there a direct edge between the starting vertex and the ending vertex? If yes, then update the transitive closure matrix value as 1.
- For k, any intermediate vertex, is there any edge between the (starting vertex & k) and (k & ending vertex) ? If yes,then update the transitive closure matrix value as 1.

4. CODE:

a) Dijkstra

```
// Dijkstra's single source shortest path using adjacency matrix representation of the graph
#include <bits/stdc++.h>
using namespace std;

// Number of vertices in the graph
#define V 9

// function to find the vertex with minimum
// distance value, from the set of vertices not yet included
// in shortest path tree
int minDistance(int dist[], bool sptSet[])
{

	// Initialize min value
	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 printSolution(int dist[])
{
	cout << "Vertex \t\t Distance from Source" << endl;
```

```
	for (int i = 0; i < V; i++)
		cout << i << " \t\t\t" << dist[i] << endl;
}

void dijkstra(int graph[V][V], int src)
{
	int dist[V]; // The output array. dist[i] will hold the shortest
	// distance from src to i

	bool sptSet[V]; // sptSet[i] will be true if vertex i is included in shortest path tree
				// or shortest distance from src to i is finalized

	// Initialize all distances as INFINITE  and stpSet[] as false
	for (int i = 0; i < V; i++)
		dist[i] = INT_MAX,  sptSet[i] = false;

	// Distance of source vertex from itself is always 0
	dist[src] = 0;

	// Find shortest path for all vertices
	for (int count = 0; count < V - 1; count++) {
		// Pick the minimum distance vertex from the set of vertices not yet processed.
		//u is always equal to src in the first iteration.
		int u = minDistance(dist, sptSet);

		// Mark the picked vertex as processed
		sptSet[u] = true;

		// Update dist value of the adjacent vertices of the picked vertex.
		for (int v = 0; v < V; v++)

			// Update dist[v] only if is not in sptSet,
			// there is an edge from u to v, and total
			// weight of path from src to v through u is
			// smaller than current value of dist[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];
	}

	// print the constructed distance array
	printSolution(dist);
}
```

```
int main()
{
        int graph[V][V] = { { 0, 4, 0, 0, 0, 0, 0, 8, 0 },
                { 4, 0, 8, 0, 0, 0, 0, 11, 0 },
                { 0, 8, 0, 7, 0, 4, 0, 0, 2 },
                { 0, 0, 7, 0, 9, 14, 0, 0, 0 },
                { 0, 0, 0, 9, 0, 10, 0, 0, 0 },
                { 0, 0, 4, 14, 10, 0, 2, 0, 0 },
                { 0, 0, 0, 0, 0, 2, 0, 1, 6 },
                { 8, 11, 0, 0, 0, 0, 1, 0, 7 },
                { 0, 0, 2, 0, 0, 0, 6, 7, 0 } };

        dijkstra(graph, 0);
        return 0;
}
```

