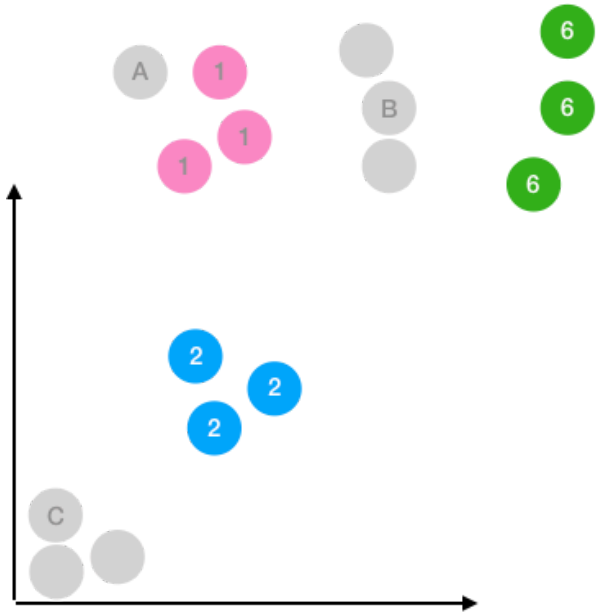
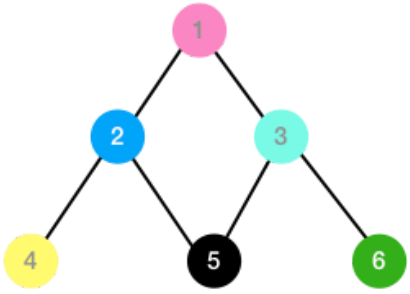
Problem 1. Tree-based cell type classification (10 points).

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.)



Cell gene expression

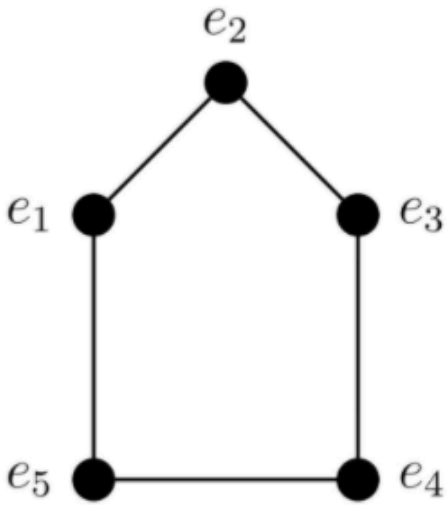


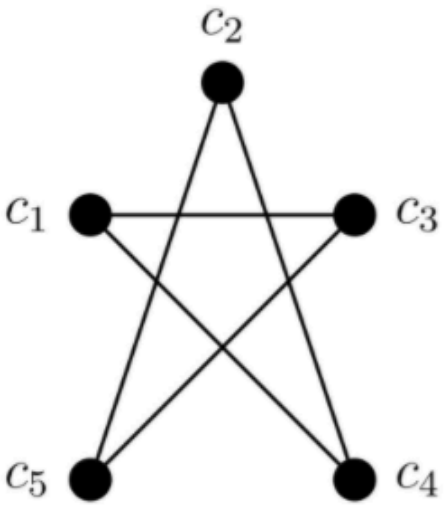
Cell type tree

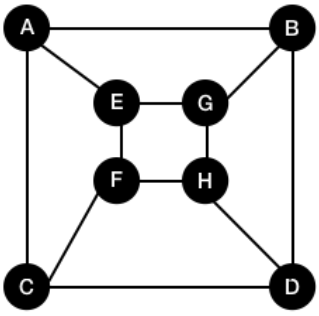
Answer:

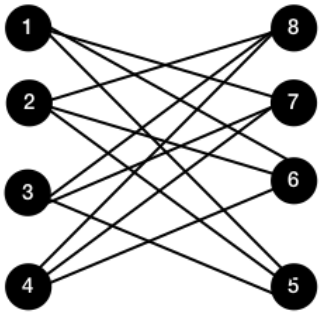
Problem 2. Graph Isomorphism (10 points).

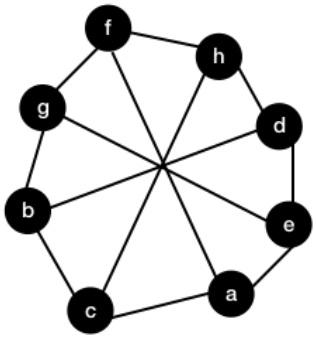
Find the graphs that are topologically equivalent (isomorphic) from the following graphs. Please also show the bijection function f.











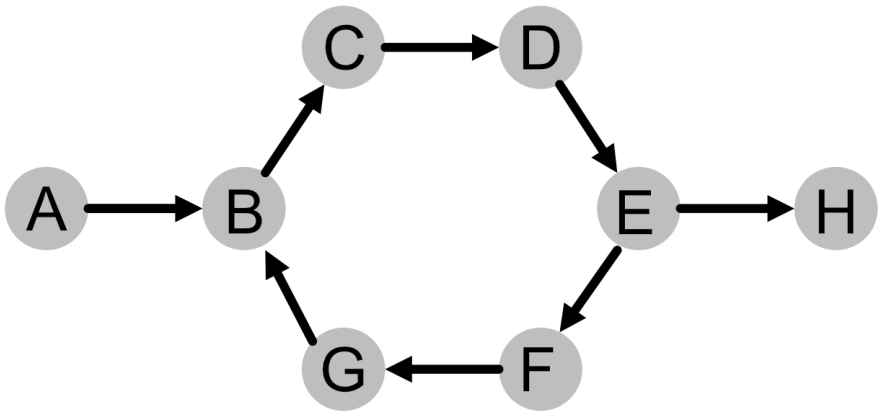
Answer:

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).



Answer: