Networked Life
CSE 112
Prof. Michael Kearns
Final Examination
May 1, 2007

NAME: _____

PENN ID: _____

Exam Score:

Problem 1:_____/10
Problem 2:_____/10
Problem 3:_____/10
Problem 4:_____/10
Problem 5:_____/10
Problem 6:_____/10
Problem 7:_____/10
Problem 8:_____/10
Problem 9:_____/10
Problem 10:_____/10

TOTAL:_____/100

This is a closed-book exam; you should have no materials other than this exam and a pencil or pen.

If you need more space to answer a problem, use the reverse side of the page, but clearly indicate where your answers are.

1. (10 points) For each item on the left, write the index of the item on the right which is the best match.

a. connectors ____	1. fewest colors required
b. market for lemons ____	2. neural network
c. dollar bill migration ____	3. cascading
d. C. Elegans ____	4. Nash equilibrium
e. baggage screening ____	5. no wealth variation
f. perfect matching ____	6. independent set
g. forest fire ____	7. the heavy tail
h. complement of clique ____	8. scaling laws of human travel
i. chromatic number ____	9. viral spread
j. no unilateral gain ____	10. interdependent security

2. (10 points)

(a) (5 points) Draw a network with 10 vertices in which the clustering coefficient and the overall rate of connectivity (i.e. the fraction of all possible edges in the network that are present) are both low. What network formation model studied in class would give rise to networks with this property?

(b) (5 points) Draw a network with 10 vertices in which the clustering coefficient is relatively high, but the overall rate of connectivity is relatively low. What network formation model studied in class would give rise to networks with this property?

3. (10 points) Consider the behavioral network science experiments in which the games being played were Coloring, Consensus, and Kings and Pawns (without tips). In each of these games, there was a precise specification of how individuals would be paid in response to their own actions and those of their neighbors in the network, so we can discuss both the maximum social welfare states (the global configurations in which the total payoff to the population is highest), and the Nash equilibria. For each of the three games, answer the following questions:

    (i) Is a maximum social welfare state always a Nash equilibrium? Explain.

    (ii) Is a Nash equilibrium always a maximum social welfare state? Explain.

Coloring:
(i)

(ii)

Consensus:
(i)

(ii)

Kings and Pawns without tips:
(i)

(ii)

4. (10 points) Consider the assigned reading “The Scaling Laws of Human Travel”.

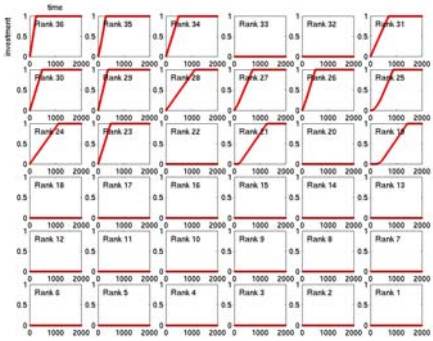
(a) (3 points) Briefly summarize the source and nature of the data analyzed in the paper.

(b) (4 points) Briefly summarize the main empirical findings of the paper.

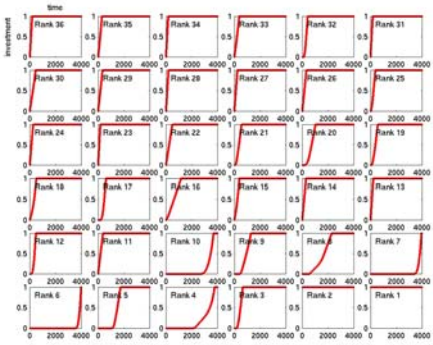
(c) (3 points) Discuss the implications of the empirical findings for the network formation model and theoretical results of Kleinberg’s paper “Navigation in a Small World”.

5. (10 points)

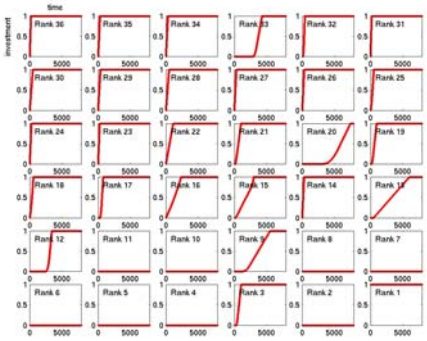
(a) (6 points) Briefly discuss what is being illustrated in the figure below, and what points are demonstrated by the diagram.



(b) (2 points) Briefly discuss how the figure below differs from that in (a), and what point is being demonstrated.



(c) (2 points) Briefly discuss how the figure below differs from that in (a) and (b), and what point is being demonstrated.



6. (10 points) Consider the network Milk-Wheat economic exchange model considered extensively in class. Draw the smallest bipartite network you can in which the number of Milk players and Wheat players is the same, each player begins with an endowment of 1.0 of their respective good, the network is connected (i.e. there is a path between any pair of players), and the equilibrium wealths are *not* all equal. Annotate your diagram with the wealth of each player at equilibrium.

7. (10 points). The following assertions all refer to the behavioral network science experiments from this semester and/or the ones from last year described in the paper "An Experimental Study of the Coloring Problem on Human Subject Networks". For each assertion, circle True or False.

(a) All networks used in the Kings and Pawns experiments were bipartite.
TRUE FALSE

(b) In the network formation model used for this semester's coloring experiments, larger values of p tended to increase the time to solution
TRUE FALSE

(c) In the network formation model used for this semester's consensus experiments, larger values of p tended to increase the time to solution
TRUE FALSE

(d) Allowing the exchange of tips tended to reduce social welfare in Kings and Pawns
TRUE FALSE

(e) In last year's coloring experiments, showing participants the entire network increased the time to solution, regardless of the network structure
TRUE FALSE

(f) In Kings and Pawns with tips allowed, the instantaneous social welfare approached its maximum possible value at some point during most experiments
TRUE FALSE

(g) In last year's coloring experiments, the Leader Cycle networks yielded the smallest average time to solution
TRUE FALSE

(h) Across all of the experiments from both last year and this year, smaller network diameter tended to lead to faster solution, regardless of the game type
TRUE FALSE

(i) Across all of the experiments from both last year and this year, higher network clustering coefficient tended to lead to faster solution, regardless of the game type
TRUE FALSE

(j) Allowing the exchange of tips dramatically improved the social welfare in Kings and Pawns when play occurred in isolated pairs
TRUE FALSE

8. (10 points) Consider a bipartite network in which one set of vertices represents movies, the other set of vertices represents actors, and there is an edge between a movie and an actor if and only if that actor appeared in that movie.

(a) (3 points) Suppose there is an actor whose degree is very large. Does this imply that there is a movie with very large degree? Explain your answer.

(b) (3 points) Suppose the degree distribution of the actors is heavy-tailed. Does this imply that the degree distribution of the movies is heavy-tailed? Explain your answer.

(c) (4 points) Suppose that the number of movies and actors is the same, and that every actor has appeared in at least d movies. What can you say about the degrees of the movies? Explain your answer.

9. (10 points) Consider a population of N people. Suppose there is a group activity for this population that obeys the following dynamics:
    - If k people participated in the activity last time, then N-k will participate this time.

(a) (3 points) Draw a diagram below of the type found in Schelling's book to represent these dynamics. Be sure to label your axes precisely.

(b) (4 points) Re-draw your diagram from part (a) below and use it to compute the eventual number of people participating if the initial number of participants is 0.

(c) (3 points) Is there any number of initial participants that will cause the eventual number of people participating to be different from your answer to part (b)?

10. (10 points)

(a) (5 points) Give an example of a model of economic exchange taking place over networks in which the wealth of individuals is entirely determined by their degrees. Be precise in your description.

(b) (5 points) Give an example of a model of economic exchange taking place over networks in which the wealth of individuals is *not* entirely determined by their degrees, and explain why it is not. Be precise in your description.