Decision Boundary Homework

In [24]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

from sklearn.ensemble import GradientBoostingClassifier
from sklearn.metrics import accuracy_score, confusion_matrix
```

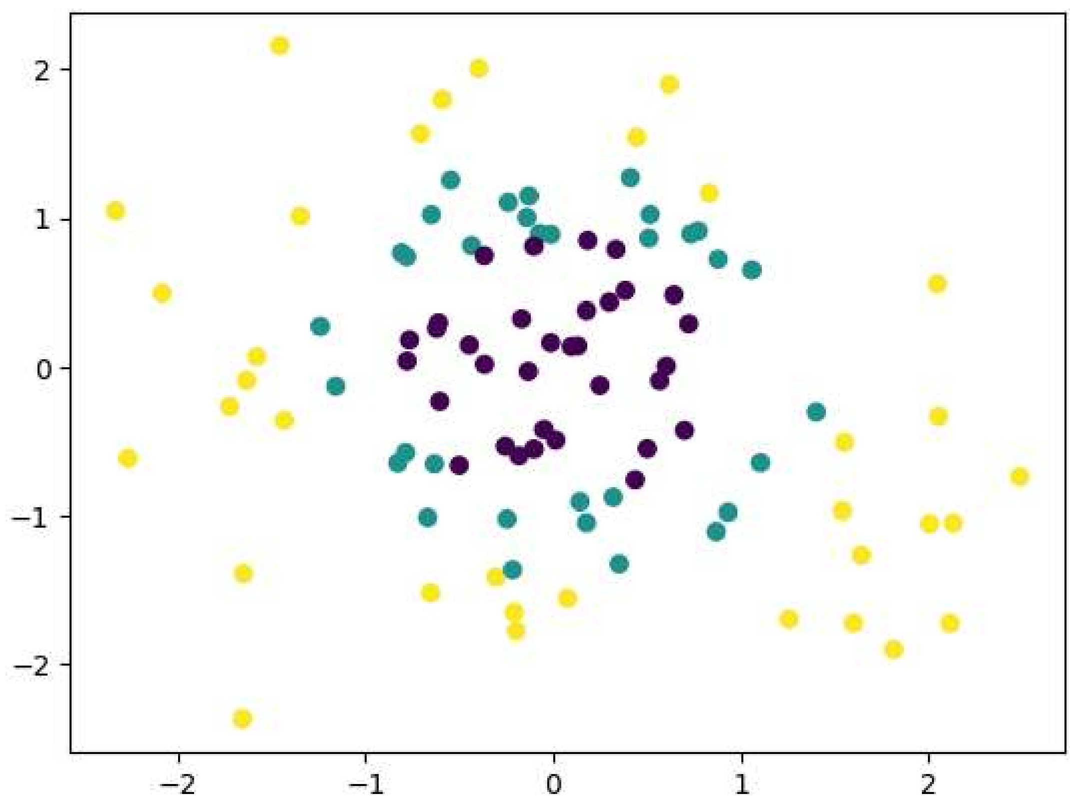
Sklearn has a couple of "standard" example data generators for use in working with classification models, these are some models used to synthesize data for practice purposes. Below are a couple of examples.

These are both pretty simple, they are using just two variables

In [ ]:
```
from sklearn.datasets import make_gaussian_quantiles, make_classification

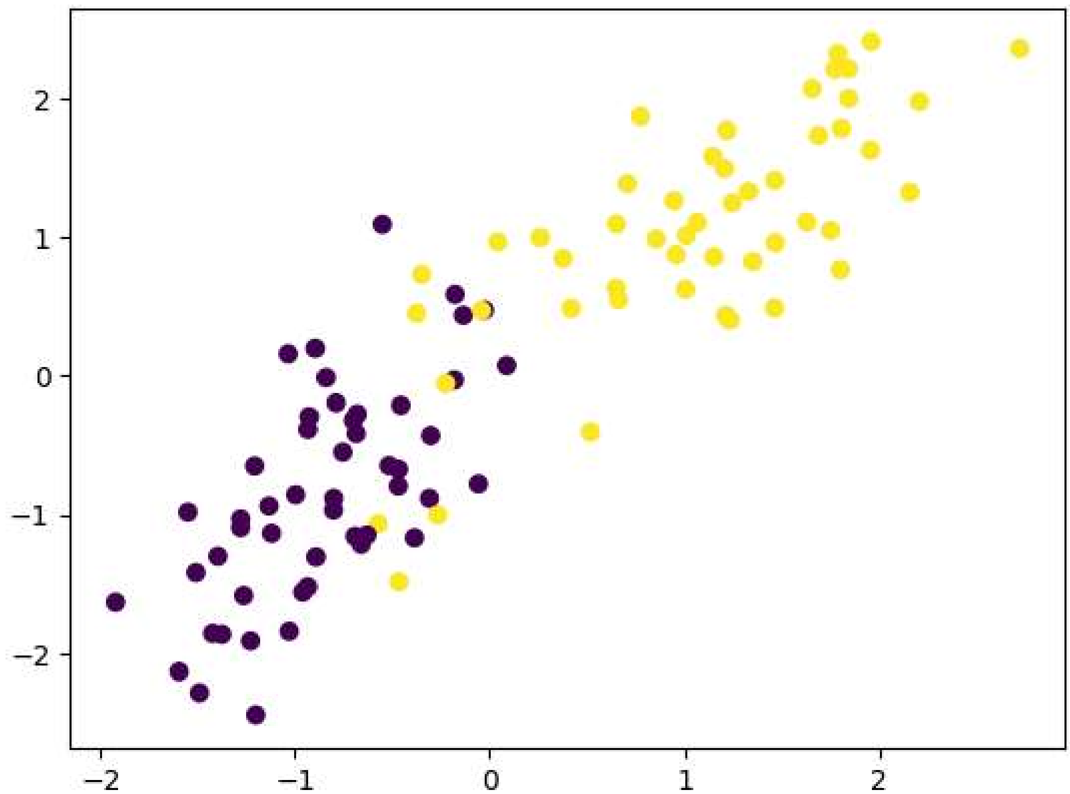
X,y=make_gaussian_quantiles(n_features=2, n_classes=3)
plt.scatter(X[:,0],X[:,1], c=y)
```

Out[ ]:
```
<matplotlib.collections.PathCollection at 0x7b47c3fd4940>
```



In [ ]:
```
X1, y1 = make_classification(
    n_features=2, n_redundant=0, n_informative=2, n_clusters_per_class=1
)
plt.scatter(X1[:,0],X1[:,1], c=y1)
```

Out[ ]: <matplotlib.collections.PathCollection at 0x7b47c1eccd60>



Question/Action

- For each of these data sets, (X,y) and (X1,y1)

a.) Generate two test sets (X_test, y_test),(X1_test,y1_test), by running the generators again, with the same parameters. This will generate test sets with the same distributions but different values.

b.) Build some a number of classifiers for each set -logistic -the logistic again, but add columns for X1^2 and X2^2 as predictors -neural net -random forest -two different boosted methods

```
Do some basic hyperparameter searches on each model (except the
logistic)
```

c.) Write a function that will allow you to pass in the model and the X, y set and then generate from that a plot of the decision boundary for the example

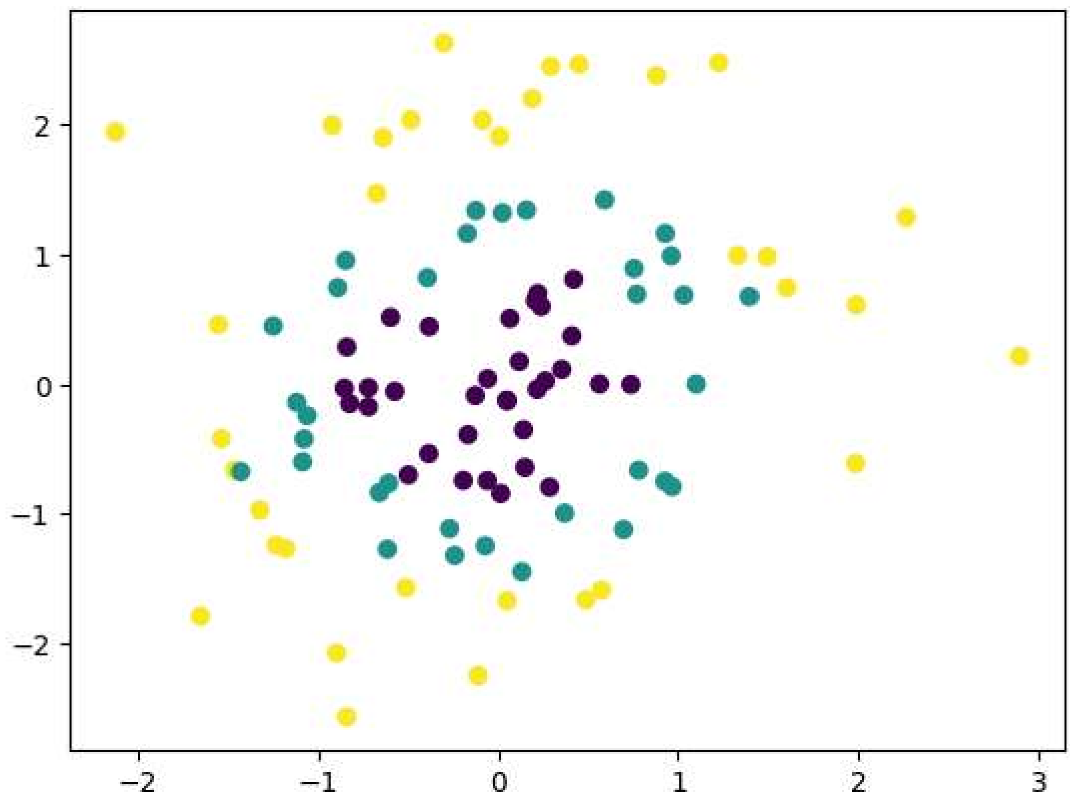
d.) Use your function to plot out the decision boundaries for each of your models and for the two data sets

e.) Based on your examination of the two data sets and the resulting plots, what can you say about the nature of the models? -which of them can generate curved boundaries? Which are all straight line boundaries? -which looks most severely overfit?

a.) Generate two test sets (X_test, y_test),(X1_test,y1_test), by running the generators again, with the same parameters. This will generate test sets with the same distributions but different values.

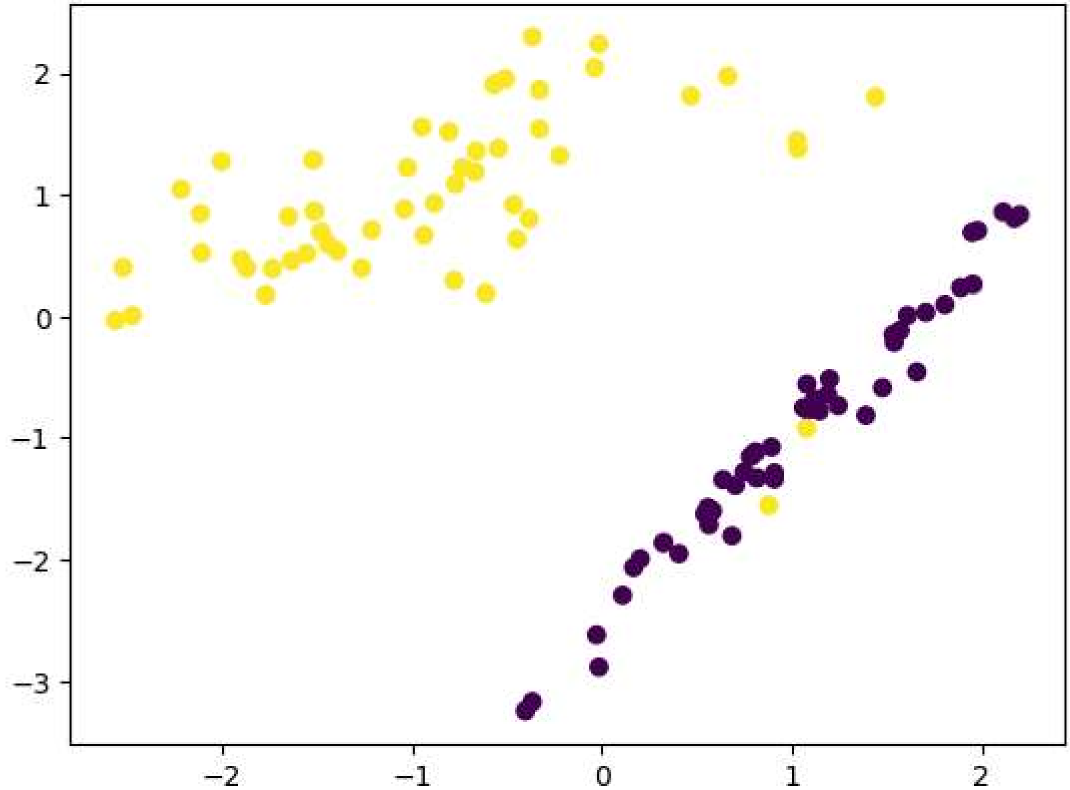
In [ ]:
```
X_test,y_test=make_gaussian_quantiles(n_features=2, n_classes=3)
plt.scatter(X_test[:,0],X_test[:,1], c=y_test)
```

Out[ ]:
```
<matplotlib.collections.PathCollection at 0x7b47c1d70e50>
```



In [ ]:
```
X1_test, y1_test = make_classification(
    n_features=2, n_redundant=0, n_informative=2, n_clusters_per_class=1
)
plt.scatter(X1_test[:,0],X1_test[:,1], c=y1_test)
```

Out[ ]:
```
<matplotlib.collections.PathCollection at 0x7b47c1de5630>
```



b.) Build some a number of classifiers for each set -logistic -the logistic again, but add columns for X1^2 and X2^2 as predictors -neural net -random forest -two different boosted methods

In [31]:
```
from sklearn.linear_model import LogisticRegression

modelLogistic1 = LogisticRegression()
# fit the model
modelLogistic1.fit(X, y)

modelLogistic1_pred = modelLogistic1.predict(X_test)
print (accuracy_score(y_test,modelLogistic1_pred))


modelLogistic2 = LogisticRegression()
# fit the model
modelLogistic2.fit(X1, y1)

modelLogistic2_pred = modelLogistic2.predict(X1_test)
print (accuracy_score(y1_test,modelLogistic2_pred))


#modelLogistic1 = LogisticRegression()
# fit the model
#modelLogistic1.fit(X_test, y_test)

#modelLogistic1 = LogisticRegression()
# fit the model
#modelLogistic1.fit(X1_test, y1_test)
```

```
0.33
0.25
```

In [78]:
```
modelLogisticV1 = LogisticRegression()
# fit the model
#modelLogisticV1.fit(np.concatenate((X,X**2),axis=1), y)
modelLogisticV1.fit(X**2, y)
modelLogisticV1_pred = modelLogisticV1.predict(X_test**2)






modelLogisticV2 = LogisticRegression()
# fit the model
#modelLogisticV2.fit(np.concatenate((X1,X1**2),axis=1), y1)
modelLogisticV2.fit(X1**2, y1)

modelLogisticV2_pred = modelLogisticV2.predict(X1_test**2)



print (accuracy_score(y_test,modelLogisticV1_pred))
print (accuracy_score(y1_test,modelLogisticV2_pred))

#modelLogisticV3 = LogisticRegression()
# fit the model
#modelLogisticV3.fit(np.concatenate((X_test,X_test**2),axis=1), y_test)

#modelLogisticV4 = LogisticRegression()
# fit the model
#modelLogisticV4.fit(np.concatenate((X1_test,X1_test**2),axis=1), y1_test)
```

```
0.95
0.47
```

In [26]:
```
# Nural Net

from sklearn.neural_network import MLPClassifier
clf = MLPClassifier(solver='adam', alpha=1e-5, random_state=1, batch_size=int(min(200/
clf.fit(X, y)


clf_pred = clf.predict(X_test)





clf1 = MLPClassifier(solver='adam', alpha=1e-5, random_state=1, batch_size=int(min(200
clf1.fit(X1, y1)

#clf2 = MLPClassifier(solver='adam', alpha=1e-5, random_state=1, batch_size=int(min(20
#clf2.fit(X1_test, y1_test)

#clf3 = MLPClassifier(solver='adam', alpha=1e-5, random_state=1, batch_size=int(min(20
#clf3.fit(X_test, y_test)
clf1_pred = clf1.predict(X1_test)


print (accuracy_score(y_test,clf_pred))
print (accuracy_score(y1_test,clf1_pred))
```

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Iteration 1, loss = 1.25246050
Iteration 2, loss = 1.24335680
Iteration 3, loss = 1.23481095
Iteration 4, loss = 1.22736959
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Iteration 8, loss = 1.19792055
Iteration 9, loss = 1.19154283
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Iteration 12, loss = 1.17455877
Iteration 13, loss = 1.16931349
Iteration 14, loss = 1.16389207
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Iteration 18, loss = 1.14645438
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Iteration 3, loss = 0.87837307
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/usr/local/lib/python3.10/dist-packages/sklearn/neural_network/_multilayer_perceptro
n.py:686: ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached
and the optimization hasn't converged yet.
  warnings.warn(
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/usr/local/lib/python3.10/dist-packages/sklearn/neural_network/_multilayer_perceptro
n.py:686: ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached
and the optimization hasn't converged yet.
  warnings.warn(
```

In [60]:

```python
#-random forest

from sklearn.ensemble import RandomForestClassifier

rnd_clf = RandomForestClassifier(n_estimators=500, max_leaf_nodes=50, n_jobs=-1)
rnd_clf.fit(X, y)



y_pred_rf = rnd_clf.predict(X_test)

print (sum(y_pred_rf==y_test)/y_test.size)
```

```
0.88
```

In [61]:

```python
rnd_clf2 = RandomForestClassifier(n_estimators=500, max_leaf_nodes=8, n_jobs=-1)
rnd_clf2.fit(X1, y1)


y_pred_rf = rnd_clf.predict(X1_test)

print (sum(y_pred_rf==y1_test)/y1_test.size)
```

```
0.14
```

In [52]:

```python
# Gradient Boosting


from sklearn.ensemble import GradientBoostingClassifier
from sklearn.metrics import accuracy_score, confusion_matrix
gb_clf=GradientBoostingClassifier(learning_rate=0.1, n_estimators=100, subsample=1, ma

gb_clf.fit(X, y)

y_pred_gb = rnd_clf.predict(X_test)
print (accuracy_score(y_test,y_pred_gb))
```

```
0.42
```

In [53]:
```python
# Gradient Boosting2


from sklearn.ensemble import GradientBoostingClassifier
from sklearn.metrics import accuracy_score, confusion_matrix
gb_clf2=GradientBoostingClassifier(learning_rate=0.1, n_estimators=100, subsample=1, m

gb_clf2.fit(X1, y1)

y2_pred_gb = rnd_clf.predict(X1_test)
print (accuracy_score(y1_test,y2_pred_gb))
```

```
0.21
```

In [46]:
```python
import xgboost

xgb_reg = xgboost.XGBClassifier()
xgb_reg.fit(X,y)
y_pred_XG = xgb_reg.predict(X_test)

print (accuracy_score(y_test,y_pred))
```

```
0.85
```

In [47]:
```python
import xgboost

xgb_reg2 = xgboost.XGBClassifier()
xgb_reg2.fit(X1,y1)
y1_pred = xgb_reg.predict(X1_test)

print (accuracy_score(y1_test,y1_pred))
```

```
0.15
```

c.) Write a function that will allow you to pass in the model and the X, y set and then generate from that a plot of the decision boundary for the example

In [33]:
```python

```

Out[33]:
```
array([1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0,
       0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0, 1, 1, 1, 0, 0, 1, 1, 0, 1, 1,
       0, 0, 1, 0, 1, 1, 1, 1, 0, 1, 1, 1, 0, 0, 1, 0, 1, 1, 1, 1, 1, 1,
       1, 1, 1, 0, 1, 1, 0, 0, 1, 0, 1, 1, 1, 0, 1, 1, 0, 1, 1, 1, 0, 1,
       1, 1, 0, 1, 1, 1, 0, 0, 0, 0, 1, 1])
```

In [81]:
```python
def decisionBoundary(model, X,y,special):
  # define bounds of the domain
  min1, max1 = X[:, 0].min()-1, X[:, 0].max()+1
  min2, max2 = X[:, 1].min()-1, X[:, 1].max()+1
  # define the x and y scale
  x1grid = np.arange(min1, max1, 0.1)
  x2grid = np.arange(min2, max2, 0.1)
  # create all of the lines and rows of the grid
  xx, yy = np.meshgrid(x1grid, x2grid)
  # flatten each grid to a vector
  r1, r2 = xx.flatten(), yy.flatten()
  r1, r2 = r1.reshape((len(r1), 1)), r2.reshape((len(r2), 1))
```

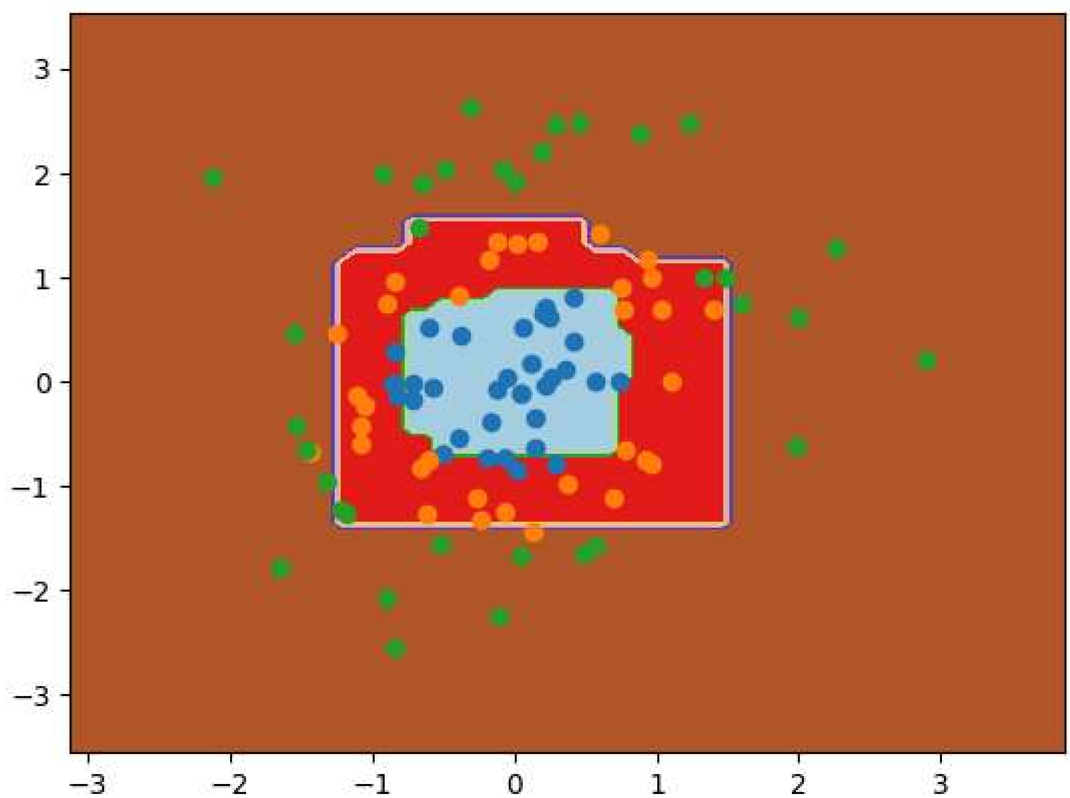
```
# horizontal stack vectors to create x1,x2 input for the model
grid = np.hstack((r1,r2))

if special == False:
  y_pred_grid = model.predict(grid)
else:
  y_pred_grid = model.predict(grid**2)
zz = y_pred_grid.reshape(xx.shape)
plt.contourf(xx, yy, zz, cmap='Paired')

for class_value in range(len(np.unique(y))):
  # get row indexes for samples with this class
  row_ix = np.where(y == class_value)
  # create scatter of these samples
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```

d.) Use your function to plot out the decision boundaries for each of your models and for the two data sets

XGboost

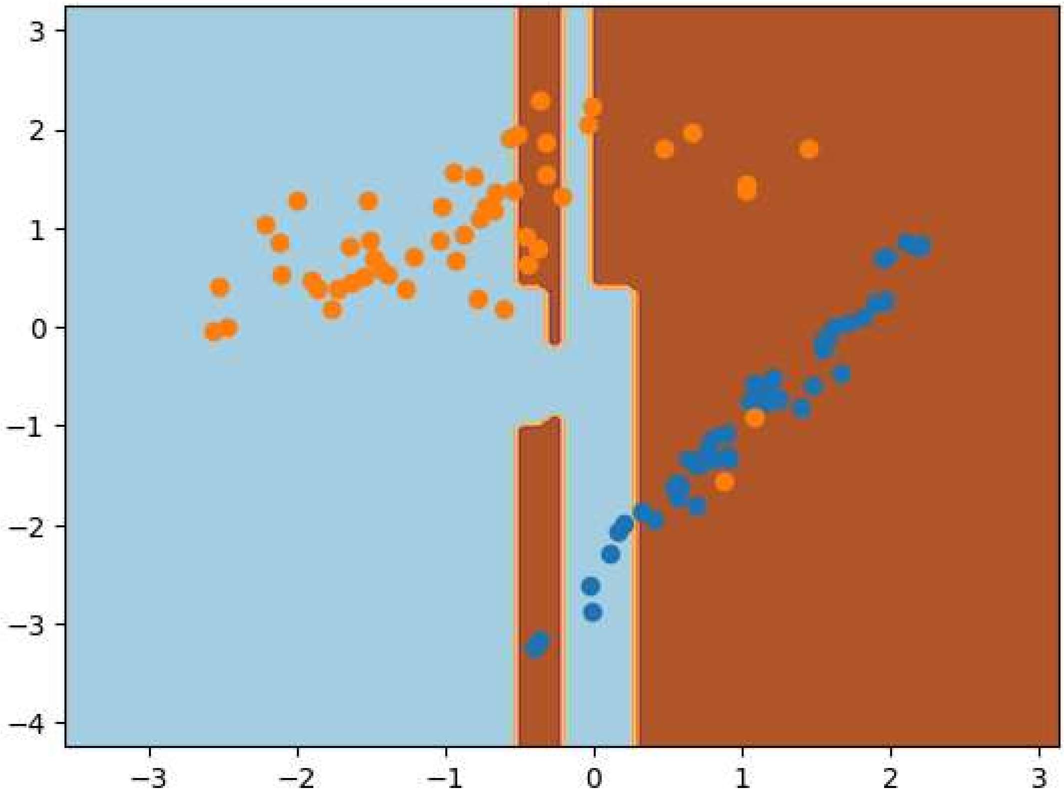
In [96]:
```
#XHboost
decisionBoundary(xgb_reg,X_test,y_test,False)
```

```
&lt;ipython-input-81-125e0d01568d&gt;:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



