MIDTERM EXAMINATION
Networked Life (NETS 112)
October 24, 2017
Prof. Michael Kearns

This is a closed-book exam. You should have no material on your desk other than the exam itself and a pencil or pen. If you run out of room on a page, you may use the back, but be sure to indicate you have done so. You may also make annotations directly on any diagrams given.

Name:

Problem 1: _____/10

Problem 2: _____/15

Problem 3: _____/15

Problem 4: _____/15

Problem 5: _____/15

Problem 6: _____/15

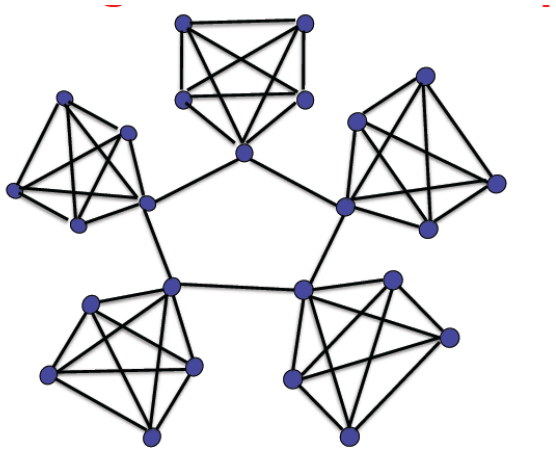
Problem 7: _____/15

TOTAL: _____/100

Problem 1 (10 points). Next each lettered item on the left, write the number of the item on the right that is the best match.

(a) Kleinberg	1. greetings and salutations
(b) clustering coefficient	2. Raleigh NC
(c) inverse polynomial	3. closest attribute
(d) Taylor Swift's breakfast	4. counting triangles
(e) downtown Philadelphia	5. predicting cascades
(f) second largest component	6. 1.59
(g) Ashour	7. broadcast virality
(h) Where's George	8. Erdos
(i) sociological navigation model	9. heavy tails
(j) content less important	10. 2.0

Problem 2 (15 points). For this problem, consider the network shown below.



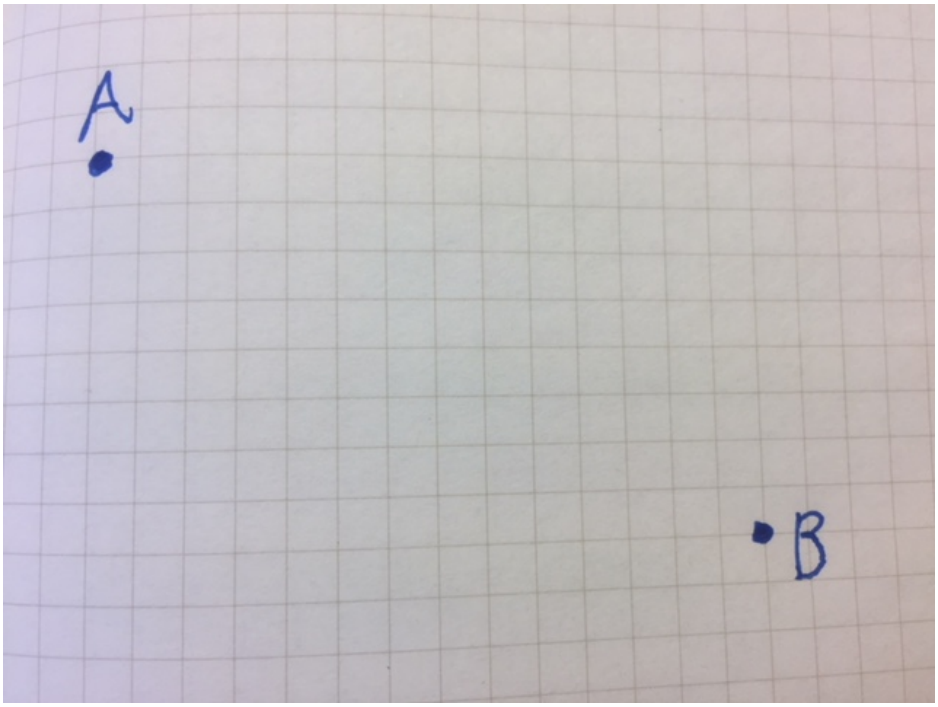
(a) Precisely compute the clustering coefficient of this network. You do not have to give your answer in decimal form, but simplify it as much as possible, and show your work and calculations.

(b) Precisely compute the edge density of this network, which is the fraction of possible edges that are actually present. You do not have to give your answer in decimal form, but simplify it as much as possible, and show your work and calculations.

(c) Based on your answers to (a) and (b), discuss whether this network is highly clustered or not, and why.

Problem 3 (15 points). Write a summary of major course results and findings to date in bulleted form. By a result or finding, we mean a specific scientific conclusion in one of the assigned readings, the outcome of an in-class simulation or demo, a theme or point emphasized in lecture, etc. For each bullet, you should be brief (one or two sentences) but precise, and cite the source if possible. An example bullet would be "In Kleinberg's navigation model, only for exponent 2.0 does a local algorithm find short paths". You should aim for coverage/breadth as well, so you shouldn't have a separate bullet that says "In Kleinberg's navigation model, for exponents > 2.0 the diameter is large". As a rough guideline, if you have 15-20 bullets that cover all/most major themes, that's probably about right. Answers will be graded for both coverage and precision.

Problem 4 (15 points). Consider the grid network consisting of the entire image below, in which there is a vertex at every grid point, and two distinguished vertices have been labeled A and B. Consider Kleinberg's model and algorithm for navigation when the goal is to route a message from vertex A to vertex B.

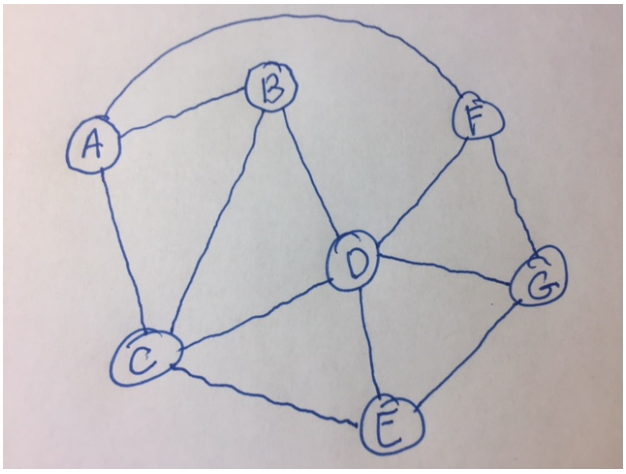


(a) Add two "long distance" edges to this network such that each edge travels at most grid distance 8, and such that Kleinberg's algorithm for navigation could now find a path from A to B of length at most 8. Clearly label these new edges 1 and 2.

(b) Add two "long distance" edges to this network such that each edge travels at most grid distance 8, and such that the distance between A and B is at most 12, but Kleinberg's algorithm for navigation would never use either of the new edges. Clearly label these new edges 3 and 4.

(c) Could adding edges to the grid ever cause Kleinberg's algorithm for navigation to find *longer* paths than in the grid alone? If so, add such a new edge and clearly label it 5. If not, explain why this is impossible.

Problem 5 (15 points). Imagine that the vertices in the network below represent Penn students, and there is an edge between two students if they are close friends who spend a great deal of time together. Close friends would prefer to have different ringtones on their cellphones so that when they are together, there isn't confusion about whose phone is ringing.



(a) As clearly as precisely as you can, describe how one can use the network to find a choice of ringtones for the students so that such confusion never arises, yet the overall number of ringtones used is small.

(b) Use you answer in (a) to find a specific ringtone assignment to the students in the network that minimizes the number of different ringtones used. Letting the unique ringtones be denoted 1, 2, 3, etc., show your solution by clearly labeling each student/vertex by their assigned ringtone.

(c) For a general connected network on N vertices, what are the smallest and largest numbers of different ringtones that could be required to avoid confusion? Explain your answer.

Problem 6 (15 points). Fill in the blanks in each of the sentences below.

(a) The tendency for squash players to play against opponents of similar ability is an example of the phenomenon of _____.

(b) The Facebook recruitment study we read found that people were more likely to join Facebook the more _____ the group of friends they were shown was.

(c) The Erdos Project studies a social network in which the vertices represents researchers in the field of _____.

(d) One of the purposes of Travers and Milgram accompanying their chain letter by a roster was to prevent the occurrences of _____ in the navigation process.

(e) Two of the papers we read measured the relative "depth" or "shallowness" of a cascade by a quantity called the _____.

(f) The "forest fire" contagion demo in class and in the videos exhibited a "tipping point" when the fraction of forested cells was approximately _____ percent.

(g) The random network contagion demo exhibited in class and in the videos exhibited a "tipping" point when the average vertex degree was approximately _____.

(h) The smallest and largest possible values for the clustering coefficient of a network are _____ and _____ respectively.

(i) The maximum number of vertices possible in a network with all degrees at most d and (worst-case) diameter at most k grows _____ in d and _____ in k.

(j) An example of a large-scale directed network is _____.

(k) Among people with a finite Erdos number, the number of people with Erdos number 5 is much _____ than the number of people with Erdos number 10.

(l) One of our readings found that the use of "moral-emotional" language in tweets _____ their virality.

(m) A biological network with high clustering coefficient is nervous system of the species of _____ known as *C. Elegans*.

(n) A technological network with high clustering coefficient is the North American _____.

(o) Even without precise definitions, it it generally agreed that "small diameter" should mean diameter that is independent of, or only logarithmically growing, in _____.

Problem 7 (15 points). Consider the network in the image below. For each of the four main "universal" structural properties of social networks discussed in recent lectures, indicate whether this network has those properties or not, and justify your answer as precisely as possible.