In [1]:

```
import numpy as np
from matplotlib import pyplot as plt
import seaborn as sns
import matplotlib
```

1. Generate Datasets

In [2]:

```
sample_per_class = 500
```

In [3]:

```
label = np.concatenate([np.zeros(sample_per_class),np.ones(sample_per_class)]).astype(int)
```

In [4]:

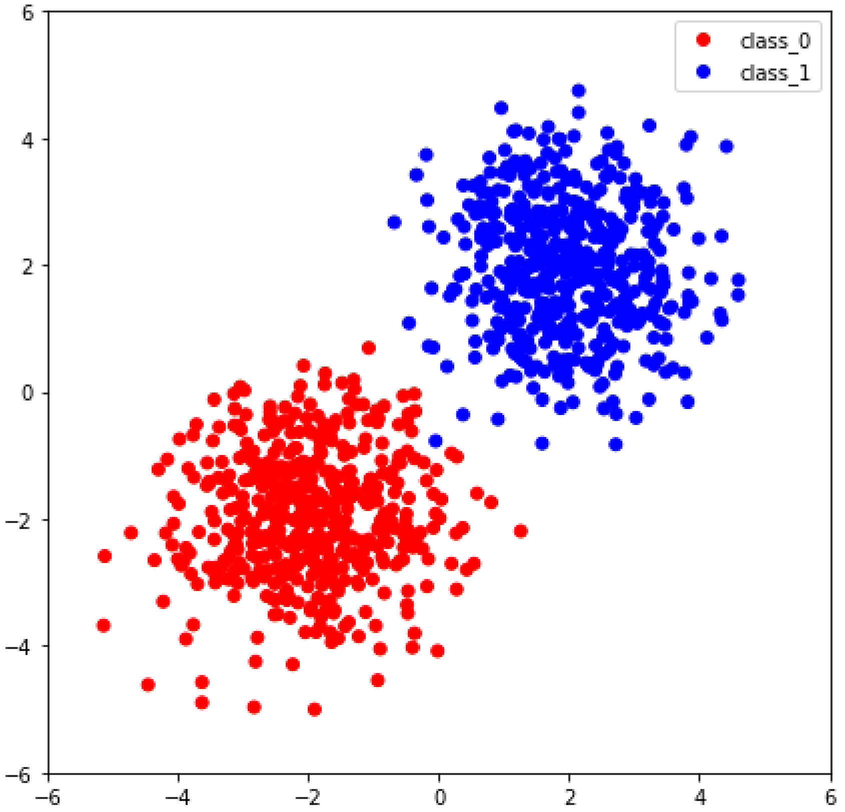
```
from matplotlib.colors import ListedColormap
from matplotlib.lines import Line2D
def myplot(data,label):
    colors = ListedColormap(['red','blue'])
    plt.figure(figsize=(7,7))
    plt.xlim(-6,6)
    plt.ylim(-6,6)
    scatterplot = plt.scatter(data[:,0],data[:,1],c=label,cmap=colors)
    plt.legend(handles=scatterplot.legend_elements()[0],labels=['class_0','class_1'])
```

Gaussian Distributions

In [5]:

```
gauss_1 = np.random.multivariate_normal(mean=[-2,-2],cov=[[1,0],[0,1]],size=sample_per_class)
gauss_2 = np.random.multivariate_normal(mean=[2,2],cov=[[1,0],[0,1]],size=sample_per_class)
gauss = np.concatenate([gauss_1,gauss_2])
gauss_label = np.copy(label)

myplot(gauss,gauss_label)
```



XOR Distributions

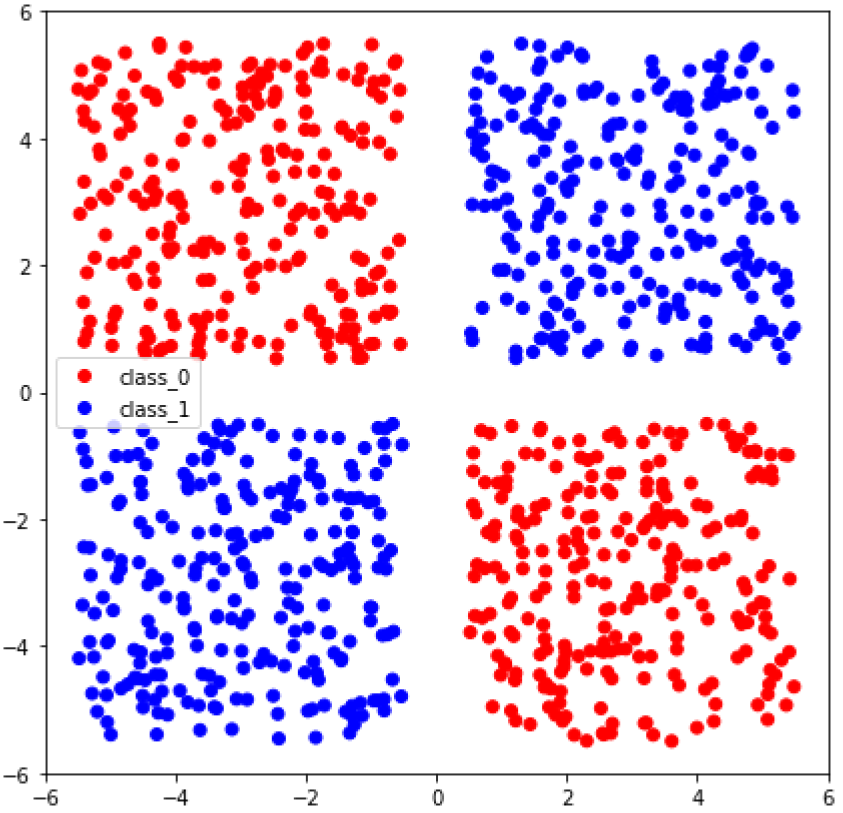
In [49]:

```
xor_shift = 3
n_xor = int(sample_per_class/2)
xor_1_l = np.random.uniform(-2.5,2.5,(n_xor,2))+np.array([-xor_shift,xor_shift])
xor_1_r = np.random.uniform(-2.5,2.5,(n_xor,2))+np.array([xor_shift,-xor_shift])

xor_2_l = np.random.uniform(-2.5,2.5,(n_xor,2))+np.array([xor_shift,xor_shift])
xor_2_r = np.random.uniform(-2.5,2.5,(n_xor,2))+np.array([-xor_shift,-xor_shift
])

xor = np.concatenate([xor_1_l,xor_1_r,xor_2_l,xor_2_r])
xor_label = np.copy(label)

myplot(xor,xor_label)
```



Circular Distributions

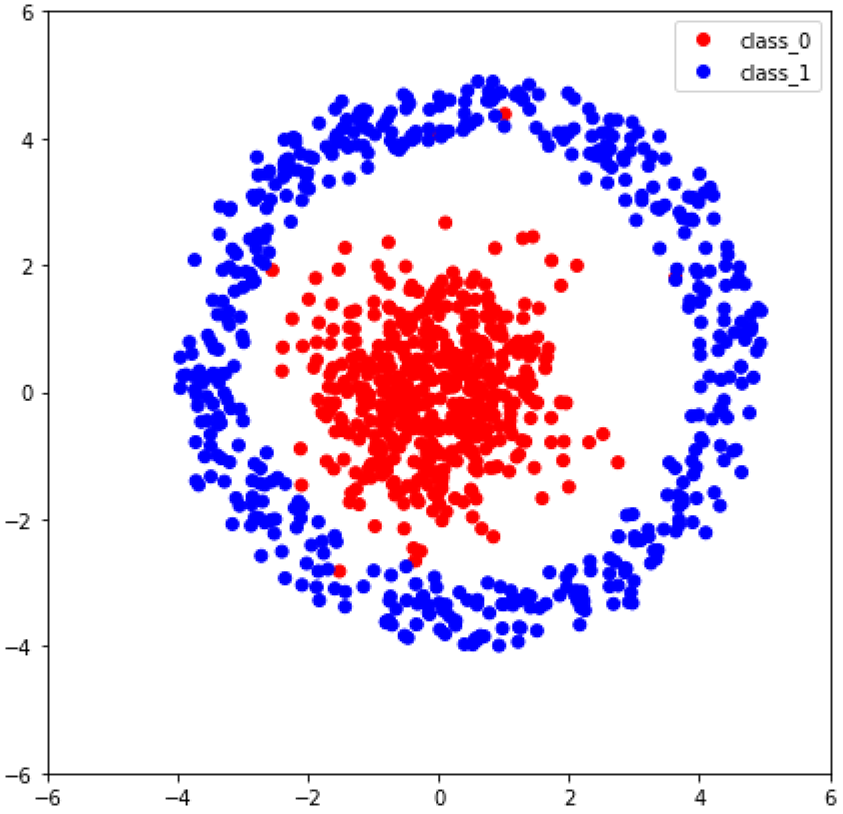
In [7]:

```
cir_1 = np.random.multivariate_normal(mean=[0,0],cov=[[1,0],[0,1]],size=sample_per_class)

cir2_angle = np.random.uniform(0,2*np.pi,[sample_per_class,1])
cir_2 = 4*np.hstack((np.sin(cir2_angle),np.cos(cir2_angle))) + np.random.rand(500,2)

circular = np.concatenate([cir_1,cir_2])
cir_label = np.copy(label)

myplot(circular,cir_label)
```



Spiral Distributions

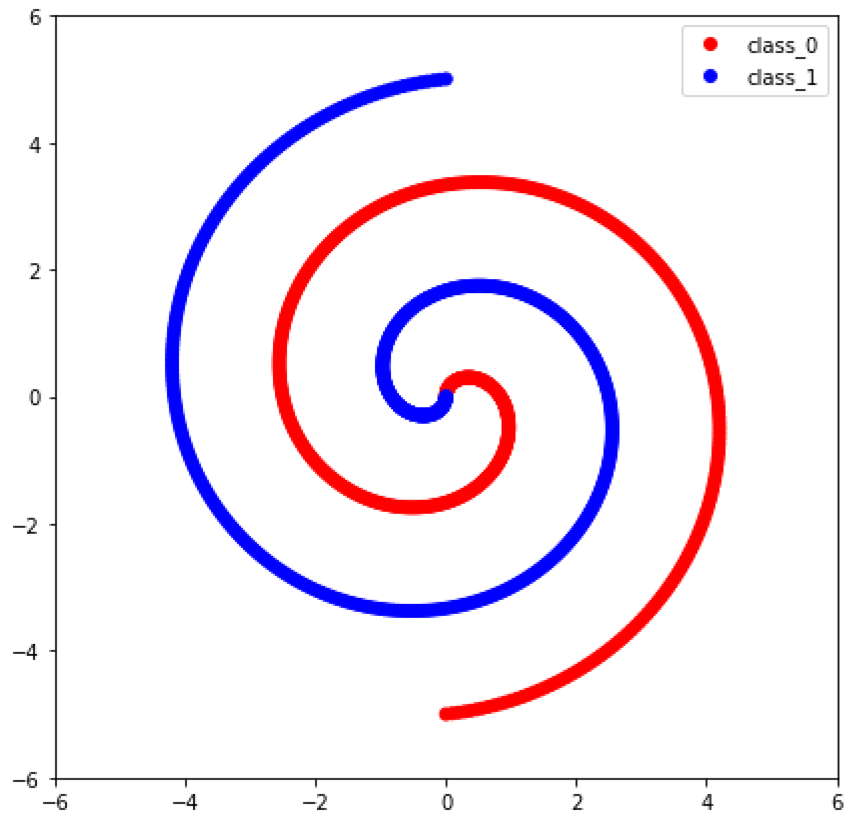
In [8]:

```
spical_r = np.linspace(start=0,stop=5,num = sample_per_class).reshape(-1,1)
spiral_angle = np.linspace(0,3*np.pi,sample_per_class).reshape(-1,1)

spiral_1 = spical_r*np.hstack((np.sin(spiral_angle),np.cos(spiral_angle)))
spiral_2 = -1*spiral_1

spiral = np.concatenate([spiral_1,spiral_2])
spiral_label = np.copy(label)

myplot(spiral,spiral_label)
```



2.) knn classifier

In [9]:

```
from sklearn.neighbors import KNeighborsClassifier as KNN
```

Split training, testing data

In [10]:

```
from sklearn.model_selection import train_test_split
```

In [11]:

```
g_train,g_test,g_label_train,g_label_test = train_test_split(gauss, gauss_label, test_size=0.5, random_state=99)
x_train,x_test,x_label_train,x_label_test = train_test_split(xor, xor_label, test_size=0.5, random_state=99)
c_train,c_test,c_label_train,c_label_test = train_test_split(circular, cir_label, test_size=0.5, random_state=99)
s_train,s_test,s_label_train,s_label_test = train_test_split(spiral, spiral_label, test_size=0.5, random_state=99)
```

In [55]:

```
def pred_viz(data,label,n_neighbors,ret_model=False):
    x_train,x_test,y_train,y_test = train_test_split(data, label, test_size=0.5, random_state=99)
    knn = KNN(n_neighbors=n_neighbors).fit(x_train,y_train)
    pred = knn.predict(x_test)
    acc = sum(pred==y_test)/len(pred)
    print(acc*100,'%')
    class_plot = y_test + ~(pred==y_test)*2
    plt.figure(figsize=(7,7))
    plt.xlim(-6,6)
    plt.ylim(-6,6)
    colors_dict = {0:'red',1:'blue',2:'green',3:'orange'}
    colors = ListedColormap(['red','blue','green','orange'])
    scatter = plt.scatter(x_test[:,0],x_test[:,1],c=[colors_dict[i] for i in class_plot],cmap=colors,label=class_plot)
    legend_elements = [Line2D([0], [0], marker='o', color='w', label='class_0',markerfacecolor='red', markersize=7),
                   Line2D([0], [0], marker='o', color='w', label='class_1',markerfacecolor='blue', markersize=7),
                   Line2D([0], [0], marker='o', color='w', label='class_0 miss',markerfacecolor='green', markersize=7),
                       Line2D([0], [0], marker='o', color='w', label='class_1 miss',markerfacecolor='orange', markersize=7)
                         ]

    plt.legend(handles=legend_elements)
    if ret_model :
        return knn
```

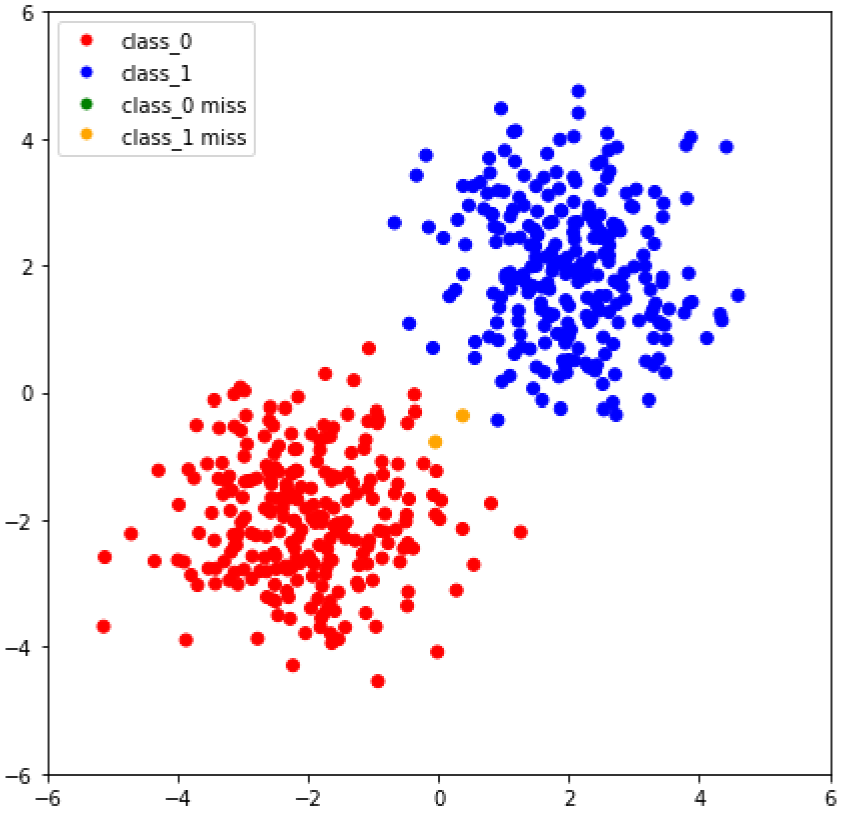
Gaussian data

knn k=1

```
In [56]:
```

```
knn_gauss_k1 = pred_viz(gauss,gauss_label,1,ret_model=True)
```

```
99.6 %
```

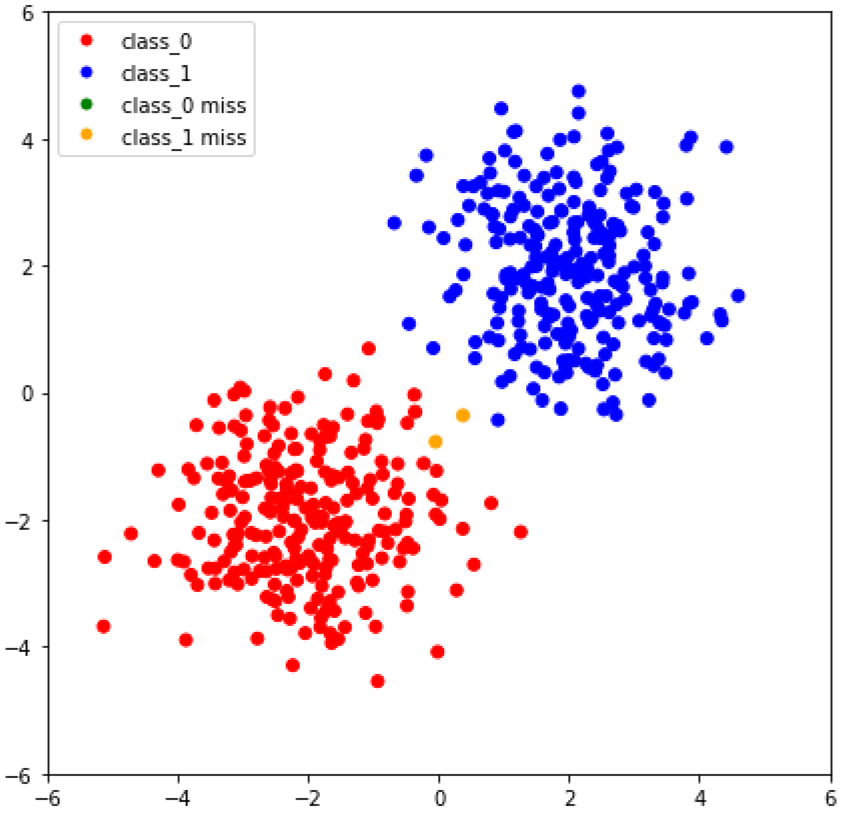


knn k=3

In [57]:

```
knn_gauss_k3 = pred_viz(gauss,gauss_label,3,ret_model=True)
```

```
99.6 %
```

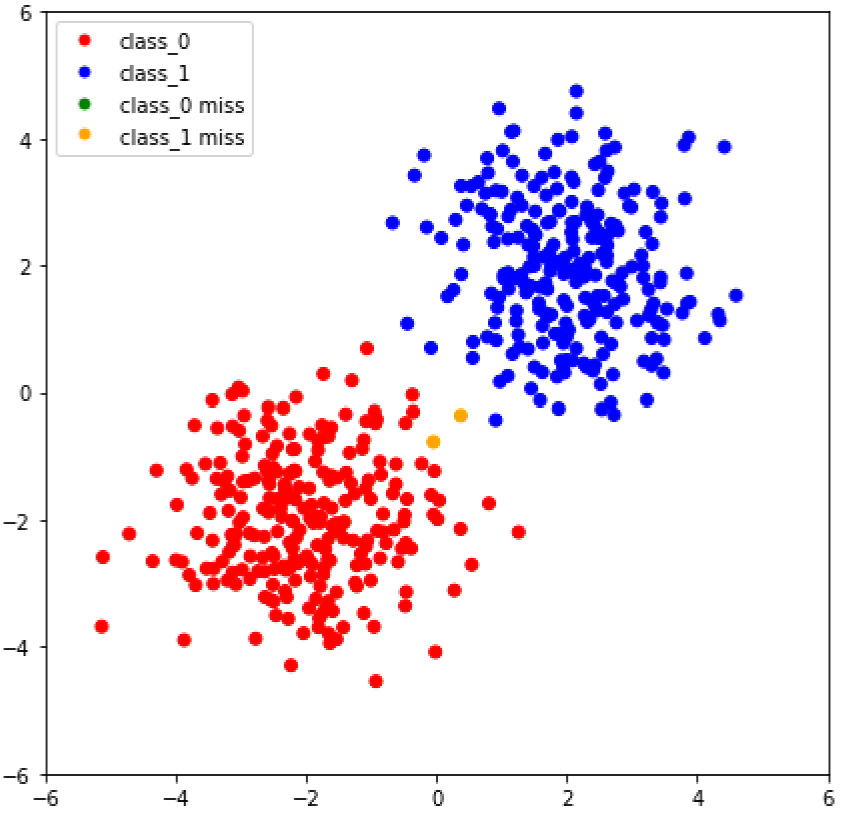


knn k=5

In [58]:

```
knn_gauss_k5 = pred_viz(gauss,gauss_label,5,ret_model=True)
```

```
99.6 %
```



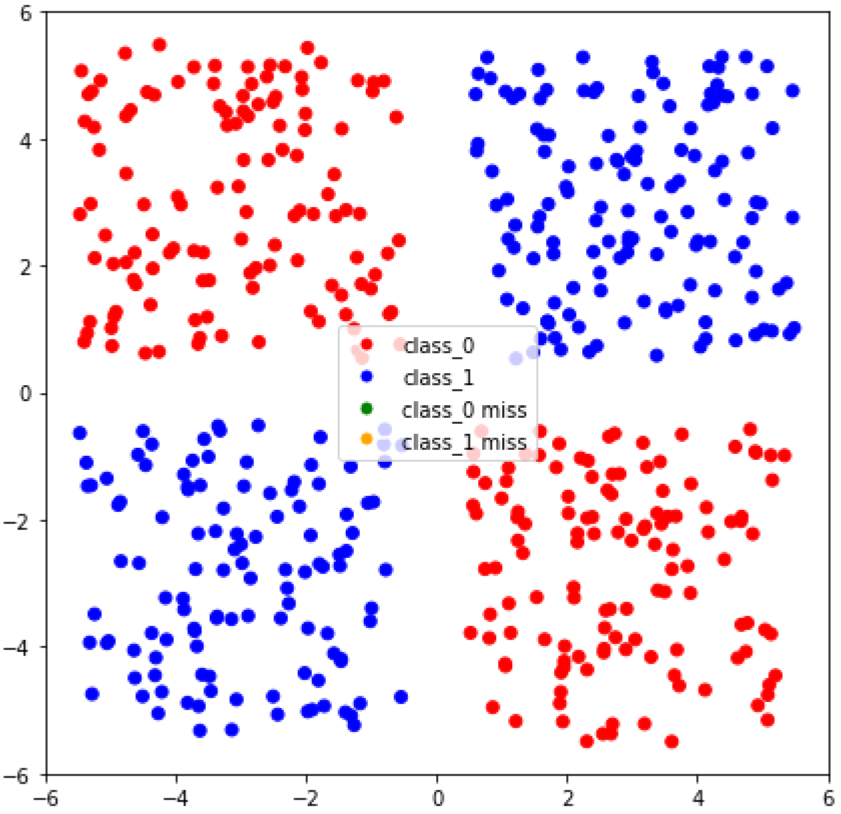
XOR data

knn k=1

In [59]:

```
knn_xor_k1 = pred_viz(xor,xor_label,1,ret_model=True)
```

```
100.0 %
```

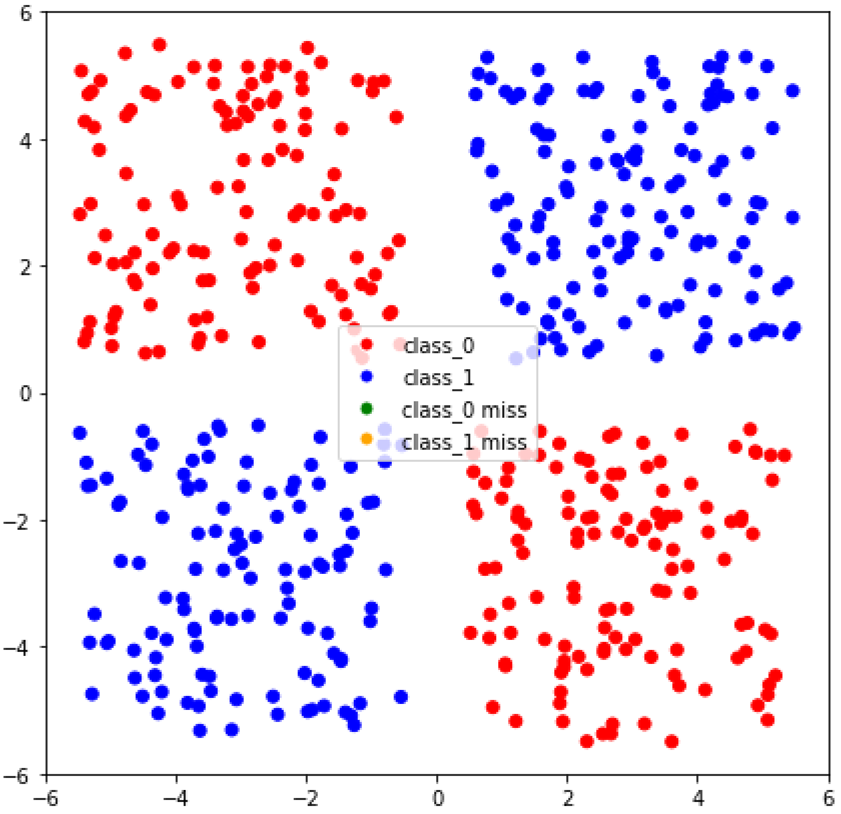


knn k=3

In [60]:

```
knn_xor_k3 = pred_viz(xor,xor_label,3,ret_model=True)
```

```
100.0 %
```

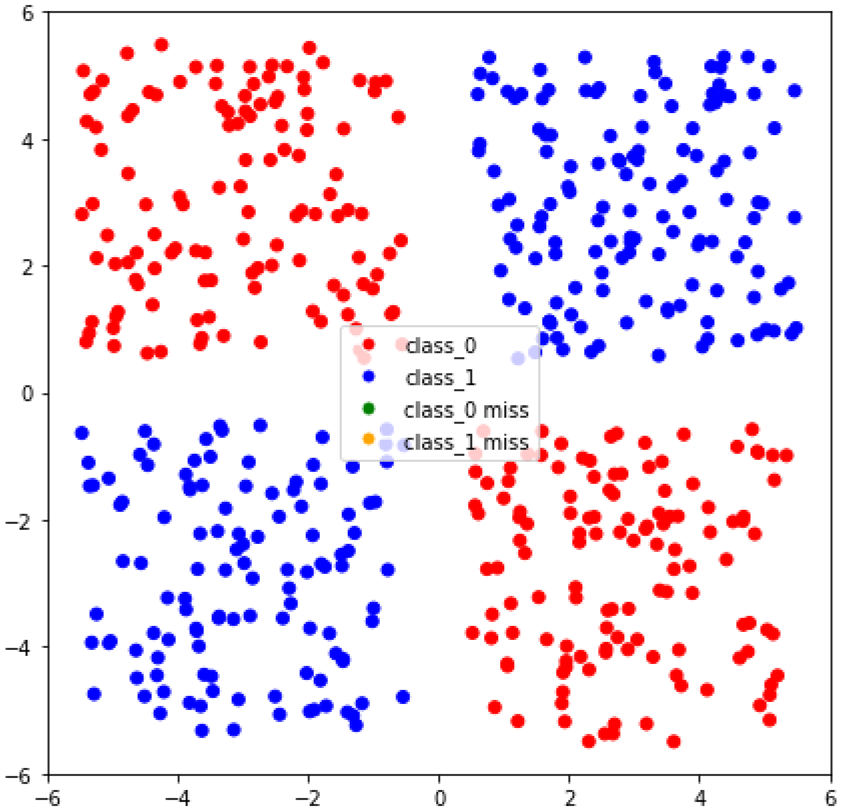


knn k=5

In [61]:

```
knn_xor_k5 = pred_viz(xor,xor_label,5,ret_model=True)
```

```
100.0 %
```



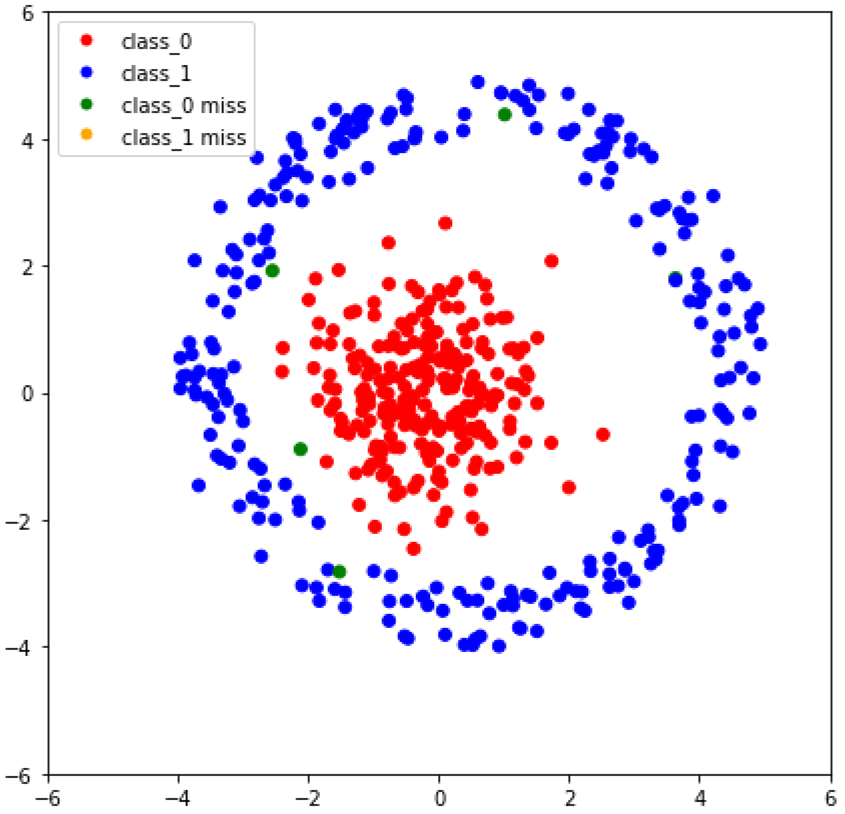
Circular data

knn k=1

In [62]:

```
knn_cir_k1 = pred_viz(circular,cir_label,1,ret_model=True)
```

```
99.0 %
```

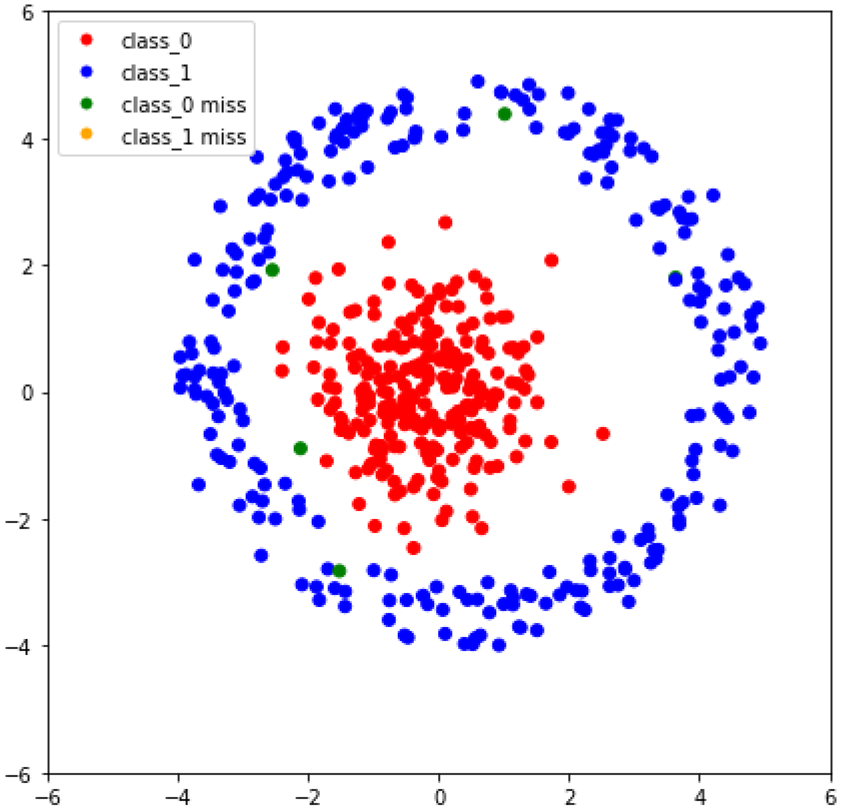


knn k=3

In [20]:

```
knn_cir_k3 = pred_viz(circular,cir_label,3,ret_model=True)
```

```
99.0 %
```

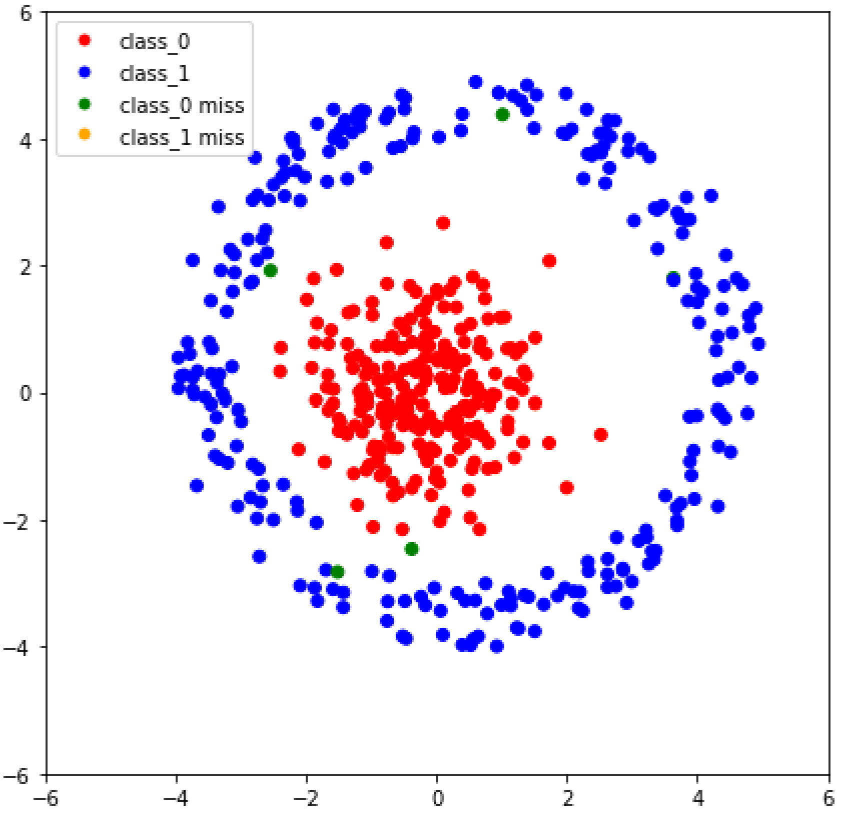


knn k=5

In [21]:

```
knn_cir_k5 = pred_viz(circular,cir_label,5,ret_model=True)
```

```
99.0 %
```



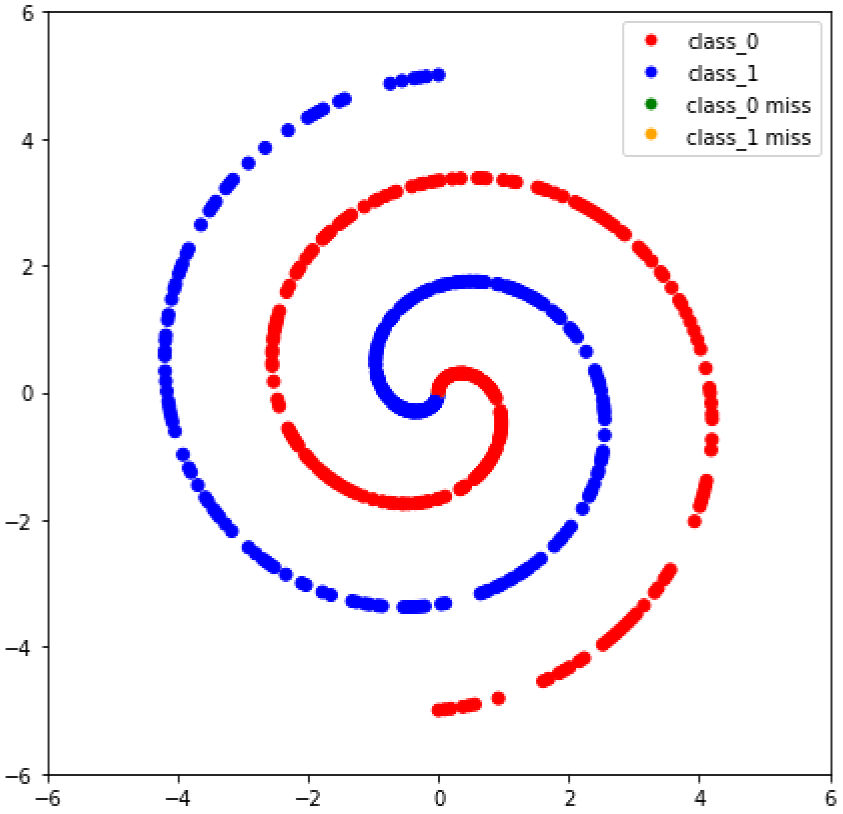
Spiral data

knn k=1

In [22]:

```
knn_spiral_k1 = pred_viz(spiral,spiral_label,1,ret_model=True)
```

```
99.6 %
```

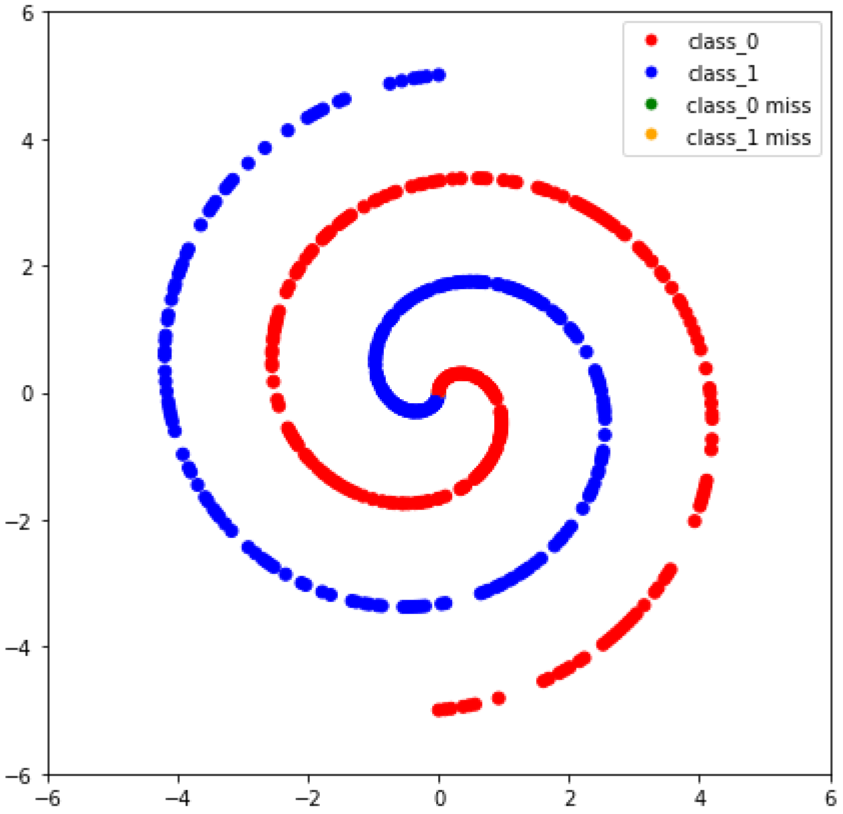


knn k=3

In [23]:

```
knn_spiral_k3 = pred_viz(spiral,spiral_label,3,ret_model=True)
```

```
99.6 %
```

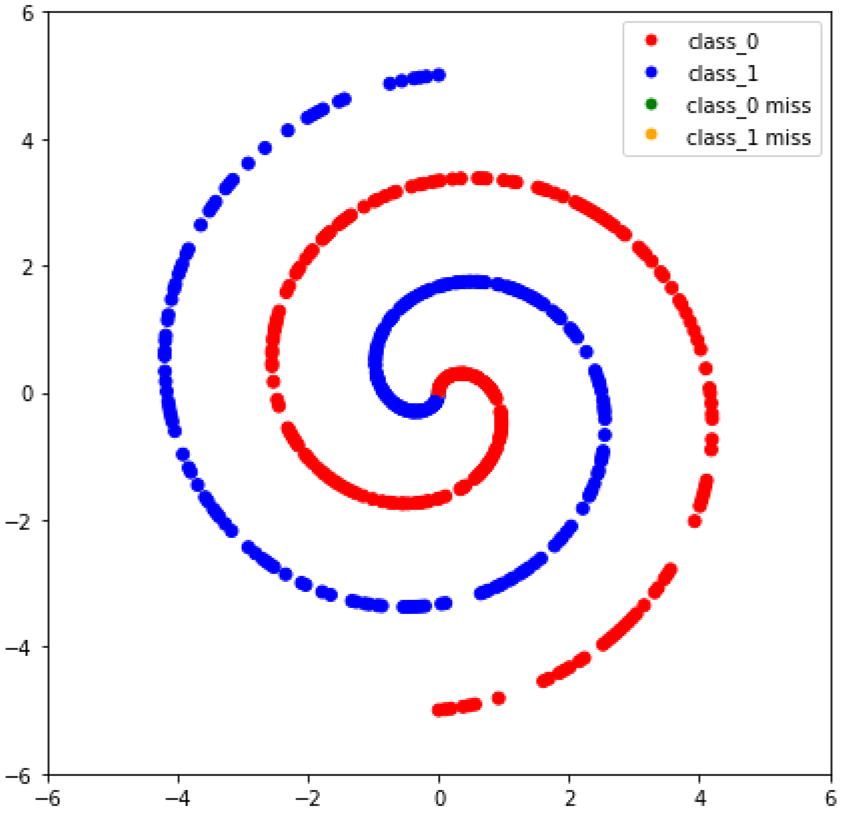


knn k=5

In [24]:

```
knn_spiral_k5 = pred_viz(spiral,spiral_label,5,ret_model=True)
```

```
99.8 %
```



Decision boundary

In [25]:

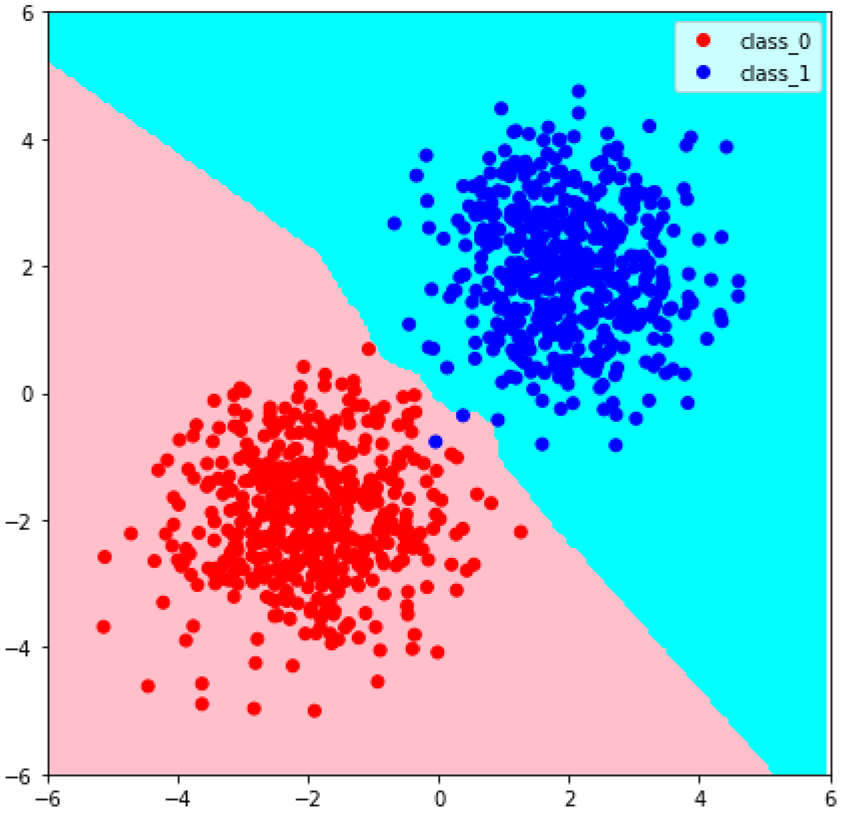
```
def plot_decisionBoundary(model,data,label,plot_min=-6,plot_max=6):
    xx,yy = np.meshgrid(np.arange(plot_min,plot_max,0.05),np.arange(plot_min,plot_max,0.05))
    pred_db = model.predict(np.c_[xx.ravel(),yy.ravel()])
    colors = ListedColormap(['red','blue'])
    colors_db = ['pink','cyan']
    plt.figure(figsize=(7,7))
    plt.xlim(-6,6)
    plt.ylim(-6,6)
    plt.contourf(xx,yy,pred_db.reshape(xx.shape),cmap=matplotlib.colors.ListedColormap(colors_db))
    scatterplot = plt.scatter(data[:,0],data[:,1],c=label,cmap=colors)
    plt.legend(handles=scatterplot.legend_elements()[0],labels=['class_0','class_1'])
```

Gaussian data

knn k=1

In [26]:

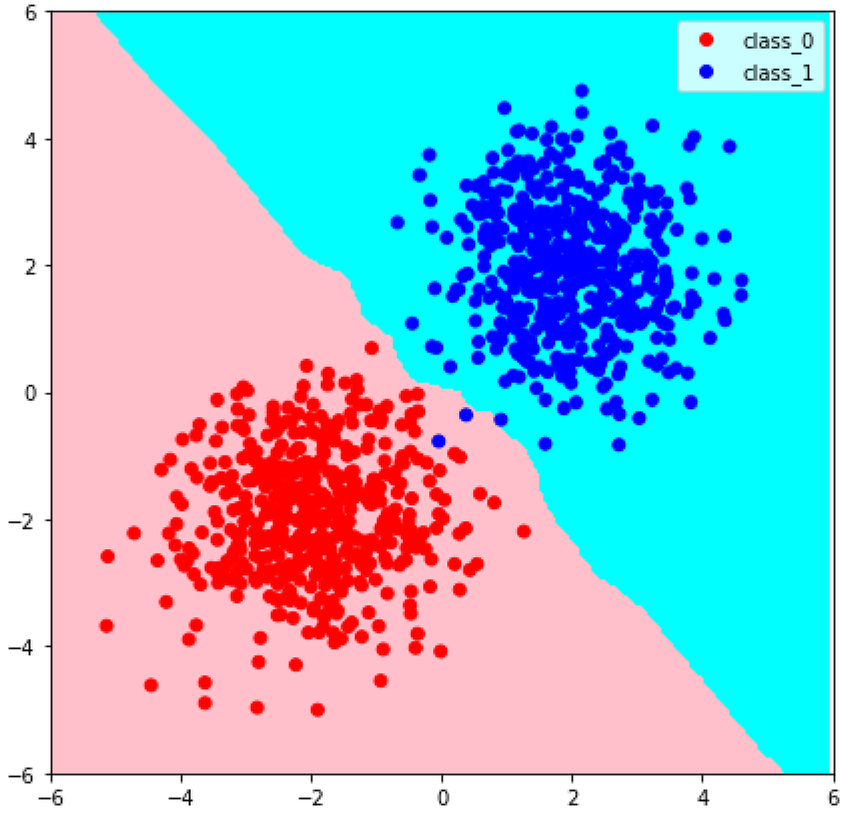
```
plot_decisionBoundary(knn_gauss_k1,gauss,gauss_label)
```



knn k=3

In [27]:

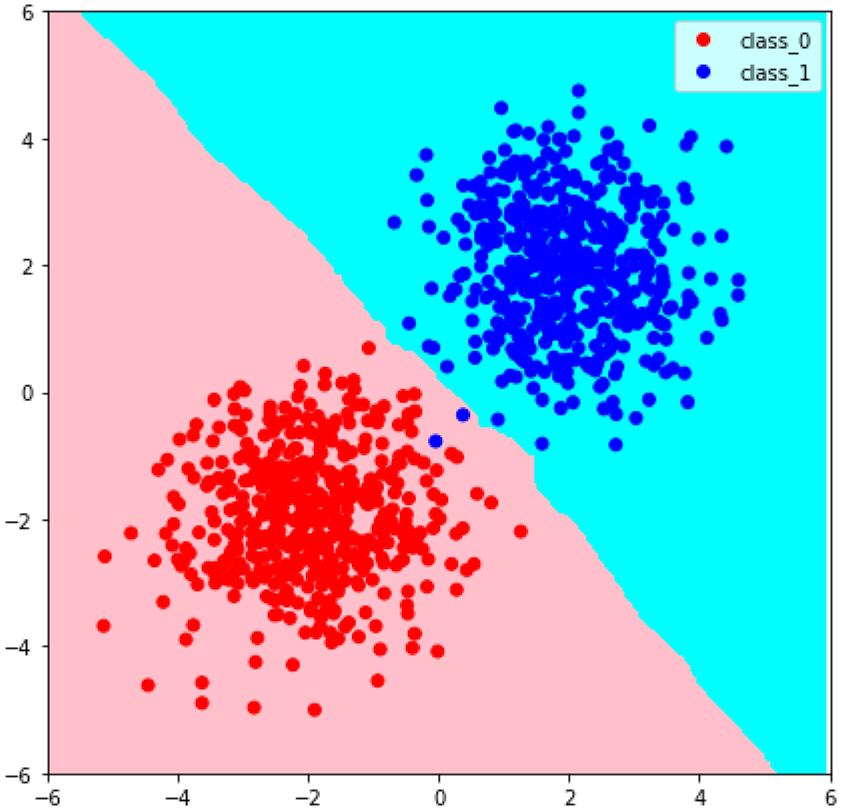
```
plot_decisionBoundary(knn_gauss_k3,gauss,gauss_label)
```



knn k=5

In [28]:

```
plot_decisionBoundary(knn_gauss_k5,gauss,gauss_label)
```

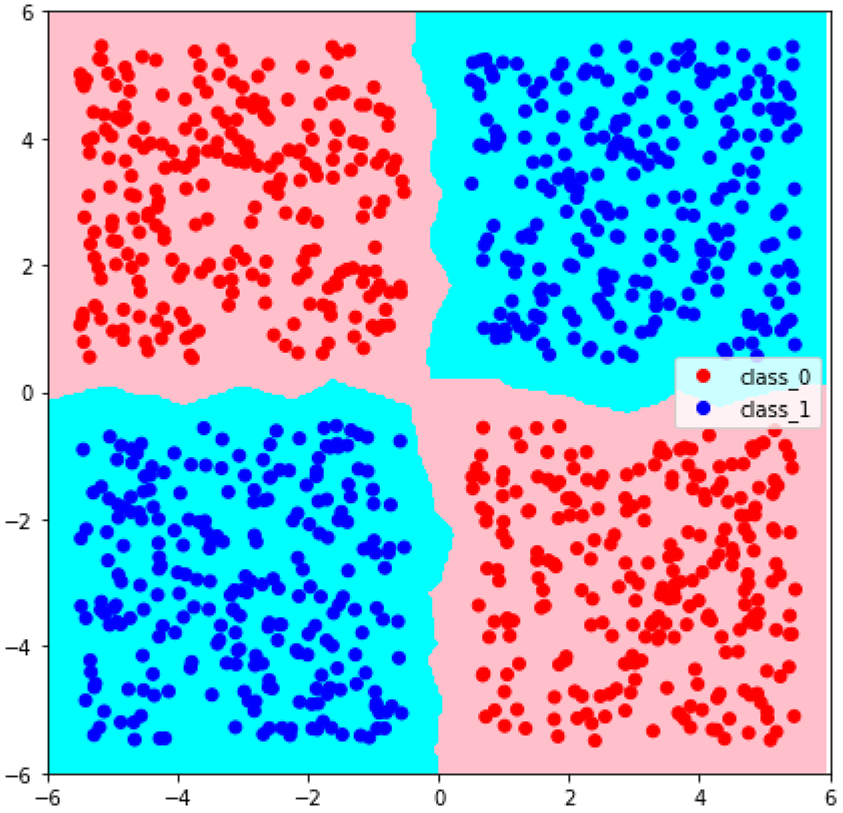


Xor data

knn k=1

In [29]:

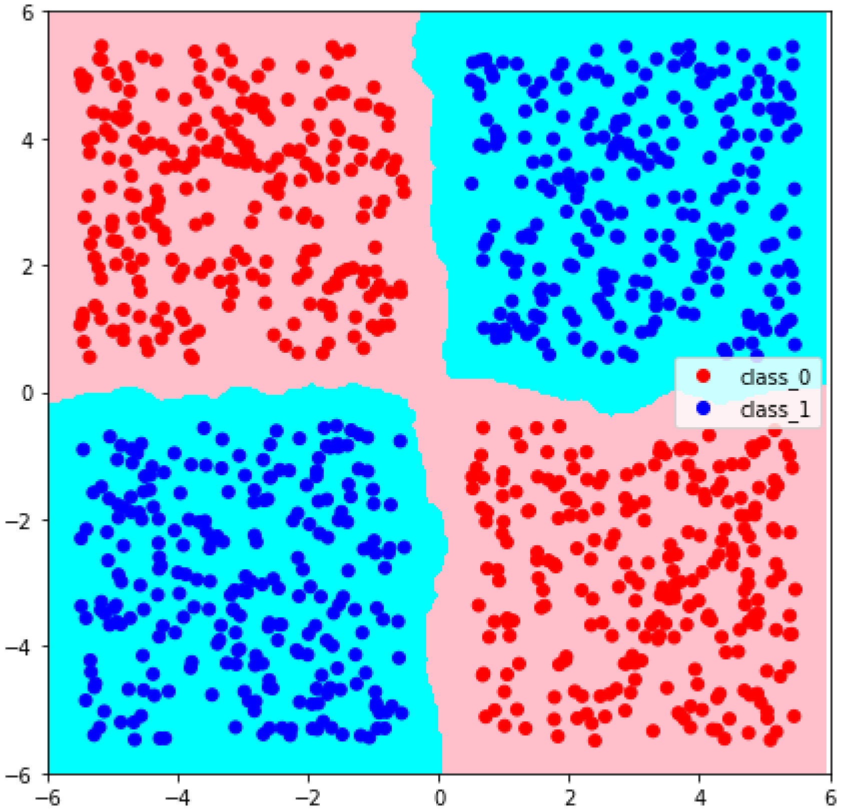
```
plot_decisionBoundary(knn_xor_k1,xor,xor_label)
```



knn k=3

In [30]:

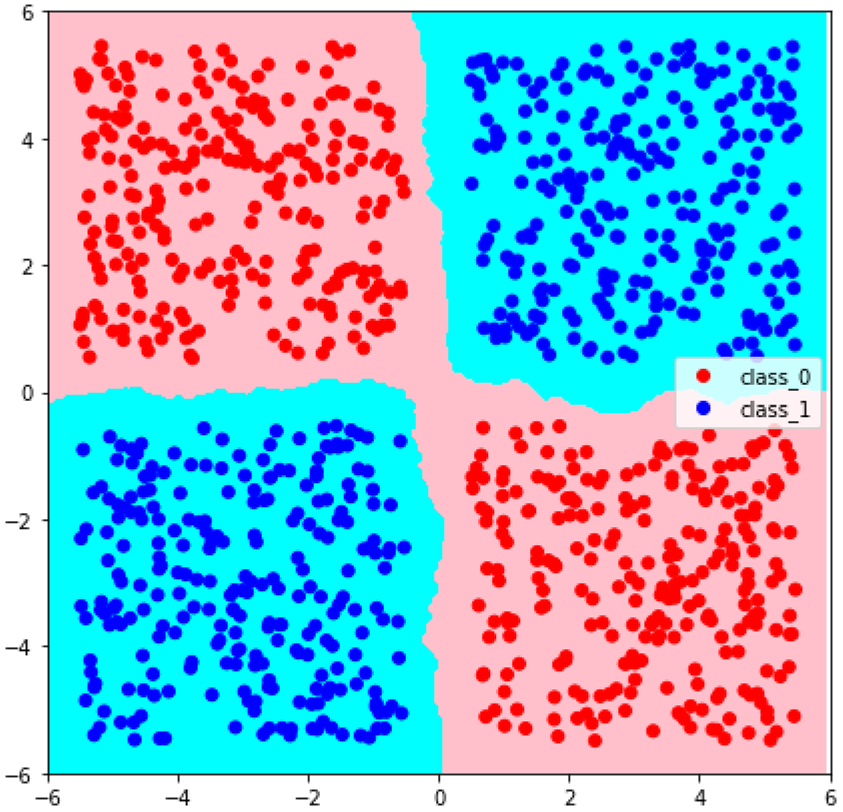
```
plot_decisionBoundary(knn_xor_k3,xor,xor_label)
```



knn k=5

In [31]:

```
plot_decisionBoundary(knn_xor_k5,xor,xor_label)
```

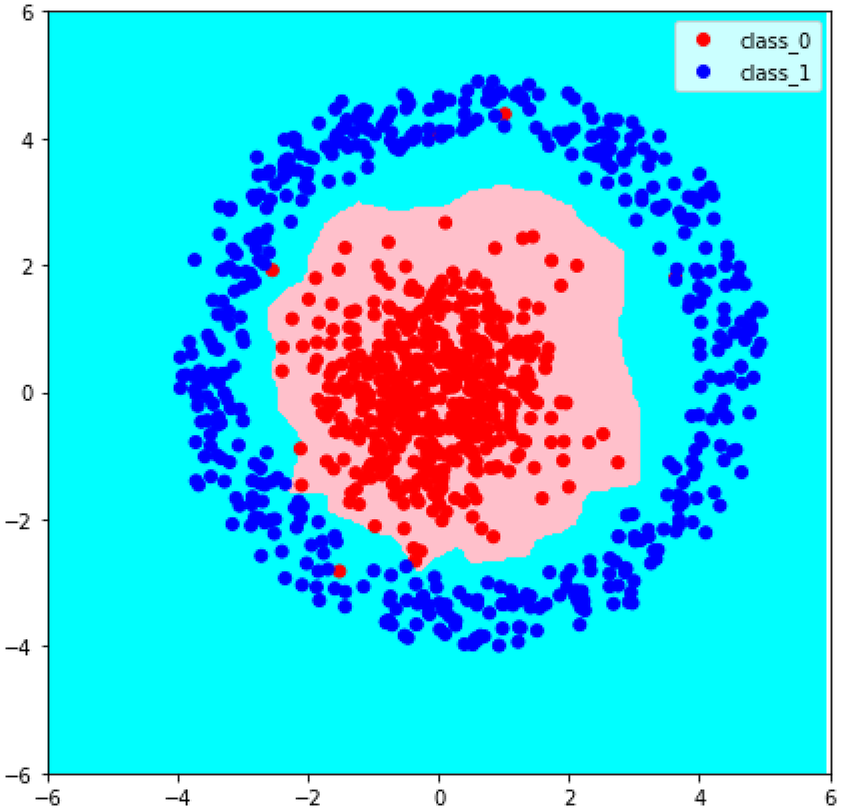


Circular data

knn k=1

In [32]:

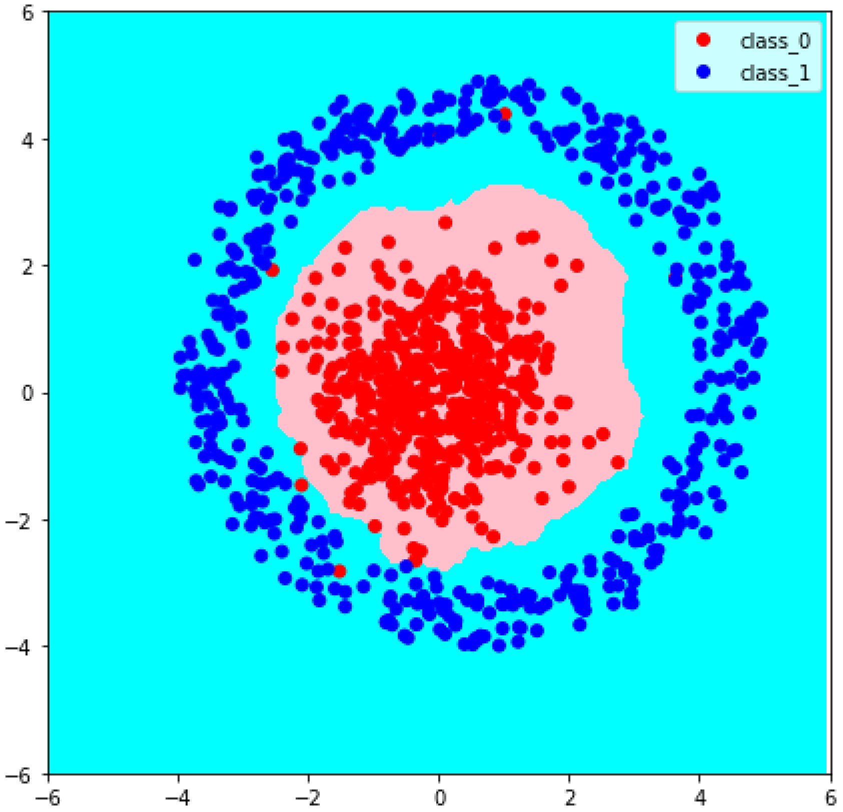
```
plot_decisionBoundary(knn_cir_k1,circular,cir_label)
```



knn k=3

In [33]:

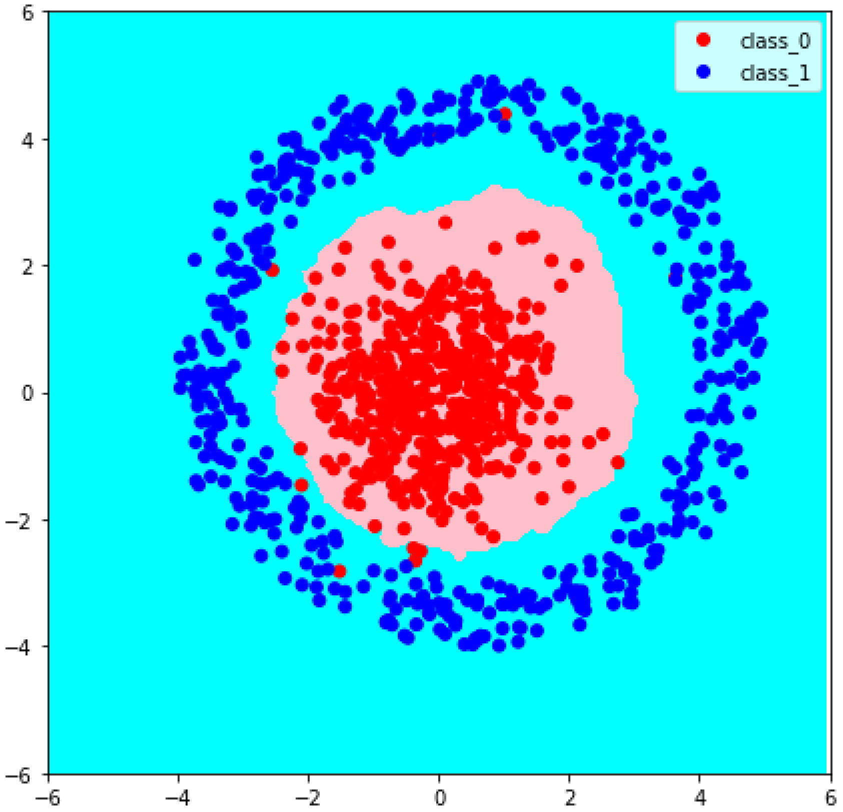
```
plot_decisionBoundary(knn_cir_k3,circular,cir_label)
```



knn k=5

In [34]:

```
plot_decisionBoundary(knn_cir_k5,circular,cir_label)
```

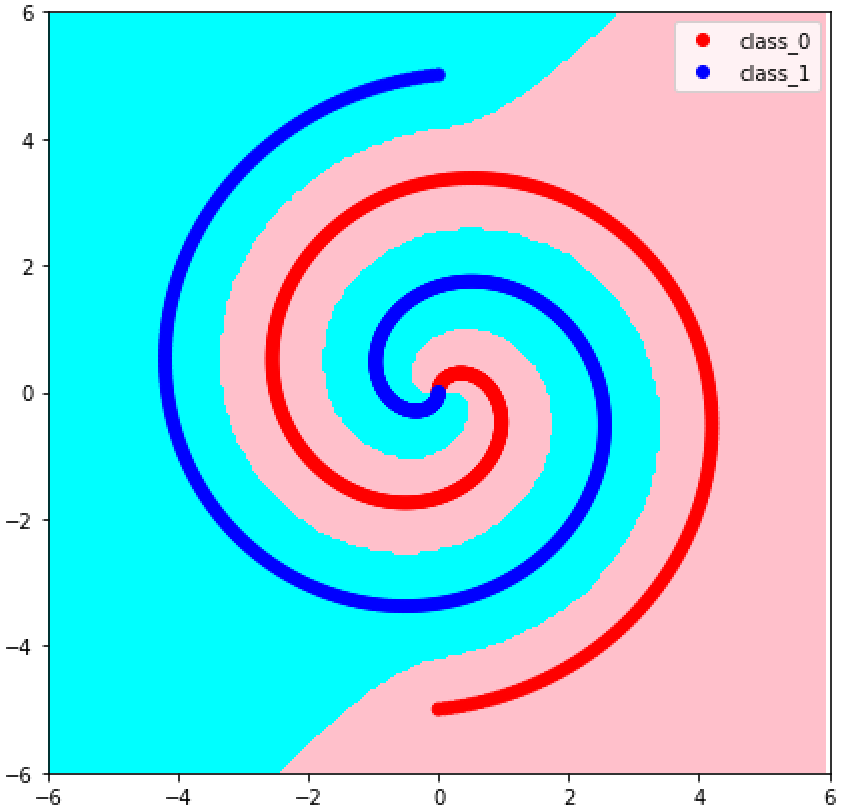


Spiral data

knn k=1

In [35]:

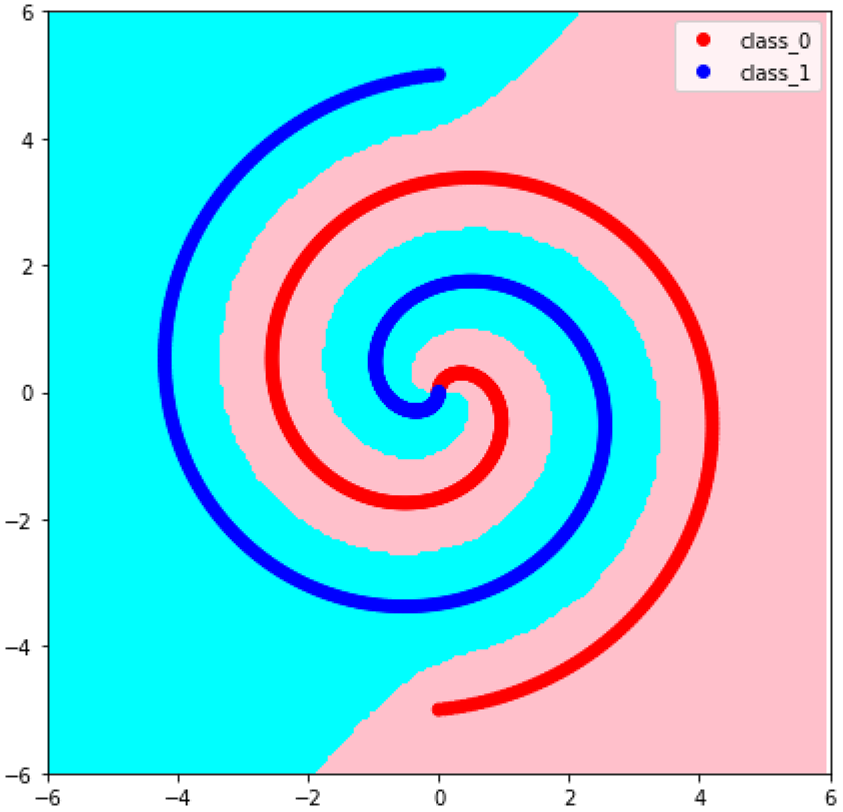
```
plot_decisionBoundary(knn_spiral_k1,spiral,spiral_label)
```



knn k=3

In [36]:

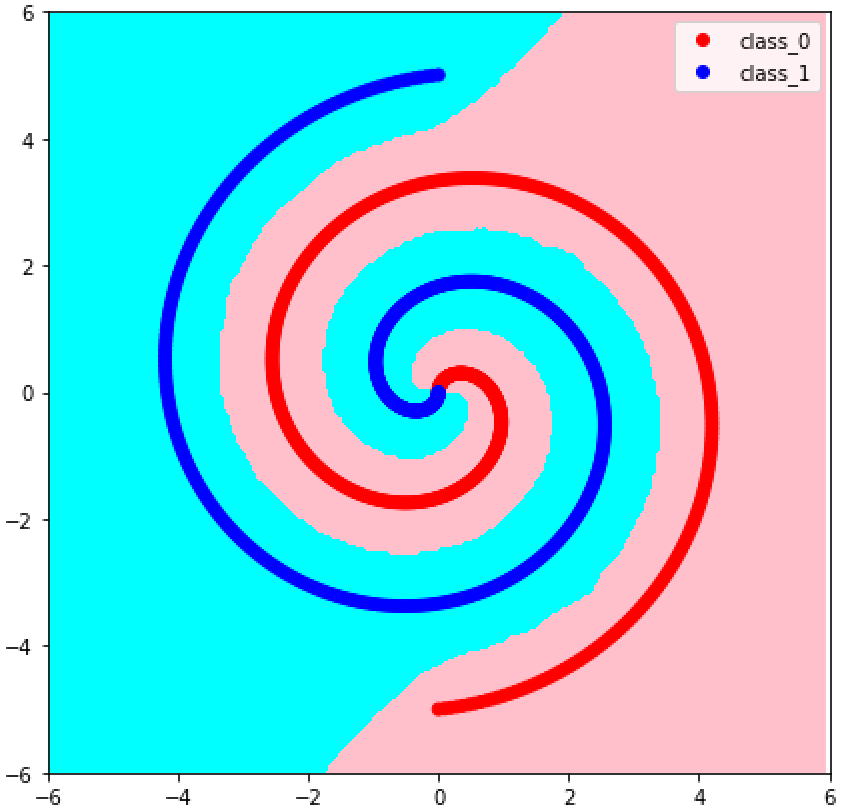
```
plot_decisionBoundary(knn_spiral_k3,spiral,spiral_label)
```



knn k=5

In [37]:

```
plot_decisionBoundary(knn_spiral_k5,spiral,spiral_label)
```



Additional

(Animation Decision boundary by k)

In [39]:

```
from matplotlib import animation
```

In [40]:

```
from IPython.display import display,HTML
```

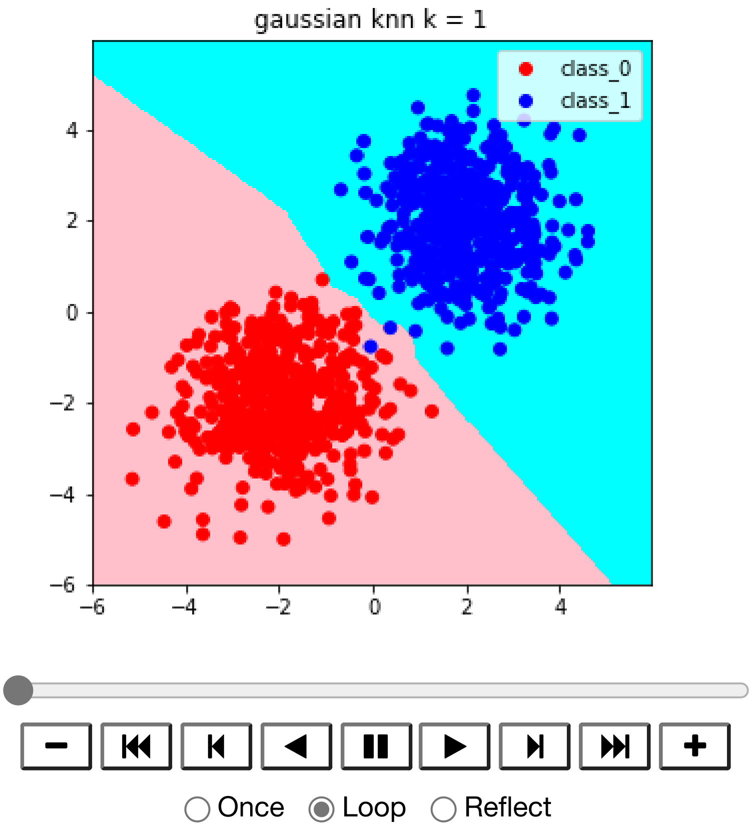
In [41]:

```
def update_gauss(k):
    data= gauss
    label = gauss_label
    plot_min=-6
    plot_max=6
    x_train,x_test,y_train,y_test = train_test_split(data, label, test_size=0.5, random_state=99)
    model = KNN(n_neighbors=k+1).fit(x_train,y_train)
    xx,yy = np.meshgrid(np.arange(plot_min,plot_max,0.05),np.arange(plot_min,plot_max,0.05))
    pred_db = model.predict(np.c_[xx.ravel(),yy.ravel()])
    colors = ListedColormap(['red','blue'])
    colors_db = ['pink','cyan']
    plt.xlim(-6,6)
    plt.ylim(-6,6)
    ax.contourf(xx,yy,pred_db.reshape(xx.shape),cmap=matplotlib.colors.ListedColormap(colors_db))
    scatterplot = ax.scatter(data[:,0],data[:,1],c=label,cmap=colors)
    ax.legend(handles=scatterplot.legend_elements()[0],labels=['class_0','class_1'])
    ax.set_title('gaussian knn k = '+str(k+1))
    plt.close()
```

In [42]:

```
fig, ax = plt.subplots(figsize=(5,5))
anim_gauss = animation.FuncAnimation(fig, update_gauss, frames=15,interval=500,
repeat=True)
plt.close()
HTML(anim_gauss.to_jshtml())
```

Out[42]:



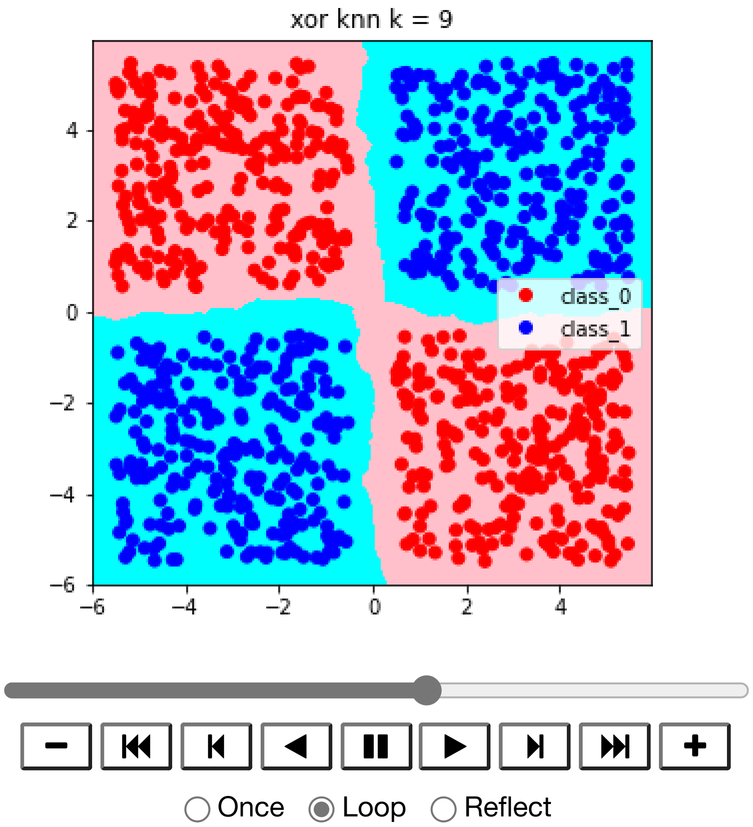
In [43]:

```
def update_xor(k):
    data= xor
    label = xor_label
    plot_min=-6
    plot_max=6
    x_train,x_test,y_train,y_test = train_test_split(data, label, test_size=0.5,
random_state=99)
    model = KNN(n_neighbors=k+1).fit(x_train,y_train)
    xx,yy = np.meshgrid(np.arange(plot_min,plot_max,0.05),np.arange(plot_min,plo
t_max,0.05))
    pred_db = model.predict(np.c_[xx.ravel(),yy.ravel()])
    colors = ListedColormap(['red','blue'])
    colors_db = ['pink','cyan']
    plt.xlim(-6,6)
    plt.ylim(-6,6)
    ax.contourf(xx,yy,pred_db.reshape(xx.shape),cmap=matplotlib.colors.ListedCol
ormap(colors_db))
    scatterplot = ax.scatter(data[:,0],data[:,1],c=label,cmap=colors)
    ax.legend(handles=scatterplot.legend_elements()[0],labels=['class_0','class_
1'])
    ax.set_title('xor knn k = '+str(k+1))
    plt.close()
```

In [44]:

```
fig, ax = plt.subplots(figsize=(5,5))
anim_xor = animation.FuncAnimation(fig, update_xor, frames=15,interval=500, repe
at=True)
plt.close()
HTML(anim_xor.to_jshtml())
```

Out[44]:



○ Once ● Loop ○ Reflect

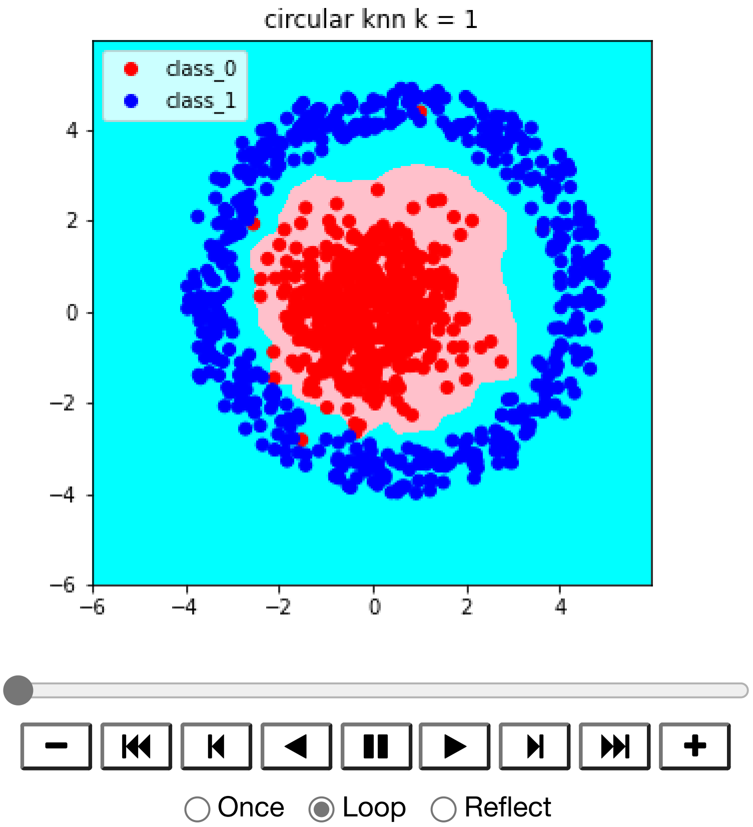
In [45]:

```
def update_cir(k):
    data= circular
    label = cir_label
    plot_min=-6
    plot_max=6
    x_train,x_test,y_train,y_test = train_test_split(data, label, test_size=0.5, random_state=99)
    model = KNN(n_neighbors=k+1).fit(x_train,y_train)
    xx,yy = np.meshgrid(np.arange(plot_min,plot_max,0.05),np.arange(plot_min,plot_max,0.05))
    pred_db = model.predict(np.c_[xx.ravel(),yy.ravel()])
    colors = ListedColormap(['red','blue'])
    colors_db = ['pink','cyan']
    plt.xlim(-6,6)
    plt.ylim(-6,6)
    ax.contourf(xx,yy,pred_db.reshape(xx.shape),cmap=matplotlib.colors.ListedColormap(colors_db))
    scatterplot = ax.scatter(data[:,0],data[:,1],c=label,cmap=colors)
    ax.legend(handles=scatterplot.legend_elements()[0],labels=['class_0','class_1'])
    ax.set_title('circular knn k = '+str(k+1))
    plt.close()
```

In [46]:

```
fig, ax = plt.subplots(figsize=(5,5))
plt.close()
anim_cir = animation.FuncAnimation(fig, update_cir, frames=15,interval=500, repeat=True)
HTML(anim_cir.to_jshtml())
```

Out[46]:



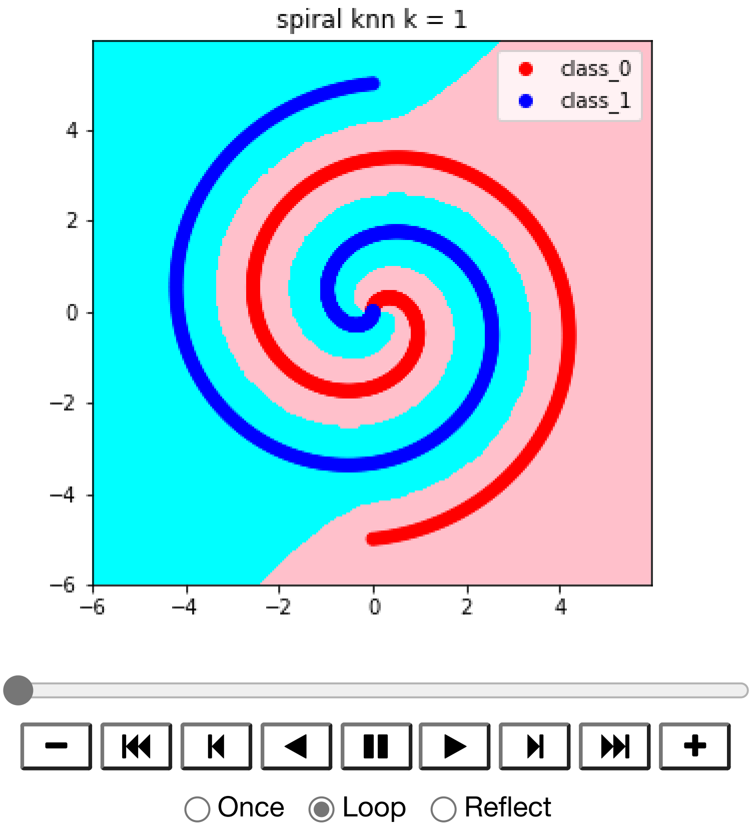
In [47]:

```
def update_spiral(k):
    data= spiral
    label = spiral_label
    plot_min=-6
    plot_max=6
    x_train,x_test,y_train,y_test = train_test_split(data, label, test_size=0.5,
random_state=99)
    model = KNN(n_neighbors=k+1).fit(x_train,y_train)
    xx,yy = np.meshgrid(np.arange(plot_min,plot_max,0.05),np.arange(plot_min,plo
t_max,0.05))
    pred_db = model.predict(np.c_[xx.ravel(),yy.ravel()])
    colors = ListedColormap(['red','blue'])
    colors_db = ['pink','cyan']
    plt.xlim(-6,6)
    plt.ylim(-6,6)
    ax.contourf(xx,yy,pred_db.reshape(xx.shape),cmap=matplotlib.colors.ListedCol
ormap(colors_db))
    scatterplot = ax.scatter(data[:,0],data[:,1],c=label,cmap=colors)
    ax.legend(handles=scatterplot.legend_elements()[0],labels=['class_0','class_
1'])
    ax.set_title('spiral knn k = '+str(k+1))
    plt.close()
```

In [48]:

```
fig, ax = plt.subplots(figsize=(5,5))
plt.close()
anim_spiral = animation.FuncAnimation(fig, update_spiral, frames=15,interval=500
, repeat=True)
HTML(anim_spiral.to_jshtml())
```

Out[48]:


spiral knn k = 1
class_0
class_1
○ Once
● Loop
○ Reflect