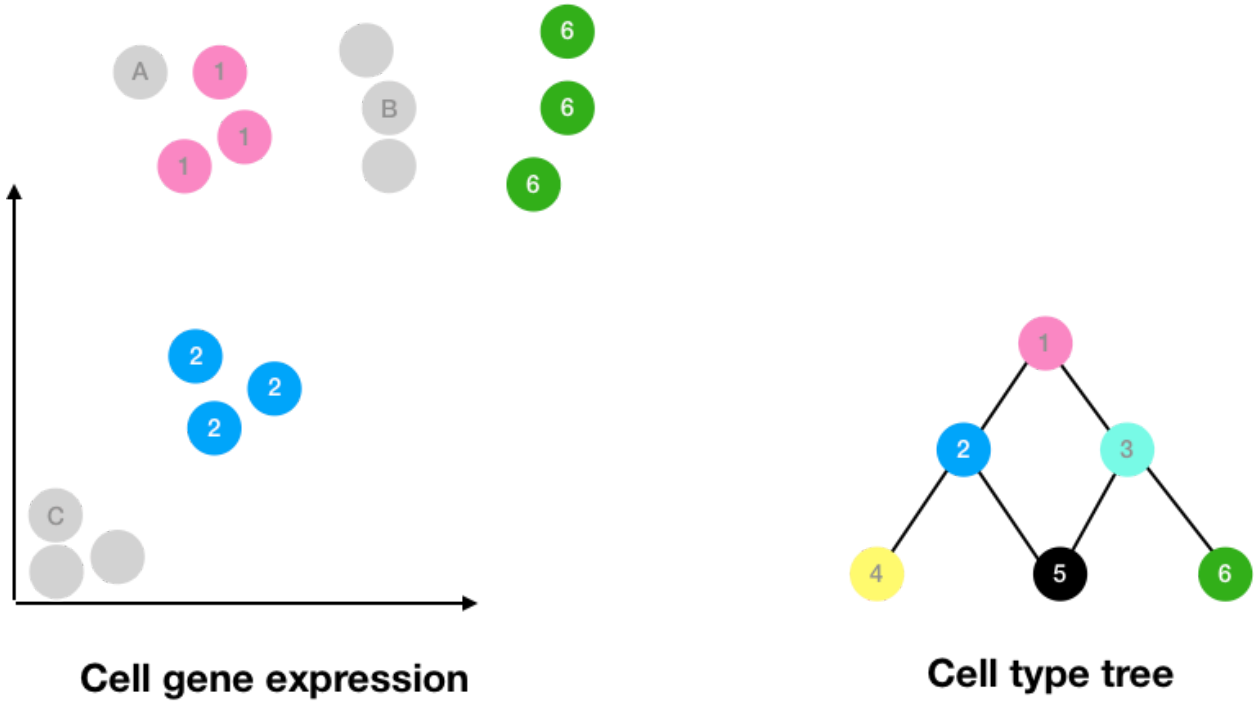
Problem 1. Tree-based cell type classification (10 points).

We observed the expression of many cells (left panel). We know the cell types of some of them (colored in **blue, pink, green**). We don't know the cell types of the remaining (colored in **gray**). There are in total six cell types (**blue, pink, cyan, yellow, green, black**). Their similarities are documented in a cell type tree, which can help us do the classification (right panel). Using the tree-based classification method we introduced, what might be the cell type of A, B, C? (You only need to write down the color of A, B and C.) This problem is related to the last few slides of the big cat examples we introduced in the protein function prediction.



