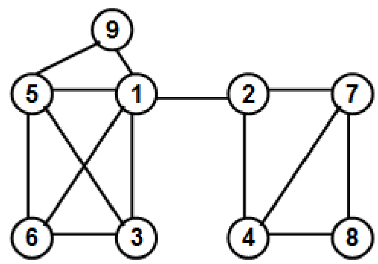
CSC 539 Computational Epidemics
Summer 2022
Jackson State University
Exam 4
Instructor: Dr. Natarajan Meghanathan

Total Points: 125 **Due: July 27th, 2022, 11.59 PM in Canvas**

Q1: 100 pts) Consider the graph given below and a virus attack (on the nodes of the graph) that spreads per the SIS model. Let the link infection probability (β) be 0.2 and the average time for an infected node to recover (1/μ) be 2 (rounds in a simulation).



a: 6 pts) Determine the R0 for the disease on this graph.
b: 7 pts) Using the R0 of (a), determine the minimum number of nodes in this graph that need to be vaccinated to establish "herd immunity" for the susceptible/but non-vaccinated nodes of the graph.
c: 40 pts) Determine the Neighborhood based Node Centrality (NBNC) tuples for the nodes of this graph and rank the nodes on the basis of the extent to which they play the role of bridge nodes in this graph. Show all the work details.
d: 40 pts) Use the required number of top-ranked bridge node(s) of the graph (based on the results of parts-(b) and (c)) for vaccination (to establish herd immunity) and run a simulation of the SIS model for **10 rounds or stop at an earlier round if no nodes are infected at the end of the latest round**.

Let node '4' be the initially infected node in the graph.

Use the random numbers below to decide if a node in a link is to get infected or not in any round.

Link	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10
1…2	0.50276	0.104678	0.228795	0.771742	0.055301	0.910983	0.647594	0.634862	0.25285	0.790143
1…3	0.838151	0.868612	0.712249	0.989675	0.034524	0.750323	0.127702	0.344177	0.89537	0.496369
1…5	0.392343	0.79876	0.220566	0.168034	0.913286	0.864076	0.273794	0.86353	0.02127	0.025688
1…6	0.733936	0.6977	0.379317	0.716973	0.95303	0.454835	0.019911	0.655017	0.29214	0.792992
1…9	0.401498	0.095203	0.139484	0.531554	0.431669	0.739572	0.694512	0.763577	0.35319	0.379725
2…4	0.081904	0.851675	0.465302	0.367065	0.793031	0.190389	0.711698	0.60097	0.997886	0.521277
2…7	0.009307	0.325497	0.954589	0.121734	0.418122	0.289996	0.090838	0.098259	0.944249	0.159842
3…5	0.029944	0.596607	0.916754	0.337874	0.965575	0.399674	0.521497	0.950034	0.590992	0.720943
3…6	0.310377	0.723786	0.836292	0.184175	0.841531	0.970554	0.901006	0.636586	0.687292	0.708067
4…7	0.707347	0.630608	0.32906	0.475481	0.558663	0.500969	0.434461	0.49506	0.784169	0.339811
4…8	0.759166	0.426413	0.11678	0.203528	0.703292	0.464775	0.234663	0.280854	0.646305	0.598838
5…6	0.924845	0.812502	0.601736	0.545288	0.806216	0.706949	0.713728	0.138592	0.117971	0.631618
5…9	0.975092	0.092027	0.120176	0.511171	0.068351	0.614986	0.30089	0.371344	0.567742	0.329592
7…8	0.36981	0.657191	0.950143	0.112431	0.314978	0.923789	0.735038	0.929905	0.109418	0.083181

As part of your solution, include screenshots of the graphs with the nodes colored yellow (susceptible nodes) and red (infected nodes) for each round.

Show the graphs at the beginning and end of each round as well as clearly write down the infected nodes at the end of each round.

e: 7 pts) Determine the total number of infected nodes per round (based on the simulations of part-d). Interpret what this number indicates to you?

Q2 - 25 pts) Consider a group of 25 people identified with ids 0 to 24. There are two people (ids: 4 and 17) in this group who are infected with an epidemic. We seek to employ group testing to minimize the number of test kits used and still be able to individually identify and isolate the infected people. We would like to use a binary search approach for "group testing" to identify the two infected people.

(a - 15 pts) Draw a binary search tree that will illustrate the isolation of the two infected people from the groups of the people (tested with only one test kit) who are not infected.
(b - 10 pts) Determine the following:

Efficiency of the group testing approach

Tests per cleared person