This is a 60 minute, CLOSED notes, books, etc. exam.

ASK, if anything is not clear.

WORK INDIVIDUALLY. CHEATING IS NOT TOLERATED!

Strategy: Scan the entire exam first. Work on the easier ones before the harder ones. Don't waste too much time on any one problem. Length of problems is not necessarily proportional to the points.

BE NEAT. We cannot give you points for something that we can't read. Write down your assumptions. Don't just write your answer, **show how you got them.** Show all your work on the space provided and clearly mark your answers.

Write your name on each page. Check to make sure you have 5 pages.

1	25 points	Graph Layout	
2	25 points	Multivariate	
3	25 points	Graph Metrics	
4	25 points	Data Analysis	
	100 points	GRAND TOTAL	

For your exam to be graded, you need to read and sign the statement below:

I certify that I worked independently, did not cheat nor receive/give any help in this exam. I understand that any infraction will result in my failing this class. In addition, a record of any infraction will be reported to the School of Engineering, to my College provost, and that I may also be expelled from the University.

Signature: _____

1. **Graph Layout (25 points)**

   You are given the following information for the graph layout problem below:

   (a) All masses are 1. Gravitational constant is 10. Distance between node A and X is 2.

   (b) Spring constant K_s is 10, rest length of spring L_r is 1, current length of spring L_c and distance to node B is 2.

   (c) External force is 10.

   (d) Euler integration is used with a step size of h = 0.1 Assume no motion in graph initially.

   (a) (**15 points**): What is the net force acting on node X? Just write down the horizontal component of this force. The spring between node X and B forms a 45 degree line with the vertical.

   (b) (**10 points**): What is the **horizontal** displacement of node X from its current position? That is, how far did it move along the horizontal axis after 1 integration step?

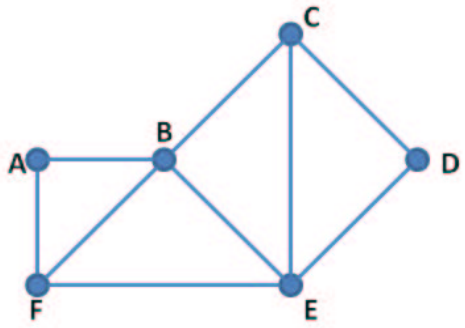
2. **Multivariate Visualization (25 points)**

   An ocean circulation model produced a time varying data with values for multiple variables at every grid point of a 3D regularly gridded data. The variables include the xyz location of the grid point in physical space, and the corresponding physical variables at the grid point such as: temperature, salinity, pressure, velocity components, nitrogen level, plankton levels, bacteria levels, ammonia concentrations, etc.

   Suggest how one may glean insight in such a data set using a barrage of scientific and information visualization methods. For this question, you should formulate a hypothesis about the data, and suggest at least 2 methods for analyzing or visualizing this data. Explain/justify your choices.

3. **Graph Metrics (25 points)**

Assume edge weights on the graph below are all 1.



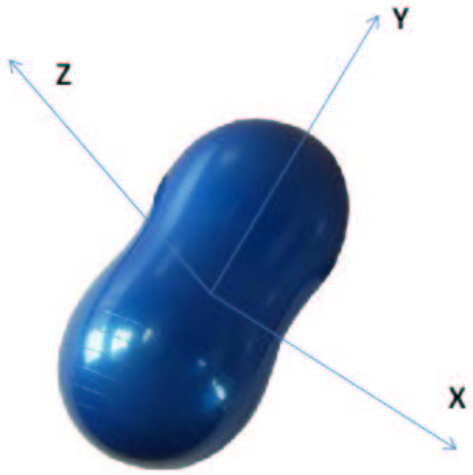
(a) (**10 points**): What is the adjacency matrix of this graph?

(b) (**10 points**): What is the degree matrix of this graph?

(c) (**5 points**): What is the laplacian matrix of this graph?

4. **Data Analysis (25 points)**

   A scatter plot of a data set with 3 variables was plotted in 3D. The bounding surface of these data points resemble a peanut shape as illustrated in the figure below. The length of the peanut is aligned with the y-axis.



   (a) (**15 points**): Using principal component analysis, What is the principal component that will maximize the variance of the projection? That is, what is the primary axis if one were to project the data down to 1-dimension. No calculation needed, but do **explain** your answer.

   (b) (**10 points**): Sketch the 1-dimensional projection.