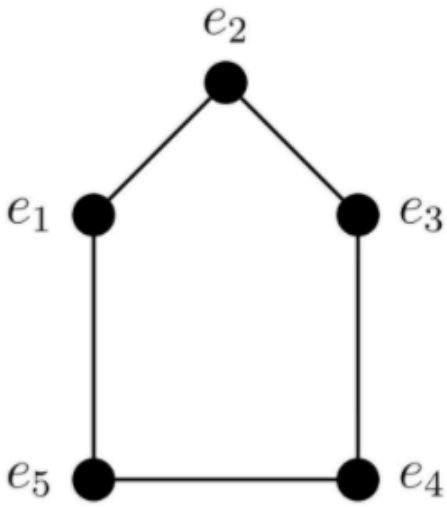
Cell gene expression

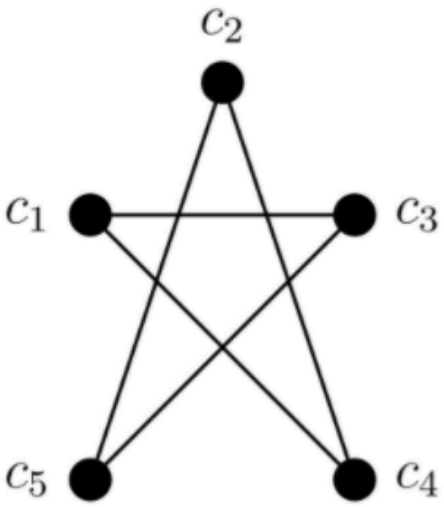
Cell type tree

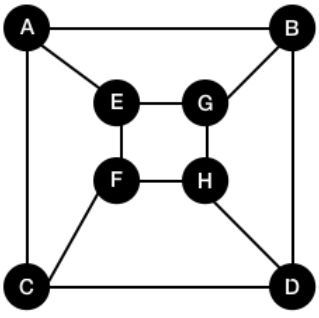
Answer:

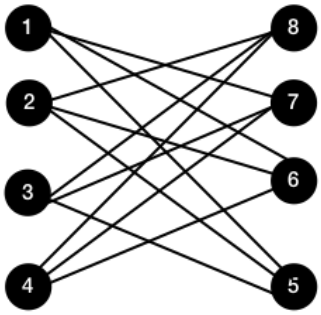
Problem 2. Graph Isomorphism (10 points).

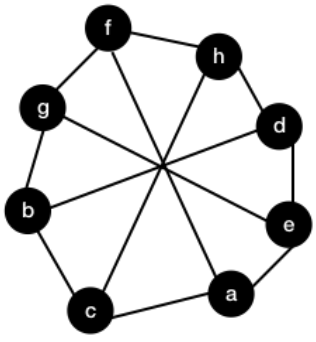
Find the graphs that are topologically equivalent (isomorphic) from the following graphs. Please also show the bijection function f. You only need to write the answer; no need to show the steps. As some graphs could be too large to use the algorithm we introduced in the class. You don't necessarily need to use that algorithm. This problem is related to the last few slides of graph basics slides.











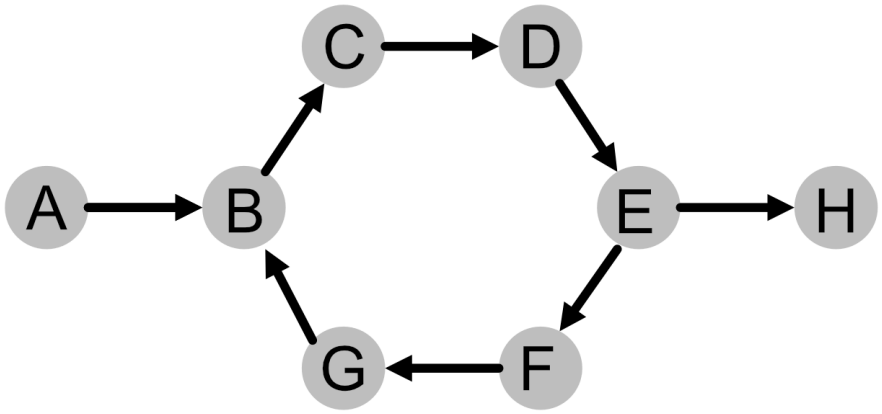
Answer:

Problem 3. Graph irreducible and aperiodic (10 points)**.**

Graph 1 is a directed graph that has 8 nodes and 8 directed edges.

Is this graph irreducible? If it is **not** irreducible, which single edge can we add to make it irreducible? Please list **all** the possible edges, including the self-loop if applicable. (5 points)

Is this graph aperiodic? If it is **not** aperiodic, which single edge can we add to make it aperiodic? Please list **all** the possible edges, including the self-loop if applicable.(5 points).
This problem is introduced in the advanced graph diffusion lecture.



Answer: