```
import numpy as np
import math
```

New Section

New Section

```
from sklearn.datasets import make_classification
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.discriminant_analysis import QuadraticDiscriminantAnalysis
from sklearn.naive_bayes import GaussianNB
from sklearn import svm
from sklearn.model_selection import RepeatedStratifiedKFold
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import train_test_split
from sklearn import metrics
from sklearn.metrics import precision_score, recall_score, accuracy_score, f1_score, confusion_matrix
import matplotlib.pyplot as plt
```

Spiral Dataset

```
# Ques 2 a LDA
```

```
import pandas as pd
```

Warning: you are connected to a GPU runtime, but not utilizing the GPU. Change to a standard runtime ×

```
df = pd.read_csv('/content/sample_data/spiral1.csv')

print(df)

X=df[['x','y']]
#X= df[['x1','x2']]
y=df['label']
```

```
                x          y  label
0    -1.60023    7.69407    0.0
1     7.03777    9.76350    1.0
2     9.29608   -9.16002    0.0
3     3.95189   12.31531    1.0
4     0.56410    4.34127    0.0
..        ...        ...    ...
995  14.23334   -2.59433    0.0
996   1.54775   10.99383    1.0
997   8.59973    2.69069    1.0
998  -7.24296    3.13314    0.0
999   7.24604  -10.25400    0.0

[1000 rows x 3 columns]
```

```
df.head()
```

	x	y	label
0	-1.60023	7.69407	0.0
1	7.03777	9.76350	1.0
2	9.29608	-9.16002	0.0
3	3.95189	12.31531	1.0
4	0.56410	4.34127	0.0

```
x_train, x_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, random_state = 42)
```

```
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size = 0.3, random_state = 42)

def LDA(x_train, y_train,x_test):

  model = LinearDiscriminantAnalysis()
  # Train model
  model.fit(x_train,y_train)
  # define model evaluation method
  cv = RepeatedStratifiedKFold(n_splits=10, n_repeats=3, random_state=1)
  # evaluate model
  scores = cross_val_score(model, X, y, scoring='accuracy', cv=cv, n_jobs=-1)

  # Predict test data
  y_pred = model.predict(x_test)
  #ppv = precision_score(y, scores)

  return model, cv, y_pred, scores
```

```
model, cv, y_pred, scores = LDA(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
```

```
    Mean Accuracy: 0.750 (0.049)
```

```
def get_metrics(y_test, y_pred):
  # Model Accuracy: how often is the classifier correct?
  score = metrics.accuracy_score(y_test, y_pred)
  #print("Accuracy:",score)
  ppv = precision_score(y_test, y_pred)
  #print(ppv)
```

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```
  npv = 0
  if(fn!=0):
    npv = tn / (tn + fn) # Specificity
    #print (npv)

  specificity = tn / (tn + fp) # Sensitivity (Recall)

  #print(specificity)

  sensitivity = recall_score(y_test, y_pred)
  #print(sensitivity)

  return score, ppv, npv, specificity, sensitivity
```

```
def plotGraph(X,y):
  plt.figure(figsize=(10,6))
  plt.scatter(X['x1'], X['x2'], c=y, cmap='Spectral')
  plt.show()
```

```
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
     Accuracy Score: 0.7633333333333333
     PPV: 0.7516339869281046
     NPV: 0.7755102040816326
     specificity: 0.75
     sensitivity: 0.777027027027027
```

```
# 2b
```

```
def QDA(x_train, y_train, x_test):
  # Train thr model
  model = QuadraticDiscriminantAnalysis()
  model.fit(x_train, y_train)
  y_pred = model.predict(x_test)
  #Define method to evaluate model
  cv = RepeatedStratifiedKFold(n_splits=10, n_repeats=3, random_state=1)

  #evaluate model with 10 folds
  scores = cross_val_score(model, X, y, scoring='accuracy', cv=cv, n_jobs=-1)

  return model, cv, y_pred, scores
```

```
model, cv, y_pred, scores = QDA(x_train, y_train, x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
```

```
    Mean Accuracy: 0.749 (0.050)
```

```
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
     Accuracy Score: 0.7633333333333333
     PPV: 0.7516339869281046
     NPV: 0.7755102040816326
     specificity: 0.75
     sensitivity: 0.777027027027027
```

```
# que 2 c
```

Warning: you are connected to a GPU runtime, but not utilizing the GPU. Change to a standard runtime ✕

```
def NB(x_train, y_train,x_test):
  model = GaussianNB()
  model.fit(x_train, y_train)
  y_pred = model.predict(x_test)
  #Define method to evaluate model
  cv = RepeatedStratifiedKFold(n_splits=10, n_repeats=3, random_state=1)

  #evaluate model with 10 folds
  scores = cross_val_score(model, X, y, scoring='accuracy', cv=cv, n_jobs=-1)

  print("Naive Bayes score: ",model.score(x_test, y_test))
  return model, cv, y_pred, scores
```

```
model, cv, y_pred, scores = NB(x_train, y_train, x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

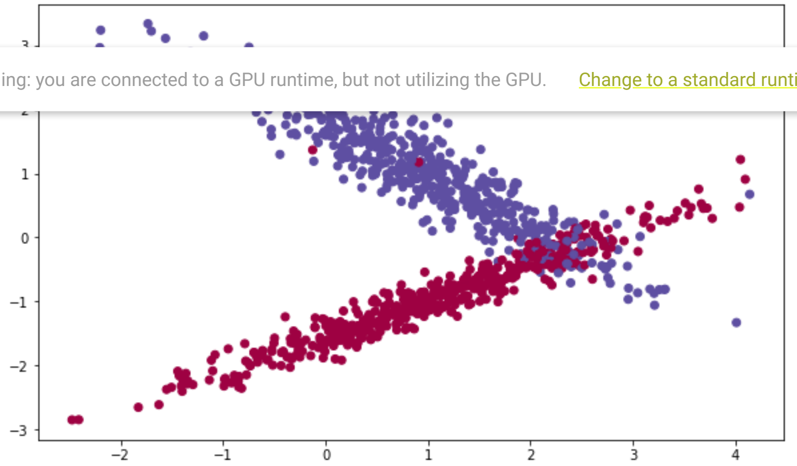
```
    Naive Bayes score:  0.7433333333333333
    Mean Accuracy: 0.733 (0.047)
     Accuracy Score: 0.7433333333333333
     PPV: 0.7320261437908496
     NPV: 0.7551020408163265
     specificity: 0.7302631578947368
     sensitivity: 0.7567567567567568
```

```
# ques 2 d
```

```
# # Import train_test_split function
# from sklearn.model_selection import train_test_split

# # Split dataset into training set and test set
# X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,random_state=109) # 70% training and 30% test
# SVM model

def SVM(x_train, y_train, x_test):
  #Create a svm Classifier
  model = svm.SVC(kernel='linear') # Linear Kernel

  #Train the model using the training sets
  model.fit(x_train, y_train)

  #Predict the response for test dataset
  y_pred = model.predict(x_test)
  #Define method to evaluate model
  cv = RepeatedStratifiedKFold(n_splits=10, n_repeats=3, random_state=1)

  #evaluate model with 10 folds
  scores = cross_val_score(model, X, y, scoring='accuracy', cv=cv, n_jobs=-1)

  return model, cv, y_pred, scores


model, cv, y_pred, scores = SVM(x_train, y_train, x_test)
# summarize result

accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
 Accuracy Score: 0.76
 PPV: 0.7533333333333333
 NPV: 0.7666666666666667
 specificity: 0.756578947368421
 sensitivity: 0.7635135135135135
```

```
plotGraph(X,y)
```



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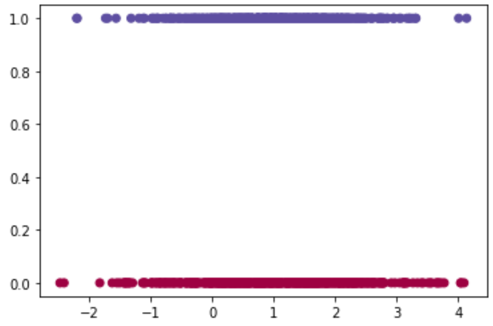
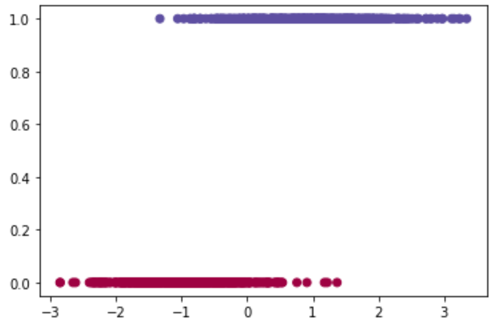
```
plt.scatter(X['x1'],y,c=y,cmap='Spectral')
plt.show()
```



```
plt.scatter(X['x2'],y,c=y,cmap='Spectral')
plt.show()
```



Applying above models on ALL Datasets

Circles Dataset

```
df = pd.read_csv('/content/sample_data/circles0.3.csv')
X= df[['x1','x2']]
y=df['label']

x_train, x_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, random_state = 42)
```

```
model, cv, y_pred, scores = LDA(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

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```
     Accuracy Score: 0.5
     PPV: 0.4918918918918919
     NPV: 0.5130434782608696
     specificity: 0.38562091503267976
     sensitivity: 0.6190476190476191
```

```
model, cv, y_pred, scores = QDA(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
    Mean Accuracy: 0.992 (0.009)
     Accuracy Score: 0.9933333333333333
     PPV: 1.0
     NPV: 0.9870967741935484
     specificity: 1.0
     sensitivity: 0.9863945578231292
```

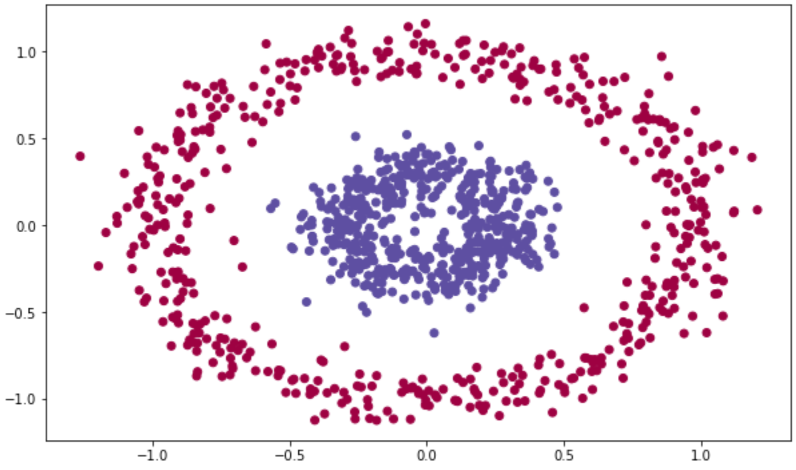
```
model, cv, y_pred, scores = NB(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
    Naive Bayes score:  0.9933333333333333
    Mean Accuracy: 0.992 (0.009)
     Accuracy Score: 0.9933333333333333
     PPV: 1.0
     NPV: 0.9870967741935484
     specificity: 1.0
     sensitivity: 0.9863945578231292
```

```
model, cv, y_pred, scores = SVM(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Mean Accuracy: 0.626 (0.028)
 Accuracy Score: 0.62
 PPV: 0.5673469387755102
 NPV: 0.8545454545454545
 specificity: 0.30718954248366015
 sensitivity: 0.9455782312925171
```

```
plotGraph(X,y)
```



```
plt.scatter(X['x1'],y,c=y,cmap='Spectral')
plt.show()
```

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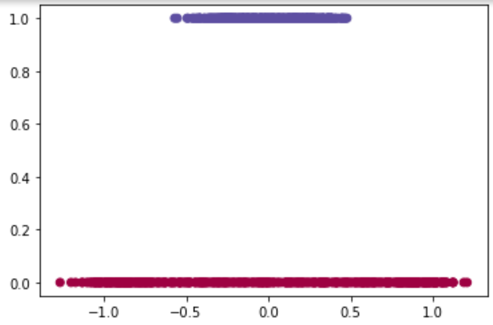
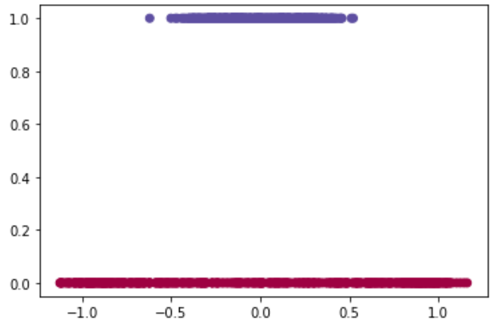


```
plt.scatter(X['x2'],y,c=y,cmap='Spectral')
plt.show()
```



Moons1 Dataset

```
df = pd.read_csv('/content/sample_data/moons1.csv')
```

```
df.head()
```

	x1	x2	label
0	-0.674481	0.469321	0
1	0.566712	-0.284153	1
2	-0.257384	0.230913	1
3	1.868980	0.610969	1
4	-0.579194	0.842457	0

```
X= df[['x1','x2']]
y=df['label']
```

```
x_train, x_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, random_state = 42)
```

```
model, cv, y_pred, scores = LDA(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Mean Accuracy: 0.883 (0.033)
 Accuracy Score: 0.8733333333333333
 PPV: 0.8859060402684564
 NPV: 0.8609271523178808
 specificity: 0.8843537414965986
 sensitivity: 0.8627450980392157
```

```
model, cv, y_pred, scores = QDA(x_train, y_train,x_test)
```

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```
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Mean Accuracy: 0.882 (0.034)
 Accuracy Score: 0.8733333333333333
 PPV: 0.8859060402684564
 NPV: 0.8609271523178808
 specificity: 0.8843537414965986
 sensitivity: 0.8627450980392157
```

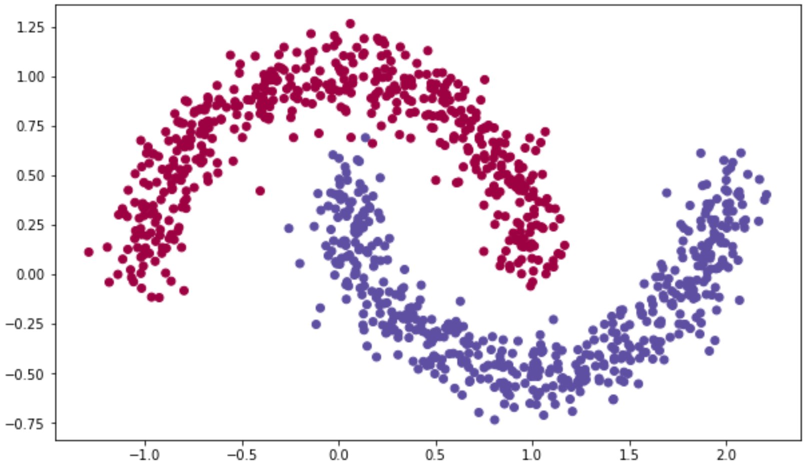
```
model, cv, y_pred, scores = NB(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Naive Bayes score:  0.8733333333333333
Mean Accuracy: 0.883 (0.032)
 Accuracy Score: 0.8733333333333333
 PPV: 0.8859060402684564
 NPV: 0.8609271523178808
 specificity: 0.8843537414965986
 sensitivity: 0.8627450980392157
```

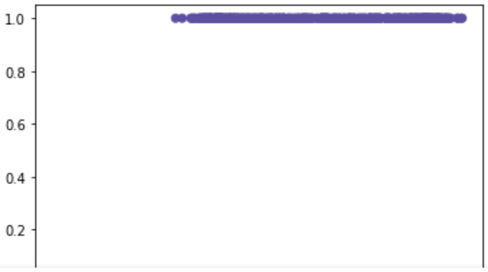
```
model, cv, y_pred, scores = SVM(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Mean Accuracy: 0.880 (0.034)
 Accuracy Score: 0.86
 PPV: 0.87248322147651
 NPV: 0.847682119205298
 specificity: 0.8707482993197279
 sensitivity: 0.8496732026143791
```

```
plotGraph(X,y)
```



```
plt.scatter(X['x1'],y,c=y,cmap='Spectral')
plt.show()
```



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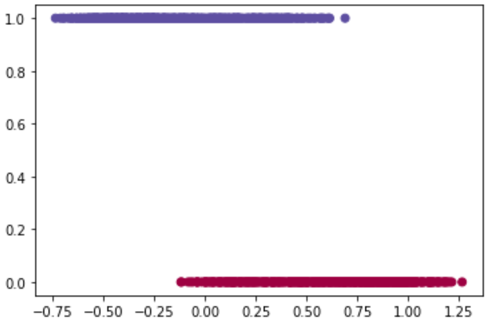
```
plt.scatter(X['x2'],y,c=y,cmap='Spectral')
plt.show()
```



Half Kernel Dataset

```
df = pd.read_csv('/content/sample_data/halfkernel.csv')
df.head()
```

	x1	x2	label
0	-2.93	-9.01	0
1	-9.33	11.40	0
2	-3.36	4.51	0
3	-7.29	10.40	0
4	-9.72	-12.00	0

```
X= df[['x1','x2']]
y=df['label']

x_train, x_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, random_state = 42)
```

```
model, cv, y_pred, scores = LDA(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Mean Accuracy: 0.669 (0.041)
 Accuracy Score: 0.68
 PPV: 0.6956521739130435
 NPV: 0.6666666666666666
 specificity: 0.72
 sensitivity: 0.64
```

```
model, cv, y_pred, scores = QDA(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Mean Accuracy: 0.939 (0.024)
 Accuracy Score: 0.9366666666666666
 PPV: 0.9781021897810219
 NPV: 0.901840490797546
 specificity: 0.98
 sensitivity: 0.8933333333333333
```

```
model, cv, y_pred, scores = NB(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
```

Warning: you are connected to a GPU runtime, but not utilizing the GPU. Change to a standard runtime

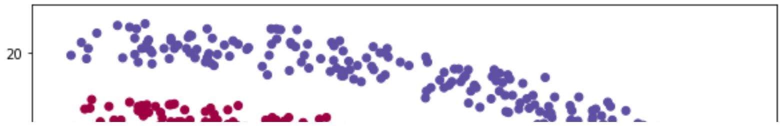
```
.ficity}\n sensitivity: {sensitivity}")
```

```
Naive Bayes score:  0.9533333333333334
Mean Accuracy: 0.941 (0.026)
 Accuracy Score: 0.9533333333333334
 PPV: 0.9927536231884058
 NPV: 0.9197530864197531
 specificity: 0.9933333333333333
 sensitivity: 0.9133333333333333
```

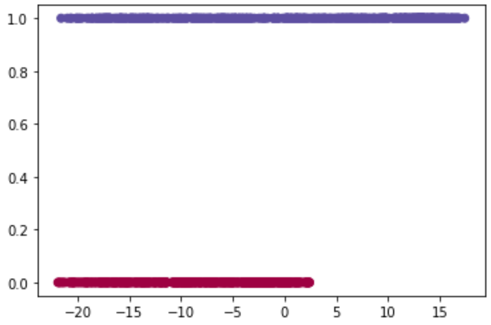
```
model, cv, y_pred, scores = SVM(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Mean Accuracy: 0.732 (0.032)
 Accuracy Score: 0.7466666666666667
 PPV: 0.8363636363636363
 NPV: 0.6947368421052632
 specificity: 0.88
 sensitivity: 0.6133333333333333
```

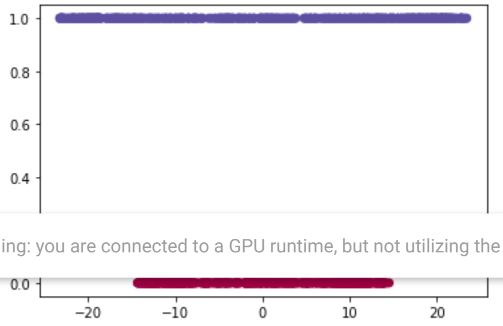
```
plotGraph(X,y)
```



```
plt.scatter(X['x1'],y,c=y,cmap='Spectral')
plt.show()
```



```
plt.scatter(X['x2'],y,c=y,cmap='Spectral')
plt.show()
```



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Two Gaussians

```
df = pd.read_csv('/content/sample_data/twogaussians42.csv')
df.head()
```

	x1	x2	label
0	0.601034	1.535353	1
1	0.755945	-1.172352	0
2	1.354479	-0.948528	0
3	3.103090	0.233485	0
4	0.753178	0.787514	1

```
X= df[['x1','x2']]
y=df['label']

x_train, x_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, random_state = 42)
```

```
model, cv, y_pred, scores = LDA(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Mean Accuracy: 0.899 (0.030)
 Accuracy Score: 0.8866666666666667
 PPV: 0.9407407407407408
 NPV: 0.8424242424242424
 specificity: 0.9455782312925171
 sensitivity: 0.8300653594771242
```

```
model, cv, y_pred, scores = QDA(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

```
Mean Accuracy: 0.948 (0.019)
 Accuracy Score: 0.94
 PPV: 0.972027972027972
 NPV: 0.910828025477707
 specificity: 0.9727891156462585
 sensitivity: 0.9084967320261438
```

```
model, cv, y_pred, scores = NB(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

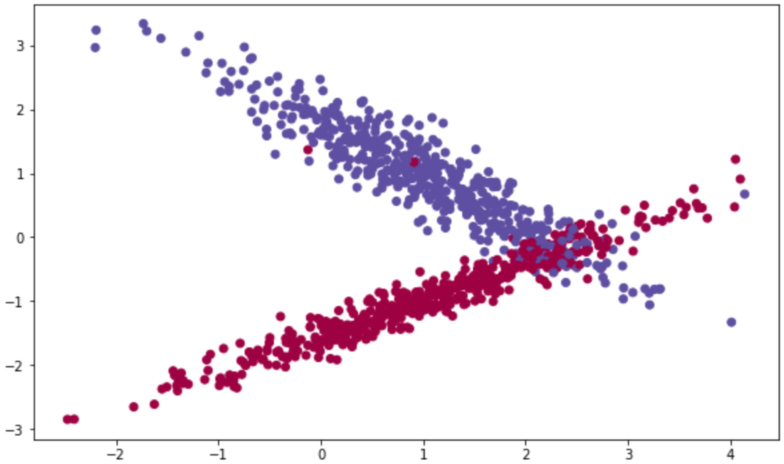
```
Naive Bayes score:  0.8833333333333333
Mean Accuracy: 0.905 (0.029)
 Accuracy Score: 0.8833333333333333
 PPV: 0.927536231884058
 NPV: 0.845679012345679
 specificity: 0.9319727891156463
 sensitivity: 0.8366013071895425
```

```
model, cv, y_pred, scores = SVM(x_train, y_train,x_test)
# summarize result
print('Mean Accuracy: %.3f (%.3f)' % (np.mean(scores), np.std(scores)))
accuracy, ppv,npv,specificity,sensitivity = get_metrics(y_test, y_pred)
print(f" Accuracy Score: {accuracy}\n PPV: {ppv}\n NPV: {npv}\n specificity: {specificity}\n sensitivity: {sensitivity}")
```

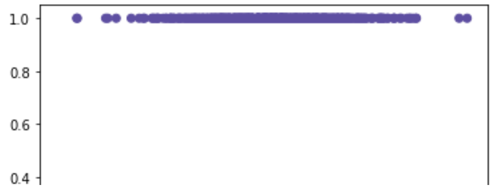
Warning: you are connected to a GPU runtime, but not utilizing the GPU. Change to a standard runtime ✕

```
 PPV: 0.9922480620155039
 NPV: 0.8538011695906432
 specificity: 0.9931972789115646
 sensitivity: 0.8366013071895425
```

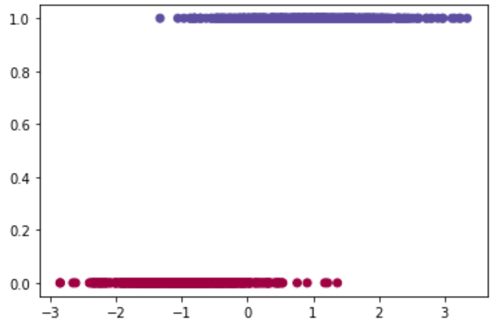
```
plotGraph(X,y)
```



```
plt.scatter(X['x1'],y,c=y,cmap='Spectral')
plt.show()
```



```
plt.scatter(X['x2'],y,c=y,cmap='Spectral')
plt.show()
```



```
# colors = {0:'red', 1:'blue'}
# markers = {0:'x', 1:'o'}


# for class_label in set(y):
#   class_indices = (y == class_label)
#                                                                         rs[class_label], marker=markers[class_label])
```

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✓ 0s completed at 2:00 AM