CO3234 Pattern Recognition Assignment-1

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In [2]:
```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import confusion_matrix

from sklearn.metrics import roc_curve, plot_roc_curve, roc_auc_score
from sklearn.preprocessing import label_binarize
from sklearn.model_selection import train_test_split
```

In [3]:
```
!ls
```
```
BankNote_Authentication.csv  q1.ipynb                t10k-labels.idx1-ubyte
pattern.ipynb                q2.ipynb                train-images.idx3-ubyte
pattern2.ipynb               t10k-images.idx3-ubyte  train-labels.idx1-ubyte
```

Importing Dataset as Dataframe

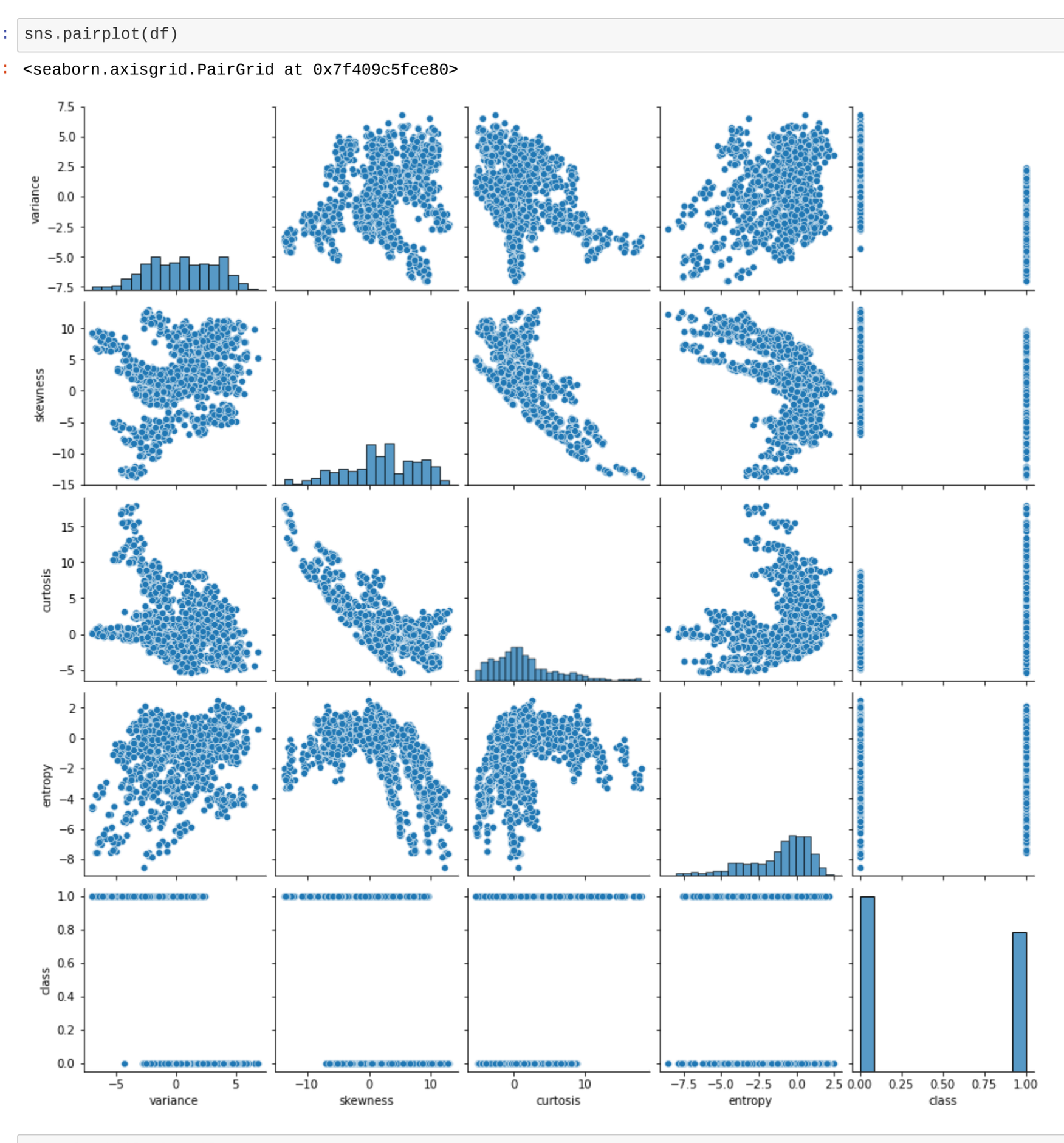
In [4]:
```python
df = pd.read_csv('./BankNote_Authentication.csv')

df
```
Out[4]:

