CSCE 5150 – Analysis of Computer Algorithms

Programming Assignment 4 – Graph Algorithms

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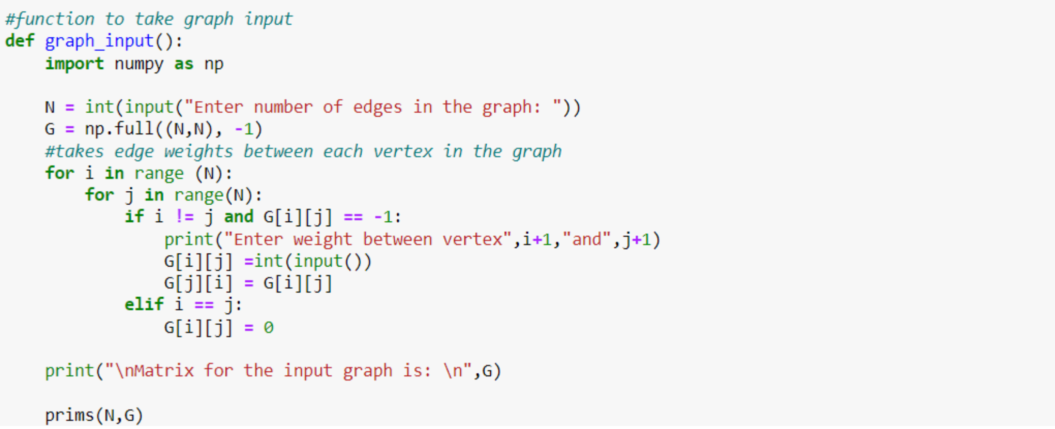
Prim's algorithm

Definition:

1. Prim's algorithm for finding the Minimum Spanning Tree (MST) for given undirected graph G (V, E) with weights.

   Prim's Algorithm:

   i. Firstly, we take graph input as a matrix, for each edge between the vertices, we take weights as input from the below function. Once we have all the vertices and edge weights, we use prims algorithm to find the Minimum Spanning Tree (MST).



```
#function to take graph input
def graph_input():
    import numpy as np

    N = int(input("Enter number of edges in the graph: "))
    G = np.full((N,N), -1)
    #takes edge weights between each vertex in the graph
    for i in range (N):
        for j in range(N):
            if i != j and G[i][j] == -1:
                print("Enter weight between vertex",i+1,"and",j+1)
                G[i][j] =int(input())
                G[j][i] = G[i][j]
            elif i == j:
                G[i][j] = 0

    print("\nMatrix for the input graph is: \n",G)

    prims(N,G)
```

   ii. We use Prim's algorithm to find the Minimum Spanning Tree (MST), I have created an array "Output" to hold all the selected vertices. We initialize the edge count to zero. Also, the 0th vertex is made true. Now we loop in V-1 times, as the MST will have less than V vertices. For each vertex, we find the adjacent vertices and calculate the weights from the first node to the current node. If the vertex already exists in the "Output", we discard that vertex and search for the nearest vertex to the selected vertex.

CSCE 5150 – Analysis of Computer Algorithms

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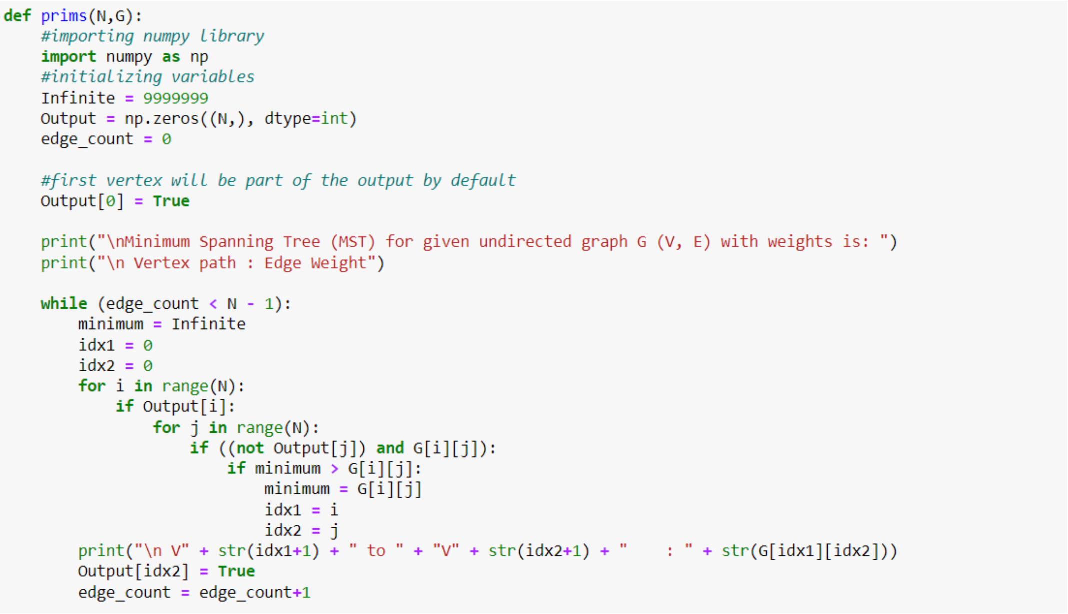

```python
def prims(N,G):
    #importing numpy library
    import numpy as np
    #initializing variables
    Infinite = 9999999
    Output = np.zeros((N,), dtype=int)
    edge_count = 0

    #first vertex will be part of the output by default
    Output[0] = True

    print("\nMinimum Spanning Tree (MST) for given undirected graph G (V, E) with weights is: ")
    print("\n Vertex path : Edge Weight")

    while (edge_count < N - 1):
        minimum = Infinite
        idx1 = 0
        idx2 = 0
        for i in range(N):
            if Output[i]:
                for j in range(N):
                    if ((not Output[j]) and G[i][j]):
                        if minimum > G[i][j]:
                            minimum = G[i][j]
                            idx1 = i
                            idx2 = j
        print("\n V" + str(idx1+1) + " to " + "V" + str(idx2+1) + "   : " + str(G[idx1][idx2]))
        Output[idx2] = True
        edge_count = edge_count+1
```

<u>Pseudocode to implement Prim’s algorithm for finding the Minimum Spanning Tree (MST) for given undirected graph G (V, E) with weights.</u>

CSCE 5150 – Analysis of Computer Algorithms

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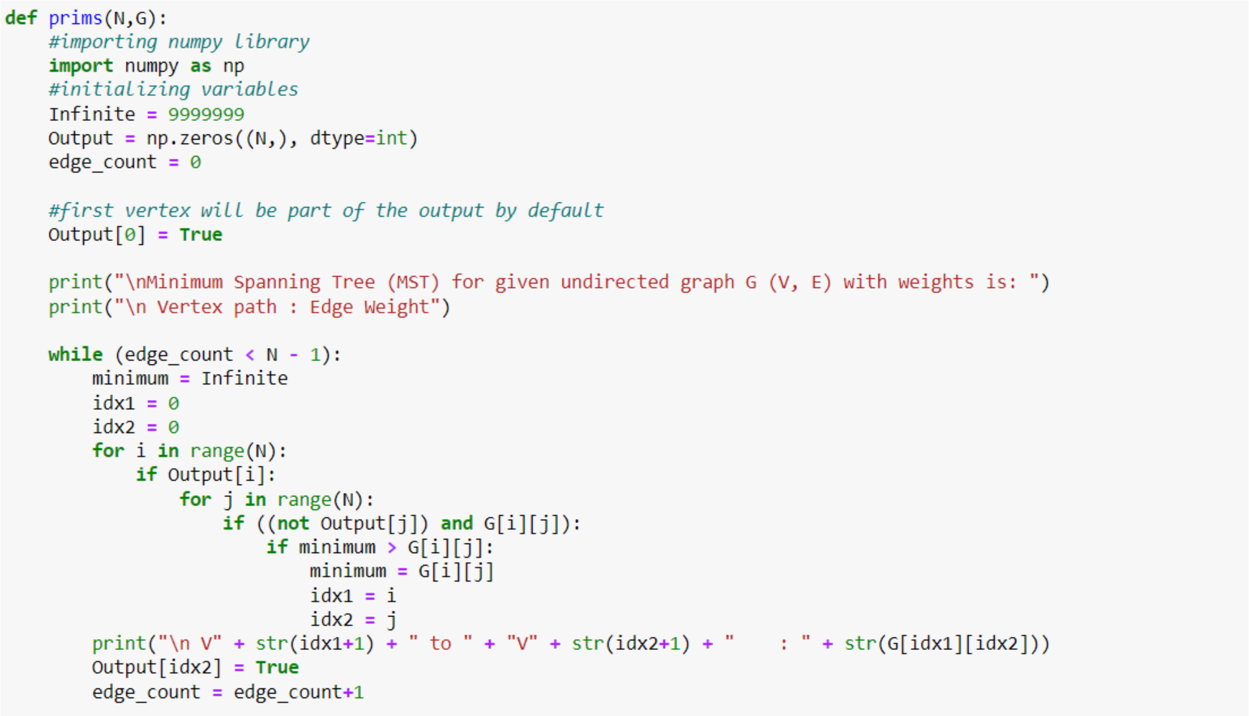

```python
def prims(N,G):
    #importing numpy library
    import numpy as np
    #initializing variables
    Infinite = 9999999
    Output = np.zeros((N,), dtype=int)
    edge_count = 0

    #first vertex will be part of the output by default
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            if Output[i]:
                for j in range(N):
                    if ((not Output[j]) and G[i][j]):
                        if minimum > G[i][j]:
                            minimum = G[i][j]
                            idx1 = i
                            idx2 = j
        print("\n V" + str(idx1+1) + " to " + "V" + str(idx2+1) + "    : " + str(G[idx1][idx2]))
        Output[idx2] = True
        edge_count = edge_count+1
```
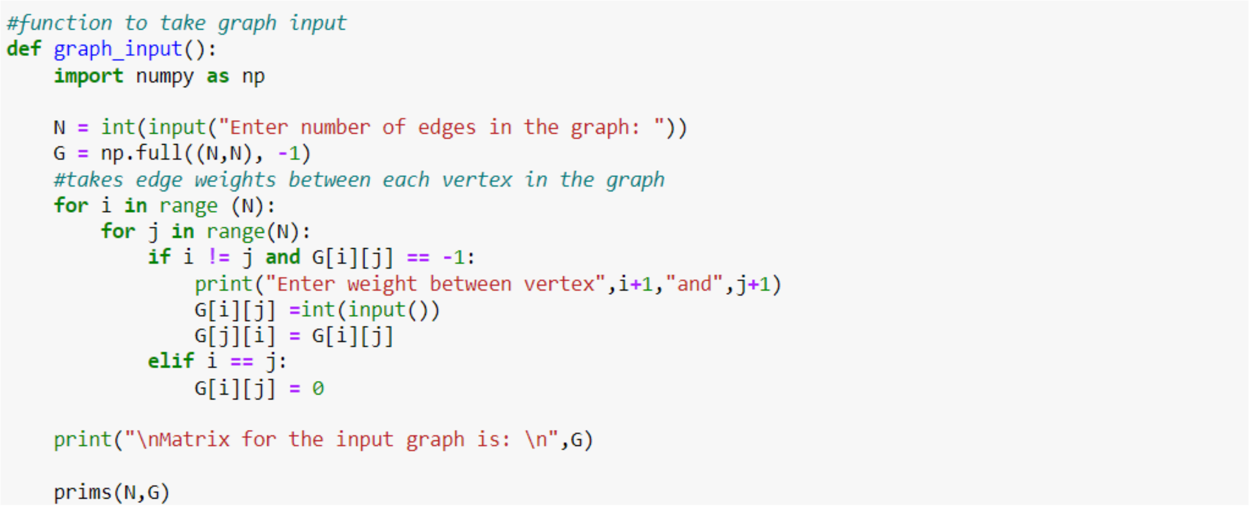
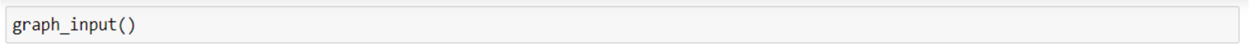



```python
#function to take graph input
def graph_input():
    import numpy as np

    N = int(input("Enter number of edges in the graph: "))
    G = np.full((N,N), -1)
    #takes edge weights between each vertex in the graph
    for i in range (N):
        for j in range(N):
            if i != j and G[i][j] == -1:
                print("Enter weight between vertex",i+1,"and",j+1)
                G[i][j] =int(input())
                G[j][i] = G[i][j]
            elif i == j:
                G[i][j] = 0

    print("\nMatrix for the input graph is: \n",G)

    prims(N,G)
```



```python
graph_input()
```

<u>Execution/ Output:</u>

1. Verify the correctness of your program by solving the problem of finding the MST for the following graph as explained in the class.

CSCE 5150 – Analysis of Computer Algorithms

Programming Assignment 4 – Graph Algorithms

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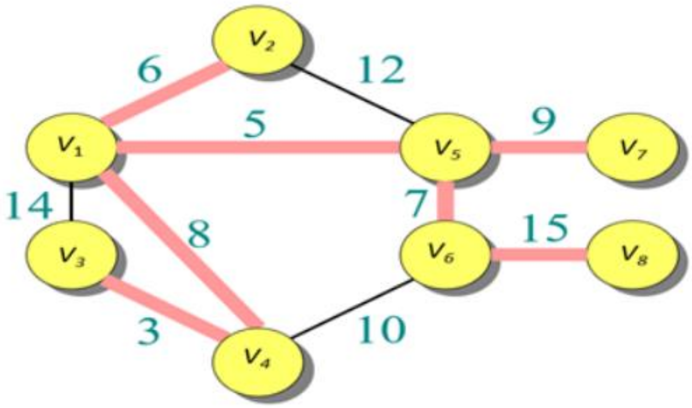

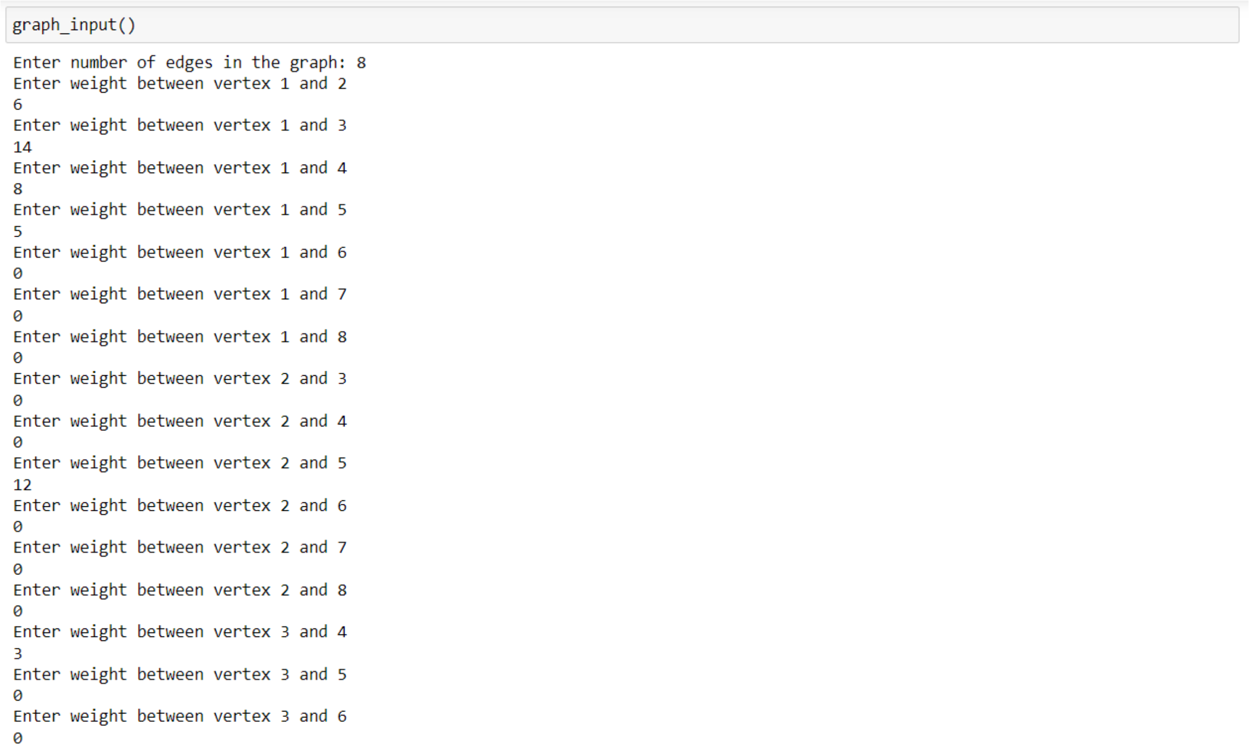

```
graph_input()
```

```
Enter number of edges in the graph: 8
Enter weight between vertex 1 and 2
6
Enter weight between vertex 1 and 3
14
Enter weight between vertex 1 and 4
8
Enter weight between vertex 1 and 5
5
Enter weight between vertex 1 and 6
0
Enter weight between vertex 1 and 7
0
Enter weight between vertex 1 and 8
0
Enter weight between vertex 2 and 3
0
Enter weight between vertex 2 and 4
0
Enter weight between vertex 2 and 5
12
Enter weight between vertex 2 and 6
0
Enter weight between vertex 2 and 7
0
Enter weight between vertex 2 and 8
0
Enter weight between vertex 3 and 4
3
Enter weight between vertex 3 and 5
0
Enter weight between vertex 3 and 6
0
```

CSCE 5150 – Analysis of Computer Algorithms

Programming Assignment 4 – Graph Algorithms

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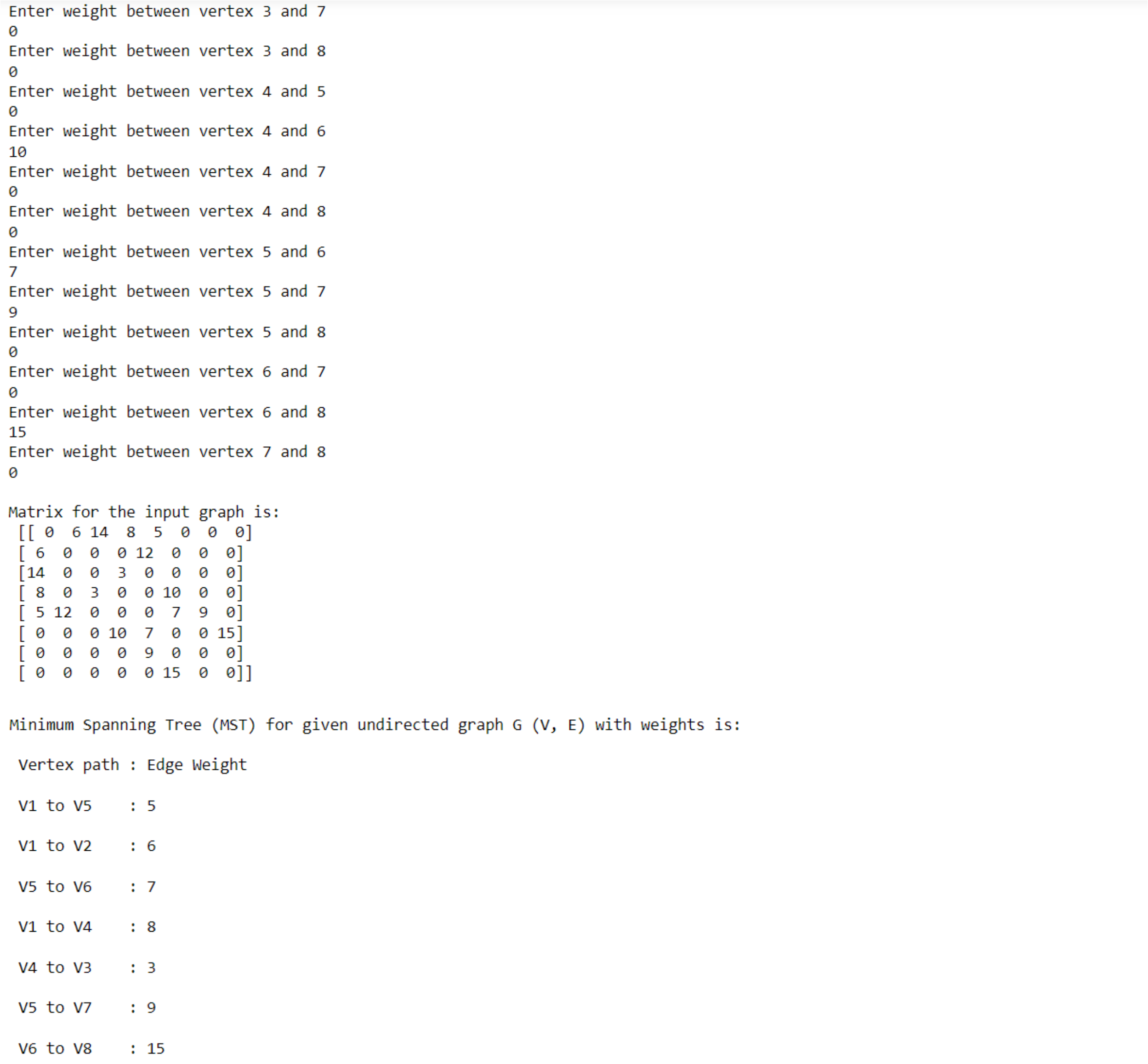

```
Enter weight between vertex 3 and 7
0
Enter weight between vertex 3 and 8
0
Enter weight between vertex 4 and 5
0
Enter weight between vertex 4 and 6
10
Enter weight between vertex 4 and 7
0
Enter weight between vertex 4 and 8
0
Enter weight between vertex 5 and 6
7
Enter weight between vertex 5 and 7
9
Enter weight between vertex 5 and 8
0
Enter weight between vertex 6 and 7
0
Enter weight between vertex 6 and 8
15
Enter weight between vertex 7 and 8
0

Matrix for the input graph is:
 [[ 0  6 14  8  5  0  0  0]
 [ 6  0  0  0 12  0  0  0]
 [14  0  0  3  0  0  0  0]
 [ 8  0  3  0  0 10  0  0]
 [ 5 12  0  0  0  7  9  0]
 [ 0  0  0 10  7  0  0 15]
 [ 0  0  0  0  9  0  0  0]
 [ 0  0  0  0  0 15  0  0]]

Minimum Spanning Tree (MST) for given undirected graph G (V, E) with weights is:

 Vertex path : Edge Weight

 V1 to V5    : 5

 V1 to V2    : 6

 V5 to V6    : 7

 V1 to V4    : 8

 V4 to V3    : 3

 V5 to V7    : 9

 V6 to V8    : 15
```

2. Verify the correctness of your program by solving the problem of finding the MST for the following graph as explained in the class.

CSCE 5150 – Analysis of Computer Algorithms

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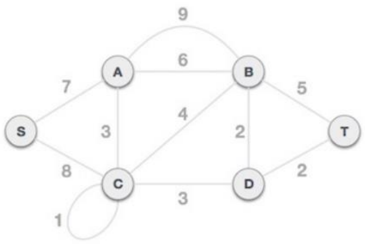

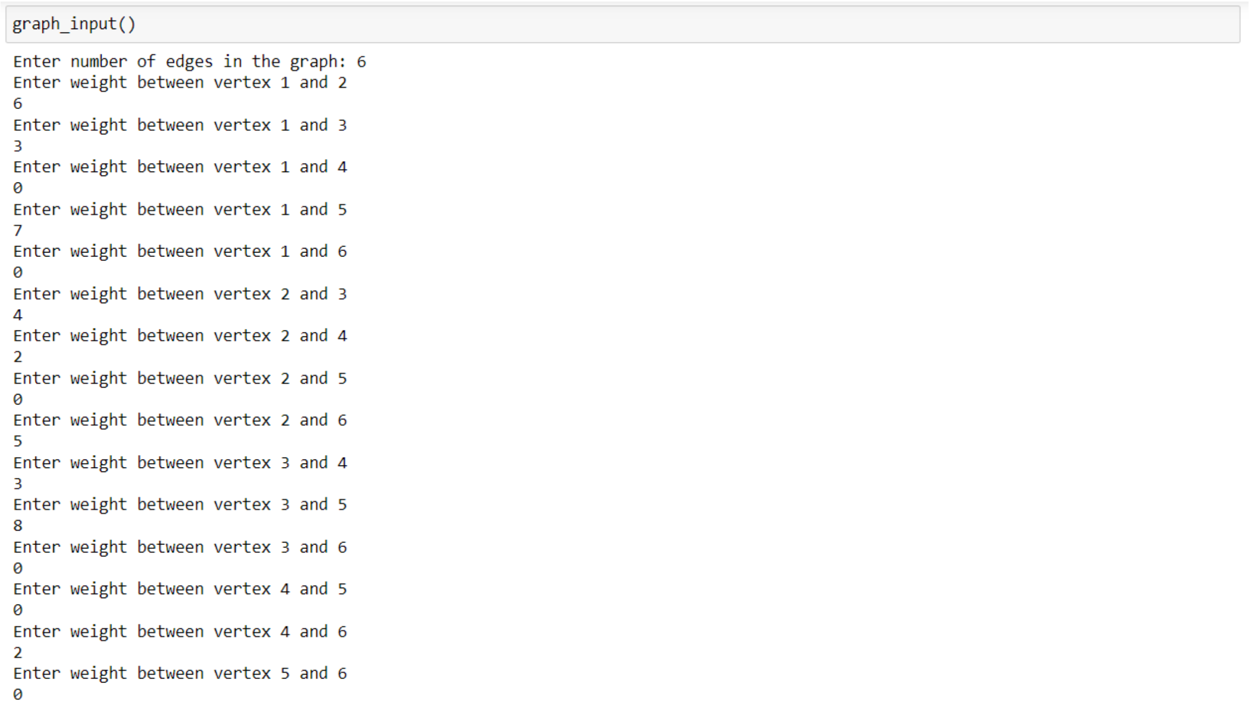

```
graph_input()
```

```
Enter number of edges in the graph: 6
Enter weight between vertex 1 and 2
6
Enter weight between vertex 1 and 3
3
Enter weight between vertex 1 and 4
0
Enter weight between vertex 1 and 5
7
Enter weight between vertex 1 and 6
0
Enter weight between vertex 2 and 3
4
Enter weight between vertex 2 and 4
2
Enter weight between vertex 2 and 5
0
Enter weight between vertex 2 and 6
5
Enter weight between vertex 3 and 4
3
Enter weight between vertex 3 and 5
8
Enter weight between vertex 3 and 6
0
Enter weight between vertex 4 and 5
0
Enter weight between vertex 4 and 6
