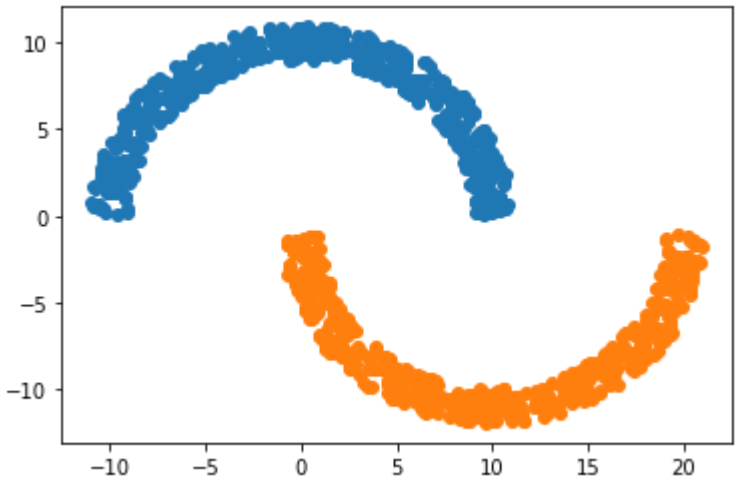
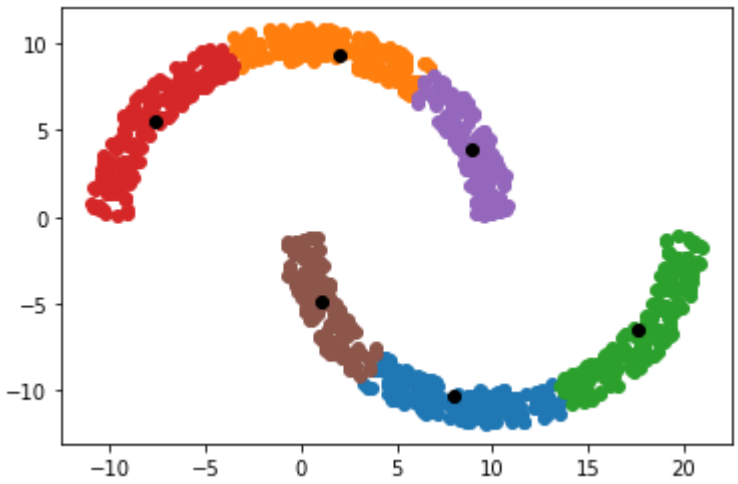
In [313]:
```
varx = []
vary = []
# d = 1

# variables initialized
radius = 10
width = 2
distance = 1

# creating the random values for the half moons
randMat = np.random.rand(2, 500)

# calculating radius and theta
r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]

# calculating first and second half moons, one upside down
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance

# putting these into respective lists
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

# graphing these results
plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.show()
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

#using scikit learn to create clusters
kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

# assigning clusters and points different colors
x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
```

```
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')
plt.show()

# printing means and variance
clusters = kmeans.cluster_centers_
variancex = np.var(xarr)
variancey = np.var(yarr)

varx.append(variancex)
vary.append(variancey)

print(clusters, '\n', variancex, variancey)
```

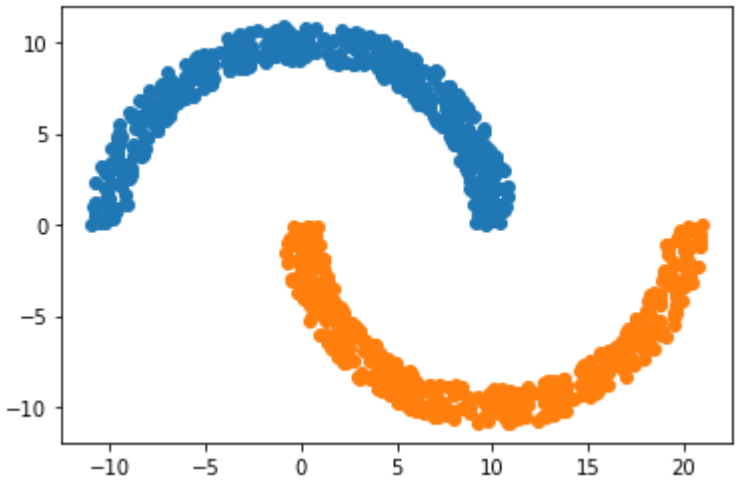


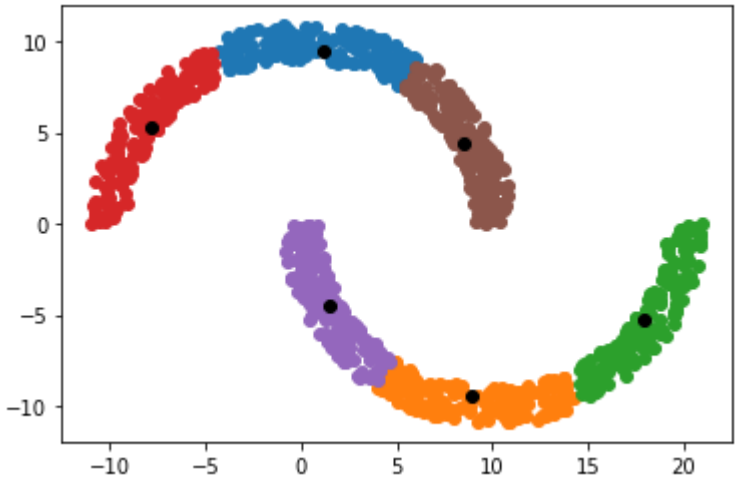



```
[[  7.97797052 -10.30842366]
 [  1.99901035   9.3160815 ]
 [ 17.64412876  -6.48255982]
 [ -7.64412876   5.48255982]
 [  8.86885078   3.94458296]
 [  1.11330254  -4.91595402]]
 66.74132863648681 58.791770089945686
```

In [314]:
```
# same implementation as above
# hence no commenting

# d = 0

radius = 10
width = 2
distance = 0

randMat = np.random.rand(2, 500)

r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

cluster = np.ones(1000)
numClusters = 6
centroidX = [-10, 0, 10, 0, 10, 20]
centroidY = [10, 15, 10, 5, -5, 5]

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.show()
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])
```

```
plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')
plt.show()

clusters = kmeans.cluster_centers_
variancex = np.var(xarr)
variancey = np.var(yarr)

varx.append(variancex)
vary.append(variancey)

print(clusters, '\n', variancex, variancey)
```

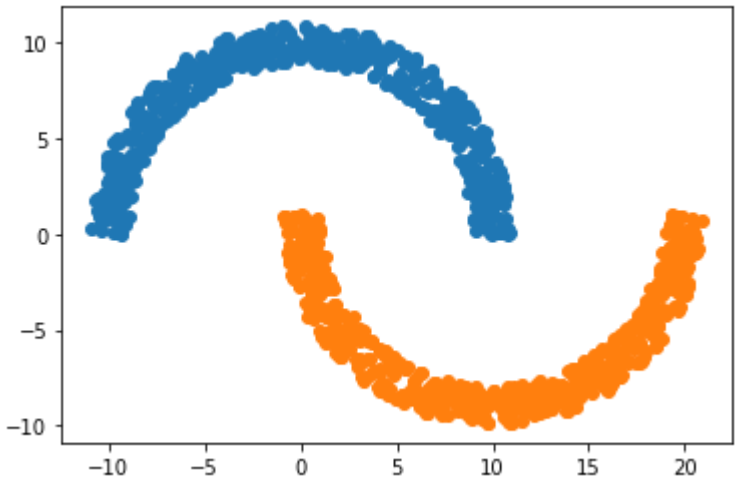


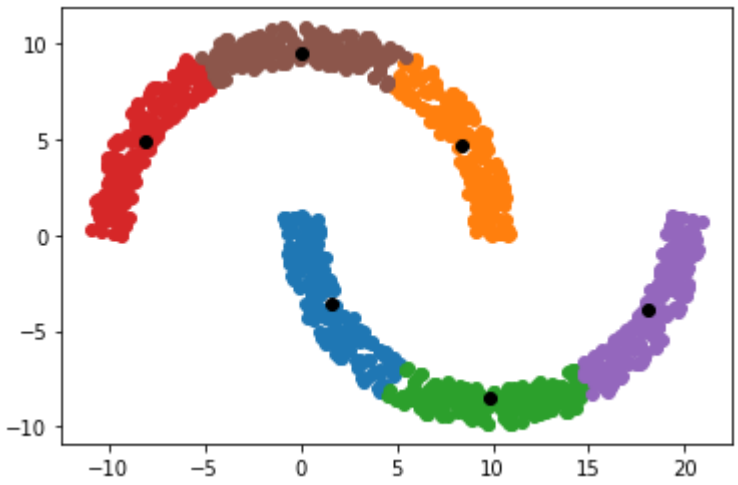



```
[[ 1.12295146  9.44608447]
 [ 8.87704854 -9.44608447]
 [17.89721048 -5.26467015]
 [-7.89721048  5.26467015]
 [ 1.50283364 -4.44285288]
 [ 8.49716636  4.44285288]]
 66.65157261929946 50.751223162327804
```

In [315]:
```
# d = -1

radius = 10
width = 2
distance = -1

randMat = np.random.rand(2, 500)

r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

cluster = np.ones(1000)
numClusters = 6
centroidX = [-10, 0, 10, 0, 10, 20]
centroidY = [10, 15, 10, 5, -5, 5]

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.show()
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
```

```
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')
plt.show()

clusters = kmeans.cluster_centers_
variancex = np.var(xarr)
variancey = np.var(yarr)
varx.append(variancex)
vary.append(variancey)

print(clusters, '\n', variancex, variancey)
```

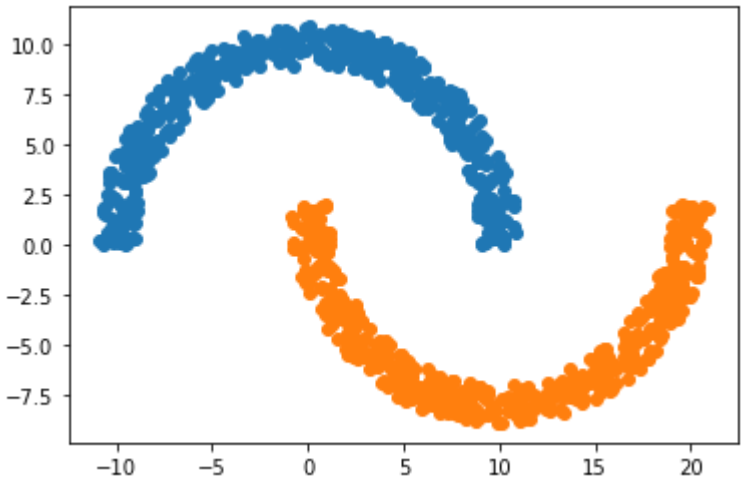


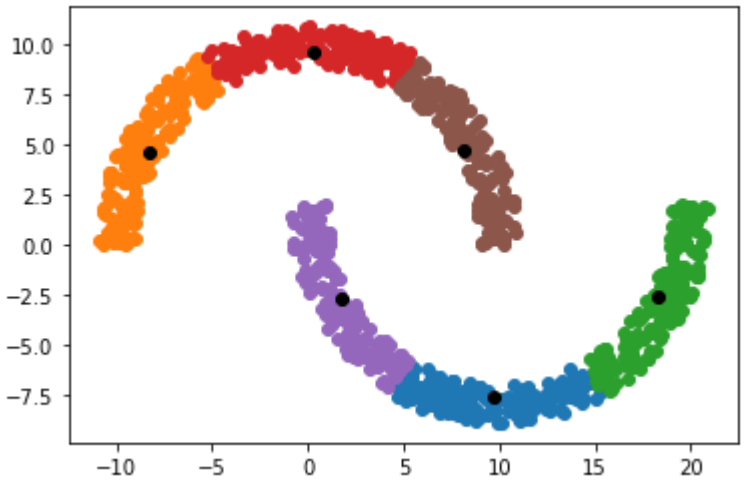



```
[[ 1.61310038e+00 -3.62332244e+00]
 [ 8.35157685e+00  4.67776093e+00]
 [ 9.88954140e+00 -8.49384738e+00]
 [-8.08670669e+00  4.91880230e+00]
 [ 1.80695296e+01 -3.94482873e+00]
 [ 1.39127674e-02  9.49622786e+00]]
 73.66150479031116 43.82535472707498
```

In [316]:
```
# d = -2

radius = 10
width = 2
distance = -2

randMat = np.random.rand(2, 500)

r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

cluster = np.ones(1000)
numClusters = 6
centroidX = [-10, 0, 10, 0, 10, 20]
centroidY = [10, 15, 10, 5, -5, 5]

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.show()
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
```

```
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')
plt.show()

clusters = kmeans.cluster_centers_
variancex = np.var(xarr)
variancey = np.var(yarr)

varx.append(variancex)
vary.append(variancey)
print(clusters, '\n', variancex, variancey)
```

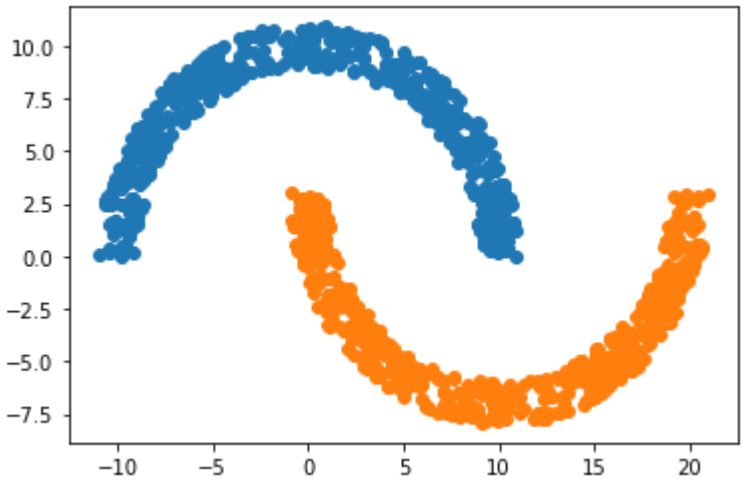


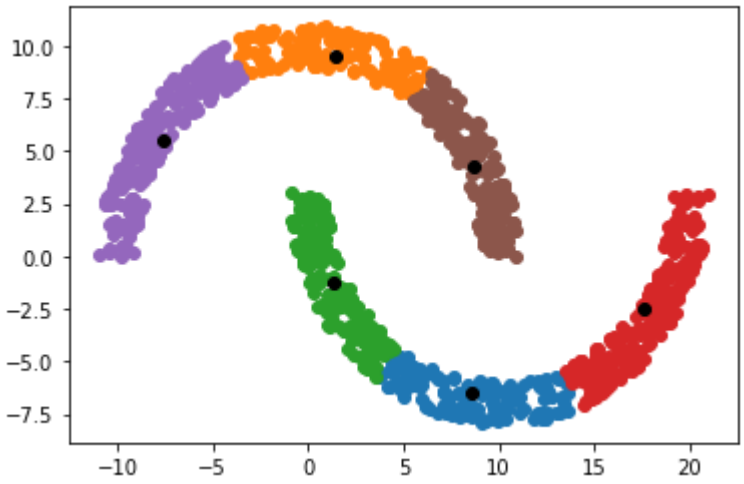



```
[[ 9.65679997 -7.60317647]
 [-8.29985297  4.61526915]
 [18.29985297 -2.61526915]
 [ 0.34320003  9.60317647]
 [ 1.81170574 -2.74242725]
 [ 8.18829426  4.74242725]]
 84.53567677866545 38.00506577051836
```

In [317]:
```
# d = -3

radius = 10
width = 2
distance = -3

randMat = np.random.rand(2, 500)

r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

cluster = np.ones(1000)
numClusters = 6
centroidX = [-10, 0, 10, 0, 10, 20]
centroidY = [10, 15, 10, 5, -5, 5]

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.show()
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
```

```
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')
plt.show()

clusters = kmeans.cluster_centers_
variancex = np.var(xarr)
variancey = np.var(yarr)
varx.append(variancex)
vary.append(variancey)
print(clusters, '\n', variancex, variancey)
```

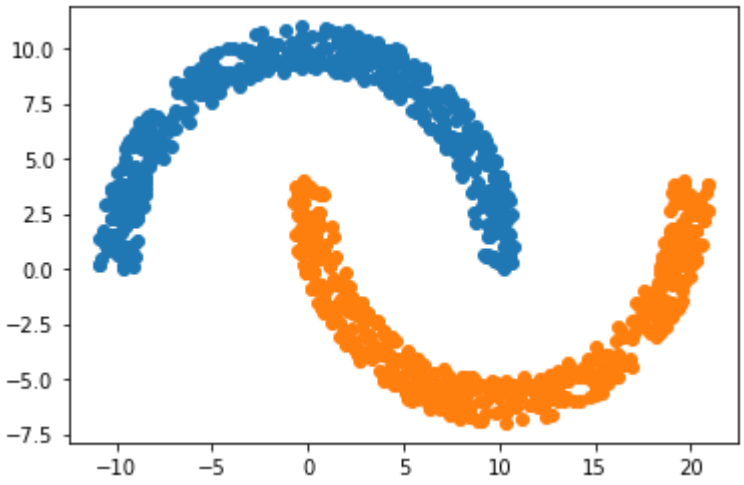


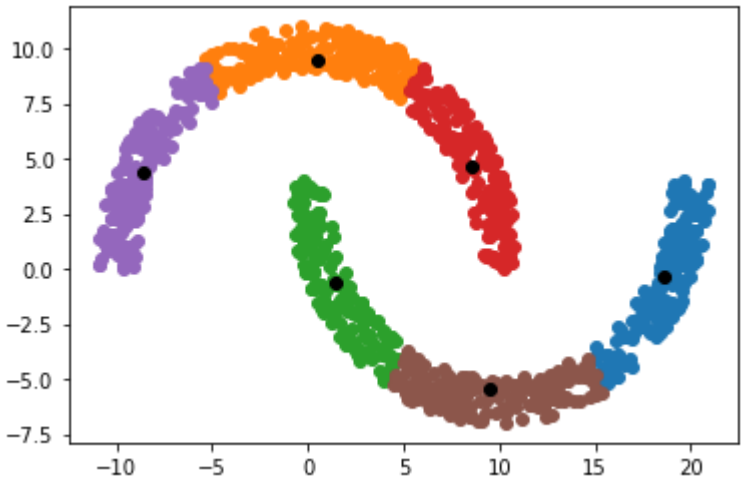



```
[[ 8.53709682 -6.47798706]
 [ 1.46290318  9.47798706]
 [ 1.36455806 -1.26894451]
 [17.59479257 -2.53078389]
 [-7.59479257  5.53078389]
 [ 8.63544194  4.26894451]]
 73.82724057231472 32.136134987718144
```

In [318]:
```
# d = -4

radius = 10
width = 2
distance = -4

randMat = np.random.rand(2, 500)

r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

cluster = np.ones(1000)
numClusters = 6
centroidX = [-10, 0, 10, 0, 10, 20]
centroidY = [10, 15, 10, 5, -5, 5]

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.show()
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
```

```
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')
plt.show()

clusters = kmeans.cluster_centers_
variancex = np.var(xarr)
variancey = np.var(yarr)
varx.append(variancex)
vary.append(variancey)
print(clusters, '\n', variancex, variancey)
```

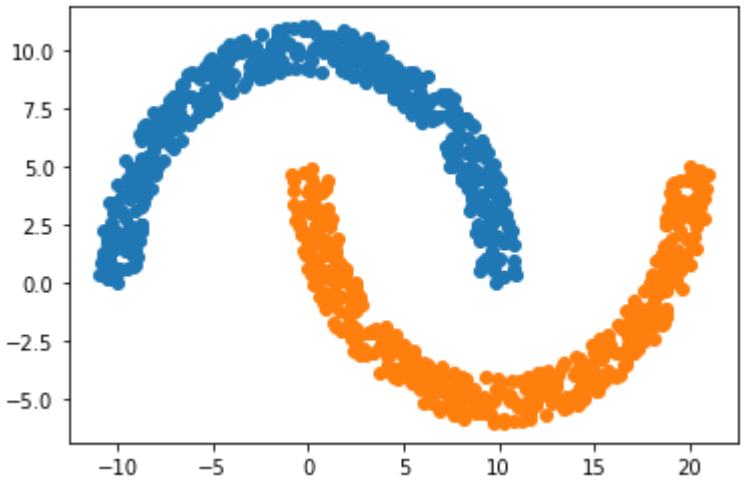


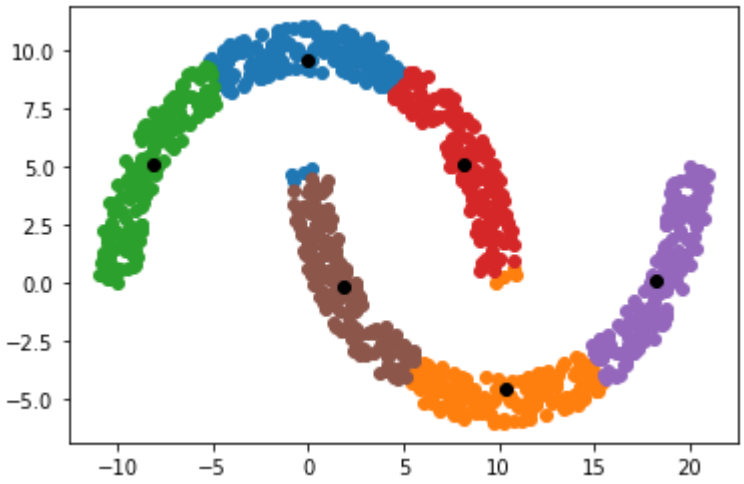



```
[[18.55599495 -0.33183815]
 [ 0.5227752   9.45904507]
 [ 1.43583747 -0.67167858]
 [ 8.56416253  4.67167858]
 [-8.55599495  4.33183815]
 [ 9.4772248  -5.45904507]]
 74.63374956149308 27.672552519967248
```

In [319]:
```
# d = -5

radius = 10
width = 2
distance = -5

randMat = np.random.rand(2, 500)

r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

cluster = np.ones(1000)
numClusters = 6
centroidX = [-10, 0, 10, 0, 10, 20]
centroidY = [10, 15, 10, 5, -5, 5]

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.show()
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
```

```
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')
plt.show()

clusters = kmeans.cluster_centers_
variancex = np.var(xarr)
variancey = np.var(yarr)
varx.append(variancex)
vary.append(variancey)
print(clusters, '\n', variancex, variancey)
```

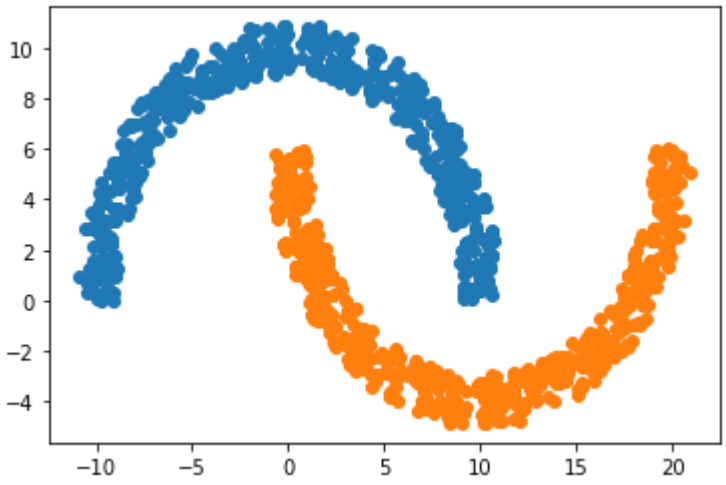


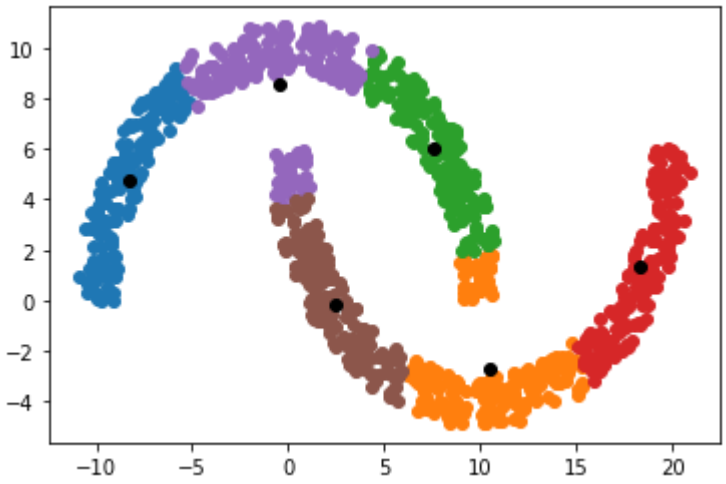



```
[[-0.08183611  9.52120276]
 [10.35082705 -4.50878654]
 [-8.07368707  5.06501211]
 [ 8.16571564  5.11919548]
 [18.19714487  0.10205973]
 [ 1.87595402 -0.16143588]]
 74.55492322991878 25.099163026448515
```

In [320]:
```
# d = -6

radius = 10
width = 2
distance = -6

randMat = np.random.rand(2, 500)

r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

cluster = np.ones(1000)
numClusters = 6
centroidX = [-10, 0, 10, 0, 10, 20]
centroidY = [10, 15, 10, 5, -5, 5]

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.show()
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
```

```
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')
plt.show()

clusters = kmeans.cluster_centers_
variancex = np.var(xarr)
variancey = np.var(yarr)
varx.append(variancex)
vary.append(variancey)
print(clusters, '\n', variancex, variancey)
```

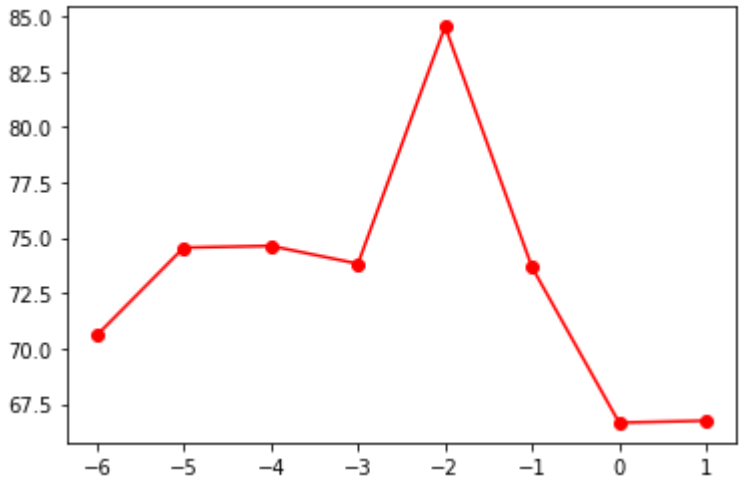


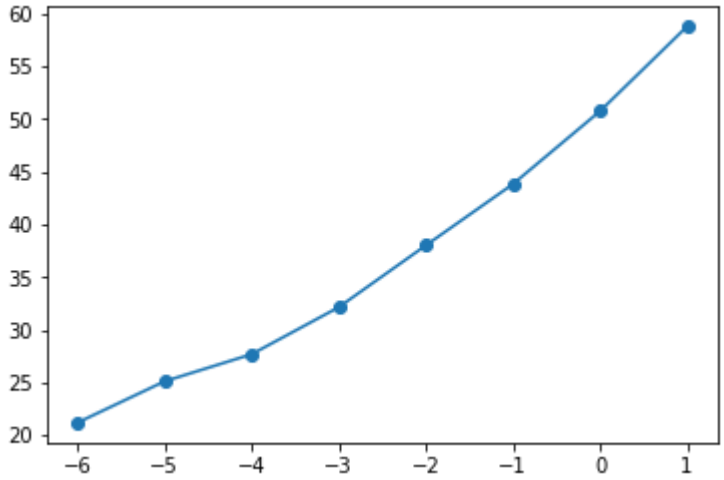



```
[[-8.27710922  4.73772444]
 [10.52924458 -2.69458127]
 [ 7.58734287  6.05310139]
 [18.31655249  1.31273457]
 [-0.45071411  8.60312385]
 [ 2.50428638 -0.17849901]]
 70.59473810656054 21.173757186492143
```

In [ ]:
```
# the identification of the clusters gets worse for
# 1, 2, and 3 as the value of d becomes smaller
```

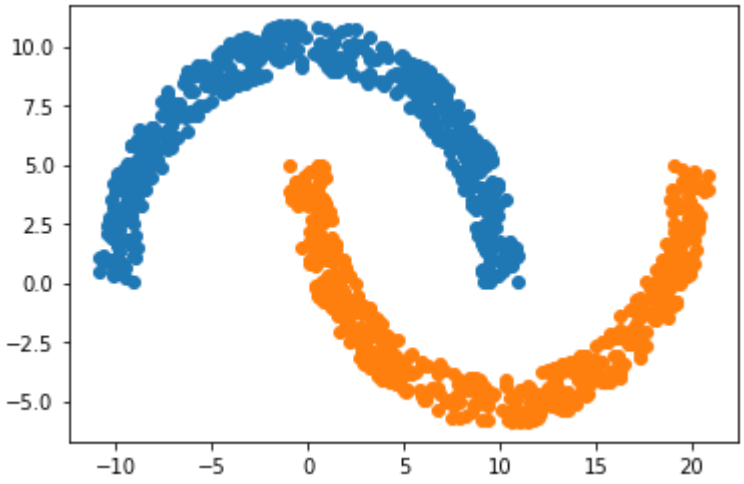
In [329]:
```
d = [1, 0,-1, -2, -3, -4, -5, -6]
plt.plot(d, varx, 'ro-')
plt.show()

plt.plot(d, vary, 'o-')
plt.show()
```



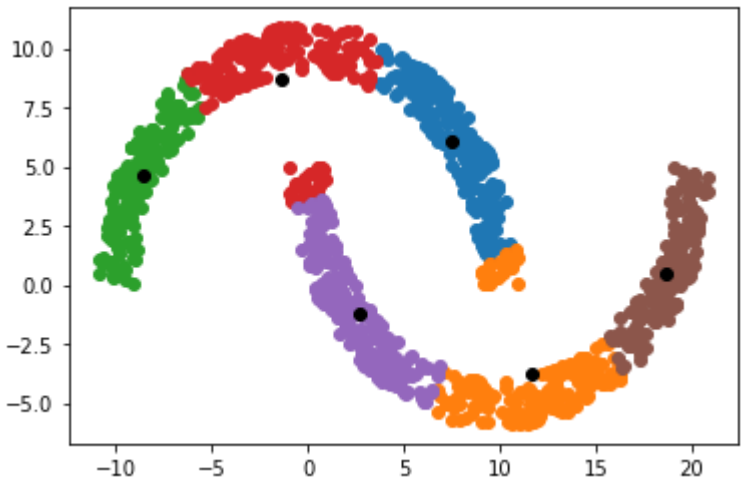


In [269]:
```
import numpy as np
import matplotlib.pyplot as plt
radius = 10
width = 2
distance = -5

randMat = np.random.rand(2, 500)

r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

cluster = np.ones(1000)
numClusters = 6
centroidX = [-10, 0, 10, 0, 10, 20]
centroidY = [10, 15, 10, 5, -5, 5]

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.show()
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
```

```
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')

# works with distance = -4
```



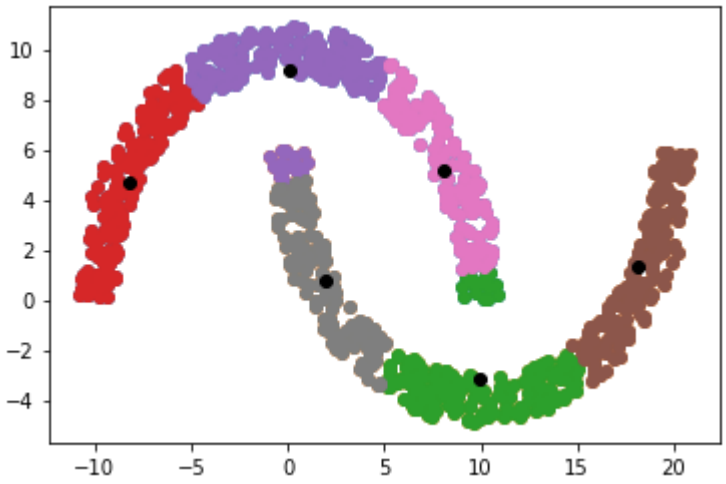
Out[269]: [<matplotlib.lines.Line2D at 0x211e414bc08>]



In [270]:
```
import numpy as np
import matplotlib.pyplot as plt
radius = 10
width = 2
distance = -6

randMat = np.random.rand(2, 500)

r = (radius - width/2) + width * randMat[0,:]
theta = np.pi * randMat[1,:]
x1, y1 = r*np.cos(theta), r*np.sin(theta)
x2, y2 = -r*np.cos(theta)+radius, -r*np.sin(theta)-distance
xarr = list(x1) + list(x2)
yarr = list(y1) + list(y2)
zipXY = zip(list(xarr), list(yarr))
zipXY = list(zipXY)

cluster = np.ones(1000)
numClusters = 6
centroidX = [-10, 0, 10, 0, 10, 20]
centroidY = [10, 15, 10, 5, -5, 5]

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
#plt.plot(centroidX, centroidY, 'o')

from sklearn.cluster import KMeans

kmeans = KMeans(n_clusters = 6, random_state = 0).fit(zipXY)

x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if kmeans.labels_[i] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif kmeans.labels_[i] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif kmeans.labels_[i] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif kmeans.labels_[i] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif kmeans.labels_[i] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif kmeans.labels_[i] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])

plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
plt.plot(x4, y4, 'o')
```

```
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(kmeans.cluster_centers_[:,0], kmeans.cluster_centers_[:,1], 'ko')

# works with distance = -4
```

Out[270]: [<matplotlib.lines.Line2D at 0x211e41e0cc8>]



In [ ]:
```
# c
# the results were worse than that of the RBF network,
# as there was some problems of misclassification especially
# with the d = -6 graph.
# the RBF had no misclassification

# d
#
```

In [ ]:
```
# previous attempt that didn't end up working
```

In [196]:
```
def compute_euclidean_distance(point, centroid):
    return np.sqrt(np.sum((np.array(point).T - centroid)**2))

def assign_label_cluster(distance, data_point, centroids):
    index_of_minimum = min(distance, key=distance.get)
    return [index_of_minimum, data_point, centroids[index_of_minimum]]

def compute_new_centroids(cluster_label, centroids):
    return np.array(cluster_label + centroids)/2

def iterate_k_means(data_points, centroids, total_iteration):
    label = []
    cluster_label = []
    total_points = len(data_points)
    k = len(centroids)

    for iteration in range(0, total_iteration):
        for index_point in range(0, total_points):
            distance = {}
            for index_centroid in range(0, k):
                distance[index_centroid] = compute_euclidean_distance(data_poi
nts[index_point], centroids[index_centroid])
            label = assign_label_cluster(distance, data_points[index_point], c
entroids)
            centroids[label[0]] = compute_new_centroids(np.array(label[1]), ce
ntroids[label[0]])

            if iteration == (total_iteration - 1):
                cluster_label.append(label)

    return [cluster_label, centroids]
```

In [197]:
```
data_points = np.array(list(zip(xarr,yarr)))
total_iteration = 100
centroids = np.array([[-10, 0], [0, 10], [10, 0], [0, -5], [10, -15], [20, -5
]])
[cluster_label, new_centroids] = iterate_k_means(data_points, centroids, total
_iteration)
```

