Network Science
PHYS 5116, Fall 2021

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Assignment 2, due by Oct. 29th, 6pm.

You are only allowed to hand in a single file containing all your work, either a PDF or a stapled paper copy. If you attempt to hand in more than one file, we will grade only one of the files, selected at random. Please name your single file as LASTNAME.pdf, *e.g.* Shekhtman.pdf

1. *Scale-free networks (25 points).* Write a computer code to generate networks of size N with a power-law degree distribution with degree exponent γ. Refer to SECTION 4.9 for the procedure. Generate three networks with $\gamma = 2.2$ and with $N = 10^3$, $N = 10^4$ and $N = 10^5$ nodes, respectively. What is the percentage of multi-link and selfloops in each network? Generate more networks to plot this percentage in function of N. Do the same for networks with $\gamma = 3$.

2. *Visualization (25 points).* Download the dataset `netscience.zip` from the website. As described in the text file, this is a coauthorship network of scientists working on network theory and experiment compiled by Mark Newman in 2006. Visualize the largest component of the network (Gephi may be the easiest choice of software, but you are free to use your favorite), considering the following:

- Degree
- Other measures of centrality
- Community structure

Make appropriate use of color, size and layout to create a clear and informative visualization. Describe your approach and comment on your observations (about a paragraph for each).

3. *Copying Model (30 points).* Use the rate equation approach to show that the directed copying model leads to a scale-free network with incoming degree exponent

$$\gamma_i = \frac{2-p}{1-p}.$$

Hint: First calculate the value of β relating k_i and t and then use Eq. 5.10 to calculate γ.

4. *Structural Cutoffs* (20 points). Calculate the structural cutoff k_s for the undirected networks listed in Table 4.1. Based on the plots in Image 7.10, predict for each network whether k_s is larger or smaller than the maximum expected degree k_{max}. Confirm your prediction by calculating k_{max}.