2
Enter weight between vertex 5 and 6
0
```

CSCE 5150 – Analysis of Computer Algorithms

Programming Assignment 4 – Graph Algorithms

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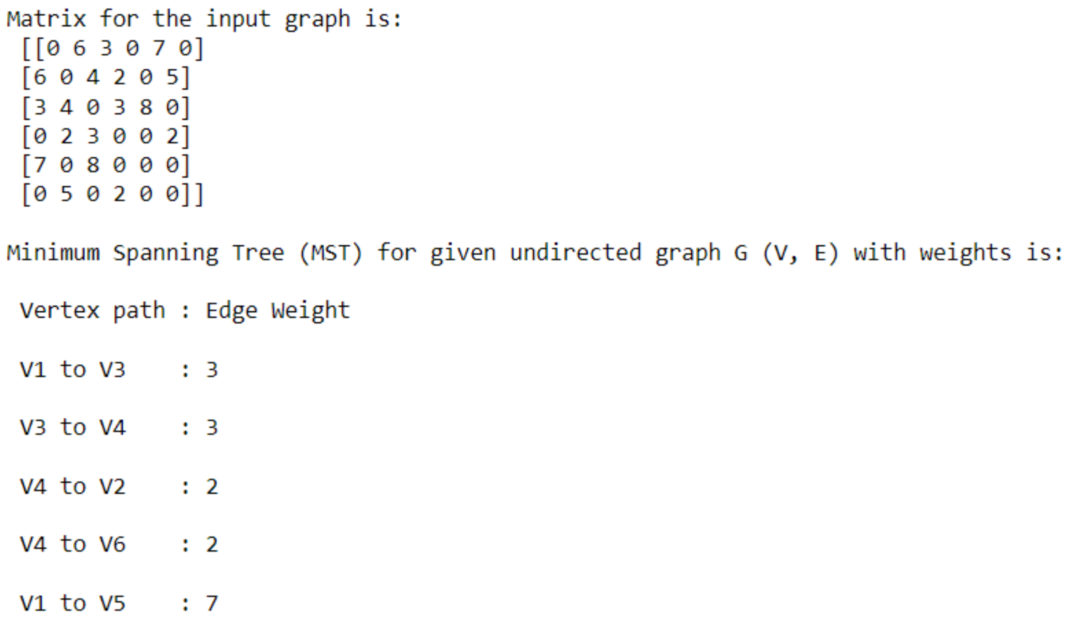
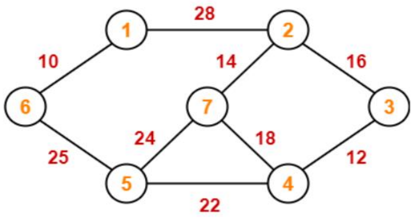


```
Matrix for the input graph is:
 [[0 6 3 0 7 0]
 [6 0 4 2 0 5]
 [3 4 0 3 8 0]
 [0 2 3 0 0 2]
 [7 0 8 0 0 0]
 [0 5 0 2 0 0]]

Minimum Spanning Tree (MST) for given undirected graph G (V, E) with weights is:

 Vertex path : Edge Weight

 V1 to V3    : 3

 V3 to V4    : 3

 V4 to V2    : 2

 V4 to V6    : 2

 V1 to V5    : 7
```

3. Verify the correctness of your program by solving the problem of finding the MST for the following graph as explained in the class.



CSCE 5150 – Analysis of Computer Algorithms

Programming Assignment 4 – Graph Algorithms

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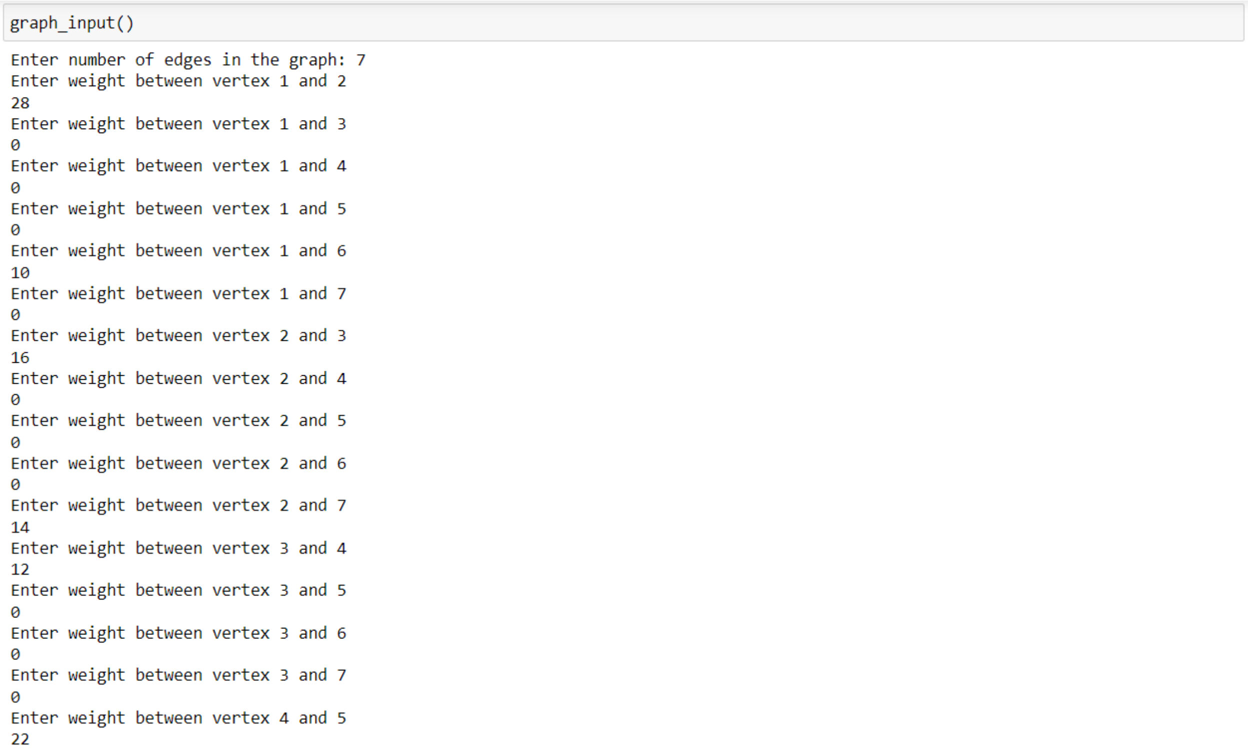

```
graph_input()
```

```
Enter number of edges in the graph: 7
Enter weight between vertex 1 and 2
28
Enter weight between vertex 1 and 3
0
Enter weight between vertex 1 and 4
0
Enter weight between vertex 1 and 5
0
Enter weight between vertex 1 and 6
10
Enter weight between vertex 1 and 7
0
Enter weight between vertex 2 and 3
16
Enter weight between vertex 2 and 4
0
Enter weight between vertex 2 and 5
0
Enter weight between vertex 2 and 6
0
Enter weight between vertex 2 and 7
14
Enter weight between vertex 3 and 4
12
Enter weight between vertex 3 and 5
0
Enter weight between vertex 3 and 6
0
Enter weight between vertex 3 and 7
0
Enter weight between vertex 4 and 5
22
```

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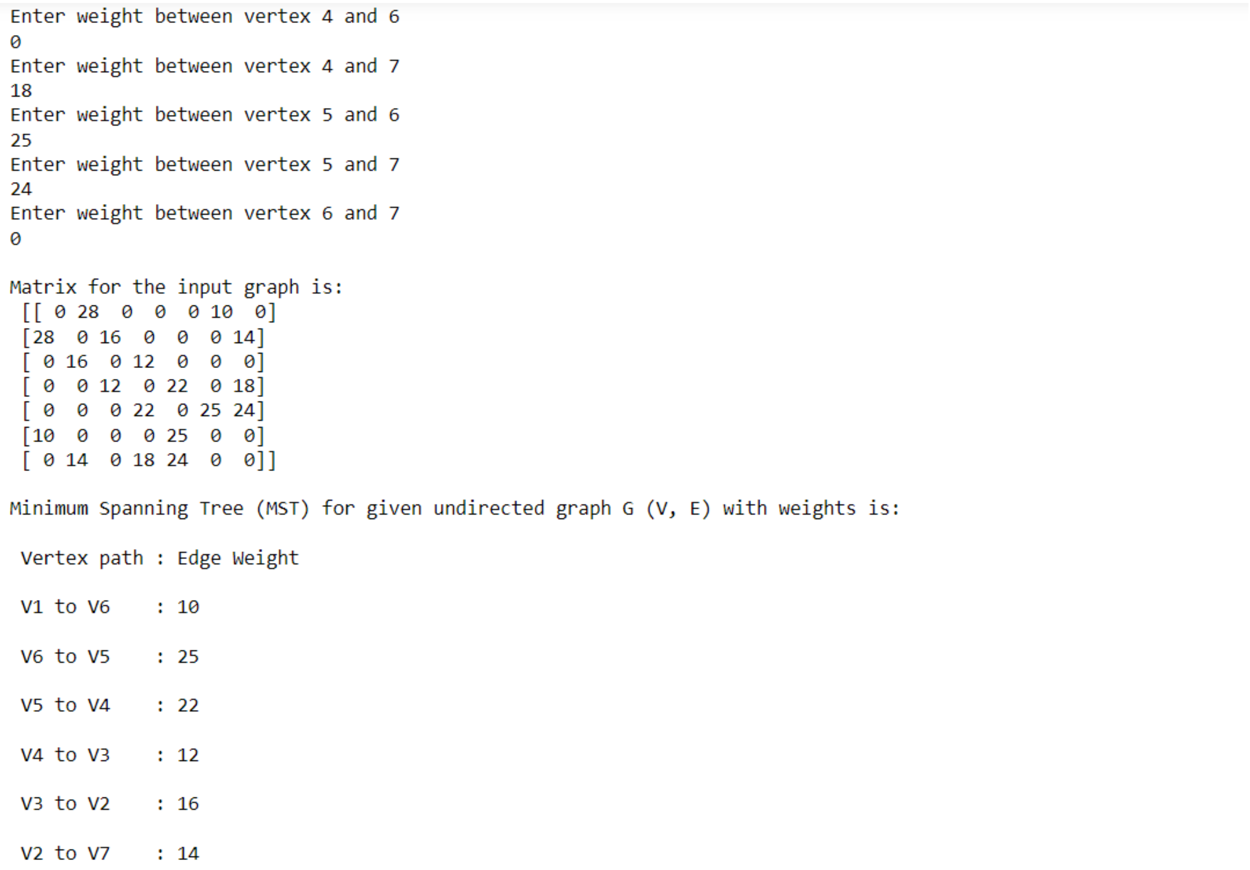

```
Enter weight between vertex 4 and 6
0
Enter weight between vertex 4 and 7
18
Enter weight between vertex 5 and 6
25
Enter weight between vertex 5 and 7
24
Enter weight between vertex 6 and 7
0

Matrix for the input graph is:
 [[ 0 28  0  0  0 10  0]
 [28  0 16  0  0  0 14]
 [ 0 16  0 12  0  0  0]
 [ 0  0 12  0 22  0 18]
 [ 0  0  0 22  0 25 24]
 [10  0  0  0 25  0  0]
 [ 0 14  0 18 24  0  0]]

Minimum Spanning Tree (MST) for given undirected graph G (V, E) with weights is:

 Vertex path : Edge Weight

 V1 to V6    : 10

 V6 to V5    : 25

 V5 to V4    : 22

 V4 to V3    : 12

 V3 to V2    : 16

 V2 to V7    : 14
```