Complex Networks Exam (16 points)
January 6, 2023

All documents allowed. Read all directions carefully and write well-argued answers.
Try to be concise but precise.
Write your master specialty (e.g., Physics, Biology, etc.) on your answer sheet.
You can write your answers in English or French.

Figure 1: Subway Network of Lyon+funiculars

Let's consider the subway network of Lyon (subway+funiculars). We represent it as a network with each node representing a station, and edges represent a direct connection between those stations.

There are 15 nodes in the D line, 14 nodes in the red one, 10 nodes in the blue line, 5 on the yellow line, and 4 in the funiculars. In total, there are 43 nodes.

1. (2 points) Do you think that this network is a *small world* network ? Discuss your answer. You do not need to make exact computations (i.e., compute the log of something or the distance between pairs of nodes).

2. (2 points) Among nodes having a degree strictly above 2, which one(s) have higher/lower betweenness ? Justify your answers, if possible in a numeric way (that can be approximate)

3. (2 points) Considering that the position of stations on the map is accurate, and taking into account the legend, plot an **approximate** deterrence function.

4. (2 points) Let's consider that a subway takes exactly 2 minutes to go from any station to the next one in the same line. Changing line takes exactly 6 minutes. We start from station *Jean Macé*, and we want to reach station *Hôtel de Ville Louis Pradel*. If we represent this as a dynamic network, what would you say is the shortest path ? The Foremost path ? The Fastest path ?

5. (2 points) How relevant do you think it is to interprete this network in term of spatial structure ? In term of community structure ? In term of core-periphery structure ?

6. (4 points) We would like to evaluate how efficient is this network as a public transport network. In particular, we are interested in 1)how efficient it is to move people from any point A to any other point B, taking into account the size of the network (number of lines, length of the lines...) and 2)how resilient it is, i.e., how much is the traffic affected if one line, or one station, is out of order. Propose scores and methods (existing ones or of your own design), including appropriate null models, to test those aspects. There is no single right answer, just make proposals of experiment you would design, based on what we have seen during the class.