In [198]:
```
def print_label_data(result):
    print("Result of k-Means Clustering: \n")
    for data in result[0]:
        print("data point: {}".format(data[1]))
        print("cluster number: {} \n".format(data[0]))
    print("Last centroids position: \n {}".format(result[1]))

print_label_data([cluster_label, new_centroids])
```

```
Result of k-Means Clustering:

data point: [-9.31440331  3.71699145]
cluster number: 0

data point: [-7.13984176  5.49372178]
cluster number: 0

data point: [1.45675035 9.30592797]
cluster number: 1

data point: [-1.90017261  9.64217671]
cluster number: 1

data point: [-2.33196893  9.15864369]
cluster number: 1

data point: [-4.47047823  8.20318698]
cluster number: 1

data point: [-3.88853653  9.3628014 ]
cluster number: 1

data point: [-0.14830542  9.8517248 ]
cluster number: 1

data point: [-8.65518152  4.56503879]
cluster number: 0

data point: [-8.49385214  5.76627032]
cluster number: 0

data point: [6.04701848 8.49482935]
cluster number: 1

data point: [-8.91795806  4.16439968]
cluster number: 0

data point: [-1.62569152  9.22704468]
cluster number: 1

data point: [0.43569262 9.87065237]
cluster number: 1

data point: [-3.82983906  9.88562501]
cluster number: 1

data point: [-9.34402244  0.41133442]
cluster number: 0

data point: [1.62190371 9.96155715]
cluster number: 1

data point: [4.83534633 9.03600658]
cluster number: 1

data point: [0.17235152 9.67221088]
```

```
cluster number: 1

data point: [ 0.32297009 10.66217553]
cluster number: 1

data point: [-9.49949857  1.38051799]
cluster number: 0

data point: [-3.62470704 10.33667307]
cluster number: 1

data point: [8.97907352 4.1474621 ]
cluster number: 2

data point: [-0.70679788  9.62506549]
cluster number: 1

data point: [8.37637377 4.55552667]
cluster number: 2

data point: [5.50575618 8.71255339]
cluster number: 1

data point: [8.15827682 7.23192568]
cluster number: 2

data point: [-1.84357867  8.86174854]
cluster number: 1

data point: [7.83589133 7.59516832]
cluster number: 2

data point: [10.07498138  3.62173723]
cluster number: 2

data point: [1.9380453  9.26384685]
cluster number: 1

data point: [-4.27564465  9.34414334]
cluster number: 1

data point: [ 2.53600007 10.35358093]
cluster number: 1

data point: [10.73098195  0.46784877]
cluster number: 2

data point: [ 1.0735844  10.57949996]
cluster number: 1

data point: [9.45966922 2.38463893]
cluster number: 2

data point: [-9.98705556  4.28285247]
cluster number: 0

data point: [2.00028456 8.86409576]
```

```
cluster number: 1

data point: [7.69390553 6.85359405]
cluster number: 2

data point: [-6.02072382  8.78661502]
cluster number: 1

data point: [-3.44316815  8.57189841]
cluster number: 1

data point: [4.5942137  7.83807836]
cluster number: 2

data point: [-9.71570995  0.57194572]
cluster number: 0

data point: [-6.23489253  7.37097581]
cluster number: 1

data point: [-7.88690193  6.24029492]
cluster number: 1

data point: [4.53428806 8.42360823]
cluster number: 2

data point: [-8.6309524   5.54095696]
cluster number: 1

data point: [9.35379734 3.46421332]
cluster number: 2

data point: [-5.30270947  9.60159573]
cluster number: 1

data point: [8.58201737 5.81141879]
cluster number: 2

data point: [ 1.66979743 10.51676976]
cluster number: 1

data point: [7.12669328 7.93140241]
cluster number: 2

data point: [-9.49213315  3.54480981]
cluster number: 0

data point: [-8.18202127  4.67014589]
cluster number: 0

data point: [-7.23605685  6.0838068 ]
cluster number: 0

data point: [10.86067311  1.34414783]
cluster number: 2

data point: [-6.74534691  6.29490932]
```

```
cluster number: 0

data point: [-6.18433047  8.2545939 ]
cluster number: 0

data point: [9.9557015  3.54225301]
cluster number: 2

data point: [-5.40862409  7.26339363]
cluster number: 0

data point: [-4.76977403  8.03863893]
cluster number: 0

data point: [-9.79447475  0.94346561]
cluster number: 0

data point: [-8.10264057  7.18577591]
cluster number: 0

data point: [8.63847814 4.49216606]
cluster number: 2

data point: [-8.95580403  2.20890333]
cluster number: 0

data point: [-7.80571837  6.47538413]
cluster number: 0

data point: [10.19538725  0.39501302]
cluster number: 2

data point: [5.16952351 8.00388576]
cluster number: 1

data point: [7.12116917 5.66263029]
cluster number: 2

data point: [-1.06018422  9.68025109]
cluster number: 1

data point: [-8.60357174  3.37275902]
cluster number: 0

data point: [5.01840748 7.69003431]
cluster number: 1

data point: [-9.30748473  0.85727844]
cluster number: 0

data point: [9.71245541 1.41339015]
cluster number: 2

data point: [-8.94680341  2.36944342]
cluster number: 0

data point: [-5.21017362  7.4497337 ]
```

```
cluster number: 0

data point: [-2.71221383 10.06536859]
cluster number: 1

data point: [0.85468933 8.97593528]
cluster number: 1

data point: [8.15011391 6.04420022]
cluster number: 2

data point: [10.41695921  1.84780802]
cluster number: 2

data point: [-0.24130923  9.33573847]
cluster number: 1

data point: [1.08409811e+01 2.85252003e-03]
cluster number: 2

data point: [-8.3785572   5.16480275]
cluster number: 0

data point: [1.96416155 9.91833287]
cluster number: 1

data point: [6.30451368 7.97210052]
cluster number: 1

data point: [-9.28742502  5.77708244]
cluster number: 0

data point: [ 2.43404632 10.49461096]
cluster number: 1

data point: [-8.03998102  6.5941889 ]
cluster number: 0

data point: [3.04060412 9.45363445]
cluster number: 1

data point: [ 4.13449634 10.16464707]
cluster number: 1

data point: [7.95348255 5.03166385]
cluster number: 2

data point: [8.54023743 4.09358253]
cluster number: 2

data point: [-3.00645321  9.26470142]
cluster number: 1

data point: [-10.73050834   0.23574912]
cluster number: 0

data point: [-8.40630797  3.96681666]
```

```
cluster number: 0

data point: [6.9114578  7.90625792]
cluster number: 2

data point: [-6.17586607  6.94793024]
cluster number: 0

data point: [9.6534393  2.36889039]
cluster number: 2

data point: [5.67909394 7.35251374]
cluster number: 2

data point: [9.85755042 3.70507738]
cluster number: 2

data point: [-10.53575032   3.12466368]
cluster number: 0

data point: [7.71131357 4.9714715 ]
cluster number: 2

data point: [-4.57572038  8.08003502]
cluster number: 1

data point: [6.05284261 6.75767714]
cluster number: 2

data point: [6.40751775 7.13873229]
cluster number: 2

data point: [-8.26873278  4.19589697]
cluster number: 0

data point: [8.98710688 2.63760228]
cluster number: 2

data point: [-1.87113673 10.17767013]
cluster number: 1

data point: [9.43452136 4.15879138]
cluster number: 2

data point: [-6.57237542  8.54527622]
cluster number: 1

data point: [-8.23624661  5.43036706]
cluster number: 0

data point: [-8.9854879   6.32897245]
cluster number: 0

data point: [-7.48698449  7.59091376]
cluster number: 0

data point: [-1.74547864 10.0204297 ]
```

```
cluster number: 1

data point: [8.28939637 7.16136609]
cluster number: 2

data point: [-0.66888906  9.88510013]
cluster number: 1

data point: [-8.81608808  5.0887013 ]
cluster number: 0

data point: [7.07760312 7.71925645]
cluster number: 2

data point: [10.11692554  2.78709037]
cluster number: 2

data point: [ 0.29512954 10.91795633]
cluster number: 1

data point: [8.92794221 1.65225101]
cluster number: 2

data point: [-5.62816964  9.29791796]
cluster number: 0

data point: [-10.26200374   2.67759557]
cluster number: 0

data point: [10.68866559  2.25497232]
cluster number: 2

data point: [0.6275788  9.91900691]
cluster number: 1

data point: [6.49064966 7.08941489]
cluster number: 2

data point: [10.70269656  1.2254057 ]
cluster number: 2

data point: [-1.66980039 10.78883128]
cluster number: 1

data point: [-0.60196938  9.73594199]
cluster number: 1

data point: [10.40062146  2.12182523]
cluster number: 2

data point: [-5.54408648  8.51649184]
cluster number: 0

data point: [-9.44353831  1.44701862]
cluster number: 0

data point: [8.25342715 6.06850895]
```

```
cluster number: 2

data point: [ 1.99430295 10.68111276]
cluster number: 1

data point: [-5.3733256   8.16170497]
cluster number: 0

data point: [-9.65835205  4.90689635]
cluster number: 0

data point: [5.19770381 9.49727456]
cluster number: 1

data point: [8.26833536 4.29360463]
cluster number: 2

data point: [4.90332313 8.32610209]
cluster number: 1

data point: [1.39399734 9.04396826]
cluster number: 1

data point: [ 0.35276562 10.21431424]
cluster number: 1

data point: [-0.39938169  9.49005873]
cluster number: 1

data point: [ 1.20253518 10.26722447]
cluster number: 1

data point: [-7.9851677   6.61368491]
cluster number: 0

data point: [-9.88078072  2.96164824]
cluster number: 0

data point: [ 1.1549892  10.00911718]
cluster number: 1

data point: [7.29910915 5.7026195 ]
cluster number: 2

data point: [-1.94165555 10.6862412 ]
cluster number: 1

data point: [3.55900105 8.49097783]
cluster number: 1

data point: [8.14106504 5.51385961]
cluster number: 2

data point: [-0.62318892  9.86284804]
cluster number: 1

data point: [0.38043377 9.33292211]
```

```
cluster number: 1

data point: [-9.14613918  4.80846377]
cluster number: 0

data point: [9.24417818 0.91574942]
cluster number: 2

data point: [ 3.93254975 10.17374028]
cluster number: 1

data point: [-9.18100625  6.00876692]
cluster number: 0

data point: [-5.44162111  7.65198699]
cluster number: 0

data point: [-5.30591948  9.13829059]
cluster number: 0

data point: [-9.33046626  3.61463638]
cluster number: 0

data point: [-7.33585792  5.87225314]
cluster number: 0

data point: [-5.07181398  8.27521167]
cluster number: 0

data point: [9.53599157 2.3294729 ]
cluster number: 2

data point: [9.77654177 0.12557602]
cluster number: 2

data point: [-8.19079531  5.3881156 ]
cluster number: 0

data point: [10.67895346  2.45648802]
cluster number: 2

data point: [-8.49608605  5.96248726]
cluster number: 0

data point: [9.54439919 0.69309206]
cluster number: 2

data point: [-10.56919171   2.49797342]
cluster number: 0

data point: [-6.71045446  7.30156425]
cluster number: 0

data point: [-9.61117656  4.58002763]
cluster number: 0

data point: [10.11023175  1.70626414]
```

```
cluster number: 2

data point: [1.59092221 9.15385608]
cluster number: 1

data point: [-0.01233452 10.05185425]
cluster number: 1

data point: [-6.8213038   8.26275619]
cluster number: 0

data point: [-3.71197768  9.92094888]
cluster number: 1

data point: [-2.05323652  9.63035555]
cluster number: 1

data point: [6.3321071  8.08524243]
cluster number: 1

data point: [5.85366881 7.18486902]
cluster number: 1

data point: [-7.47199938  5.76246862]
cluster number: 0

data point: [-7.66460547  6.25096197]
cluster number: 0

data point: [-8.7611537   3.30918151]
cluster number: 0

data point: [-7.88111495  7.0346129 ]
cluster number: 0

data point: [-2.60261154  9.35612916]
cluster number: 1

data point: [ 2.27752993 10.42245986]
cluster number: 1

data point: [ 1.42615832 10.52768485]
cluster number: 1

data point: [1.65598905 8.86952757]
cluster number: 1

data point: [-10.74947671   0.78367611]
cluster number: 0

data point: [8.95887417 5.72466032]
cluster number: 2

data point: [-5.43048899  7.30115954]
cluster number: 0

data point: [-0.3492869   9.21981594]
```

```
cluster number: 1

data point: [-7.48243852  8.00223295]
cluster number: 0

data point: [-4.17821291  9.07182632]
cluster number: 0

data point: [-10.0320666    3.20590401]
cluster number: 0

data point: [-7.80700944  5.61954421]
cluster number: 0

data point: [-10.75424676   1.29963802]
cluster number: 0

data point: [ 1.53508621 10.56622663]
cluster number: 1

data point: [5.63525102 8.39189536]
cluster number: 1

data point: [9.03163912 1.10879642]
cluster number: 2

data point: [-6.81288439  6.70436706]
cluster number: 0

data point: [-8.63742543  2.56578662]
cluster number: 0

data point: [-10.26739973   2.84605045]
cluster number: 0

data point: [-5.51808022  8.20347534]
cluster number: 0

data point: [10.12875758  2.23668094]
cluster number: 2

data point: [5.13163602 9.1036448 ]
cluster number: 1

data point: [-8.41177268  4.20380835]
cluster number: 0

data point: [-2.66881905  9.12327076]
cluster number: 1

data point: [9.32759512 0.36930961]
cluster number: 2

data point: [-7.91639024  5.17925295]
cluster number: 0

data point: [-6.50832144  7.85609372]
```

```
cluster number: 0

data point: [-3.71256435  8.6015351 ]
cluster number: 1

data point: [2.85345637 9.6606046 ]
cluster number: 1

data point: [8.43063297 6.95366238]
cluster number: 2

data point: [8.79245098 2.24188789]
cluster number: 2

data point: [-5.63109683  7.0310341 ]
cluster number: 0

data point: [7.71733776 6.55578593]
cluster number: 2

data point: [-8.62553835  6.40191679]
cluster number: 0

data point: [10.34491307  0.6960982 ]
cluster number: 2

data point: [5.76086822 9.09172096]
cluster number: 1

data point: [8.19820317 4.93702087]
cluster number: 2

data point: [6.4995476  8.34993339]
cluster number: 1

data point: [-4.66507198  9.78748816]
cluster number: 0

data point: [ 1.93361835 10.20216759]
cluster number: 1

data point: [ 2.40581652 10.03409774]
cluster number: 1

data point: [9.05121065 0.72244499]
cluster number: 2

data point: [3.53449602 9.45626785]
cluster number: 1

data point: [7.51484374 8.02510394]
cluster number: 1

data point: [-5.77046801  9.28736792]
cluster number: 0

data point: [9.40518054 3.16898421]
```

```
cluster number: 2

data point: [-5.21428956  9.1724305 ]
cluster number: 0

data point: [4.94952533 9.61029122]
cluster number: 1

data point: [-10.30822543   2.3636658 ]
cluster number: 0

data point: [8.40818239 6.48025232]
cluster number: 2

data point: [9.57144935 1.55278655]
cluster number: 2

data point: [-7.66220079  7.71686684]
cluster number: 0

data point: [9.93273168 0.07996166]
cluster number: 2

data point: [9.84790907 4.86785525]
cluster number: 2

data point: [7.15911094 5.66886802]
cluster number: 2

data point: [8.64125868 2.6829889 ]
cluster number: 2

data point: [-5.23157047  8.57949607]
cluster number: 0

data point: [-3.2352685   9.64530203]
cluster number: 0

data point: [-10.05691764   1.69605401]
cluster number: 0

data point: [3.93132993 9.57201527]
cluster number: 1

data point: [9.06968349 1.48460002]
cluster number: 2

data point: [-9.24301931  3.18653478]
cluster number: 0

data point: [-9.20380502  3.44871304]
cluster number: 0

data point: [-8.98247076  0.78290685]
cluster number: 0

data point: [-1.59129271  9.10123332]
```

```
cluster number: 1

data point: [-7.79270709  7.05499525]
cluster number: 0

data point: [-8.99150664  1.38340207]
cluster number: 0

data point: [9.07664707 4.2719822 ]
cluster number: 2

data point: [-6.82954988  5.90607828]
cluster number: 0

data point: [8.81915613 5.78144323]
cluster number: 2

data point: [-6.52021383  7.60439119]
cluster number: 0

data point: [-8.67007648  5.76444323]
cluster number: 0

data point: [-6.87813412  7.54047471]
cluster number: 0

data point: [-7.88167182  7.54835727]
cluster number: 0

data point: [-10.61041496   1.61458753]
cluster number: 0

data point: [-9.62232221  3.90309446]
cluster number: 0

data point: [8.92740713 5.55071708]
cluster number: 2

data point: [-6.70308364  7.24888961]
cluster number: 0

data point: [-8.33204094  5.9401162 ]
cluster number: 0

data point: [9.39695157 2.64931255]
cluster number: 2

data point: [5.63733487 7.80624241]
cluster number: 2

data point: [-9.40285144  4.61161763]
cluster number: 0

data point: [-7.77919946  7.69945709]
cluster number: 0

data point: [-6.59648063  8.61196721]
```

```
cluster number: 0

data point: [-5.78568222  7.22053243]
cluster number: 0

data point: [-0.35153555  9.19867037]
cluster number: 1

data point: [-0.86540574  9.6664517 ]
cluster number: 1

data point: [9.49435034 3.5859643 ]
cluster number: 2

data point: [10.25539073  1.03263988]
cluster number: 2

data point: [-8.91243257  1.34818155]
cluster number: 0

data point: [5.63105247 7.71696735]
cluster number: 1

data point: [6.01681402 8.54228528]
cluster number: 1

data point: [6.35673819 6.74437746]
cluster number: 1

data point: [8.71268788 2.58229183]
cluster number: 2

data point: [ 4.23966281 10.07176199]
cluster number: 1

data point: [-0.39027048  9.1956388 ]
cluster number: 1

data point: [ 0.29401719 10.574429  ]
cluster number: 1

data point: [6.03474975 7.32198286]
cluster number: 2

data point: [-9.05598741  2.20421761]
cluster number: 0

data point: [9.92461754 3.79278361]
cluster number: 2

data point: [10.84690654  0.5718235 ]
cluster number: 2

data point: [2.70489549 9.50760832]
cluster number: 1

data point: [1.92092596 8.81576975]
```

```
cluster number: 1

data point: [-8.4531257   3.17882789]
cluster number: 0

data point: [9.36275752 2.31326426]
cluster number: 2

data point: [9.16217302 1.85415964]
cluster number: 2

data point: [3.62559091 8.5873009 ]
cluster number: 1

data point: [7.17492585 5.50176802]
cluster number: 2

data point: [-7.13964306  7.88088667]
cluster number: 0

data point: [10.49758796  2.87445527]
cluster number: 2

data point: [-6.70477036  7.64466216]
cluster number: 0

data point: [6.49586485 6.71161126]
cluster number: 1

data point: [9.44453308 3.72999465]
cluster number: 2

data point: [10.35497522  0.60167411]
cluster number: 2

data point: [-0.33924515 10.17366349]
cluster number: 1

data point: [-5.64311257  7.92196718]
cluster number: 0

data point: [1.84947789 9.81648903]
cluster number: 1

data point: [-9.15052892  3.28865855]
cluster number: 0

data point: [9.49979695 5.15273219]
cluster number: 2

data point: [-10.57185231   2.89878357]
cluster number: 0

data point: [-6.01887432  7.63419873]
cluster number: 0

data point: [ 0.95196095 10.24633863]
```

```
cluster number: 1

data point: [-0.38847044  9.07934866]
cluster number: 1

data point: [-4.85478871  7.69192747]
cluster number: 0

data point: [9.19568604 0.9629783 ]
cluster number: 2

data point: [-7.1992575   7.07519529]
cluster number: 0

data point: [5.17050875 7.40547332]
cluster number: 1

data point: [9.88466037 2.49472702]
cluster number: 2

data point: [7.27607186 5.96508734]
cluster number: 2

data point: [7.84344025 7.60170991]
cluster number: 2

data point: [-6.84403806  6.15623173]
cluster number: 0

data point: [9.26195685 1.57261232]
cluster number: 2

data point: [2.51300363 9.17739224]
cluster number: 1

data point: [-5.6789379   7.39253118]
cluster number: 0

data point: [-10.00989339   3.35514489]
cluster number: 0

data point: [0.24785144 9.5813881 ]
cluster number: 1

data point: [9.85288076 3.5703559 ]
cluster number: 2

data point: [6.75315743 6.1016956 ]
cluster number: 2

data point: [ 0.69177072 10.42515816]
cluster number: 1

data point: [-5.85616679  8.16812597]
cluster number: 0

data point: [0.08293673 9.43150292]
```

```
cluster number: 1

data point: [-2.07991298  9.16419052]
cluster number: 1

data point: [4.95264654 9.64927237]
cluster number: 1

data point: [7.36443716 5.27967017]
cluster number: 2

data point: [-8.08172992  5.45535695]
cluster number: 0

data point: [9.31997831 1.46808643]
cluster number: 2

data point: [7.46025531 5.88880797]
cluster number: 2

data point: [8.31538188 7.15798713]
cluster number: 2

data point: [-8.1054984   6.80995265]
cluster number: 0

data point: [8.07913116 4.94245011]
cluster number: 2

data point: [3.704263   8.22149861]
cluster number: 1

data point: [-8.31737137  7.16597491]
cluster number: 0

data point: [-10.90666595   0.79949458]
cluster number: 0

data point: [4.60461401 8.57021644]
cluster number: 1

data point: [-7.06531641  6.26001375]
cluster number: 0

data point: [-0.67192998  9.66816912]
cluster number: 1

data point: [9.57321908 1.10532485]
cluster number: 2

data point: [10.38754302  2.30855119]
cluster number: 2

data point: [3.54203689 9.77155759]
cluster number: 1

data point: [7.43744223 6.75090335]
```

```
cluster number: 2

data point: [-2.23279882  8.71974624]
cluster number: 1

data point: [-5.95460498  7.01711926]
cluster number: 0

data point: [-10.21593406   3.64585308]
cluster number: 0

data point: [1.68885092 9.47288266]
cluster number: 1

data point: [ 4.26987794 10.10187708]
cluster number: 1

data point: [4.615694   7.85910165]
cluster number: 1

data point: [9.99051125 0.68596276]
cluster number: 2

data point: [10.30137327  3.54685028]
cluster number: 2

data point: [-8.26337864  3.96196364]
cluster number: 0

data point: [-9.21383274  1.62650387]
cluster number: 0

data point: [7.56317144 7.17719794]
cluster number: 1

data point: [-3.32132232  9.27936515]
cluster number: 1

data point: [-1.41155476  9.8260415 ]
cluster number: 1

data point: [ 1.8543523  10.59844343]
cluster number: 1

data point: [ 4.07371394 10.0761537 ]
cluster number: 1

data point: [8.79272989 4.58162959]
cluster number: 2

data point: [3.88298681 8.85461648]
cluster number: 1

data point: [8.14251968 4.47356325]
cluster number: 2

data point: [3.60619972 8.64024767]
```

```
cluster number: 1

data point: [-9.36299448  0.6967044 ]
cluster number: 0

data point: [9.99674753 3.82998484]
cluster number: 2

data point: [-9.01474312  3.95733892]
cluster number: 0

data point: [3.33408538 8.99981288]
cluster number: 1

data point: [5.98986621 7.82021494]
cluster number: 1

data point: [-0.64697733 10.81078039]
cluster number: 1

data point: [9.12939316 5.91435848]
cluster number: 2

data point: [9.0264918  2.22383883]
cluster number: 2

data point: [-9.99453954  0.33504956]
cluster number: 0

data point: [8.93127755 4.63414523]
cluster number: 2

data point: [9.17871437 5.37127556]
cluster number: 2

data point: [-1.98084593  9.69735445]
cluster number: 1

data point: [10.27536945  2.18329358]
cluster number: 2

data point: [-0.83352288  9.08091652]
cluster number: 1

data point: [-8.58472833  3.62666677]
cluster number: 0

data point: [-8.94995357  4.58648454]
cluster number: 0

data point: [-9.1686832   1.40004651]
cluster number: 0

data point: [-3.91353838  8.78819438]
cluster number: 1

data point: [-10.8418564    1.40997639]
```

```
cluster number: 0

data point: [-5.70663533  6.99005758]
cluster number: 1

data point: [5.46839935 8.54680069]
cluster number: 2

data point: [-9.44032734  0.08310381]
cluster number: 0

data point: [6.95600434 5.91234045]
cluster number: 2

data point: [-9.35448069  4.45477801]
cluster number: 0

data point: [-1.68860421 10.20817077]
cluster number: 1

data point: [-9.37106396  0.9395649 ]
cluster number: 0

data point: [-8.22912582  3.97565427]
cluster number: 0

data point: [ 1.89848547 10.81406167]
cluster number: 1

data point: [9.58724632 2.68234326]
cluster number: 2

data point: [-8.56485255  4.27033893]
cluster number: 0

data point: [-1.28578223  9.95629202]
cluster number: 1

data point: [-9.24729029  0.90494367]
cluster number: 0

data point: [5.01261617 8.68019941]
cluster number: 1

data point: [-10.7601154    1.72719726]
cluster number: 0

data point: [-9.30647179  4.15059278]
cluster number: 0

data point: [-9.74519689  0.42491289]
cluster number: 0

data point: [5.73138953 7.30652262]
cluster number: 1

data point: [1.81050158 9.29093481]
```

```
cluster number: 1

data point: [9.95954203 2.64869084]
cluster number: 2

data point: [-8.96028219  3.35856429]
cluster number: 0

data point: [-8.66437725  5.92127361]
cluster number: 0

data point: [-4.75304484  7.84999844]
cluster number: 0

data point: [-5.00233621  9.54171899]
cluster number: 0

data point: [4.57011774 9.2934747 ]
cluster number: 1

data point: [-7.23784897  6.58602382]
cluster number: 0

data point: [10.33582748  0.44139841]
cluster number: 2

data point: [-9.57593055  1.0806898 ]
cluster number: 0

data point: [-10.60269206   1.47734441]
cluster number: 0

data point: [ 0.94644339 10.32368798]
cluster number: 1

data point: [7.33879558 8.13584088]
cluster number: 1

data point: [10.56820008  1.88409854]
cluster number: 2

data point: [7.18815726 5.81676941]
cluster number: 1

data point: [-6.71202935  6.18750338]
cluster number: 0

data point: [1.38805432 9.97499053]
cluster number: 1

data point: [10.11698322  2.3291917 ]
cluster number: 2

data point: [0.98192397 9.30072625]
cluster number: 1

data point: [-6.77543293  7.32761881]
```

```
cluster number: 0

data point: [-6.88368619  7.60715209]
cluster number: 0

data point: [10.86208432  0.90396187]
cluster number: 2

data point: [-4.37418431  9.68361161]
cluster number: 0

data point: [-9.93253255  4.07852709]
cluster number: 0

data point: [-7.4624569   6.60832938]
cluster number: 0

data point: [-6.89763879  6.33440706]
cluster number: 0

data point: [9.03834714 2.46576745]
cluster number: 2

data point: [-6.3994333   7.11268659]
cluster number: 0

data point: [-10.25391251   2.07016306]
cluster number: 0

data point: [-10.42367807   2.73832744]
cluster number: 0

data point: [1.86375997 9.93067302]
cluster number: 1

data point: [4.05402648 8.3099927 ]
cluster number: 1

data point: [9.00702018 2.973062  ]
cluster number: 2

data point: [-10.0683545    1.54046353]
cluster number: 0

data point: [5.71639888 7.10539886]
cluster number: 1

data point: [6.17038204 6.57057336]
cluster number: 1

data point: [7.45862677 6.27858029]
cluster number: 1

data point: [-3.62176935  9.33102409]
cluster number: 0

data point: [-6.52821122  8.02281202]
```

```
cluster number: 0

data point: [5.86858814 9.2480125 ]
cluster number: 1

data point: [-9.80927527  3.5670779 ]
cluster number: 0

data point: [-4.14541046  9.01482686]
cluster number: 0

data point: [-0.63576536  9.59782481]
cluster number: 0

data point: [-2.04794303  9.65819744]
cluster number: 0

data point: [ 1.56247199 10.6635471 ]
cluster number: 0

data point: [-6.85618223  5.94327657]
cluster number: 0

data point: [-3.24087315  8.43545734]
cluster number: 0

data point: [-2.62597521  9.31577985]
cluster number: 0

data point: [-7.72481621  7.45558892]
cluster number: 0

data point: [7.5482393  7.31703344]
cluster number: 1

data point: [ 1.93811189 10.73660485]
cluster number: 1

data point: [9.39069933 0.55651128]
cluster number: 2

data point: [7.74245246 6.90825966]
cluster number: 1

data point: [4.99607932 9.78496861]
cluster number: 1

data point: [-0.81168669 10.01419847]
cluster number: 0

data point: [10.17245907  0.09069474]
cluster number: 2

data point: [5.49193272 8.54672711]
cluster number: 1

data point: [-0.27187793  9.77513202]
```

```
cluster number: 0

data point: [-9.01563815  0.22001649]
cluster number: 3

data point: [7.15628888 7.73229676]
cluster number: 1

data point: [-9.68674122  0.16837117]
cluster number: 3

data point: [10.70828862  1.64538936]
cluster number: 2

data point: [4.05781601 9.69812776]
cluster number: 1

data point: [7.93452457 4.93272996]
cluster number: 1

data point: [-3.34971377 10.14863745]
cluster number: 0

data point: [0.77774358 9.91494462]
cluster number: 0

data point: [-0.69280867  9.64821538]
cluster number: 0

data point: [10.49606405  2.47722313]
cluster number: 2

data point: [-6.77686435  6.77194147]
cluster number: 3

data point: [2.81211937 9.66018281]
cluster number: 0

data point: [7.33094878 5.97111612]
cluster number: 1

data point: [9.56239885 3.5126559 ]
cluster number: 2

data point: [-5.16554404  9.62265092]
cluster number: 0

data point: [9.78081945 2.99921308]
cluster number: 2

data point: [5.89759787 6.96686562]
cluster number: 1

data point: [-7.52980576  5.97309503]
cluster number: 3

data point: [3.81087339 9.16969999]
```

```
cluster number: 1

data point: [-10.01743444   2.30787668]
cluster number: 3

data point: [10.22341498  0.53734953]
cluster number: 2

data point: [9.78484921 2.88555024]
cluster number: 2

data point: [-5.7260589   8.28099449]
cluster number: 0

data point: [-2.01255863  9.62830359]
cluster number: 0

data point: [-10.34593624   0.2350665 ]
cluster number: 3

data point: [10.57178623  3.00726963]
cluster number: 2

data point: [-2.20485754 10.18728171]
cluster number: 0

data point: [8.21296094 6.37432105]
cluster number: 1

data point: [7.7680488 6.6110373]
cluster number: 1

data point: [7.78053002 5.51952287]
cluster number: 1

data point: [2.56466784 8.65502445]
cluster number: 0

data point: [5.19295666 7.5533875 ]
cluster number: 1

data point: [3.2881091  8.96720759]
cluster number: 1

data point: [-8.08661126  4.69319819]
cluster number: 3

data point: [-9.33392234  3.0890223 ]
cluster number: 3

data point: [-3.32309301  9.70041825]
cluster number: 0

data point: [9.04125735 0.15562312]
cluster number: 2

data point: [9.54971024 5.23349184]
```

```
cluster number: 2

data point: [ 3.69761105 10.17401397]
cluster number: 1

data point: [ 0.84406475 10.42281009]
cluster number: 0

data point: [ 1.08885673 10.71571298]
cluster number: 0

data point: [-9.16536338  0.89977187]
cluster number: 3

data point: [-1.11968833  9.30861951]
cluster number: 0

data point: [-1.70158774  9.02638136]
cluster number: 0

data point: [19.31440331  1.28300855]
cluster number: 5

data point: [17.13984176 -0.49372178]
cluster number: 5

data point: [ 8.54324965 -4.30592797]
cluster number: 2

data point: [11.90017261 -4.64217671]
cluster number: 2

data point: [12.33196893 -4.15864369]
cluster number: 2

data point: [14.47047823 -3.20318698]
cluster number: 5

data point: [13.88853653 -4.3628014 ]
cluster number: 5

data point: [10.14830542 -4.8517248 ]
cluster number: 2

data point: [18.65518152  0.43496121]
cluster number: 5

data point: [18.49385214 -0.76627032]
cluster number: 5

data point: [ 3.95298152 -3.49482935]
cluster number: 2

data point: [18.91795806  0.83560032]
cluster number: 5

data point: [11.62569152 -4.22704468]
```

```
cluster number: 2

data point: [ 9.56430738 -4.87065237]
cluster number: 2

data point: [13.82983906 -4.88562501]
cluster number: 5

data point: [19.34402244  4.58866558]
cluster number: 5

data point: [ 8.37809629 -4.96155715]
cluster number: 2

data point: [ 5.16465367 -4.03600658]
cluster number: 2

data point: [ 9.82764848 -4.67221088]
cluster number: 2

data point: [ 9.67702991 -5.66217553]
cluster number: 2

data point: [19.49949857  3.61948201]
cluster number: 5

data point: [13.62470704 -5.33667307]
cluster number: 2

data point: [1.02092648 0.8525379 ]
cluster number: 1

data point: [10.70679788 -4.62506549]
cluster number: 2

data point: [1.62362623 0.44447333]
cluster number: 1

data point: [ 4.49424382 -3.71255339]
cluster number: 2

data point: [ 1.84172318 -2.23192568]
cluster number: 1

data point: [11.84357867 -3.86174854]
cluster number: 2

data point: [ 2.16410867 -2.59516832]
cluster number: 1

data point: [-0.07498138  1.37826277]
cluster number: 1

data point: [ 8.0619547  -4.26384685]
cluster number: 2

data point: [14.27564465 -4.34414334]
```

```
cluster number: 2

data point: [ 7.46399993 -5.35358093]
cluster number: 2

data point: [-0.73098195  4.53215123]
cluster number: 0

data point: [ 8.9264156  -5.57949996]
cluster number: 2

data point: [0.54033078 2.61536107]
cluster number: 1

data point: [19.98705556  0.71714753]
cluster number: 5

data point: [ 7.99971544 -3.86409576]
cluster number: 2

data point: [ 2.30609447 -1.85359405]
cluster number: 1

data point: [16.02072382 -3.78661502]
cluster number: 5

data point: [13.44316815 -3.57189841]
cluster number: 5

data point: [ 5.4057863  -2.83807836]
cluster number: 2

data point: [19.71570995  4.42805428]
cluster number: 5

data point: [16.23489253 -2.37097581]
cluster number: 5

data point: [17.88690193 -1.24029492]
cluster number: 5

data point: [ 5.46571194 -3.42360823]
cluster number: 2

data point: [18.6309524  -0.54095696]
cluster number: 5

data point: [0.64620266 1.53578668]
cluster number: 1

data point: [15.30270947 -4.60159573]
cluster number: 5

data point: [ 1.41798263 -0.81141879]
cluster number: 1

data point: [ 8.33020257 -5.51676976]
```

```
cluster number: 2

data point: [ 2.87330672 -2.93140241]
cluster number: 2

data point: [19.49213315  1.45519019]
cluster number: 5

data point: [18.18202127  0.32985411]
cluster number: 5

data point: [17.23605685 -1.0838068 ]
cluster number: 5

data point: [-0.86067311  3.65585217]
cluster number: 0

data point: [16.74534691 -1.29490932]
cluster number: 5

data point: [16.18433047 -3.2545939 ]
cluster number: 5

data point: [0.0442985  1.45774699]
cluster number: 1

data point: [15.40862409 -2.26339363]
cluster number: 5

data point: [14.76977403 -3.03863893]
cluster number: 5

data point: [19.79447475  4.05653439]
cluster number: 5

data point: [18.10264057 -2.18577591]
cluster number: 5

data point: [1.36152186 0.50783394]
cluster number: 1

data point: [18.95580403  2.79109667]
cluster number: 5

data point: [17.80571837 -1.47538413]
cluster number: 5

data point: [-0.19538725  4.60498698]
cluster number: 0

data point: [ 4.83047649 -3.00388576]
cluster number: 2

data point: [ 2.87883083 -0.66263029]
cluster number: 2

data point: [11.06018422 -4.68025109]
```

```
cluster number: 5

data point: [18.60357174  1.62724098]
cluster number: 5

data point: [ 4.98159252 -2.69003431]
cluster number: 2

data point: [19.30748473  4.14272156]
cluster number: 5

data point: [0.28754459 3.58660985]
cluster number: 0

data point: [18.94680341  2.63055658]
cluster number: 5

data point: [15.21017362 -2.4497337 ]
cluster number: 5

data point: [12.71221383 -5.06536859]
cluster number: 5

data point: [ 9.14531067 -3.97593528]
cluster number: 5

data point: [ 1.84988609 -1.04420022]
cluster number: 2

data point: [-0.41695921  3.15219198]
cluster number: 0

data point: [10.24130923 -4.33573847]
cluster number: 5

data point: [-0.84098113  4.99714748]
cluster number: 0

data point: [18.3785572  -0.16480275]
cluster number: 5

data point: [ 8.03583845 -4.91833287]
cluster number: 5

data point: [ 3.69548632 -2.97210052]
cluster number: 2

data point: [19.28742502 -0.77708244]
cluster number: 5

data point: [ 7.56595368 -5.49461096]
cluster number: 2

data point: [18.03998102 -1.5941889 ]
cluster number: 5

data point: [ 6.95939588 -4.45363445]
```

```
cluster number: 2

data point: [ 5.86550366 -5.16464707]
cluster number: 2

data point: [ 2.04651745 -0.03166385]
cluster number: 1

data point: [1.45976257 0.90641747]
cluster number: 1

data point: [13.00645321 -4.26470142]
cluster number: 5

data point: [20.73050834  4.76425088]
cluster number: 5

data point: [18.40630797  1.03318334]
cluster number: 5

data point: [ 3.0885422  -2.90625792]
cluster number: 2

data point: [16.17586607 -1.94793024]
cluster number: 5

data point: [0.3465607  2.63110961]
cluster number: 0

data point: [ 4.32090606 -2.35251374]
cluster number: 2

data point: [0.14244958 1.29492262]
cluster number: 0

data point: [20.53575032  1.87533632]
cluster number: 5

data point: [2.28868643 0.0285285 ]
cluster number: 1

data point: [14.57572038 -3.08003502]
cluster number: 5

data point: [ 3.94715739 -1.75767714]
cluster number: 2

data point: [ 3.59248225 -2.13873229]
cluster number: 2

data point: [18.26873278  0.80410303]
cluster number: 5

data point: [1.01289312 2.36239772]
cluster number: 0

data point: [11.87113673 -5.17767013]
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```
cluster number: 5

data point: [0.56547864 0.84120862]
cluster number: 0

data point: [16.57237542 -3.54527622]
cluster number: 5

data point: [18.23624661 -0.43036706]
cluster number: 5

data point: [18.9854879  -1.32897245]
cluster number: 5

data point: [17.48698449 -2.59091376]
cluster number: 5

data point: [11.74547864 -5.0204297 ]
cluster number: 5

data point: [ 1.71060363 -2.16136609]
cluster number: 2

data point: [10.66888906 -4.88510013]
cluster number: 5

data point: [18.81608808 -0.0887013 ]
cluster number: 5

data point: [ 2.92239688 -2.71925645]
cluster number: 2

data point: [-0.11692554  2.21290963]
cluster number: 0

data point: [ 9.70487046 -5.91795633]
cluster number: 5

data point: [1.07205779 3.34774899]
cluster number: 0

data point: [15.62816964 -4.29791796]
cluster number: 5

data point: [20.26200374  2.32240443]
cluster number: 5

data point: [-0.68866559  2.74502768]
cluster number: 0

data point: [ 9.3724212  -4.91900691]
cluster number: 5

data point: [ 3.50935034 -2.08941489]
cluster number: 2

data point: [-0.70269656  3.7745943 ]
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cluster number: 0

data point: [11.66980039 -5.78883128]
cluster number: 5

data point: [10.60196938 -4.73594199]
cluster number: 5

data point: [-0.40062146  2.87817477]
cluster number: 0

data point: [15.54408648 -3.51649184]
cluster number: 5

data point: [19.44353831  3.55298138]
cluster number: 5

data point: [ 1.74657285 -1.06850895]
cluster number: 2

data point: [ 8.00569705 -5.68111276]
cluster number: 2

data point: [15.3733256  -3.16170497]
cluster number: 5

data point: [19.65835205  0.09310365]
cluster number: 5

data point: [ 4.80229619 -4.49727456]
cluster number: 2

data point: [1.73166464 0.70639537]
cluster number: 1

data point: [ 5.09667687 -3.32610209]
cluster number: 2

data point: [ 8.60600266 -4.04396826]
cluster number: 2

data point: [ 9.64723438 -5.21431424]
cluster number: 2

data point: [10.39938169 -4.49005873]
cluster number: 2

data point: [ 8.79746482 -5.26722447]
cluster number: 2

data point: [17.9851677  -1.61368491]
cluster number: 5

data point: [19.88078072  2.03835176]
cluster number: 5

data point: [ 8.8450108  -5.00911718]
```

```
cluster number: 2

data point: [ 2.70089085 -0.7026195 ]
cluster number: 1

data point: [11.94165555 -5.6862412 ]
cluster number: 2

data point: [ 6.44099895 -3.49097783]
cluster number: 2

data point: [ 1.85893496 -0.51385961]
cluster number: 1

data point: [10.62318892 -4.86284804]
cluster number: 2

data point: [ 9.61956623 -4.33292211]
cluster number: 2

data point: [19.14613918  0.19153623]
cluster number: 5

data point: [0.75582182 4.08425058]
cluster number: 0

data point: [ 6.06745025 -5.17374028]
cluster number: 2

data point: [19.18100625 -1.00876692]
cluster number: 5

data point: [15.44162111 -2.65198699]
cluster number: 5

data point: [15.30591948 -4.13829059]
cluster number: 5

data point: [19.33046626  1.38536362]
cluster number: 5

data point: [17.33585792 -0.87225314]
cluster number: 5

data point: [15.07181398 -3.27521167]
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data point: [0.46400843 2.6705271 ]
cluster number: 0

data point: [0.22345823 4.87442398]
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data point: [18.19079531 -0.3881156 ]
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data point: [-0.67895346  2.54351198]
```

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cluster number: 0

data point: [18.49608605 -0.96248726]
cluster number: 5

data point: [0.45560081 4.30690794]
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data point: [20.56919171  2.50202658]
cluster number: 5

data point: [16.71045446 -2.30156425]
cluster number: 5

data point: [19.61117656  0.41997237]
cluster number: 5

data point: [-0.11023175  3.29373586]
cluster number: 0

data point: [ 8.40907779 -4.15385608]
cluster number: 2

data point: [10.01233452 -5.05185425]
cluster number: 2

data point: [16.8213038  -3.26275619]
cluster number: 5

data point: [13.71197768 -4.92094888]
cluster number: 5

data point: [12.05323652 -4.63035555]
cluster number: 5

data point: [ 3.6678929  -3.08524243]
cluster number: 1

data point: [ 4.14633119 -2.18486902]
cluster number: 1

data point: [17.47199938 -0.76246862]
cluster number: 5

data point: [17.66460547 -1.25096197]
cluster number: 5

data point: [18.7611537   1.69081849]
cluster number: 5

data point: [17.88111495 -2.0346129 ]
cluster number: 5

data point: [12.60261154 -4.35612916]
cluster number: 2

data point: [ 7.72247007 -5.42245986]
```

```
cluster number: 2

data point: [ 8.57384168 -5.52768485]
cluster number: 2

data point: [ 8.34401095 -3.86952757]
cluster number: 2

data point: [20.74947671  4.21632389]
cluster number: 5

data point: [ 1.04112583 -0.72466032]
cluster number: 1

data point: [15.43048899 -2.30115954]
cluster number: 5

data point: [10.3492869  -4.21981594]
cluster number: 2

data point: [17.48243852 -3.00223295]
cluster number: 5

data point: [14.17821291 -4.07182632]
cluster number: 5

data point: [20.0320666   1.79409599]
cluster number: 5

data point: [17.80700944 -0.61954421]
cluster number: 5

data point: [20.75424676  3.70036198]
cluster number: 5

data point: [ 8.46491379 -5.56622663]
cluster number: 2

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cluster number: 0

data point: [16.81288439 -1.70436706]
cluster number: 5

data point: [18.63742543  2.43421338]
cluster number: 5

data point: [20.26739973  2.15394955]
cluster number: 5

data point: [15.51808022 -3.20347534]
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data point: [-0.12875758  2.76331906]
```

```
cluster number: 0

data point: [ 4.86836398 -4.1036448 ]
cluster number: 2

data point: [18.41177268  0.79619165]
cluster number: 5

data point: [12.66881905 -4.12327076]
cluster number: 5

data point: [0.67240488 4.63069039]
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data point: [17.91639024 -0.17925295]
cluster number: 5

data point: [16.50832144 -2.85609372]
cluster number: 5

data point: [13.71256435 -3.6015351 ]
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data point: [ 7.14654363 -4.6606046 ]
cluster number: 2

data point: [ 1.56936703 -1.95366238]
cluster number: 1

data point: [1.20754902 2.75811211]
cluster number: 0

data point: [15.63109683 -2.0310341 ]
cluster number: 5

data point: [ 2.28266224 -1.55578593]
cluster number: 1

data point: [18.62553835 -1.40191679]
cluster number: 5

data point: [-0.34491307  4.3039018 ]
cluster number: 0

data point: [ 4.23913178 -4.09172096]
cluster number: 2

data point: [1.80179683 0.06297913]
cluster number: 1

data point: [ 3.5004524  -3.34993339]
cluster number: 2

data point: [14.66507198 -4.78748816]
cluster number: 5

data point: [ 8.06638165 -5.20216759]
```

```
cluster number: 2

data point: [ 7.59418348 -5.03409774]
cluster number: 2

data point: [0.94878935 4.27755501]
cluster number: 0

data point: [ 6.46550398 -4.45626785]
cluster number: 2

data point: [ 2.48515626 -3.02510394]
cluster number: 1

data point: [15.77046801 -4.28736792]
cluster number: 5

data point: [0.59481946 1.83101579]
cluster number: 0

data point: [15.21428956 -4.1724305 ]
cluster number: 5

data point: [ 5.05047467 -4.61029122]
cluster number: 2

data point: [20.30822543  2.6363342 ]
cluster number: 5

data point: [ 1.59181761 -1.48025232]
cluster number: 1

data point: [0.42855065 3.44721345]
cluster number: 0

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cluster number: 5

data point: [0.06726832 4.92003834]
cluster number: 0

data point: [0.15209093 0.13214475]
cluster number: 1

data point: [ 2.84088906 -0.66886802]
cluster number: 1

data point: [1.35874132 2.3170111 ]
cluster number: 0

data point: [15.23157047 -3.57949607]
cluster number: 5

data point: [13.2352685  -4.64530203]
cluster number: 5

data point: [20.05691764  3.30394599]
```

```
cluster number: 5

data point: [ 6.06867007 -4.57201527]
cluster number: 2

data point: [0.93031651 3.51539998]
cluster number: 0

data point: [19.24301931  1.81346522]
cluster number: 5

data point: [19.20380502  1.55128696]
cluster number: 5

data point: [18.98247076  4.21709315]
cluster number: 5

data point: [11.59129271 -4.10123332]
cluster number: 2

data point: [17.79270709 -2.05499525]
cluster number: 5

data point: [18.99150664  3.61659793]
cluster number: 5

data point: [0.92335293 0.7280178 ]
cluster number: 1

data point: [16.82954988 -0.90607828]
cluster number: 5

data point: [ 1.18084387 -0.78144323]
cluster number: 1

data point: [16.52021383 -2.60439119]
cluster number: 5

data point: [18.67007648 -0.76444323]
cluster number: 5

data point: [16.87813412 -2.54047471]
cluster number: 5

data point: [17.88167182 -2.54835727]
cluster number: 5

data point: [20.61041496  3.38541247]
cluster number: 5

data point: [19.62232221  1.09690554]
cluster number: 5

data point: [ 1.07259287 -0.55071708]
cluster number: 1

data point: [16.70308364 -2.24888961]
```

```
cluster number: 5

data point: [18.33204094 -0.9401162 ]
cluster number: 5

data point: [0.60304843 2.35068745]
cluster number: 0

data point: [ 4.36266513 -2.80624241]
cluster number: 2

data point: [19.40285144  0.38838237]
cluster number: 5

data point: [17.77919946 -2.69945709]
cluster number: 5

data point: [16.59648063 -3.61196721]
cluster number: 5

data point: [15.78568222 -2.22053243]
cluster number: 5

data point: [10.35153555 -4.19867037]
cluster number: 2

data point: [10.86540574 -4.6664517 ]
cluster number: 2

data point: [0.50564966 1.4140357 ]
cluster number: 0

data point: [-0.25539073  3.96736012]
cluster number: 0

data point: [18.91243257  3.65181845]
cluster number: 5

data point: [ 4.36894753 -2.71696735]
cluster number: 2

data point: [ 3.98318598 -3.54228528]
cluster number: 2

data point: [ 3.64326181 -1.74437746]
cluster number: 2

data point: [1.28731212 2.41770817]
cluster number: 0

data point: [ 5.76033719 -5.07176199]
cluster number: 2

data point: [10.39027048 -4.1956388 ]
cluster number: 2

data point: [ 9.70598281 -5.574429  ]
```

```
cluster number: 2

data point: [ 3.96525025 -2.32198286]
cluster number: 2

data point: [19.05598741  2.79578239]
cluster number: 5

data point: [0.07538246 1.20721639]
cluster number: 0

data point: [-0.84690654  4.4281765 ]
cluster number: 0

data point: [ 7.29510451 -4.50760832]
cluster number: 2

data point: [ 8.07907404 -3.81576975]
cluster number: 2

data point: [18.4531257   1.82117211]
cluster number: 5

data point: [0.63724248 2.68673574]
cluster number: 0

data point: [0.83782698 3.14584036]
cluster number: 0

data point: [ 6.37440909 -3.5873009 ]
cluster number: 2

data point: [ 2.82507415 -0.50176802]
cluster number: 1

data point: [17.13964306 -2.88088667]
cluster number: 5

data point: [-0.49758796  2.12554473]
cluster number: 0

data point: [16.70477036 -2.64466216]
cluster number: 5

data point: [ 3.50413515 -1.71161126]
cluster number: 2

data point: [0.55546692 1.27000535]
cluster number: 0

data point: [-0.35497522  4.39832589]
cluster number: 0

data point: [10.33924515 -5.17366349]
cluster number: 5

data point: [15.64311257 -2.92196718]
```

```
cluster number: 5

data point: [ 8.15052211 -4.81648903]
cluster number: 2

data point: [19.15052892  1.71134145]
cluster number: 5

data point: [ 0.50020305 -0.15273219]
cluster number: 1

data point: [20.57185231  2.10121643]
cluster number: 5

data point: [16.01887432 -2.63419873]
cluster number: 5

data point: [ 9.04803905 -5.24633863]
cluster number: 2

data point: [10.38847044 -4.07934866]
cluster number: 2

data point: [14.85478871 -2.69192747]
cluster number: 5

data point: [0.80431396 4.0370217 ]
cluster number: 0

data point: [17.1992575  -2.07519529]
cluster number: 5

data point: [ 4.82949125 -2.40547332]
cluster number: 2

data point: [0.11533963 2.50527298]
cluster number: 0

data point: [ 2.72392814 -0.96508734]
cluster number: 1

data point: [ 2.15655975 -2.60170991]
cluster number: 1

data point: [16.84403806 -1.15623173]
cluster number: 5

data point: [0.73804315 3.42738768]
cluster number: 0

data point: [ 7.48699637 -4.17739224]
cluster number: 2

data point: [15.6789379  -2.39253118]
cluster number: 5

data point: [20.00989339  1.64485511]
```

```
cluster number: 5

data point: [ 9.75214856 -4.5813881 ]
cluster number: 2

data point: [0.14711924 1.4296441 ]
cluster number: 0

data point: [ 3.24684257 -1.1016956 ]
cluster number: 1

data point: [ 9.30822928 -5.42515816]
cluster number: 2

data point: [15.85616679 -3.16812597]
cluster number: 5

data point: [ 9.91706327 -4.43150292]
cluster number: 2

data point: [12.07991298 -4.16419052]
cluster number: 2

data point: [ 5.04735346 -4.64927237]
cluster number: 1

data point: [ 2.63556284 -0.27967017]
cluster number: 1

data point: [18.08172992 -0.45535695]
cluster number: 5

data point: [0.68002169 3.53191357]
cluster number: 0

data point: [ 2.53974469 -0.88880797]
cluster number: 1

data point: [ 1.68461812 -2.15798713]
cluster number: 1

data point: [18.1054984  -1.80995265]
cluster number: 5

data point: [1.92086884 0.05754989]
cluster number: 1

data point: [ 6.295737   -3.22149861]
cluster number: 2

data point: [18.31737137 -2.16597491]
cluster number: 5

data point: [20.90666595  4.20050542]
cluster number: 5

data point: [ 5.39538599 -3.57021644]
```

```
cluster number: 2

data point: [17.06531641 -1.26001375]
cluster number: 5

data point: [10.67192998 -4.66816912]
cluster number: 2

data point: [0.42678092 3.89467515]
cluster number: 0

data point: [-0.38754302  2.69144881]
cluster number: 0

data point: [ 6.45796311 -4.77155759]
cluster number: 2

data point: [ 2.56255777 -1.75090335]
cluster number: 1

data point: [12.23279882 -3.71974624]
cluster number: 2

data point: [15.95460498 -2.01711926]
cluster number: 5

data point: [20.21593406  1.35414692]
cluster number: 5

data point: [ 8.31114908 -4.47288266]
cluster number: 2

data point: [ 5.73012206 -5.10187708]
cluster number: 2

data point: [ 5.384306   -2.85910165]
cluster number: 2

data point: [0.00948875 4.31403724]
cluster number: 0

data point: [-0.30137327  1.45314972]
cluster number: 0

data point: [18.26337864  1.03803636]
cluster number: 5

data point: [19.21383274  3.37349613]
cluster number: 5

data point: [ 2.43682856 -2.17719794]
cluster number: 1

data point: [13.32132232 -4.27936515]
cluster number: 5

data point: [11.41155476 -4.8260415 ]
```

```
cluster number: 5

data point: [ 8.1456477  -5.59844343]
cluster number: 2

data point: [ 5.92628606 -5.0761537 ]
cluster number: 2

data point: [1.20727011 0.41837041]
cluster number: 1

data point: [ 6.11701319 -3.85461648]
cluster number: 2

data point: [1.85748032 0.52643675]
cluster number: 1

data point: [ 6.39380028 -3.64024767]
cluster number: 2

data point: [19.36299448  4.3032956 ]
cluster number: 5

data point: [0.00325247 1.17001516]
cluster number: 0

data point: [19.01474312  1.04266108]
cluster number: 5

data point: [ 6.66591462 -3.99981288]
cluster number: 2

data point: [ 4.01013379 -2.82021494]
cluster number: 2

data point: [10.64697733 -5.81078039]
cluster number: 2

data point: [ 0.87060684 -0.91435848]
cluster number: 1

data point: [0.9735082  2.77616117]
cluster number: 0

data point: [19.99453954  4.66495044]
cluster number: 5

data point: [1.06872245 0.36585477]
cluster number: 1

data point: [ 0.82128563 -0.37127556]
cluster number: 1

data point: [11.98084593 -4.69735445]
cluster number: 2

data point: [-0.27536945  2.81670642]
```

```
cluster number: 0

data point: [10.83352288 -4.08091652]
cluster number: 2

data point: [18.58472833  1.37333323]
cluster number: 5

data point: [18.94995357  0.41351546]
cluster number: 5

data point: [19.1686832   3.59995349]
cluster number: 5

data point: [13.91353838 -3.78819438]
cluster number: 2

data point: [20.8418564   3.59002361]
cluster number: 5

data point: [15.70663533 -1.99005758]
cluster number: 2

data point: [ 4.53160065 -3.54680069]
cluster number: 1

data point: [19.44032734  4.91689619]
cluster number: 5

data point: [ 3.04399566 -0.91234045]
cluster number: 1

data point: [19.35448069  0.54522199]
cluster number: 5

data point: [11.68860421 -5.20817077]
cluster number: 2

data point: [19.37106396  4.0604351 ]
cluster number: 5

data point: [18.22912582  1.02434573]
cluster number: 5

data point: [ 8.10151453 -5.81406167]
cluster number: 2

data point: [0.41275368 2.31765674]
cluster number: 0

data point: [18.56485255  0.72966107]
cluster number: 5

data point: [11.28578223 -4.95629202]
cluster number: 2

data point: [19.24729029  4.09505633]
```

```
cluster number: 5

data point: [ 4.98738383 -3.68019941]
cluster number: 1

data point: [20.7601154   3.27280274]
cluster number: 5

data point: [19.30647179  0.84940722]
cluster number: 5

data point: [19.74519689  4.57508711]
cluster number: 5

data point: [ 4.26861047 -2.30652262]
cluster number: 1

data point: [ 8.18949842 -4.29093481]
cluster number: 2

data point: [0.04045797 2.35130916]
cluster number: 0

data point: [18.96028219  1.64143571]
cluster number: 5

data point: [18.66437725 -0.92127361]
cluster number: 5

data point: [14.75304484 -2.84999844]
cluster number: 5

data point: [15.00233621 -4.54171899]
cluster number: 5

data point: [ 5.42988226 -4.2934747 ]
cluster number: 2

data point: [17.23784897 -1.58602382]
cluster number: 5

data point: [-0.33582748  4.55860159]
cluster number: 0

data point: [19.57593055  3.9193102 ]
cluster number: 5

data point: [20.60269206  3.52265559]
cluster number: 5

data point: [ 9.05355661 -5.32368798]
cluster number: 2

data point: [ 2.66120442 -3.13584088]
cluster number: 1

data point: [-0.56820008  3.11590146]
```

```
cluster number: 0

data point: [ 2.81184274 -0.81676941]
cluster number: 1

data point: [16.71202935 -1.18750338]
cluster number: 5

data point: [ 8.61194568 -4.97499053]
cluster number: 2

data point: [-0.11698322  2.6708083 ]
cluster number: 0

data point: [ 9.01807603 -4.30072625]
cluster number: 2

data point: [16.77543293 -2.32761881]
cluster number: 5

data point: [16.88368619 -2.60715209]
cluster number: 5

data point: [-0.86208432  4.09603813]
cluster number: 0

data point: [14.37418431 -4.68361161]
cluster number: 5

data point: [19.93253255  0.92147291]
cluster number: 5

data point: [17.4624569  -1.60832938]
cluster number: 5

data point: [16.89763879 -1.33440706]
cluster number: 5

data point: [0.96165286 2.53423255]
cluster number: 0

data point: [16.3994333  -2.11268659]
cluster number: 5

data point: [20.25391251  2.92983694]
cluster number: 5

data point: [20.42367807  2.26167256]
cluster number: 5

data point: [ 8.13624003 -4.93067302]
cluster number: 2

data point: [ 5.94597352 -3.3099927 ]
cluster number: 2

data point: [0.99297982 2.026938  ]
```

```
cluster number: 0

data point: [20.0683545   3.45953647]
cluster number: 5

data point: [ 4.28360112 -2.10539886]
cluster number: 2

data point: [ 3.82961796 -1.57057336]
cluster number: 2

data point: [ 2.54137323 -1.27858029]
cluster number: 1

data point: [13.62176935 -4.33102409]
cluster number: 5

data point: [16.52821122 -3.02281202]
cluster number: 5

data point: [ 4.13141186 -4.2480125 ]
cluster number: 2

data point: [19.80927527  1.4329221 ]
cluster number: 5

data point: [14.14541046 -4.01482686]
cluster number: 5

data point: [10.63576536 -4.59782481]
cluster number: 5

data point: [12.04794303 -4.65819744]
cluster number: 5

data point: [ 8.43752801 -5.6635471 ]
cluster number: 5

data point: [16.85618223 -0.94327657]
cluster number: 5

data point: [13.24087315 -3.43545734]
cluster number: 5

data point: [12.62597521 -4.31577985]
cluster number: 5

data point: [17.72481621 -2.45558892]
cluster number: 5

data point: [ 2.4517607  -2.31703344]
cluster number: 1

data point: [ 8.06188811 -5.73660485]
cluster number: 2

data point: [0.60930067 4.44348872]
```

```
cluster number: 0

data point: [ 2.25754754 -1.90825966]
cluster number: 1

data point: [ 5.00392068 -4.78496861]
cluster number: 2

data point: [10.81168669 -5.01419847]
cluster number: 5

data point: [-0.17245907  4.90930526]
cluster number: 0

data point: [ 4.50806728 -3.54672711]
cluster number: 2

data point: [10.27187793 -4.77513202]
cluster number: 5

data point: [19.01563815  4.77998351]
cluster number: 5

data point: [ 2.84371112 -2.73229676]
cluster number: 2

data point: [19.68674122  4.83162883]
cluster number: 5

data point: [-0.70828862  3.35461064]
cluster number: 0

data point: [ 5.94218399 -4.69812776]
cluster number: 2

data point: [2.06547543 0.06727004]
cluster number: 1

data point: [13.34971377 -5.14863745]
cluster number: 5

data point: [ 9.22225642 -4.91494462]
cluster number: 2

data point: [10.69280867 -4.64821538]
cluster number: 2

data point: [-0.49606405  2.52277687]
cluster number: 0

data point: [16.77686435 -1.77194147]
cluster number: 5

data point: [ 7.18788063 -4.66018281]
cluster number: 2

data point: [ 2.66905122 -0.97111612]
```

```
cluster number: 1

data point: [0.43760115 1.4873441 ]
cluster number: 0

data point: [15.16554404 -4.62265092]
cluster number: 5

data point: [0.21918055 2.00078692]
cluster number: 0

data point: [ 4.10240213 -1.96686562]
cluster number: 1

data point: [17.52980576 -0.97309503]
cluster number: 5

data point: [ 6.18912661 -4.16969999]
cluster number: 2

data point: [20.01743444  2.69212332]
cluster number: 5

data point: [-0.22341498  4.46265047]
cluster number: 0

data point: [0.21515079 2.11444976]
cluster number: 0

data point: [15.7260589  -3.28099449]
cluster number: 5

data point: [12.01255863 -4.62830359]
cluster number: 5

data point: [20.34593624  4.7649335 ]
cluster number: 5

data point: [-0.57178623  1.99273037]
cluster number: 0

data point: [12.20485754 -5.18728171]
cluster number: 2

data point: [ 1.78703906 -1.37432105]
cluster number: 1

data point: [ 2.2319512 -1.6110373]
cluster number: 1

data point: [ 2.21946998 -0.51952287]
cluster number: 1

data point: [ 7.43533216 -3.65502445]
cluster number: 2

data point: [ 4.80704334 -2.5533875 ]
```

```
cluster number: 2

data point: [ 6.7118909  -3.96720759]
cluster number: 2

data point: [18.08661126  0.30680181]
cluster number: 5

data point: [19.33392234  1.9109777 ]
cluster number: 5

data point: [13.32309301 -4.70041825]
cluster number: 5

data point: [0.95874265 4.84437688]
cluster number: 0

data point: [ 0.45028976 -0.23349184]
cluster number: 1

data point: [ 6.30238895 -5.17401397]
cluster number: 2

data point: [ 9.15593525 -5.42281009]
cluster number: 2

data point: [ 8.91114327 -5.71571298]
cluster number: 2

data point: [19.16536338  4.10022813]
cluster number: 5

data point: [11.11968833 -4.30861951]
cluster number: 2

data point: [11.70158774 -4.02638136]
cluster number: 2

Last centroids position:
 [[  0   2]
 [  1   0]
 [ 10  -4]
 [ -8   1]
 [ 10 -15]
 [ 17   1]]
```

In [199]:
```
x1, x2, x3, x4, x5, x6 = [], [], [], [], [], []
y1, y2, y3, y4, y5, y6 = [], [], [], [], [], []
for i in range(len(xarr)):
    if cluster_label[i][0] == 0:
        x1.append(xarr[i])
        y1.append(yarr[i])
    elif cluster_label[i][0] == 1:
        x2.append(xarr[i])
        y2.append(yarr[i])
    elif cluster_label[i][0] == 2:
        x3.append(xarr[i])
        y3.append(yarr[i])
    elif cluster_label[i][0] == 3:
        x4.append(xarr[i])
        y4.append(yarr[i])
    elif cluster_label[i][0] == 4:
        x5.append(xarr[i])
        y5.append(yarr[i])
    elif cluster_label[i][0] == 5:
        x6.append(xarr[i])
        y6.append(yarr[i])
```

In [200]:
```
plt.plot(x1, y1, 'o')
plt.plot(x2, y2, 'o')
plt.plot(x3, y3, 'o')
plt.plot(x4, y4, 'o')
plt.plot(x5, y5, 'o')
plt.plot(x6, y6, 'o')

plt.plot(new_centroids[:,0], new_centroids[:,1], 'ko')
```

Out[200]:
```
[<matplotlib.lines.Line2D at 0x211d1b31a88>]
```