	variance	skewness	curtosis	entropy	class
0	3.62160	8.66610	-2.8073	-0.44699	0
1	4.54590	8.16740	-2.4586	-1.46210	0
2	3.86600	-2.63830	1.9242	0.10645	0
3	3.45660	9.52280	-4.0112	-3.59440	0
4	0.32924	-4.45520	4.5718	-0.98880	0
...	...	...	...	...	...
1367	0.40614	1.34920	-1.4501	-0.55949	1
1368	-1.38870	-4.87730	6.4774	0.34179	1
1369	-3.75030	-13.45860	17.5932	-2.77710	1
1370	-3.56370	-8.38270	12.3930	-1.28230	1
1371	-2.54190	-0.65804	2.6842	1.19520	1

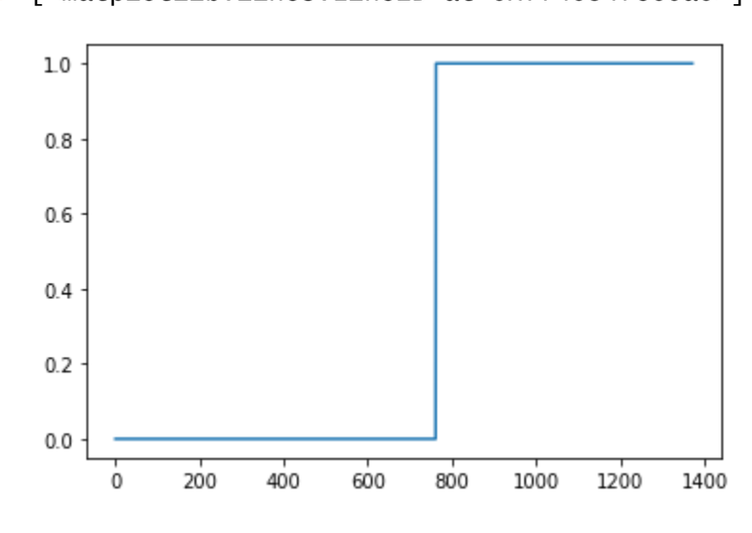
1372 rows × 5 columns

Data Visualization and Exploration

In [5]:
```python
sns.pairplot(df)
```
Out[5]: `<seaborn.axisgrid.PairGrid at 0x7f409c5fce80>`



In [6]:
```python
plt.plot(df['class'])
```
Out[6]: `[<matplotlib.lines.Line2D at 0x7f4054fe60a0>]`



Separating the target variable from the Dataset

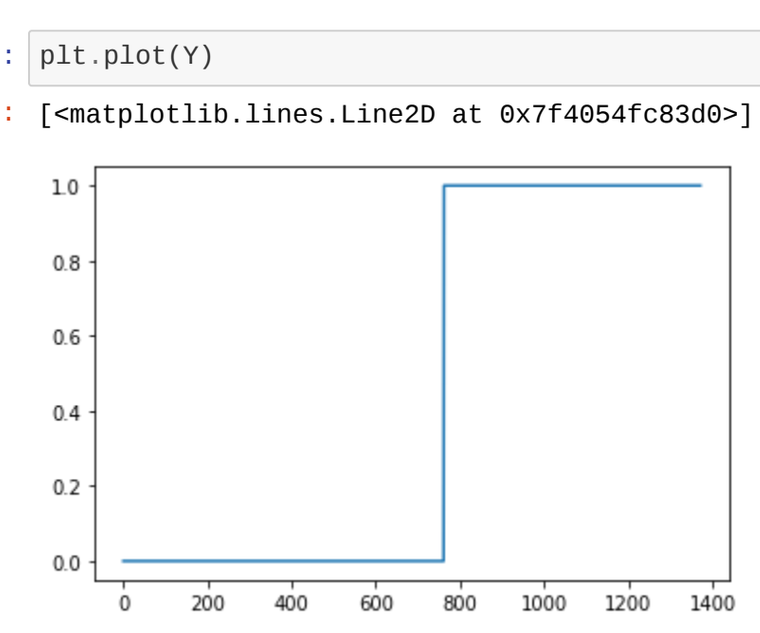
In [7]:
```python
X = df.iloc[:, :4]
X
```
Out[7]:

	variance	skewness	curtosis	entropy
0	3.62160	8.66610	-2.8073	-0.44699
1	4.54590	8.16740	-2.4586	-1.46210
2	3.86600	-2.63830	1.9242	0.10645
3	3.45660	9.52280	-4.0112	-3.59440
4	0.32924	-4.45520	4.5718	-0.98880
...	...	...	...	...
1367	0.40614	1.34920	-1.4501	-0.55949
1368	-1.38870	-4.87730	6.4774	0.34179
1369	-3.75030	-13.45860	17.5932	-2.77710
1370	-3.56370	-8.38270	12.3930	-1.28230
1371	-2.54190	-0.65804	2.6842	1.19520

1372 rows × 4 columns

In [8]:
```python
Y = df.iloc[:,4].values
Y
```
Out[8]: `array([0, 0, 0, ..., 1, 1, 1])`

In [9]:
```python
plt.plot(Y)
```
Out[9]: `[<matplotlib.lines.Line2D at 0x7f4054fc83d0>]`



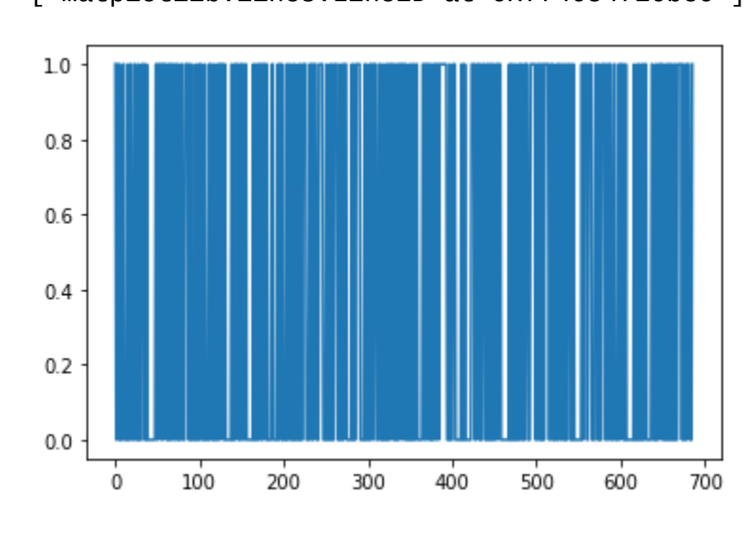
Prior Probability of both classes

In [10]:
```python
unique, counts = np.unique(df['class'], return_counts=True)
counts

print(f"Dataset:\nPrior Probability of Genuine Class is : {counts[0]/1372}\nPrior Probability of Forged Class is :
 {counts[1]/1372}")
```
```
Dataset:
Prior Probability of Genuine Class is : 0.5553935860058309
Prior Probability of Forged Class is : 0.4446064139941691
```

Test-Train Splitting

In [11]:
```python
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.5, random_state=40)
```

In [12]:
```python
plt.plot(y_train)
```
Out[12]: `[<matplotlib.lines.Line2D at 0x7f4054f20be0>]`



In [13]:
```python
unique, counts = np.unique(y_test, return_counts=True)
counts

print(f"After Splitting:\nPrior Probability of Genuine Class is : {counts[0]*2/1372}\nPrior Probability of Forged Cl
ass is : {counts[1]*2/1372}")
```
```
After Splitting:
Prior Probability of Genuine Class is : 0.5568513119533528
Prior Probability of Forged Class is : 0.44314868804664725
```

Building the classifier

In [14]:
```python
model = GaussianNB()
```

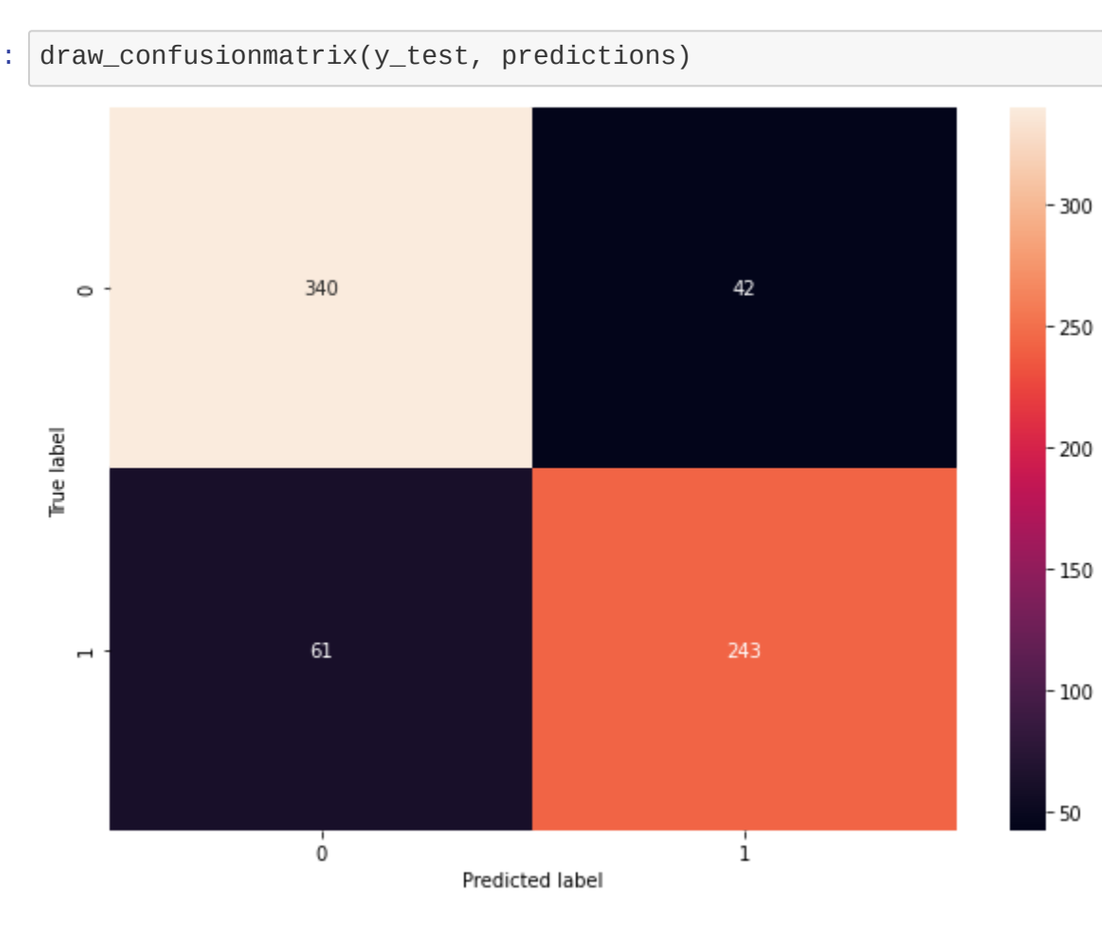
In [15]:
```python
fit = model.fit(X_train, y_train)
```

In [16]:
```python
predictions = fit.predict(X_test)
con_matrix = confusion_matrix(y_test, predictions)

print(con_matrix)
```
```
[[340  42]
 [ 61 243]]
```

In [17]:
```python
def draw_confusionmatrix(ytest, yhat):
    plt.figure(figsize=(10,7))
    cm = confusion_matrix(ytest, yhat)
    ax = sns.heatmap(cm, annot=True, fmt="d")
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
```

Confusion Matrix

In [18]:
```python
draw_confusionmatrix(y_test, predictions)
```



In [19]:
```python
def diag_sum(conmat):
    sum =0
    for i in range(len(conmat)):
        for j in range(len(conmat[0])):
            if i == j:
                sum += conmat[i,j]
    return sum
```

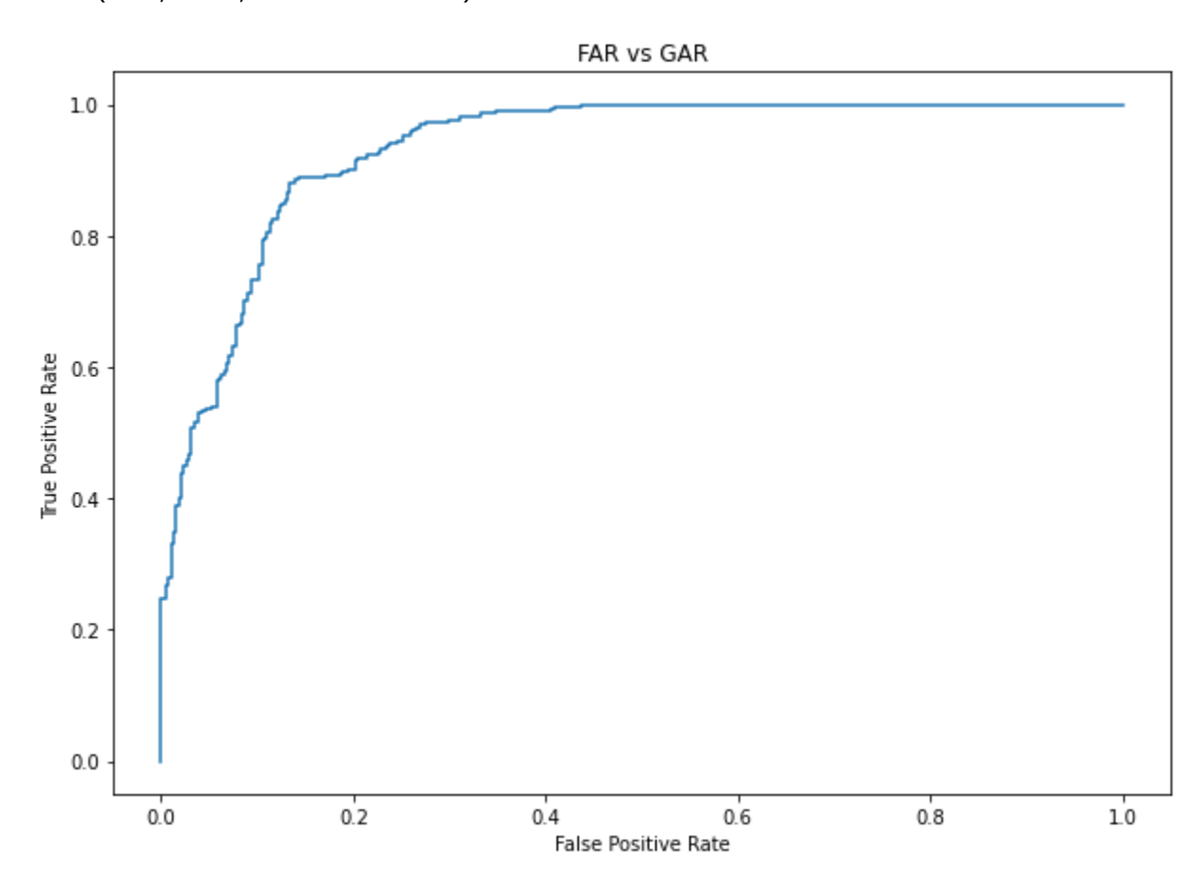
Accuracy

In [20]:
```python
accurate = diag_sum(con_matrix)
total = np.sum(con_matrix)
acc = accurate/total
print(f"accuracy = {accurate}/{total} = {acc*100}%")
```
```
accuracy = 583/686 = 84.98542274052478%
```

In [21]:
```python
probs = fit.predict_proba(X_test)
preds = probs[:,1]


fpr, tpr, threshold = roc_curve(y_test, preds)
```

ROC Curve

In [24]:
```python
plt.figure(figsize=(10,7))
plt.plot(fpr,tpr)
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.title('FAR vs GAR')
```
Out[24]: `Text(0.5, 1.0, 'FAR vs GAR')`



In [23]:
```python
auc = roc_auc_score(y_test, preds)
print(f"AUC: {auc*100}%")
```
```
AUC: 93.26346789749242%
```

Splitting the data such that 90% is genuine (class 0) and 10% is forged (class 1)

In [26]:
```python
df
```
Out[26]:

	variance	skewness	curtosis	entropy	class
0	3.62160	8.66610	-2.8073	-0.44699	0
1	4.54590	8.16740	-2.4586	-1.46210	0
2	3.86600	-2.63830	1.9242	0.10645	0
3	3.45660	9.52280	-4.0112	-3.59440	0
4	0.32924	-4.45520	4.5718	-0.98880	0
...	...	...	...	...	...
1367	0.40614	1.34920	-1.4501	-0.55949	1
1368	-1.38870	-4.87730	6.4774	0.34179	1
1369	-3.75030	-13.45860	17.5932	-2.77710	1
1370	-3.56370	-8.38270	12.3930	-1.28230	1
1371	-2.54190	-0.65804	2.6842	1.19520	1

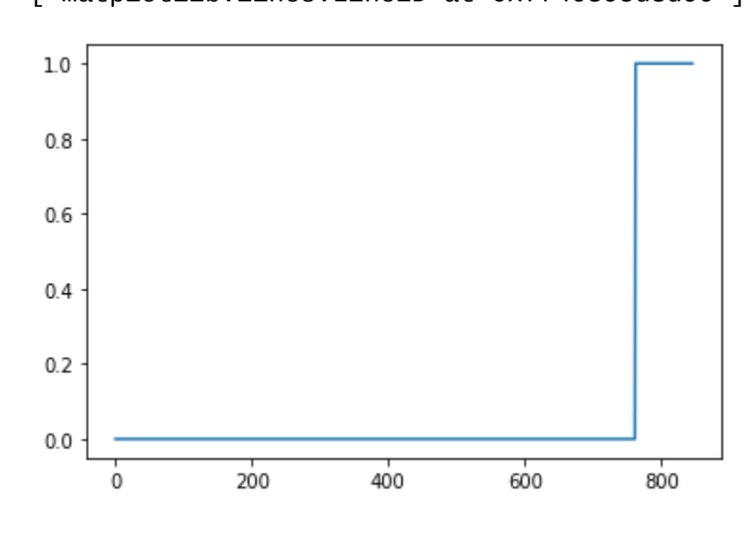
1372 rows × 5 columns

In [29]:
```python
uniques, counts = np.unique(df['class'], return_counts=True)

counts
```
Out[29]: `array([762, 610])`

In [34]:
```python
df = df[:846]
```

In [37]:
```python
uniques, counts = np.unique(df['class'], return_counts=True)

ratio = counts[0]/np.sum(counts)

print(f"After Redistribution\nPrior Probability of Genuine class = {ratio}\nPrior Probability of Forged Class = {1-r
atio}")
```
```
After Redistribution
Prior Probability of Genuine class = 0.900709219858156
Prior Probability of Forged Class = 0.099290780141844
```

In [39]:
```python
plt.plot(df['class'])
```
Out[39]: `[<matplotlib.lines.Line2D at 0x7f40395d3d90>]`



Data Splitting

In [40]:
```python
X = df.iloc[:, :4]
X
```
Out[40]:

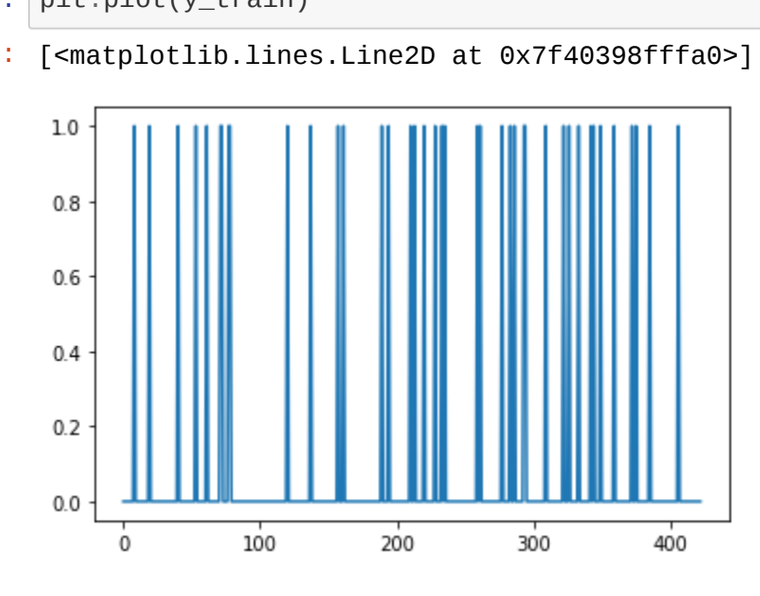
	variance	skewness	curtosis	entropy
0	3.621600	8.66610	-2.80730	-0.44699
1	4.545900	8.16740	-2.45860	-1.46210
2	3.866000	-2.63830	1.92420	0.10645
3	3.456600	9.52280	-4.01120	-3.59440
4	0.329240	-4.45520	4.57180	-0.98880
...	...	...	...	...
841	-3.885800	-12.84610	12.79570	-3.13530
842	-1.896900	-6.78930	5.27610	-0.32544
843	-0.526450	-0.24832	-0.45613	0.41938
844	0.009661	3.56120	-4.40700	-4.41030
845	-3.882600	4.89800	-0.92311	-5.08010

846 rows × 4 columns

In [43]:
```python
Y = df.iloc[:,4].values
Y
```
Out[43]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1])
```

In [44]:
```python
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.5, random_state=40)
```

In [45]:
```python
plt.plot(y_train)
```
Out[45]: `[<matplotlib.lines.Line2D at 0x7f40398fffa0>]`



Building the bayes classifier

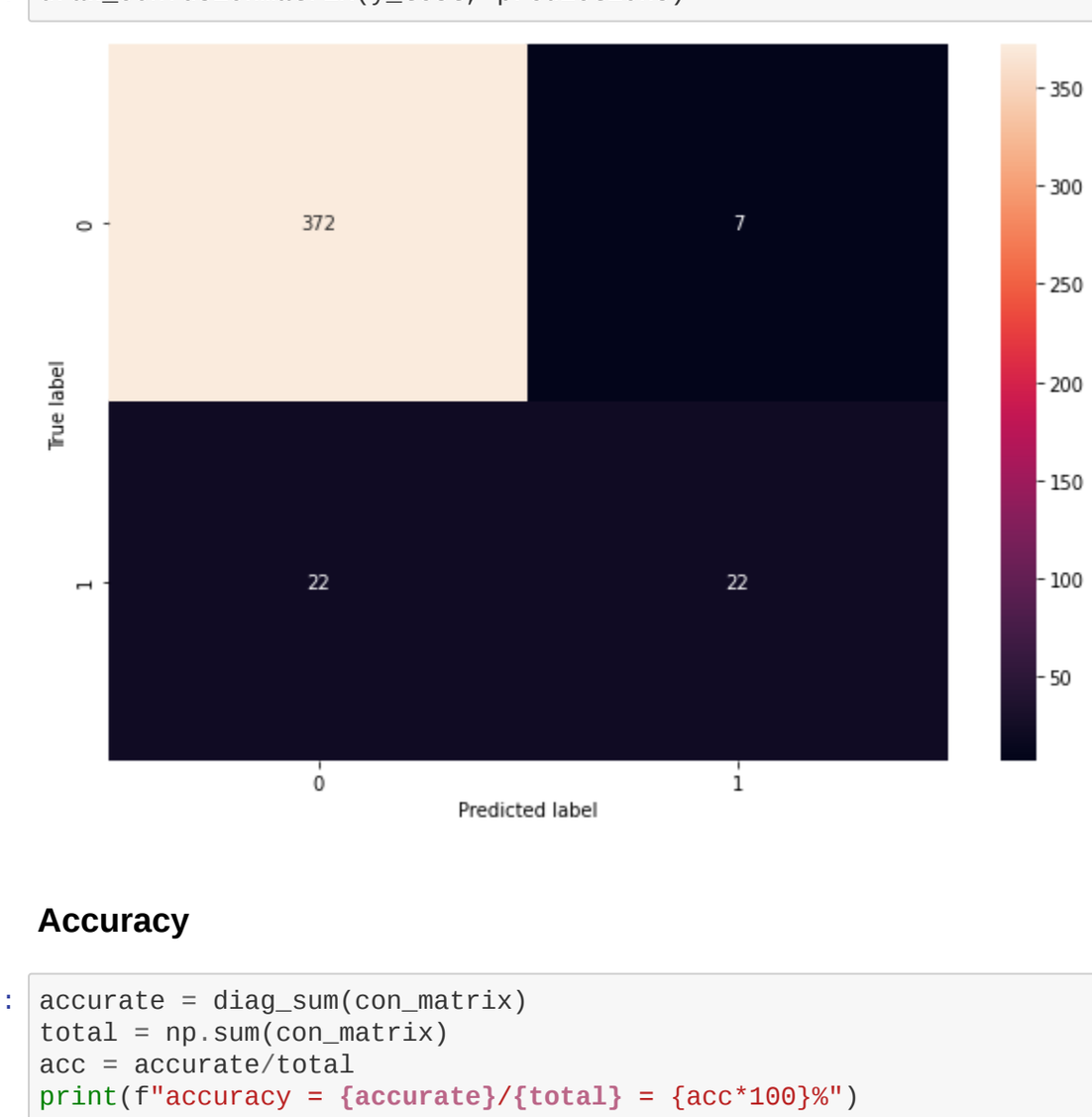
In [47]:
```python
model = GaussianNB()
```

In [48]:
```python
fit = model.fit(X_train, y_train)
```

In [49]:
```python
predictions = fit.predict(X_test)
con_matrix = confusion_matrix(y_test, predictions)

print(con_matrix)
```
```
[[372   7]
 [ 22  22]]
```

Confusion Matrix

In [50]:
```python
draw_confusionmatrix(y_test, predictions)
```



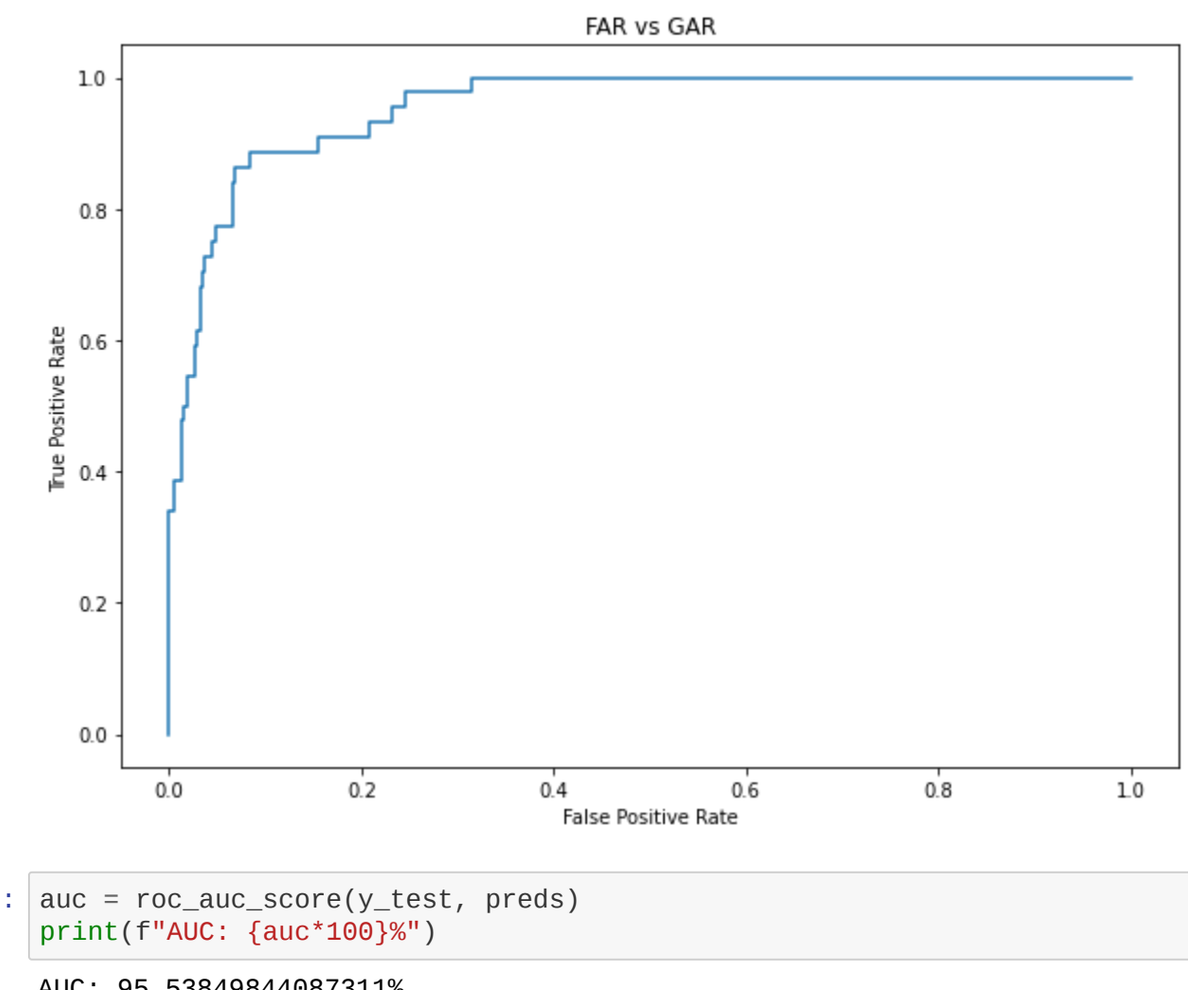
Accuracy

In [51]:
```python
accurate = diag_sum(con_matrix)
total = np.sum(con_matrix)
acc = accurate/total
print(f"accuracy = {accurate}/{total} = {acc*100}%")
```
```
accuracy = 394/423 = 93.14420803782507%
```

In [52]:
```python
probs = fit.predict_proba(X_test)
preds = probs[:,1]


fpr, tpr, threshold = roc_curve(y_test, preds)
```

ROC Curve

In [53]:
```python
plt.figure(figsize=(10,7))
plt.plot(fpr,tpr)
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.title('FAR vs GAR')
```
Out[53]: `Text(0.5, 1.0, 'FAR vs GAR')`



In [54]:
```python
auc = roc_auc_score(y_test, preds)
print(f"AUC: {auc*100}%")
```
```
AUC: 95.53849844087311%
```

In [ ]: