```
#Question 1a
import numpy as np
from scipy.linalg import norm

#Get data and process data
!wget https://course.ccs.neu.edu/cs6220/homework-4/data/f150_motor_distributors.txt
sample_data = np.loadtxt("f150_motor_distributors.txt", delimiter=",")
#As the question asks, we classify data into 5 different clusters
k = 5
```

```
--2023-02-28 07:32:33--  https://course.ccs.neu.edu/cs6220/homework-4/data/f150_motor_distributors.txt
Resolving course.ccs.neu.edu (course.ccs.neu.edu)... 129.10.117.35
Connecting to course.ccs.neu.edu (course.ccs.neu.edu)|129.10.117.35|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 255541 (250K) [text/plain]
Saving to: 'f150_motor_distributors.txt'

f150_motor_distribu 100%[===================>] 249.55K   873KB/s    in 0.3s

2023-02-28 07:32:34 (873 KB/s) - 'f150_motor_distributors.txt' saved [255541/255541]
```

```
sample_data
print(len(sample_data))
```

```
5000
```

```
#We have five pre-defined centroids, since the data is two dimensional, I will use an array to represent its pos in a two dimensic
x1 = [10,10]
x2 = [-10,-10]
x3 = [2,2]
x4 = [3,3]
x5 = [-3,-3]
centroids = []
centroids.append(x1)
centroids.append(x2)
centroids.append(x3)
centroids.append(x4)
centroids.append(x5)
```

```
#Function to calculate the cost function of each data point to the centroids
#And we assign the point to cluster where the centroid of that cluster has the minimum distance between current point and the cent
def computeCost(data, centroids, clusters):
  for point in data:
    euc_dist = []
    for i in range(k):
      euc_dist.append(np.linalg.norm(np.array(point) - np.array(centroids[i])))
    clusters[euc_dist.index(min(euc_dist))].append(point)
```

```
#Recalculate the centroids of each clsuter, we use the average of each cluster as new centroid
def recalculate_centroids(centroids, clusters, k):
  for i in range(k):
    centroids[i] = np.average(clusters[i], axis=0)
  return centroids
```

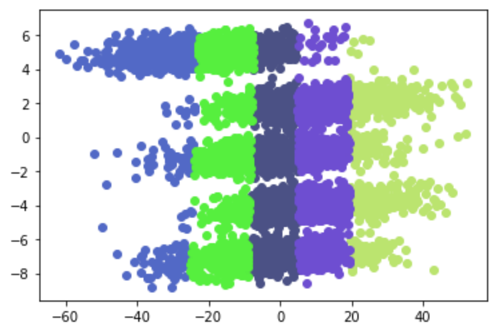
```
def recalculate_clusters(data, centroids, k):
  clusters = {}
  for i in range(k):
    clusters[i] = []
  computeCost(data, centroids, clusters)
  return clusters
```

```
#As the question asks, we iterate the process for 100 times, we first calculate the distance from each point and assign data point
#Then we recalculate the centroids and repeating calculate the distance and assignment
for i in range(100):
  clusters = recalculate_clusters(sample_data, centroids, k)
  centroids = recalculate_centroids(centroids, clusters, k)
```

```
print(clusters)
```

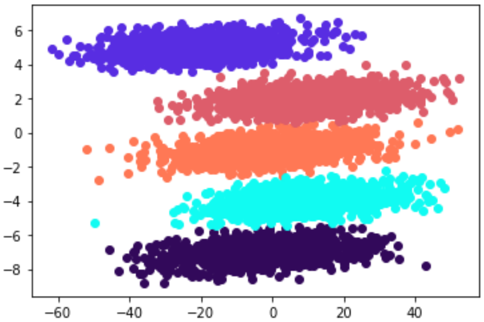
```
{0: [array([22.47614404,  2.06661161]), array([36.85173434,  2.47010346]), array([22.8325201 ,  1.70526612]), array([35.4254
```

```
import random

def generate_random_color():
  r = lambda: random.randint(0, 255)
  return '#%02X%02X%02X' % (r(),r(),r())


#Question 1b Scatter the results in two dimenstions
import matplotlib.pyplot as plt

for i in range(k):
  cluster_color = generate_random_color()
  colx = tuple(x[0] for x in clusters[i])
  coly = tuple(x[1] for x in clusters[i])
  plt.scatter(colx, coly, color = cluster_color)
```




```
#Question 2a.) To calculate Mahalanobis distance, first we wabt to calculate R=inverse of (matrix P sqaure * P)
from scipy import linalg

P = np.matrix('10 0.5; -10 0.25')
R = linalg.inv(np.dot(np.transpose(P), P))
R

     array([[ 0.00555556, -0.04444444],
            [-0.04444444,  3.55555556]])


#Compute Mahalanobis Distance
def computeMahalDist(cur_centroid, cur_data_point):
  diff = np.subtract(cur_centroid, np.array(cur_data_point))
  dist = np.dot(np.dot(np.transpose(diff), R), diff)
  # print(type(dist))
  return dist


def computeMahalCost(data, centroids, clusters):
  for point in data:
    mahal_dist = []
    for i in range(k):
      dist = computeMahalDist(centroids[i], point)
      mahal_dist.append(dist)
    clusters[mahal_dist.index(min(mahal_dist))].append(point)


#Recalculate cluster function
def recalculate_clusters_mahal(data, centroids, k):
  clusters = {}
  for i in range(k):
    clusters[i] = []
  computeMahalCost(data, centroids, clusters)
  return clusters


for i in range(100):
  clusters2 = recalculate_clusters_mahal(sample_data, centroids2, k)
  centroids2 = recalculate_centroids(centroids2, clusters2, k)


import matplotlib.pyplot as plt

for i in range(k):
  cluster_color2 = generate_random_color()
  colx1 = tuple(x[0] for x in clusters2[i])
```

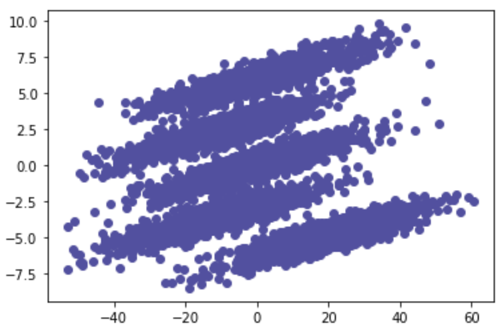
```
  coly1 = tuple(x[1] for x in clusters2[i])
  plt.scatter(colx1, coly1, color = cluster_color2)
```



```
#Question 2b.)Calculate and print out the principle components of the data
def plotPCA(df):
  x = tuple(data[0] for data in df)
  y = tuple(data[1] for data in df)
  rcolor = generate_random_color()
  plt.scatter(x, y, color = rcolor)


from sklearn.decomposition import PCA
from scipy import stats
pca = PCA()
pca.fit(sample_data)
print("For aggreagated data: ")
print(pca.components_)
```

```
For aggreagated data:
[[-0.99838317  0.05684225]
 [-0.05684225 -0.99838317]]
```

```
#Plot out PCA analysis
dfB = pca.transform(sample_data)
plotPCA(dfB)
```



```
#Question 2c.)
for i in range(5):
  cluster_data = np.array(clusters2[i])
  pca.fit(cluster_data)
  print(f"Cluster {i} :")
  print(pca.components_)
```

```
Cluster 0 :
[[ 0.99993527  0.01137789]
 [ 0.01137789 -0.99993527]]
Cluster 1 :
[[ 0.99992533  0.01222027]
 [ 0.01222027 -0.99992533]]
Cluster 2 :
[[ 0.99990986  0.01342629]
 [ 0.01342629 -0.99990986]]
Cluster 3 :
[[ 0.99993306  0.01157047]
 [-0.01157047  0.99993306]]
Cluster 4 :
[[-0.99989374 -0.01457781]
 [-0.01457781  0.99989374]]
```

```
#2d
PP = P.T @ P
K = np.linalg.eig(PP)
K
```

```
(array([200.031294,   0.281206]), matrix([[ 0.99992166, -0.01251662],
        [ 0.01251662,  0.99992166]]))
```