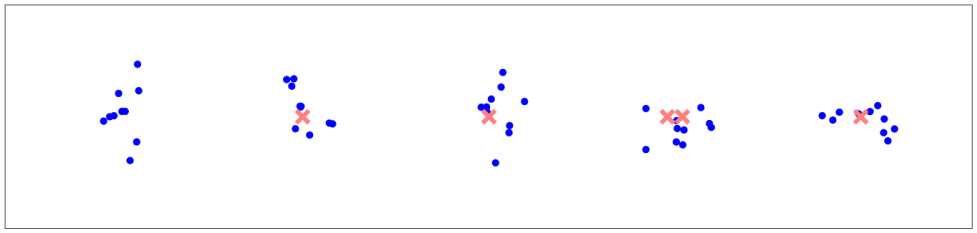
k-Means Clustering
Lab Assignment

(10) 1. Provide three example situations (maybe ones relevant to your major) that seem analogous to our "pizza-stores" model. For each situation, what are the "pizza customers" and what are the "pizza stores?"

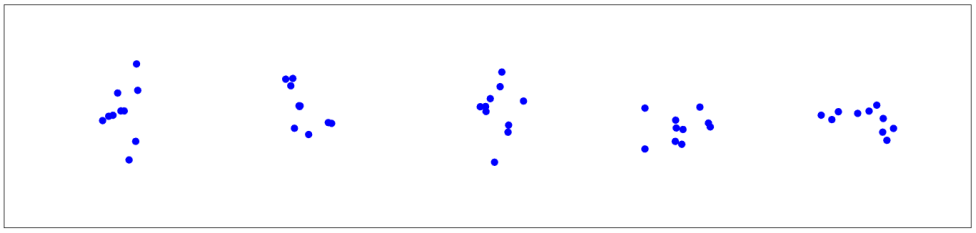
(20) 2. Perform k-Means clustering by hand on the following data with $k = 2$ and assuming the initial cluster centers are located at (4,0) and (6,2). Show your work step-by-step... what are the clusters at each step, and the new cluster centers at each step? Be sure to identify the final cluster assignments after the k-Means algorithm has converged.

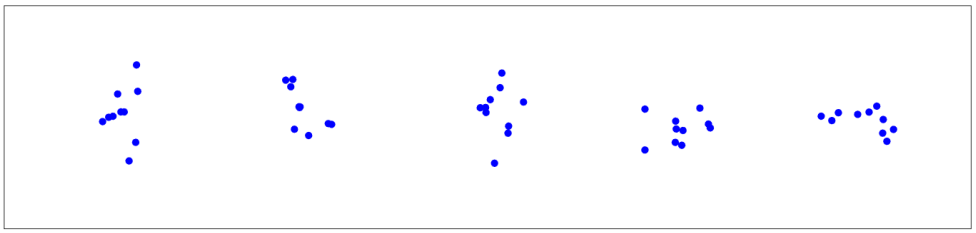
Obs.	X_1	X_2
1	1	4
2	1	3
3	0	4
4	5	1
5	6	2
6	4	0

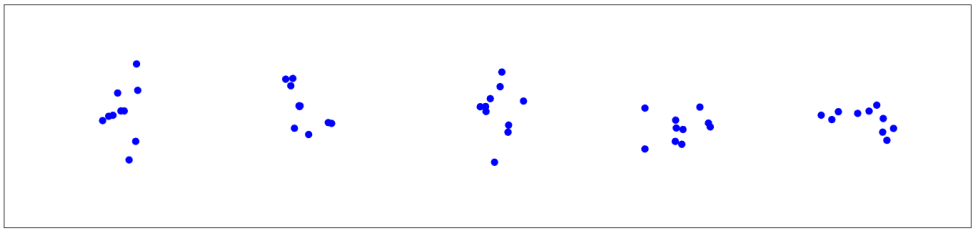
(20) 3. Consider the data set shown below, with initial cluster locations denoted by the $\times$'s.

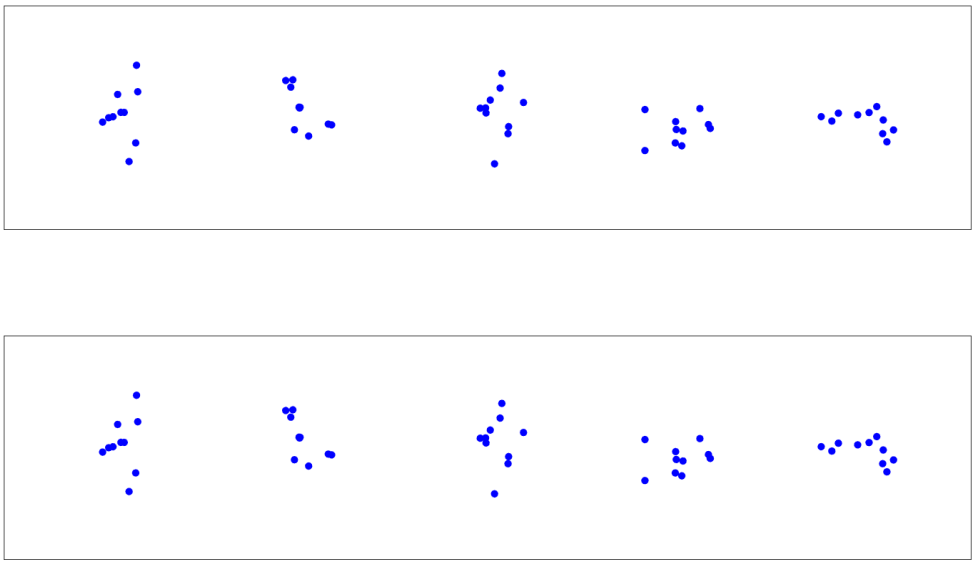


(a) What is the result of *k*-Means clustering of this data with these initial cluster locations? (Data are replicated below to assist you in iterating through *k*-Means.)







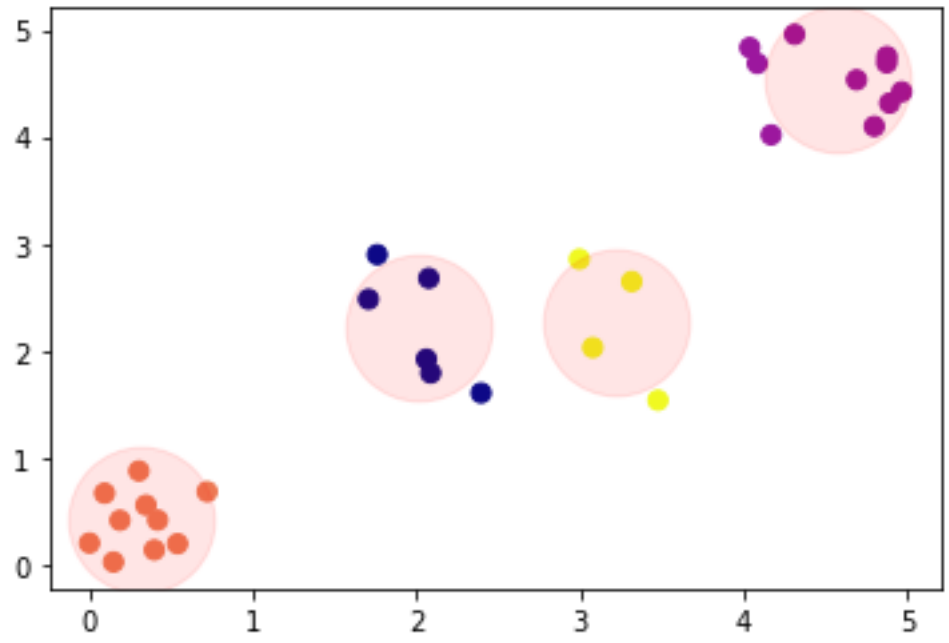


(b) In what way are the clusters found by *k*-means not satisfying? Is this result a failure of the goal (*k*-Means is inappropriate for this dataset), or a failure of the algorithm (Lloyd's Algorithm failed)? Explain why this happened... think about the way in which the initialization of the cluster centers affects subsequent minimization of the *k*-means cost function.

(30) 4. This example concerns the sample dataset `PizzaData.csv`.

(a) Load the dataset and plot it (paste your picture below).

(b) Run k-means on the pizza dataset with $k = 3$, and plot the output below. (Figure out a useful way to visualize the output clusters and cluster-centers, perhaps by using three colors and/or marker shapes.) Use a convergence criterion of = 0.02, but feel free to experiment with what happens when you tweak this parameter.


5
4
3
2
1
0
0
1
2
3
4
5

(c) Repeat k-Means clustering of the pizza dataset for $k = 1$ then $k = 2$ and then $k = 4$. What is a principled way to think about $k = 3$ being "the best choice" for this particular dataset?

(30) 5. This example concerns the sample dataset `RingData.csv`.

(a) Load the dataset and plot it (paste your picture below).
How many clusters do you see? What are they?

(b) Run k-means on the ring dataset with $k = 2$, and plot the output below, visualizing it as you did in the previous exercise. (WARNING: It's going to look odd!)

(c) In what way were the two "clusters" found by running 2-means on the ring dataset not satisfying? Is this result a failure of the goal (*k*-Means is inappropriate for this dataset), or a failure of the algorithm (Lloyd's Algorithm failed)? Explain why this happened... think about the way in which the *k*-means cost function defines a "good clustering."

(30) 6. (a) For each data point in the ring dataset, compute its distance from the origin $(0,0)$, and store these distances as a many-by-one array (`distFromOrigin`). Plot the transformed ring dataset (`distFromOrigin`). Since this dataset is now 1-dimensional, think about using a visualization technique to help you see multiple data points that may be at the same radius from the origin.

(b) Run k-means on the transformed ring dataset (`distFromOrigin`) with $k = 2$ and visualize the resulting clusters for both the transformed dataset (`distFromOrigin`) and the original (2-dimensional) ring dataset.

(c) In what way were the two "clusters" found by running 2-means on the transformed ring dataset more satisfying? Is this result due to greater consistency with the goal (*k*-Means is more appropriate for the transformed dataset), or greater consistency with the algorithm (Lloyd's Algorithm is more appropriate for the transformed dataset)? Explain why this happened... think about the way in which the *k*-means cost function defines a "good clustering."