Exercise 1. ***Network analysis.***

In this exercise, we generate (i) Erdős-Rényi and (ii) Barabási-Albert networks and analyze some of their properties.

To build an Erdős-Rényi network, begin with a set of N isolated nodes and iterate over all possible node pairs. Two nodes are connected with probability p.

Barabási-Albert networks are constructed via preferential attachment after starting from a connected network with m_0 nodes (e.g., a dyad). Preferential attachment means that a new node is connected to $m \leq m_0$ existing nodes and the probability p_i of being connected to an existing node i is proportional to the degree k_i of that node (i.e., $p_i = k_i / \sum_j k_j$).

(a) You can start with networks that have $N = 100$ nodes and later extend your analyses to networks with 1000 and 10000 nodes. Vary the connection probability p for Erdős-Rényi networks and the parameter m for Barabási-Albert networks. What is the influence of these variations on the degree distribution?

(b) Implement Dijkstra's algorithm and determine the average path length between two nodes for networks (i) and (ii) as a function of the number of nodes N. What do you observe?

Exercise 2. ***Visualizing networks with*** `graph-tool`***.***

This exercise will provide a short introduction to working with the network analysis and visualization library `graph-tool`. (A commonly used alternative is the library `NetworkX`.)

Hint. A `graph-tool` *tutorial can be found at* https://graph-tool.skewed.de/static/doc/quickstart.html.

(a) Create a Delaunay triangulation network and its minimum spanning tree using the following commands.

```
g, pos = triangulation(random((500, 2)) * 4, type="delaunay")
tree = min_spanning_tree(g)
```

(b) Visualize the resulting network that contains only those nodes that belong to the minimum spanning tree.

(c) Compute geodesic edge and node betweennness centralities and again visualize the network. Color nodes and use edge widths according to their centralities. (Edge with large centrality should have a large edge width in your plots.)