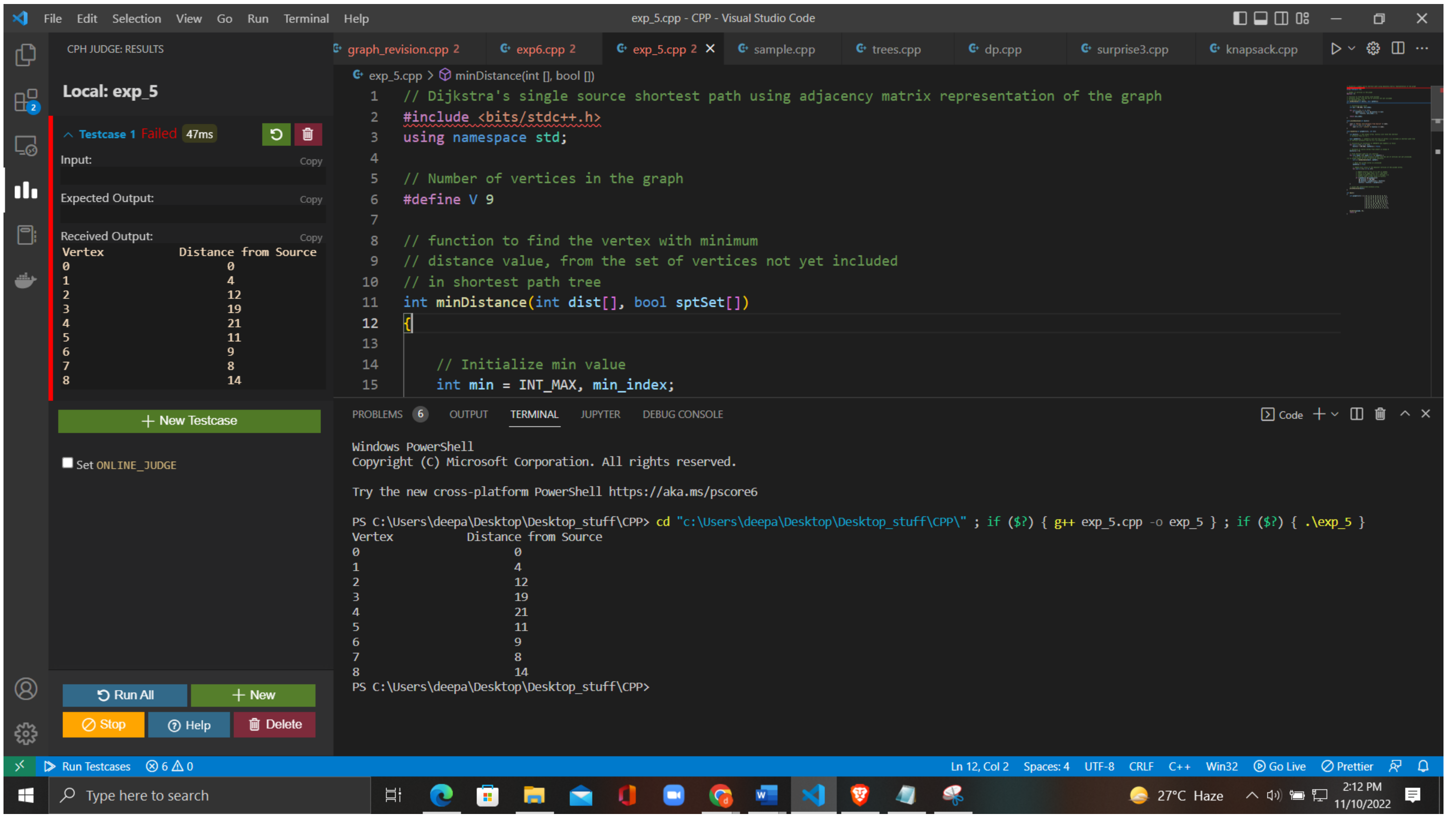
b) Transitive Closure using Warshall

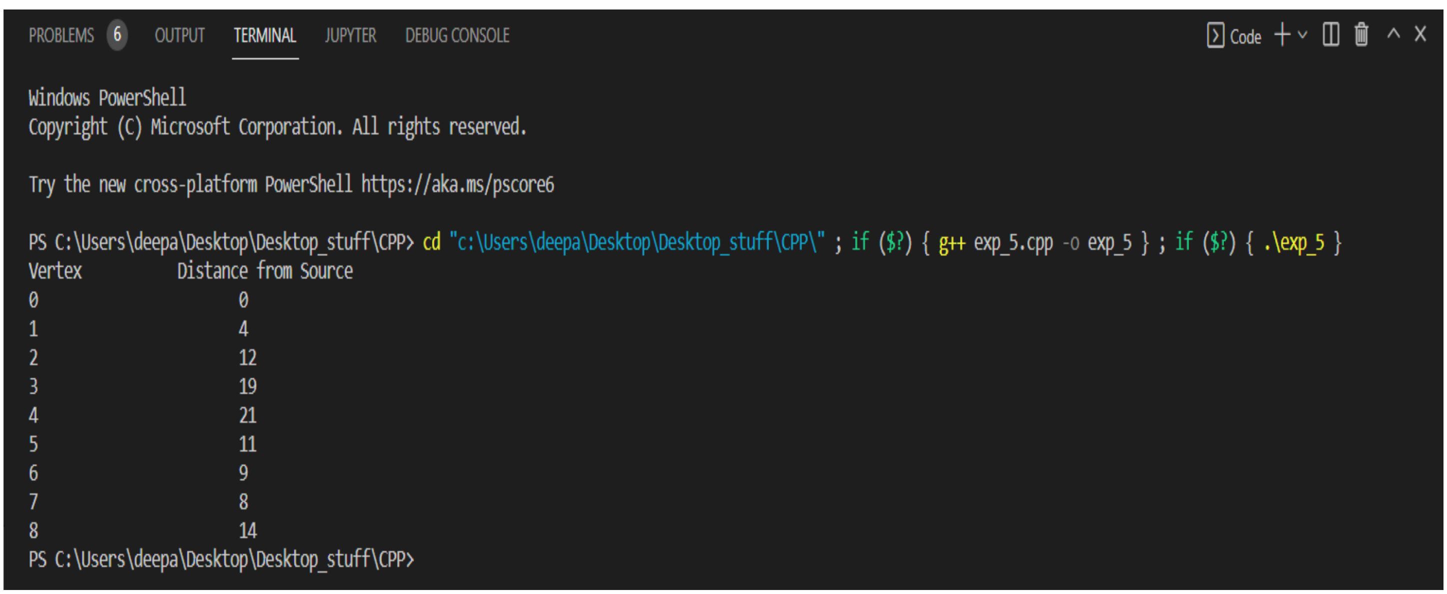
```
#include<bits/stdc++.h>
using namespace std;
#define V 4
void printSolution(int reach[][V])
{

    for (int i = 0; i < V; i++)
    {
        for (int j = 0; j < V; j++)
        {
            if(i == j)
              printf("1 ");
            else
              printf ("%d ", reach[i][j]);
        }
        cout<<"\n";
    }
}

void transitiveClosure(int graph[][V])
{
    int reach[V][V], i, j, k;
    for (i = 0; i < V; i++)
        for (j = 0; j < V; j++)
            reach[i][j] = graph[i][j];

    for (k = 0; k < V; k++)
```

```
    {
        for (i = 0; i < V; i++)
        {
            for (j = 0; j < V; j++)
            {
                reach[i][j] = reach[i][j] ||
                  (reach[i][k] && reach[k][j]);
            }
        }
    }
    cout<<"Following matrix is transitive closure of the given graph\n";
    printSolution(reach);
}

int main()
{
    int graph[V][V] = { {1, 1, 0, 1},
                        {0, 1, 1, 0},
                        {0, 0, 1, 1},
                        {0, 0, 0, 1}
                      };
    cout<<"Given graph : \n";
    printSolution(graph);
    transitiveClosure(graph);
    return 0;
    /*
              10
       (0)------->(3)
        |         /|\
       5|          |
        |          | 1
       \|/         |
       (1)------->(2)
            3        */
}
```

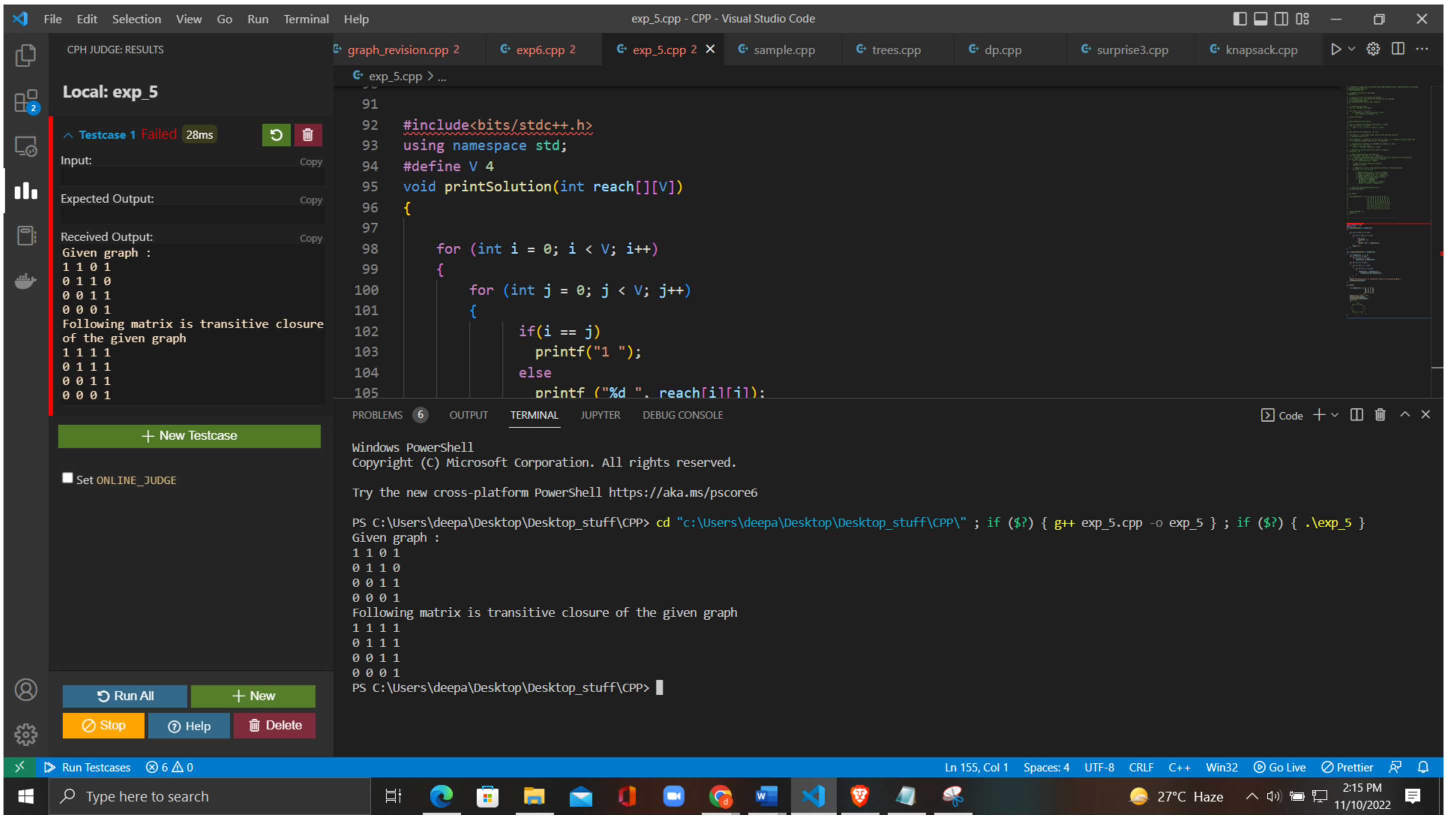
5. Result/Output:

a) Dijkstra





b) Transitive Closure using Warshall:



Learning Outcomes:

- Learn shortest paths to other vertices using Dijkstra’s algorithm.
- Learn transitive closure of a given directed graph using Warshall's algorithm.

Evaluation Grid (To be created as per the SOP and Assessment guidelines by the faculty):

Sr. No.	Parameters	Marks Obtained	Maximum Marks
1.			
2.			
3.			