Support Vector Machine

Import required packages

In [1]:
```
import numpy as np
from matplotlib.pyplot import subplots, cm
import sklearn.model_selection as skm
from ISLP import load_data, confusion_table
```

In [2]:
```
from sklearn.svm import SVC
from ISLP.svm import plot as plot_svm
from sklearn.metrics import RocCurveDisplay

roc_curve = RocCurveDisplay.from_estimator
```

Two-Class Classification Problem

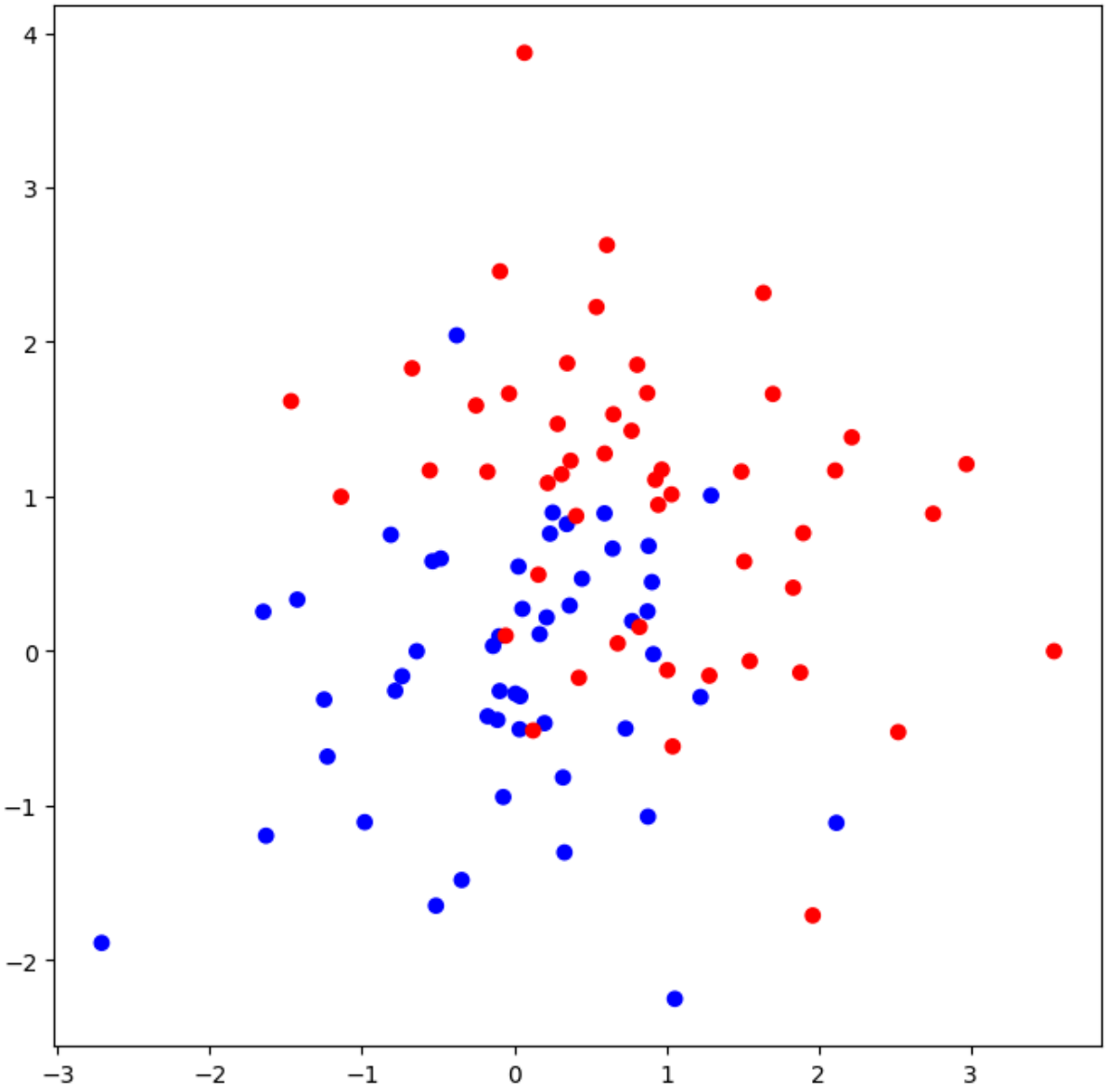
Generate the data

In [3]:
```
rng = np.random.default_rng(1)
X = rng.standard_normal((100, 2))
y = np.array([-1]*50+[1]*50)
```

Are these data linearly separable?

In [4]:
```
X[y==1] += 1
fig, ax = subplots(figsize=(8,8))
ax.scatter(X[:,0],
           X[:,1],
           c=y,
           cmap=cm.bwr)
```

Out[4]:
```
<matplotlib.collections.PathCollection at 0x12fb9fe50>
```



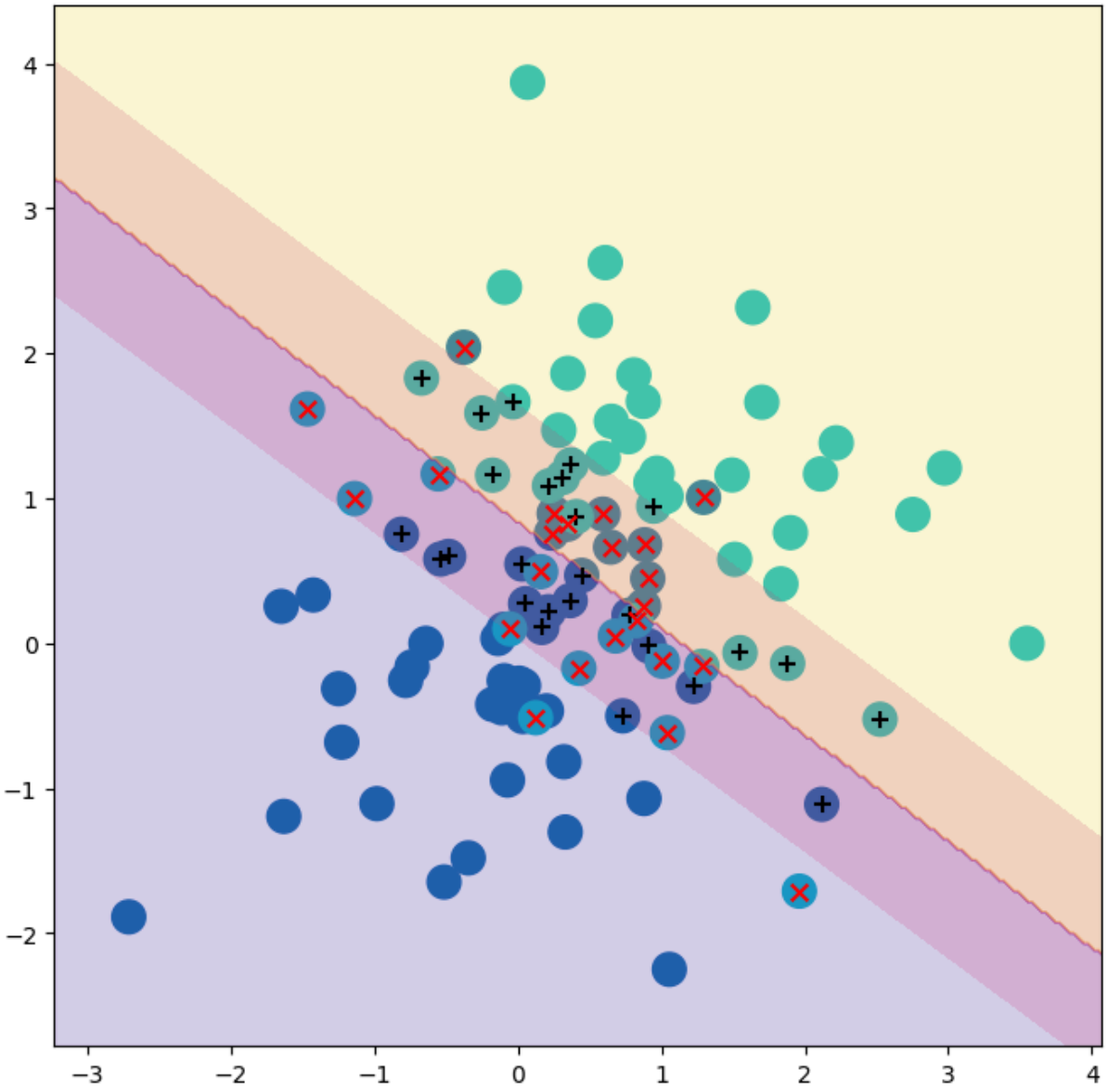
Fit a Support Vector Classfier

In [5]:
```
svm_linear = SVC(C=10, kernel = 'linear')
svm_linear.fit(X, y)
```

Out[5]:
```
SVC(C=10, kernel='linear')
```

Plot the Decision Boundary

In [6]:
```
fig, ax = subplots(figsize=(8,8))
plot_svm(X,y, svm_linear, ax=ax)
```

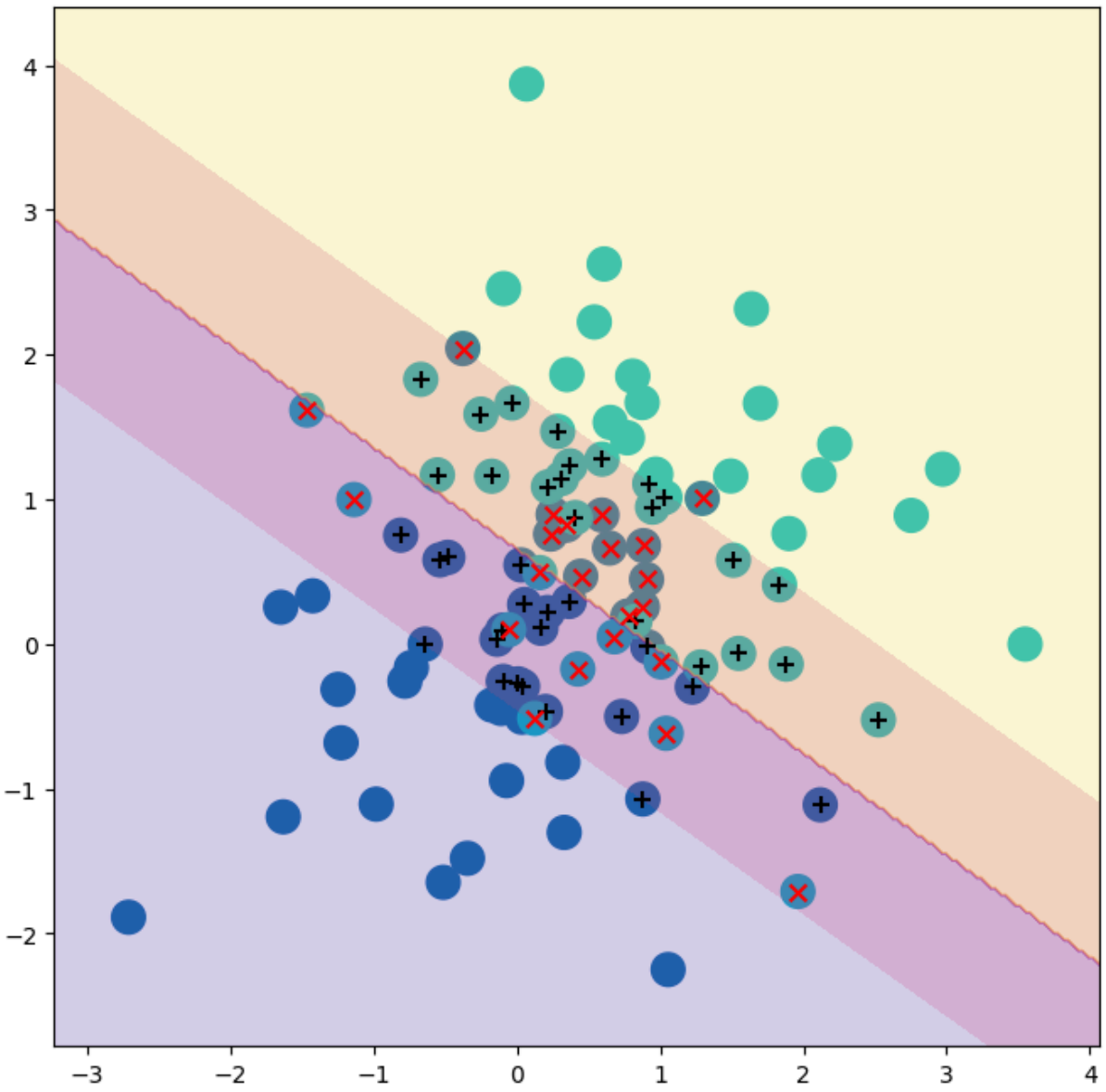


Rerun the model with smaller value of C - a larger number of support vectors

In [7]:
```
svm_linear2 = SVC(C=0.1, kernel = 'linear')
svm_linear2.fit(X, y)
```

Out[7]:
```
SVC(C=0.1, kernel='linear')
```

In [8]:
```
fig, ax = subplots(figsize=(8,8))
plot_svm(X,y, svm_linear2, ax=ax)
```



Extract the coefficients of a linear boundary

In [9]:
```
svm_linear.coef_
```

Out[9]:
```
array([[0.91505953, 1.24563919]])
```

Tune the model

In [10]:
```
kfold = skm.KFold(5,
                  random_state = 0,
                  shuffle=True)
grid = skm.GridSearchCV(svm_linear,
                        {'C':[0.001, 0.01, 0.1, 1, 5, 10, 100]},
                        refit=True,
                        cv=kfold,
                        scoring='accuracy')
grid.fit(X,y)
```

```
# what's the best model?
grid.best_params_
```

Out[10]: {'C': 1}

Print the accuracy of cross-validate model

In [11]:
```
grid.cv_results_[('mean_test_score')]
```

Out[11]: array([0.48, 0.66, 0.71, 0.72, 0.71, 0.72, 0.72])

Generate test data

In [12]:
```
X_test = rng.standard_normal((20,2))
y_test = np.array([-1]*10+[1]*10)
X_test[y_test==1] +=1
```

Predict Class labels and print Confusion Matrix

In [13]:
```
best_ = grid.best_estimator_
y_test_hat = best_.predict(X_test)
```

Generate Confusion Matrix

In [14]:
```
confusion_table(y_test_hat , y_test)
```

Out[14]:

Truth	-1	1
Predicted		
-1	8	4
1	2	6

Fit a Support Vector Machine

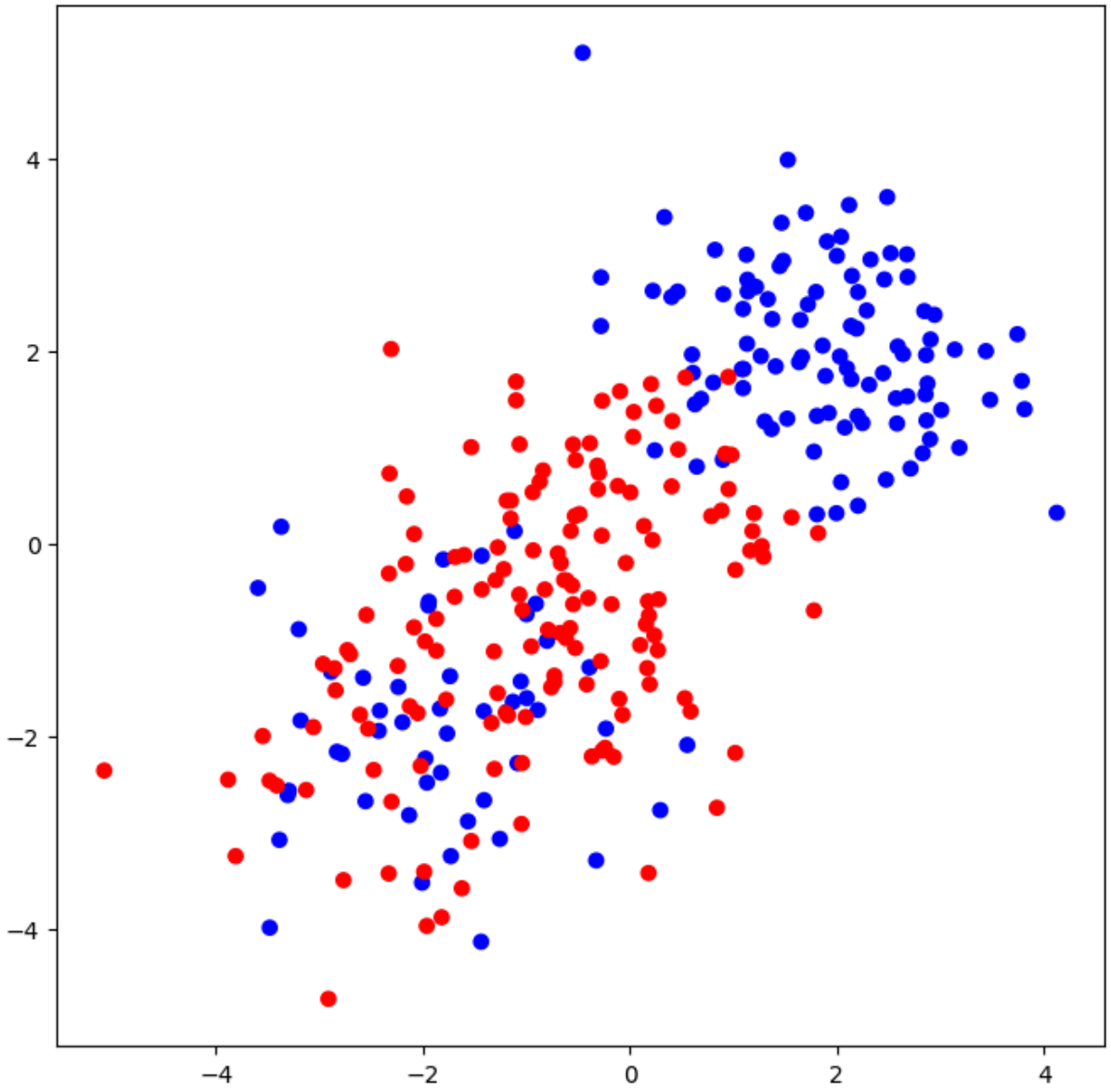
In [15]:
```
X = rng.standard_normal((300, 2))
X[:100] += 2
X[100:200] -= 2
y = np.array([1]*150+[2]*150)
```

Check the non-linear boundary

In [16]:
```
fig , ax = subplots(figsize=(8,8))
ax.scatter(X[:,0],
           X[:,1],
```

```
            c=y,
            cmap=cm.bwr)
```

Out[16]: <matplotlib.collections.PathCollection at 0x130dc5350>



Run a SVM model with a RBF kernel

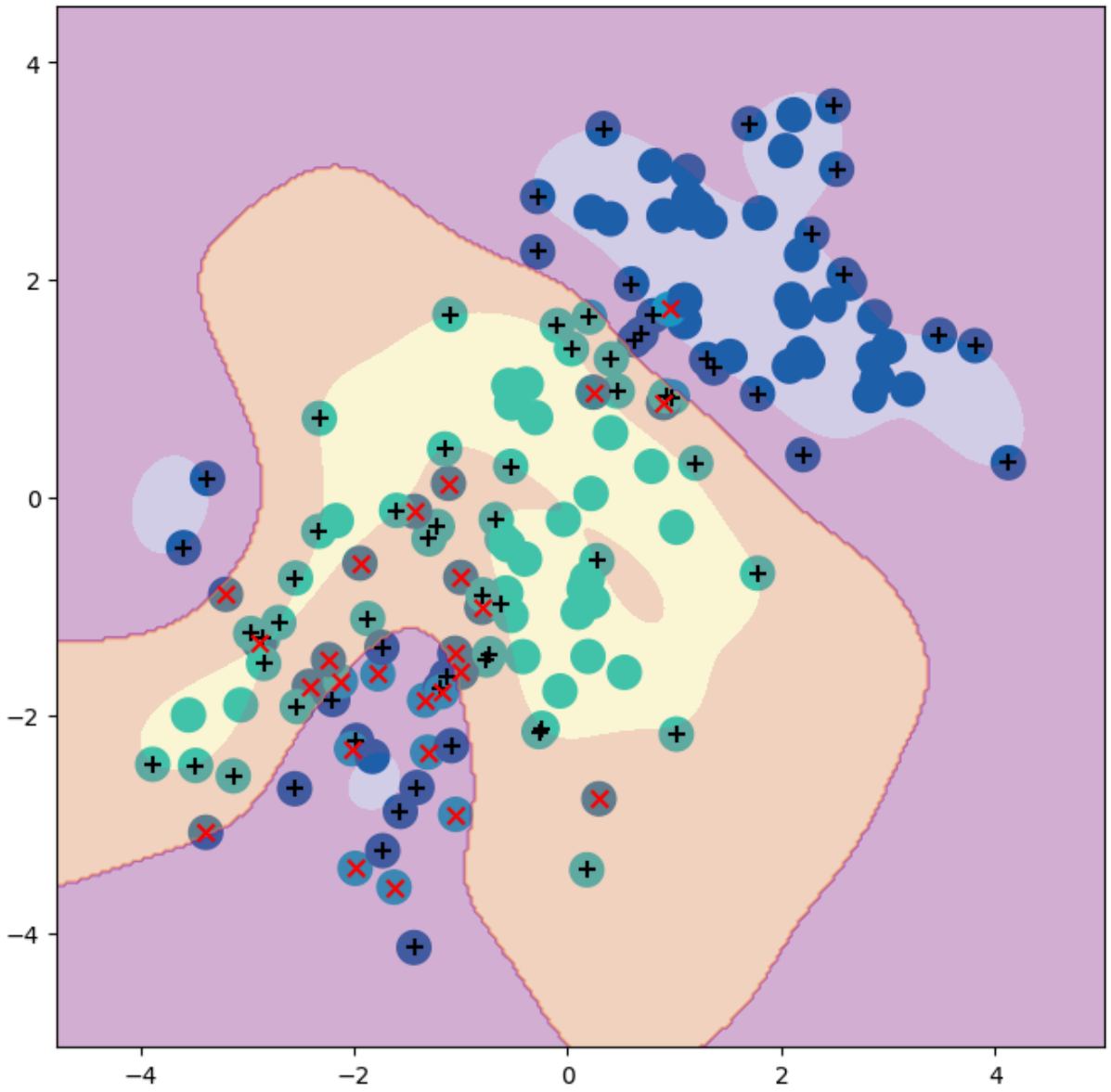
In [17]:
```
(X_train ,
X_test ,
y_train ,
y_test) = skm.train_test_split(X, y, test_size=0.5, random_state=0)

svm_rbf = SVC(kernel="rbf", gamma=1, C= 1)
svm_rbf.fit(X_train , y_train)
```

Out[17]:
```
SVC
SVC(C=1, gamma=1)
```

Check the boundary of Support Vector Machine

In [18]:
```
fig, ax = subplots(figsize=(8,8))
plot_svm(X_train,
         y_train,
         svm_rbf,
         ax=ax)
```



Use Cross-Validation to select the best choice of gamma and C

In [19]:
```
kfold = skm.KFold(5,
random_state=0,
shuffle=True)
grid = skm.GridSearchCV(svm_rbf,
                        {'C':[0.1,1,10,100,1000],
                        'gamma':[0.5,1,2,3,4]},
                        refit=True,
```

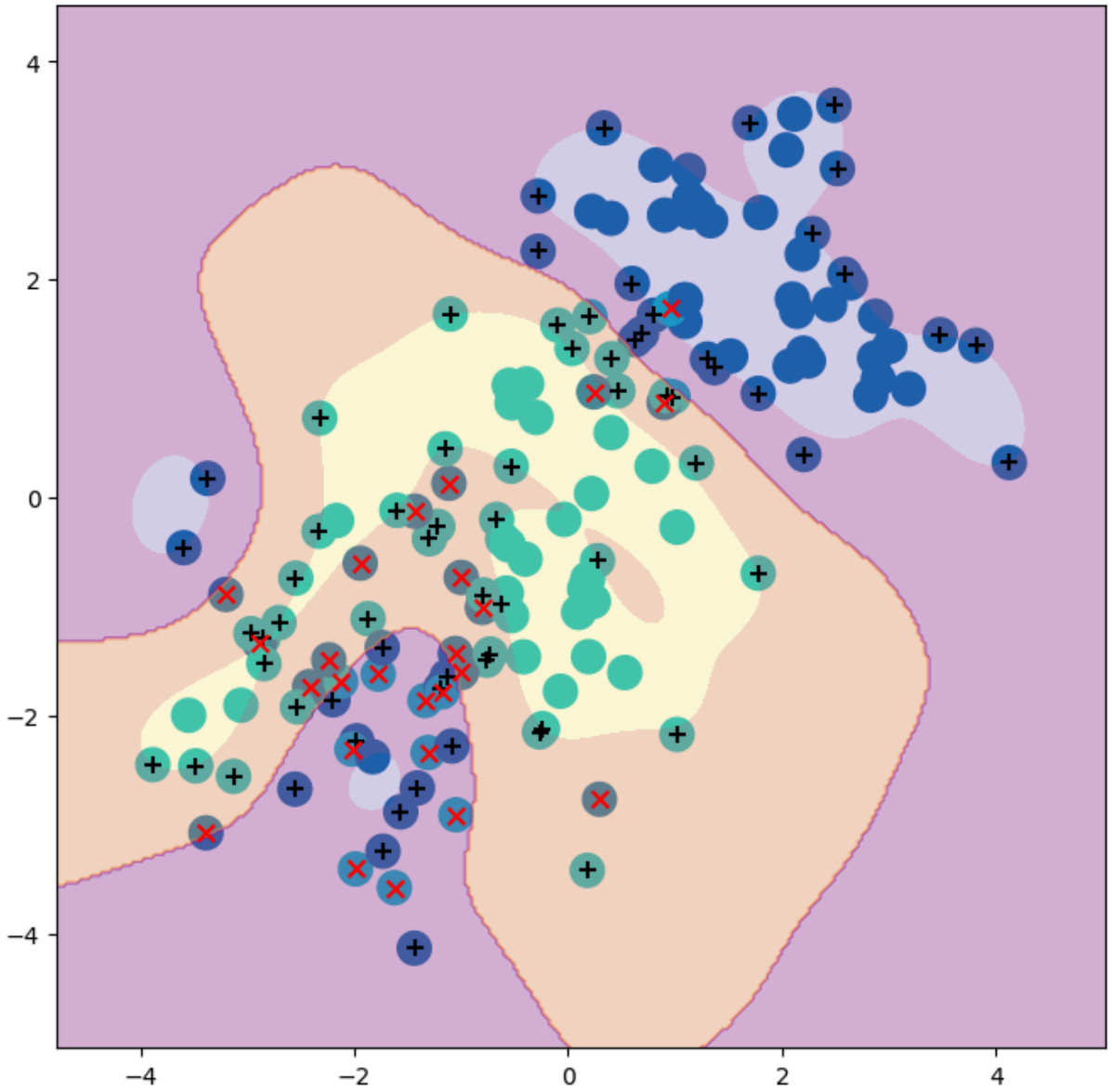
```
                           cv=kfold,
                           scoring='accuracy')

grid.fit(X_train, y_train)
grid.best_params_
```

Out[19]: {'C': 1, 'gamma': 1}

Generate the best SVM plot

In [20]:
```
best_svm = grid.best_estimator_
fig , ax = subplots(figsize=(8,8))
plot_svm(X_train,
         y_train,
         best_svm,
         ax=ax)
y_hat_test = best_svm.predict(X_test)
```



Generate the Confusion Matrix

In [21]:
```
confusion_table(y_hat_test , y_test)
```

Out[21]:

Truth	1	2
Predicted		
1	56	14
2	16	64