In [95]:
```
decisionBoundary(xgb_reg2,X1_test,y1_test,False)
```

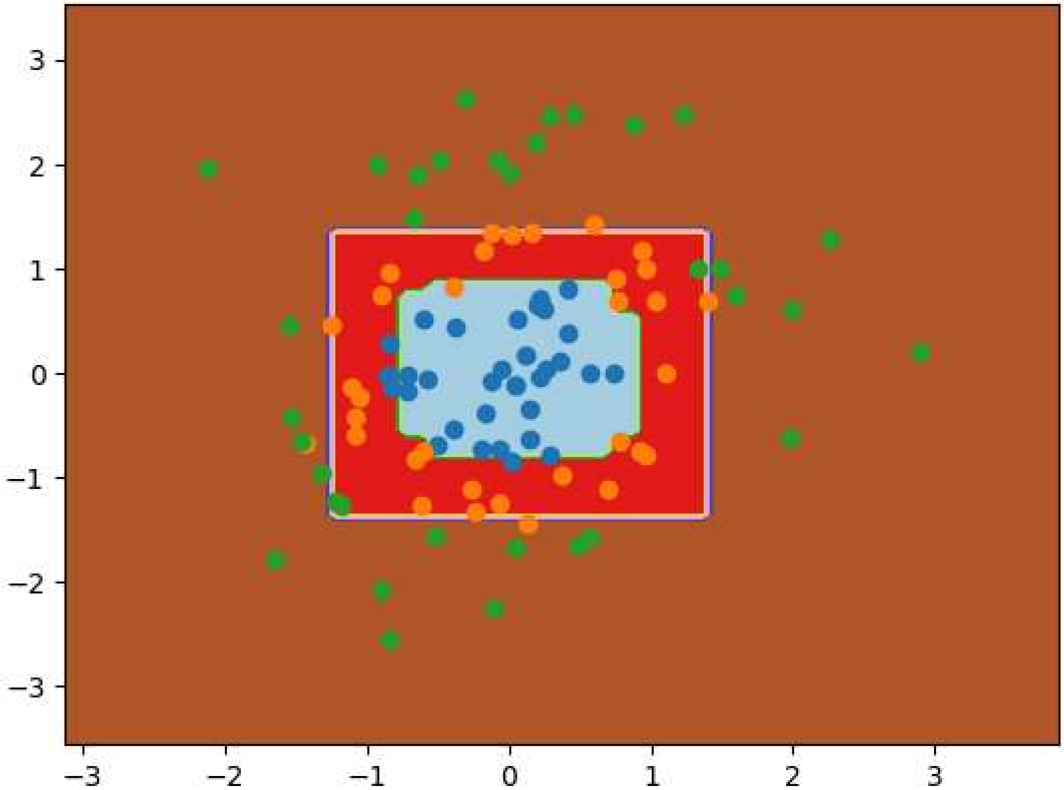
```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



In [94]:

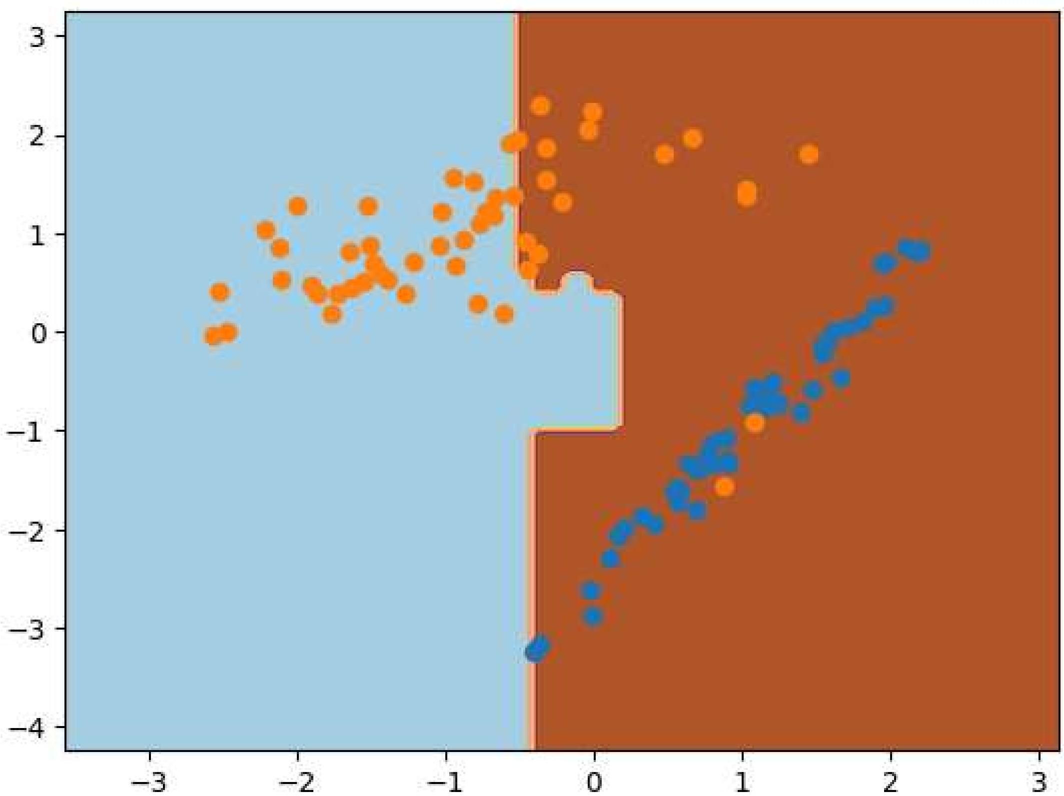
```
#Gradient Boost

decisionBoundary(gb_clf,X_test,y_test,False)
```

```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



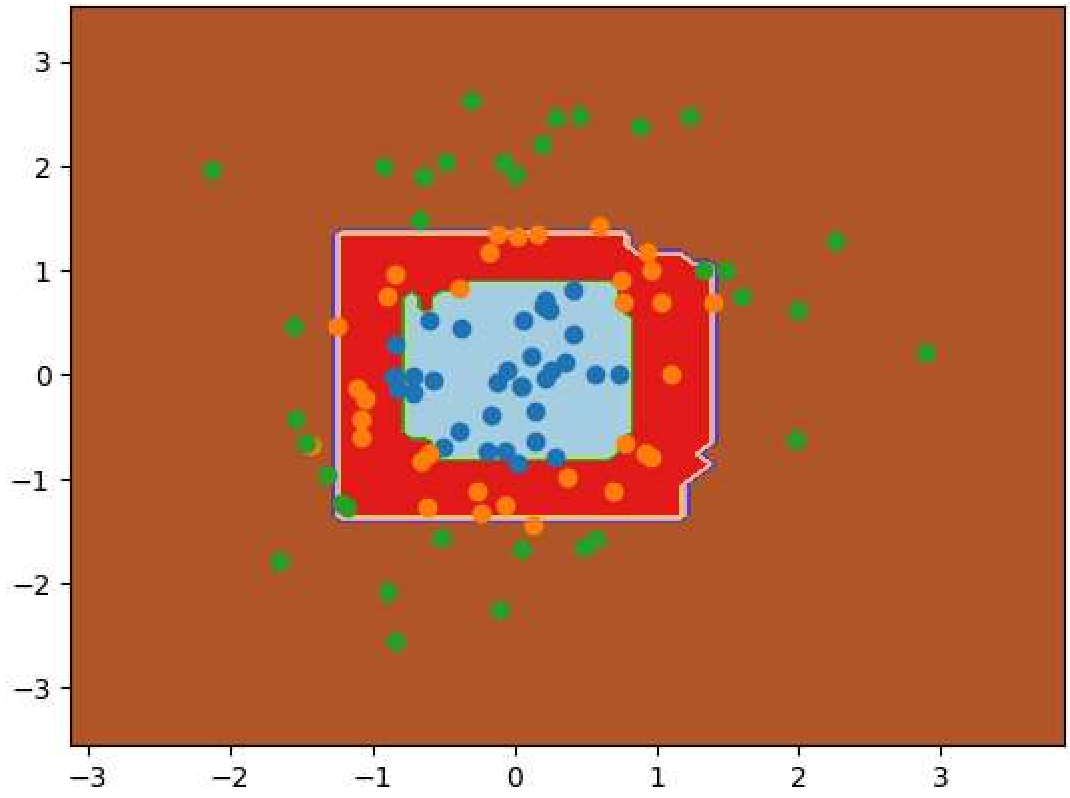
In [93]:
```
decisionBoundary(gb_clf2,X1_test,y1_test,False)
```

```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



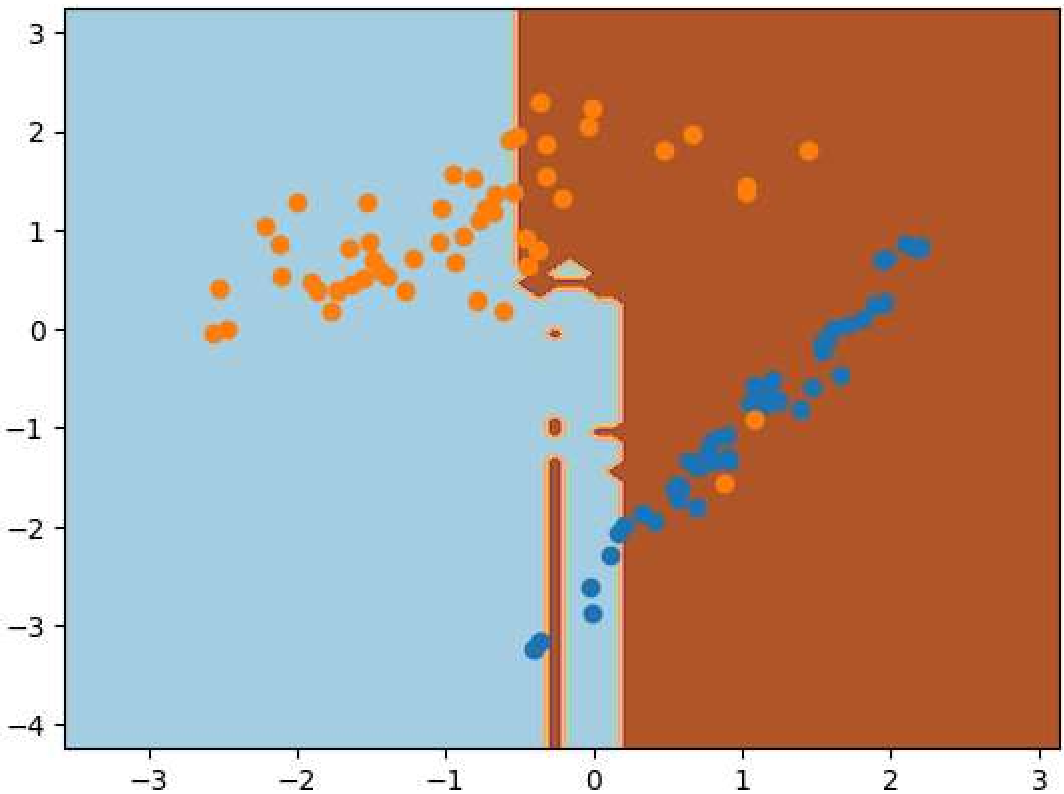
In [92]:
```
# Random Forest
decisionBoundary(rnd_clf,X_test,y_test,False)
```

```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



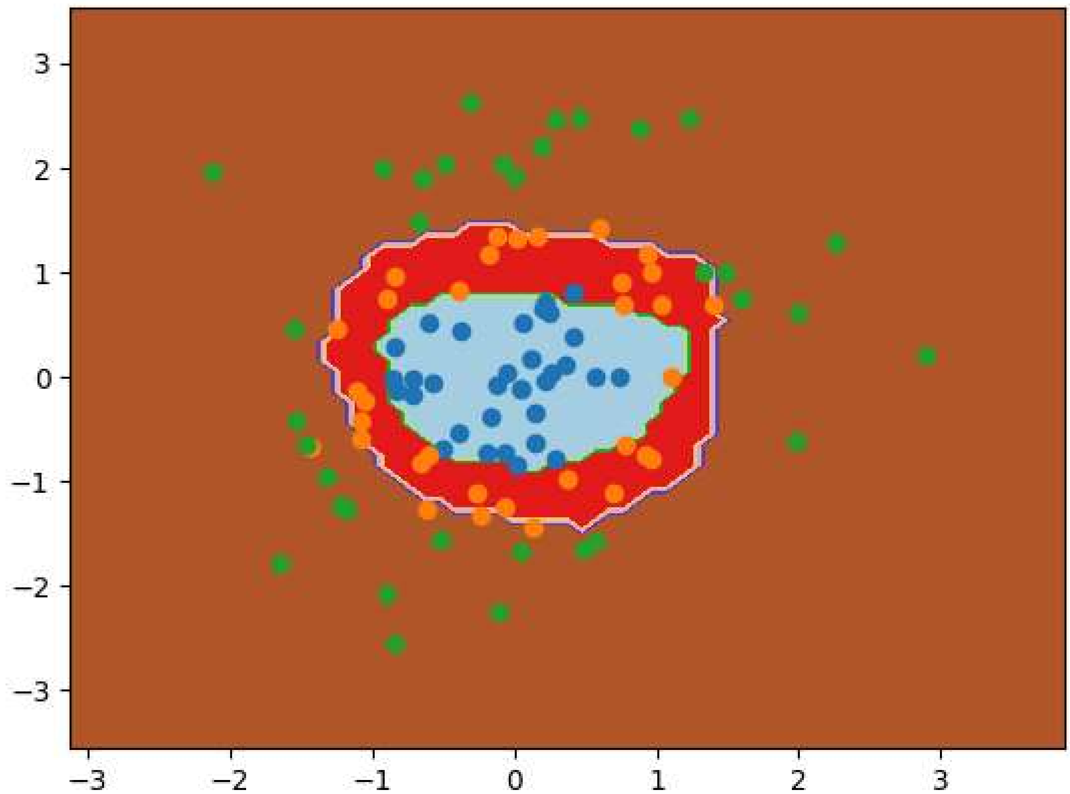
In [91]:
```
decisionBoundary(rnd_clf2,X1_test,y1_test,False)
```

```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



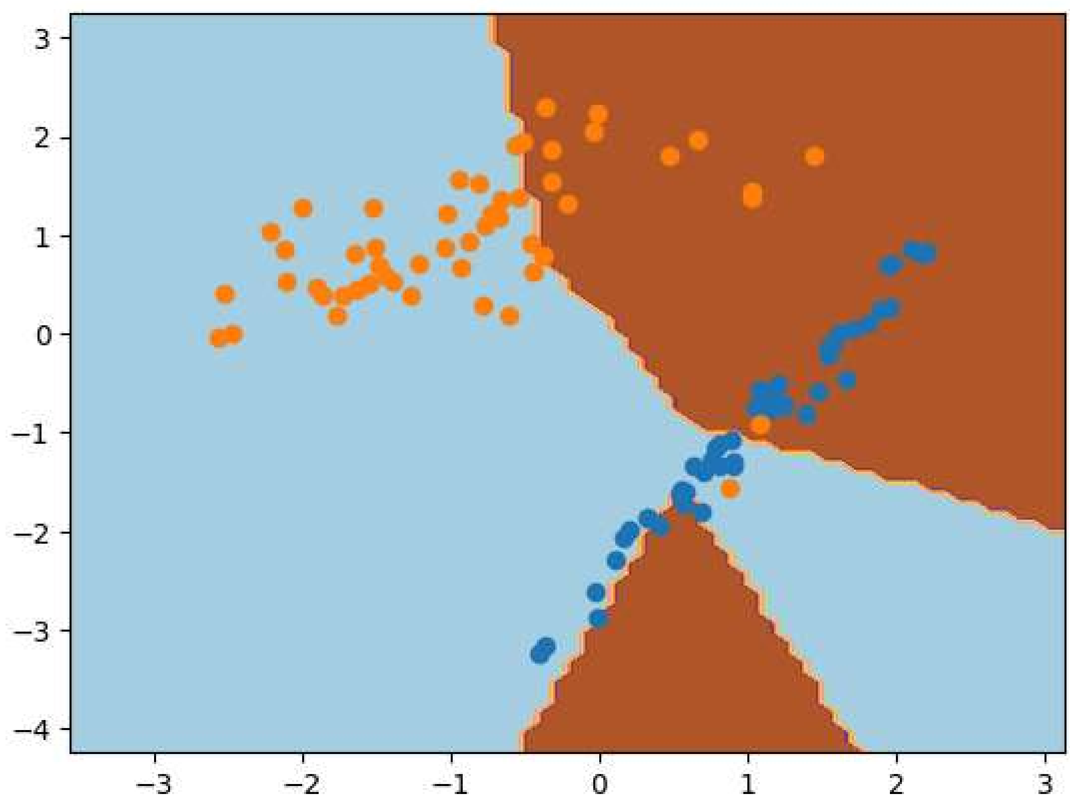
In [90]:
```
# Nural net


decisionBoundary(clf,X_test,y_test,False)
```

```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



In [89]:
```
decisionBoundary(clf1,X1_test,y1_test,False)
```

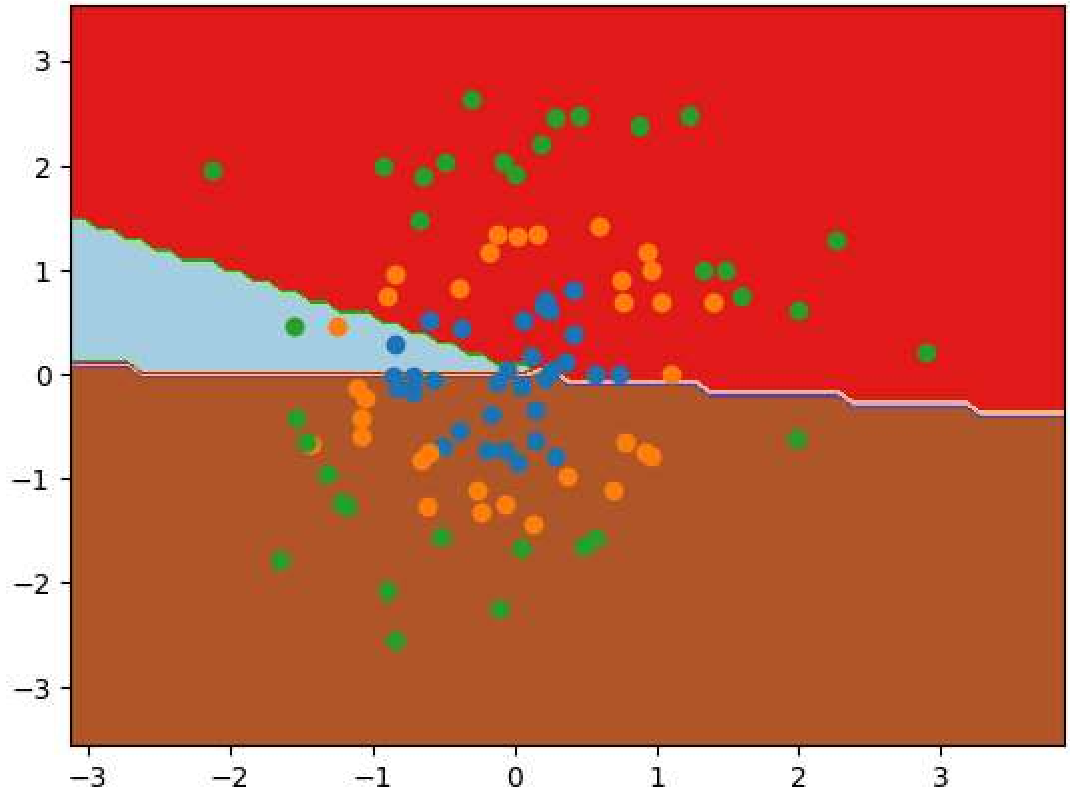
```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



In [88]:
```
#Logistic Regular
```

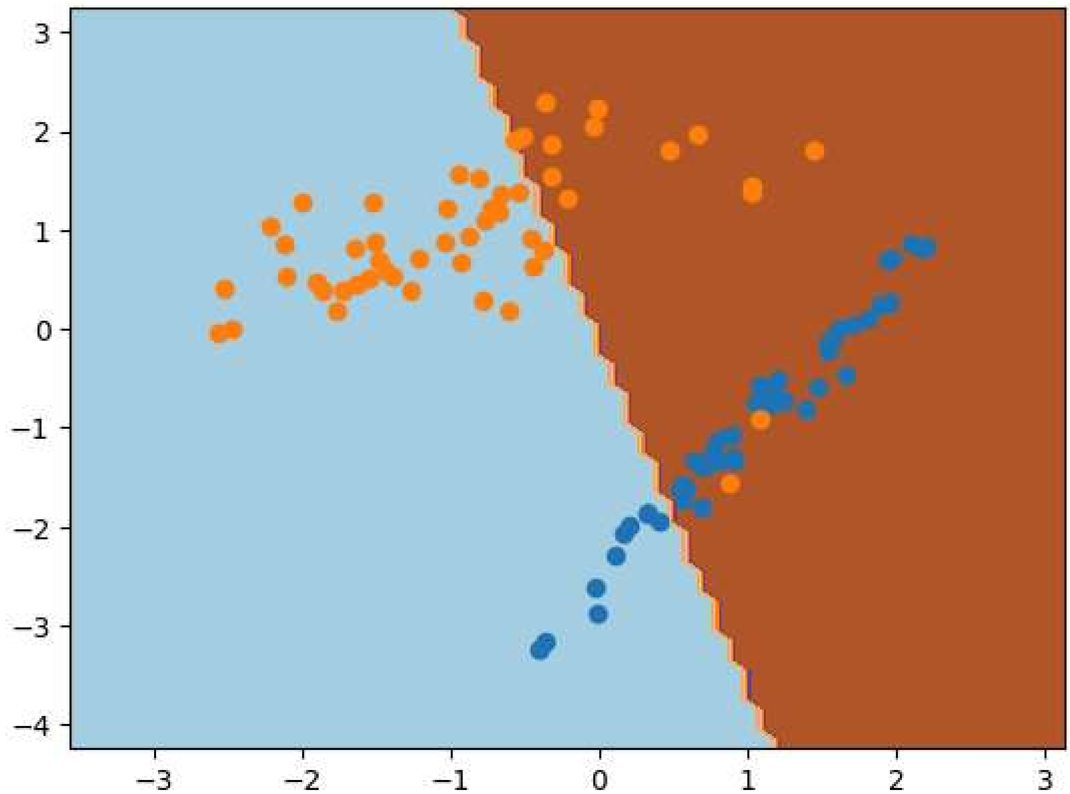
```
decisionBoundary(modelLogistic1,X_test,y_test,False)
```

```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



In [87]:
```
decisionBoundary(modelLogistic2,X1_test,y1_test,False)
```

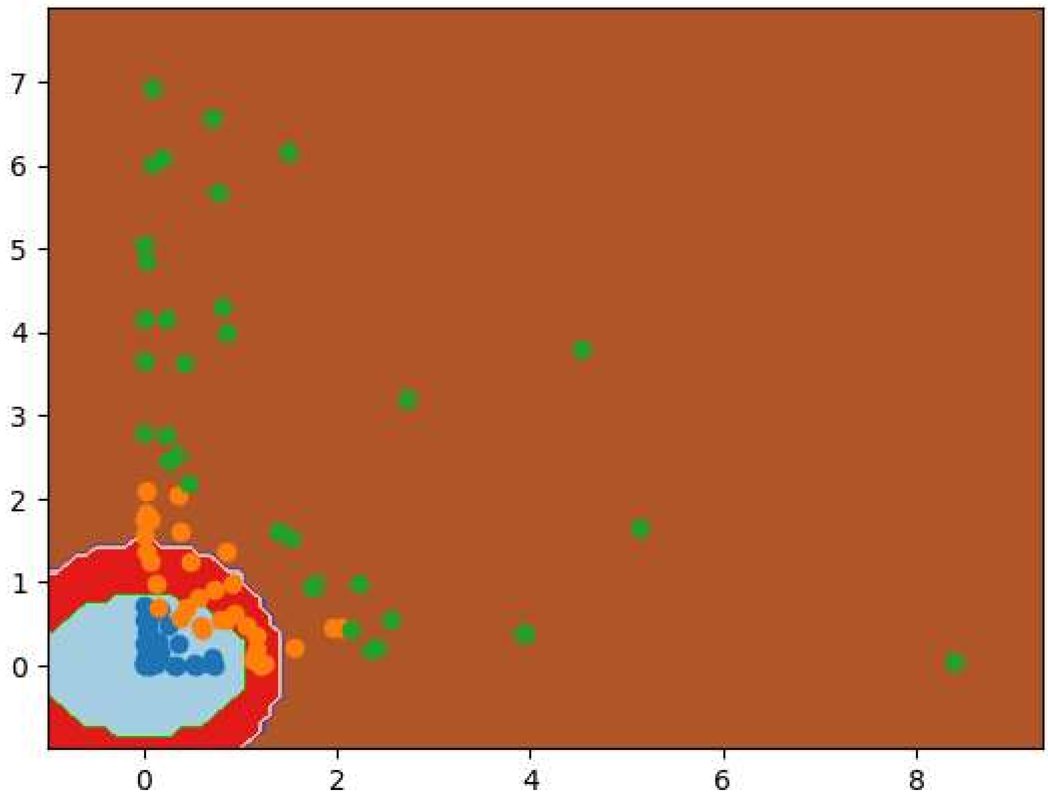
```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



In [97]:

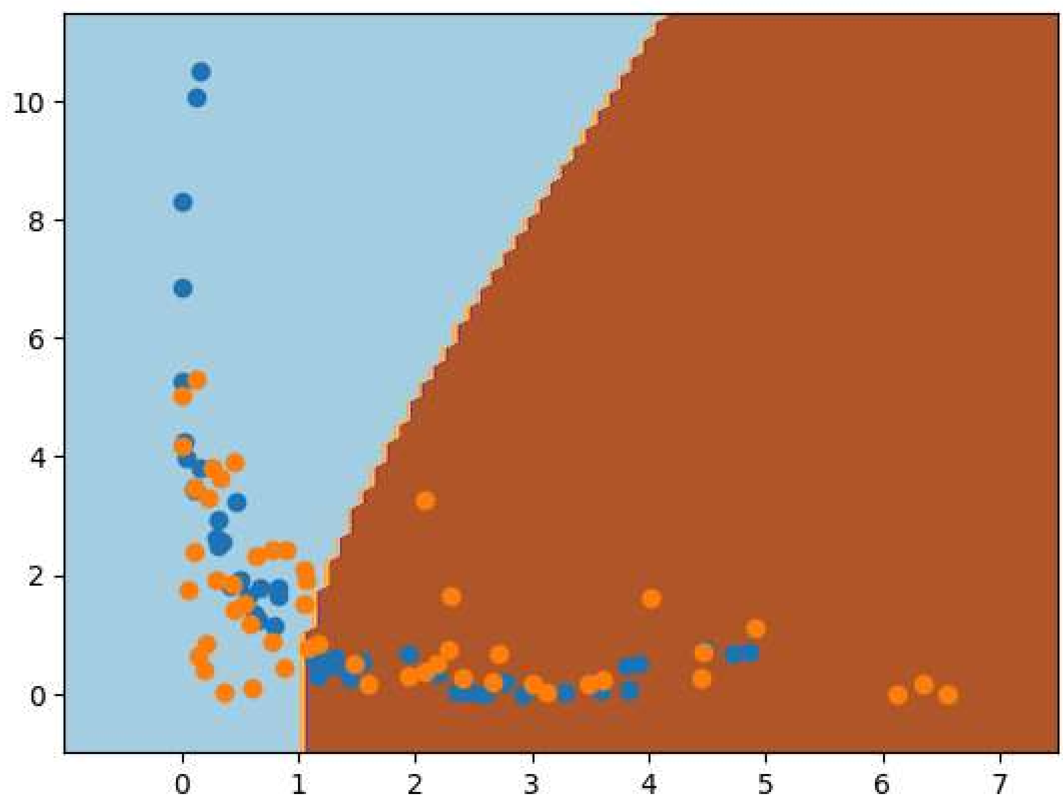
```
#LogisticX^2 and X1^2



decisionBoundary(modelLogisticV1,X_test**2,y_test,True)
```

```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



In [86]:
```
decisionBoundary(modelLogisticV2,X1_test**2,y1_test,True)
```

```
<ipython-input-81-125e0d01568d>:27: UserWarning: No data for colormapping provided vi
a 'c'. Parameters 'cmap' will be ignored
  plt.scatter(X[row_ix, 0], X[row_ix, 1], cmap='Paired')
```



e.) Based on your examination of the two data sets and the resulting plots, what can you say about the nature of the models? -which of them can generate curved boundaries? Which are all straight line boundaries?

Curved : LogisticX^2 and X1^2,Nural net Stright: XGboost, Gradient boost, random forest , regualr logistic -which looks most severely overfit? modelLogisticV1 lossts most severly overfit.

```
In [ ]:
```