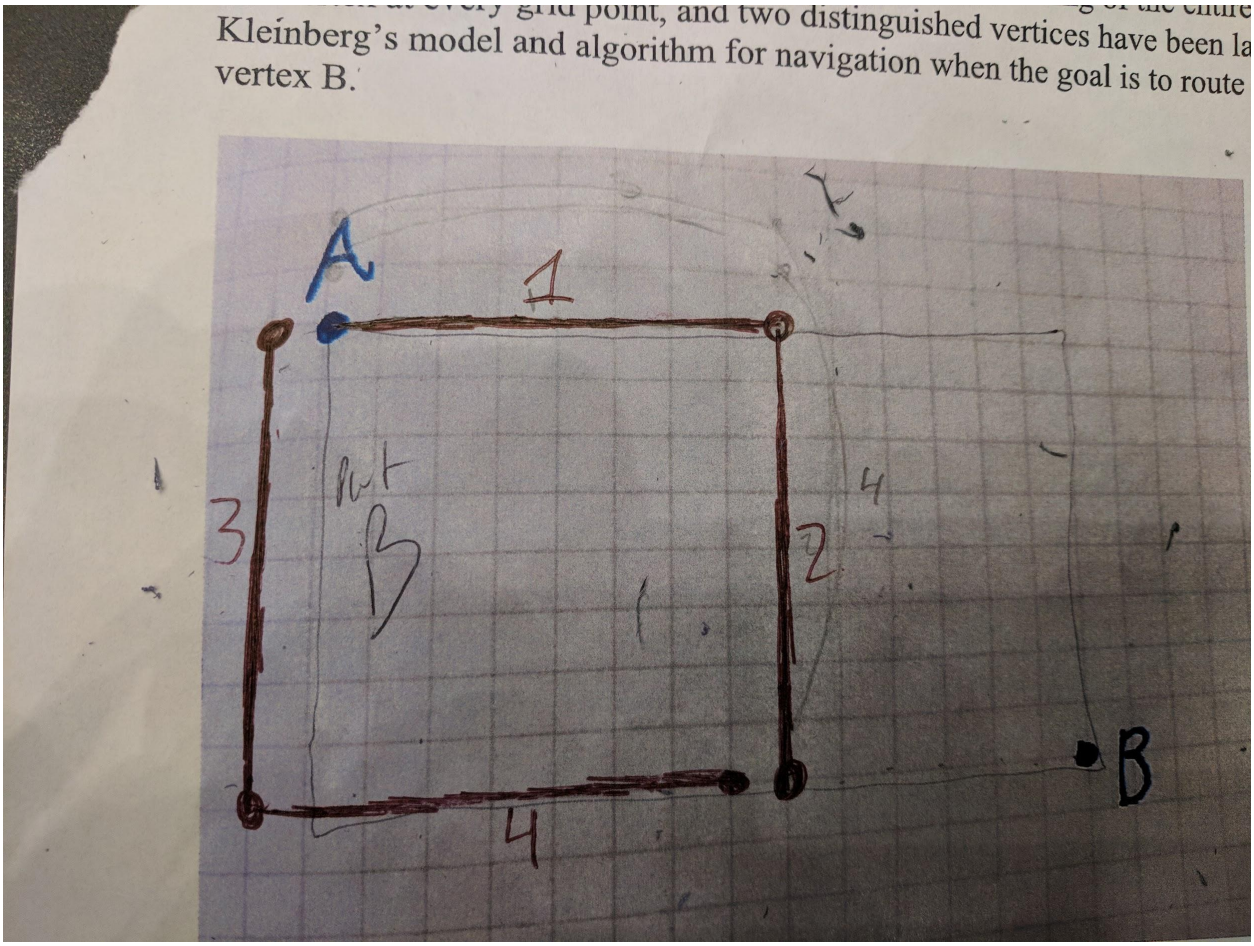
1. Samantha - Matching - **Grading:** 1 pt for each correct answer
    a. 10
    b. 4
    c. 9
    d. 7
    e. 1
    f. 2
    g. 8
    h. 6
    i. 3
    j. 5

2. Samantha - Network
    a. Clustering coefficient: 22/25 - **Grading:** 3 pts for the answer, 2 pts for showing work
        -For each exterior node: CC = 6 / (4 x (3/2)) = 1
        -For 5 interior nodes: CC = 6 / (6 x (5/2)) = 2/5
        -CC = 20 (1) + 5 (2/5) / 25 = 22/25
    b. Edge density: 11/60 - **Grading:** 3 pts for the answer, 2 pts for showing work
        - (10 x 5) + 5 / ((25 x 24) /2) = 11/60
    c. The network is highly clustered because CC >>P.
    Grading: 2 pts correctly saying “yes”, 3 pts for the correct explanation, comparing the clustering coefficient to the edge density

3. Zach - correct answers varied widely. We we're looking for a sampling of different scientific findings and results, research discussion, and/or mathematical theorems. **Grading**: answers which had at least 12 substantive findings drawn from at least 7 sources (incl. lectures, videos, readings, experiments, discussions) received 13-15 points. Answers in the 10-12 point range had a narrower range of source coverage and/or provided fewer findings. Answers which summarized a few sources/readings and/or gave fewer than 10 findings were given fewer than 10 points. Things which did not count as ‘findings’ included incorrect statements (e.g. “There are a maximum of n^3 edges in a graph on n vertices”), basic definitions (e.g. “A network is a collection of nodes and edges”), and facts which do not relate to the scientific content of the course (e.g. “Jon Kleinberg is a professor at Cornell”)

4. Zach - Kleinberg -

There are many correct answers for (a) and (b). Pictured is one such example (in brown.



a. Both edges need to be accessible and of correct length. The edges should be contained within the box defined by A and B and should, when both used, create a short path from A to B.
Grading: 2 points for each edge being correct, 1 point for them both being used to create an appropriate short path

b. A correct answer has both edges of the correct length, and both should be such that they create a short path from A to B, but the algorithm would not use them, as accessing them requires moving in the "wrong" direction.

Grading: 2 points for each edge being correct, 1 point for "bird's eye view" path finder using them for a short path

c. No. Any such edge would be ignored by the algorithm, as Kleinberg's algorithm always chooses to make progress in the direction of the target. If using an edge were to increase the distance, the algorithm would simply choose to use a gridline instead.

Grading: 2 points for saying 'no', 3 points for a correct explanation, with partial credit for incomplete explanations.

5. Adel - Coloring - 15 pts
    a. Recognize that this is a coloring problem (don't need to actually mention coloring just describe it), and use the network connections to determine the color (ringtone) of a node. Acceptable answers varied, but using a modified breadth first search was one common accepted answer, as was simply describing that starting with a vertex mark it a color and follow a path, mark neighbor a different color, etc. Points were taken off especially if looked too closely at local structure - the global structure of the graph will determine how many ringtones are needed.
    Grading: Describing a valid algorithm got full points, with partial credit for answers which were partially correct, but incomplete
    b. **Grading:** Full points for proper 3 coloring. -1 point for each additional color, no points if used N colors, or if an improper coloring. One possible correct answer would be to give A&D Ringtone 1, B,E,&F Ringtone 2, and C&G Ringtone 3
    c. 2 works in stars, chains, loops, with even number of vertices. The complete graph on N vertices requires N unique colors. Needed to say how many colors needed and describe the graph.
    Grading: 2.5 pts for largest number, 2.5 pts for smallest number.

6. Samantha - Fill in the Blank - 15 pts **Grading:** 1pt for each correct answer
    a. Homophily
    b. Diverse/disconnected
    c. Mathematics
    d. Loops/cycles
    e. Weiner index
    f. 50-60%
    g. 3-4
    h. 0 and 1
    i. Polynomially and exponentially
    j. Twitter etc. NOT the Internet
    k. Large
    l. Increased
    m. Worm/nematode
    n. Power grid/electrical system
    o. The number of vertices or nodes/the size of the network

7. Adel - Network properties - 15 pts

Four main structural properties of social networks:

If they thought that this was a complete graph, 1 pt off but look at reasoning. If reasoning is right, give pts.

1. Heavy tail degree distribution - no, visually they have symmetry (nodes have same degree)
2. Single large component - yes, there is only one component in this graph
3. Low diameter - yes, every pair of nodes is 1 or 2 hops apart. On average, 1.22 but did not need to do this calculation.
4. High clustering - no, the clustering coefficient is much lower than the edge density. A fully correct answer should compare these two quantities. Explicitly calculating them is not necessary, but we can observe that the edge density is very high, but there are few complete triangles in the graph. If you wanted to explicitly calculate them, to determine the edge density.(ED) = # of edges/# possible edges = 7*10/(10*(10-1)/2) = 7/9. The CC is actually quite small compared to this - each node has 7 connections for a total of 21 possible edges between their friends. Of the 21 possible edges that could exist, only 15 of those exist for each vertex. This means that the global clustering coefficient is 15/21** which is less than the ED. So though this may be a “high” clustering coefficient, this network is not highly clustered because you must compare the CC to the ED.

**to find the clustering coefficient of a vertex, just pick a vertex (for example v6). V6 has edges to: 0,3,4,5,7,8,9. Look at each one of these vertices and see who their connections are.
3: **5**, 2, 1, **9**, **0**, **4**, 6
The bolded vertices are friends of 6 also.
5: 2,**7**,1,**0**,6,**4**,3 (do not include 3 because it was already included).
Continue this process and sum up the bolded connections and divide by 21 to get 15/21.

Grading:

2 pts for each property - 8 pts
1 pt for correctly identifying whether the property is present - 4 pts
1 pt for reason for why or why not it has small diameter, heavy tail, highly clustered - 3 pts