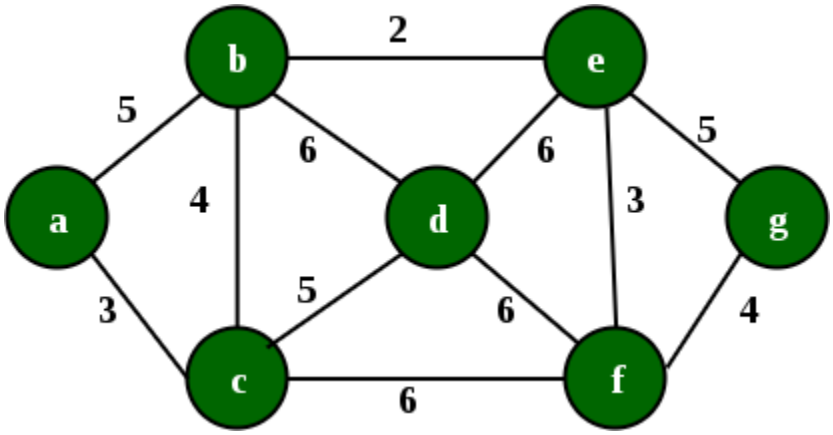
1. [Mark 10]

You work as an engineer for the Roads and Highways department in a district. The district has 7 thanas that are represented by the 7 vertices in the following graph. The edges between the vertices represent the roads that connect one thana with another and the weight of an edge represents the length of the road.

A recent flood has totally damaged these roads and immediate repair work is needed. The cost to repair a road is proportionate to its length. However, your department does not have the budget to repair all the roads so you need to repair a subset of the roads. Which algorithm should you use here to find out the roads that need to be repaired to keep all the thanas connected to one another with the **minimum** possible cost?

Show the step by step simulation of the algorithm. You may pick any algorithm of your preference that you think will solve the problem.



2. [Mark 2+6+2 = 10]

Consider the following modified ASCII scheme and the encoded message using it.

Character	a	b	c	d	e	f	g	h	i	j
m_ascii	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001

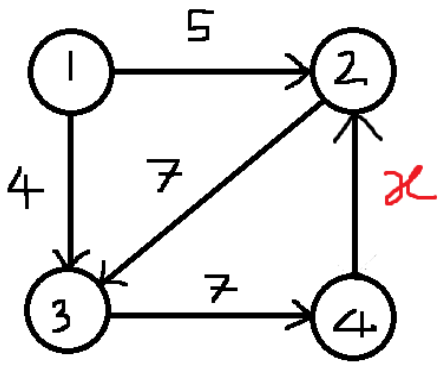
Message encoded with m_ascii code:
0000 0100 0100 1000 0100 1000 0100 1000 0001 0101 0001 0001 0110 0000 0100 1001 0010 1001

Now answer the following questions.

a) Decode the message.
b) Show simulation to find the encoding of each of the characters using Huffman coding technique. While creating a tree, less frequency nodes go to the left side of the root; left is considered as a 0, right is 1.
c) Calculate the number of bits required in the encoded message using huffman technique.

3. [Mark 4+4+3=10]

In the given graph, we want to find out the single source shortest path. The source is 1 in this case.



- Find a negative value of x such that the Dijkstra algorithm will work. Show the simulation.
- Find a negative value of x such that the Dijkstra Algorithm will not work. Use Bellman Ford Algorithm.
- Find a negative value of x such that both Dijkstra Algorithm and Bellman ford algorithm will not work. Explain the reason.

4. [Mark 4+2+4=10]

Today Alice has learned how to find the Longest Common Subsequence (LCS) of two given strings. Now she wants to find the LCS of “POLYNOMIAL” and “EXPONENTIAL”.

a. Complete the LCS table and find out the length of the LCS.

index		0	1	2	3	4	5	6	7	8	9	10
		-	P	O	L	Y	N	O	M	I	A	L
0	-											
1	E											
2	X											
3	P											
4	O											
5	N											
6	E											
7	N											
8	T											
9	I											
10	A											
11	L											

b. Let M be your LCS table. What do you understand by the value of M[3][4]?
c. Find out the LCS String from the table. Show the steps of your work.
d. **[BONUS]** Write the python code for this problem.

5. [Mark 4+2+4=10]

Two infamous thieves, Denver and Nairobi, planned to rob the famous Louvre Museum. Before the scene, they both agreed on the fact that none of them will break any item as all the items in the museum are too precious, and taking a fraction of any item won't sell on the black market. If it fits in the bag as a whole, they will take it, otherwise, leave it as it is.

Both of them arrived at the Royal Treasury with an empty knapsack weighing a total of **7 kg** each. Even though both thieves are experts in their fields, they take slightly different approaches. Denver believes he will use a Dynamic Programming Approach to rob the items in the most efficient manner possible. Nairobi, on the other hand, believes that if she chooses a Greedy Approach, she will make the most money.

The objects in the Royal Treasury Museum are listed below.

Objects	Diamond	Jewelry	Sculpture	Painting	Gold Crest
Profit ($)	3	4	12	9	12
Weight (kg)	1	2	8	4	5

a) Simulate your dynamic programming algorithm to find the maximum profit Denver can make.
b) From your memory/dp table, find out which items would he take to make this amount of profit?
c) Does Nairobi's belief remain valid after the robbery? Prove it by simulating her approach.
d) **[BONUS]** Explain the DP equation for Denver's approach.
e) **[BONUS]** Write the python code for Denvers approach.