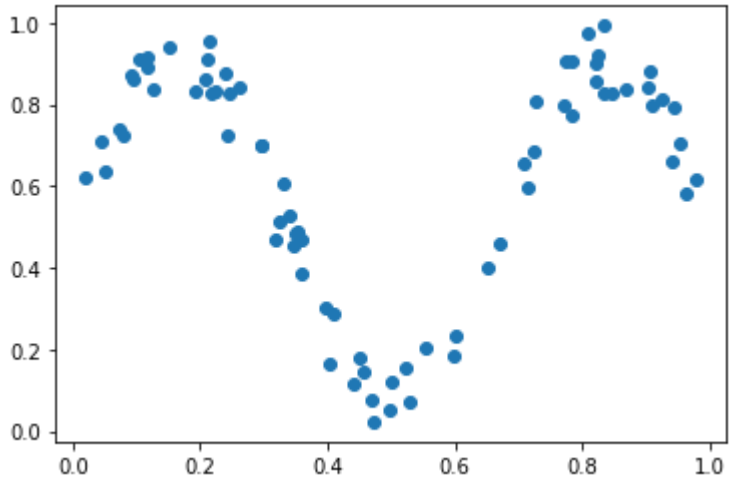
```
#Initialize the first layer
# probably helpful preliminaries
import numpy as np
import matplotlib.pyplot as plt
import random
import itertools
```

Double-click (or enter) to edit

```
#Generating the data
x = np.random.uniform(0, 1.0, (75,1)).reshape(75)
y = .5 + .4* np.sin(3*np.pi * x) + np.random.uniform(-.1, .1, (75,1)).reshape(75)
data = np.concatenate((x.reshape(75,1),y.reshape(75,1)),axis=1) #all points
plt.plot(x,y,'o')
```

```
[<matplotlib.lines.Line2D at 0x7f020d964650>]
```




```
def kmean(data,k,x,y):
  visited = set()
  clusters = np.zeros((k,2))
  #used to selected random points at clusters
  for i in range(k):
    num = random.randrange(75)
    while num in visited:
      num = random.randrange(75)
    clusters[i] = data[num]
    visited.add(num)
  prevClusterCenters = np.zeros((k,2)) #used to keep track of the previous clusters
  point_labels = np.zeros((75))

  while (np.sum(clusters-prevClusterCenters)!= 0 ): #stops when no more clusters move
    prevClusterCenters = np.array(clusters)
    for i in range(len(data)): #used to assign points a cluster
      min  = 10000000000
```

```
        index = 0
        for j in range(k):#used to find the min distance from the point to all clusters
          dist = np.sqrt((data[i][1]-clusters[j][1])**2 + (data[i][0]-clusters[j][0])**2)
          if dist<min:
            min = dist
            index = j #the index to assign that point to
        point_labels[i] = index
      for i in range(k):#used to update clusters
        sum_x = 0
        sum_y = 0
        count = 0
        for j in range(75):
          if point_labels[j] == i:
            count+=1
            sum_x += data[j][0]
            sum_y += data[j][1]
        if count>0:
          clusters[i][0] = sum_x/count
          clusters[i][1] = sum_y/count
    plt.scatter(x,y,c=point_labels,s=25, cmap = 'viridis')
    plt.show()
    plt.close()
    return clusters, point_labels


  def computeVariance(centriods, point_labels,data):
    variance = np.zeros((len(centriods)))
    maxDist = 0.0
    calc_variance = [] #This will keep the position of all clusters that only have a value of 1
    for i in range(len(centriods)):
      num_of_points = np.count_nonzero(point_labels==i)
      if(num_of_points==1): #skips all the clusters that only have 1 point
        calc_variance.append(i)
        continue
      sum = 0 #used to get the sum of the clusters
      for j in range(len(point_labels)):
        if point_labels[j] == i:
          sum = sum + (centriods[i][0]-data[j][0])**2
      #print("sum  of: ",i," ", sum, "Number of points", num_of_points)
      variance[i] = sum/(num_of_points*1.0)
    sum_of_variances = np.sum(variance[variance>0])/(np.count_nonzero(variance>0)*1.0)
    for j in calc_variance:#Calculates the variance of all clusters that only had one point
      variance[j] = sum_of_variances
    return variance
  #computeVariance(centriods,point_labels,data)


  def computeSameVariance(centriods):
    variance = np.zeros((len(centriods)))
    maxDist = 0
    for i in range(len(centriods)):
      for j in range(i+1,len(centriods)):
```

```
        distance = np.sqrt((centriods[j][0]-centriods[i][0])**2 + (centriods[j][1]-centriods[i]
        if(maxDist<distance):
          maxDist = distance
    for i in range(len(centriods)):
      variance[i] = (maxDist/np.sqrt(2*len(centriods)))**2
    return variance
  #computeSameVariance(centriods)


  def updateWeights(weights,learning_rate,radial_functions,data):
    d = .5 + .4* np.sin(3*np.pi * data[0])
    y = np.dot(weights,radial_functions)
    return weights + (learning_rate*(data[1]-y))*radial_functions


  #generates a formula to graph
  def getYValue(weights,radial_functions):
    return np.dot(weights,radial_functions)


  epoches = 100
  learning_rates = [.01,.02]
  n_clusters = [3,6,9,12,16]

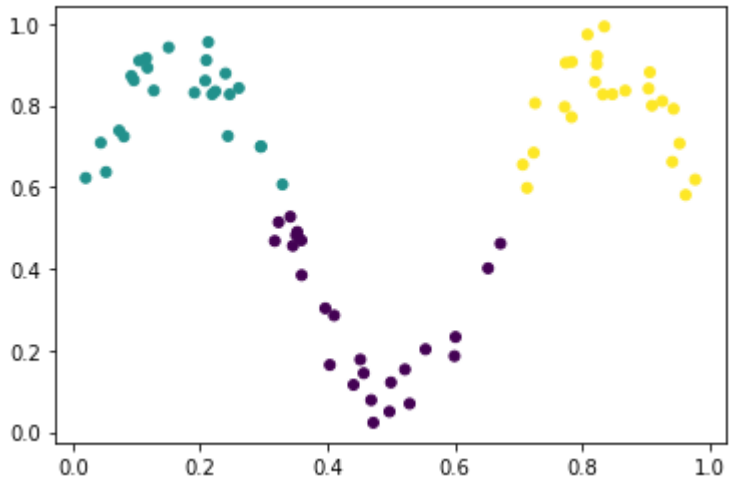
  for learning_rate in learning_rates:
    for clusters in n_clusters:
      print("The following is shows the clusters for cluster number ", clusters)
      centriods, point_labels = kmean(data,clusters,data[:,0],data[:,1]) #get the centriods cen
      variance = computeVariance(centriods,point_labels,data)
      print("Learning rate: ", learning_rate)
      print("For this run the variance is different for all clusters")
      # variance = computeSameVariance(centriods)
      weights = np.zeros((clusters+1)) #plus one because of the bias term
      for j in range(epoches):
        visited_points = set()
        for k in range(len(data)):#used to train data
          num = random.randrange(75)
          while num in visited_points:
            num = random.randrange(75)
          radial_values = np.zeros((len(centriods)+1)) #stores all the values of the radial fun
          radial_values[0] = 1 #setting the bias term
          for m in range(len(centriods)):
            diff = (data[num][0] - centriods[m][0])**2
            radial_values[m+1] = np.exp(-(1.0/(2*variance[m]))*diff)
          weights = updateWeights(weights,learning_rate,radial_values,data[num])
          visited_points.add(num)

      x_real = np.linspace(0, 1.0, 75)   # start,stop,step
      y_real = .5 + .4*np.sin(3*np.pi * x_real)
      plt.plot(x_real,y_real)
      plt.plot(data[:,0],data[:,1],'o')

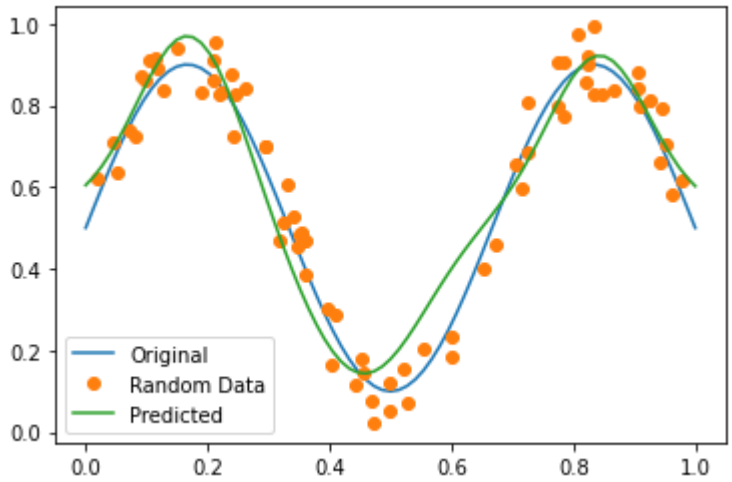
      y_plot = []
```

```
y_plot = []
for k in range(len(x_real)):#used to train data
  radial_values = np.zeros((len(centriods)+1)) #stores all the values of the radial funct
  radial_values[0] = 1 #setting the bias term
  for m in range(len(centriods)):
    diff = (x_real[k] - centriods[m][0])**2
    radial_values[m+1] = np.exp(-(1.0/(2*variance[m]))*diff)
  y_plot.append(getYValue(weights,radial_values))
plt.plot(x_real,y_plot)
plt.legend(['Original', 'Random Data','Predicted'])
plt.show()
plt.close()
```

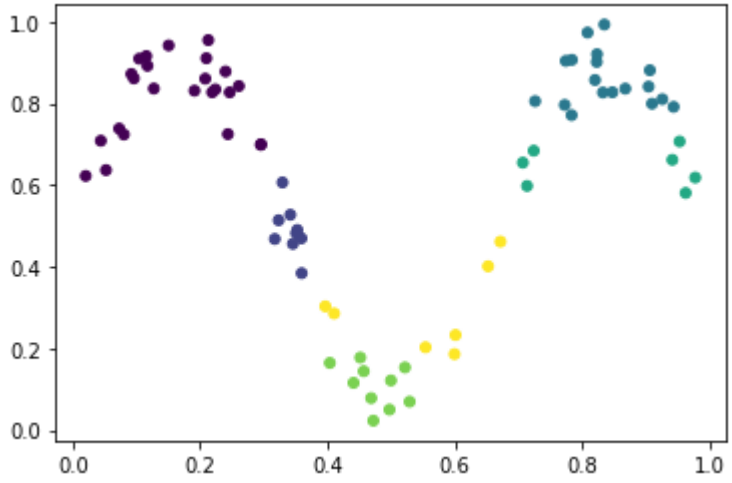
```
The following is shows the clusters for cluster number  3
```



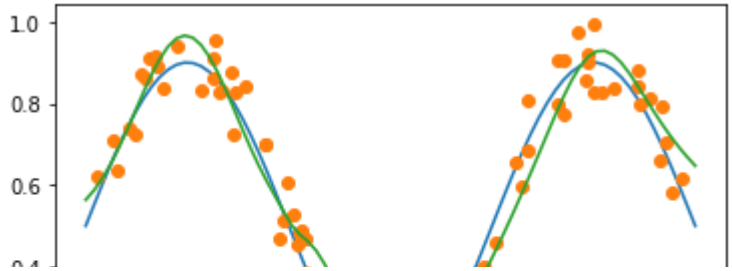
```
Learning rate:  0.01
```

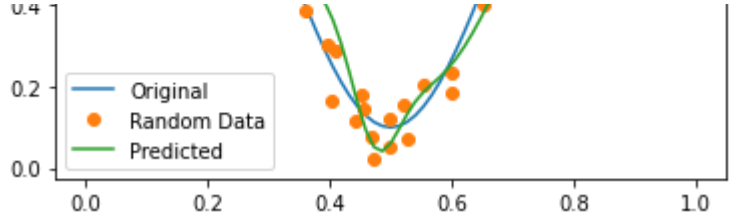



```
The following is shows the clusters for cluster number  6
```

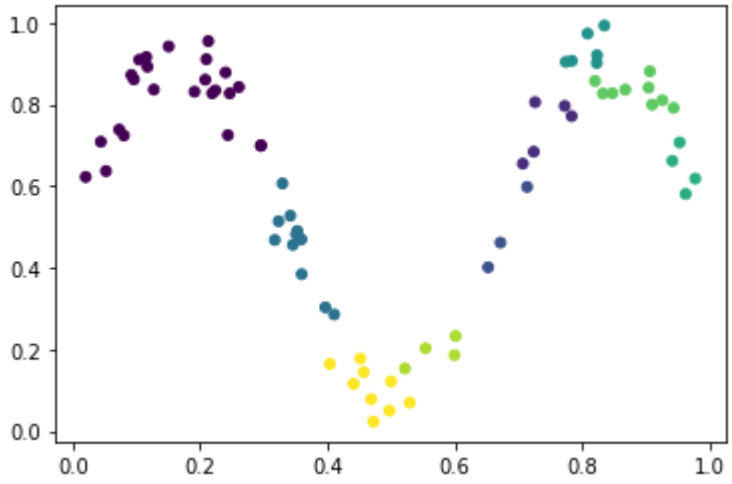


```
Learning rate:  0.01
```

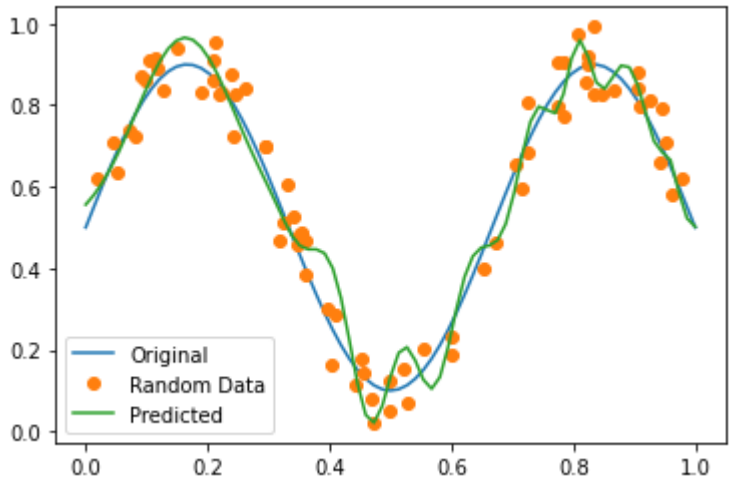




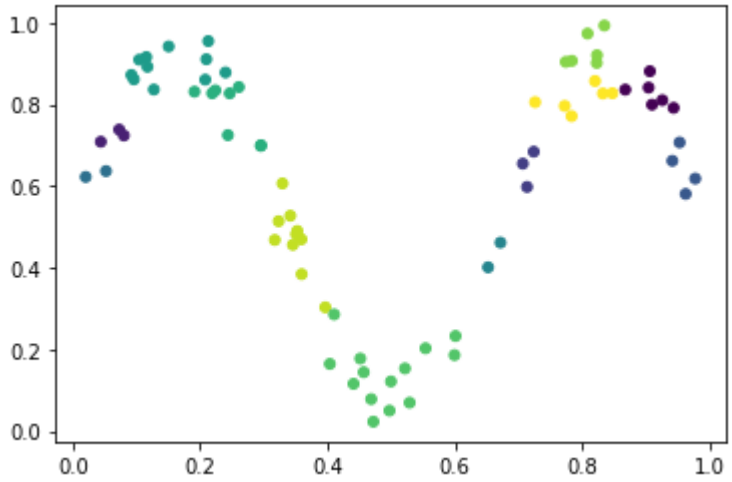
The following is shows the clusters for cluster number 9



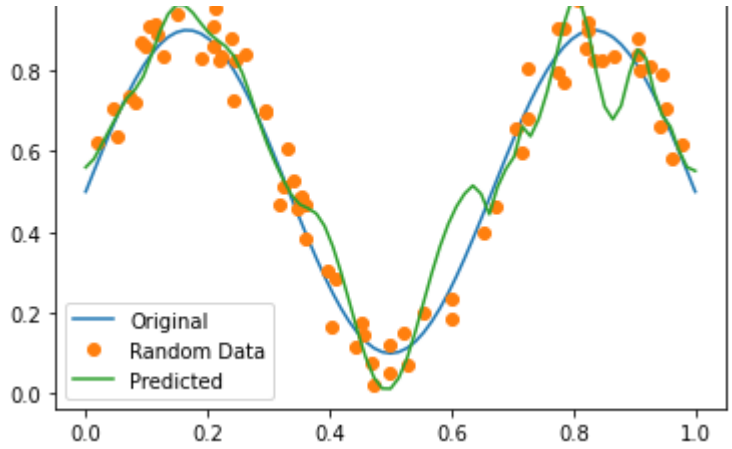
Learning rate: 0.01



The following is shows the clusters for cluster number 12



Learning rate: 0.01




```
The following is shows the clusters for cluster number  16
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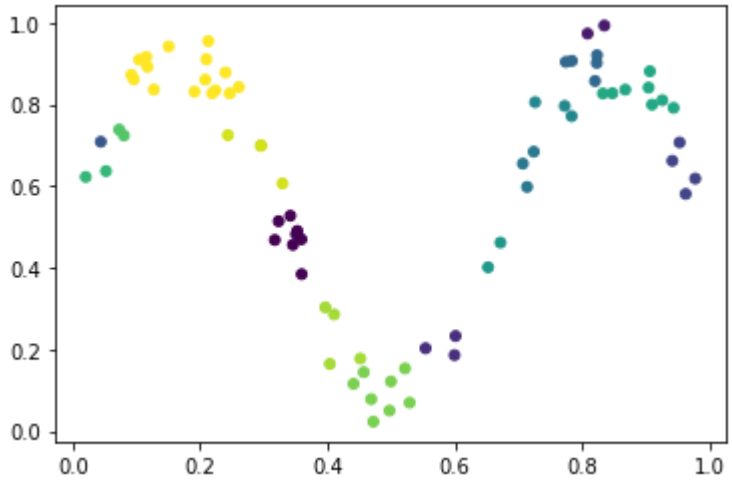
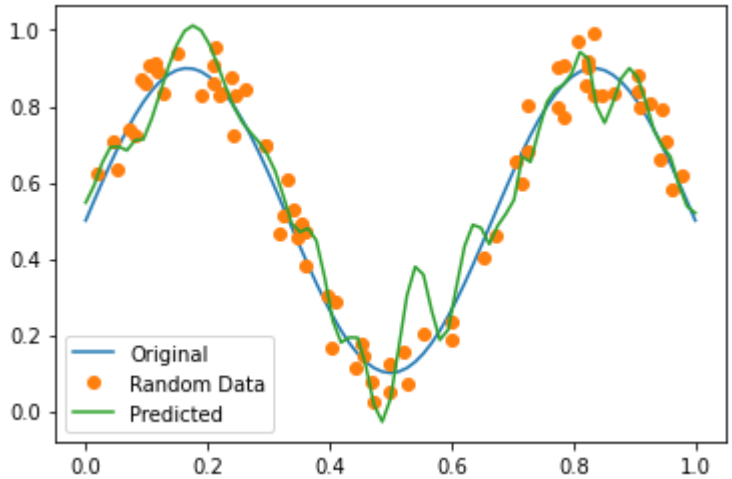


```
Learning rate:  0.01
```




```
The following is shows the clusters for cluster number  3
```