In [1]:

```
# Mounting colab at drive
from google.colab import drive
drive.mount('/content/gdrive')
```

```
Mounted at /content/gdrive
```

In [2]:

```
!unzip 'gdrive/MyDrive/Twitter Sentiment Analysis/archive.zip'
```

```
Archive:  gdrive/MyDrive/Twitter Sentiment Analysis/archive.zip
  inflating: sentiment_tweets3.csv
```

In [3]:

```
# Importing Libraries
import numpy as np
import pandas as pd
```

In [4]:

```
# Importing dataset
df = pd.read_csv('sentiment_tweets3.csv')
```

In [5]:

```
df.head(15)
```

Out[5]:

	Index	message to examine	label (depression result)
0	106	just had a real good moment. i missssssssss hi...	0
1	217	is reading manga http://plurk.com/p/mzp1e	0
2	220	@comeagainjen http://twitpic.com/2y2lx - http:...	0
3	288	@lapcat Need to send 'em to my accountant tomo...	0
4	540	ADD ME ON MYSPACE!!! myspace.com/LookThunder	0
5	624	so sleepy. good times tonight though	0
6	701	@SilkCharm re: #nbn as someone already said, d...	0
7	808	23 or 24ï¿½C possible today. Nice	0
8	1193	nite twitterville workout in the am -ciao	0
9	1324	@daNanner Night, darlin'! Sweet dreams to you	0
10	1332	Good morning everybody!	0
11	1368	Finally! I just created my WordPress Blog. The...	0
12	1578	kisha they cnt get over u til they get out frm...	0
13	1595	@nicolerichie Yes i remember that band, It was...	0
14	1861	I really love reflections and shadows	0

In [6]:

```
# Getting shape of dataset: (rows x columns)
df.shape
```

Out[6]:

```
(10314, 3)
```

In [7]:

```
# Dropping Unwanted columns
df = df.drop('Index', axis = 1)
```

In [8]:

```
# New shape of dataset
df.shape
```

Out[8]:

```
(10314, 2)
```

In [9]:

```
# Changing column name
df.columns = ['Tweets', 'Polarity']
df.head(15)
```

Out[9]:

	Tweets	Polarity
0	just had a real good moment. i missssssssss hi...	0
1	is reading manga http://plurk.com/p/mzp1e	0
2	@comeagainjen http://twitpic.com/2y2lx - http:...	0
3	@lapcat Need to send 'em to my accountant tomo...	0
4	ADD ME ON MYSPACE!!! myspace.com/LookThunder	0
5	so sleepy. good times tonight though	0
6	@SilkCharm re: #nbn as someone already said, d...	0
7	23 or 24ï¿½C possible today. Nice	0
8	nite twitterville workout in the am -ciao	0
9	@daNanner Night, darlin'! Sweet dreams to you	0
10	Good morning everybody!	0
11	Finally! I just created my WordPress Blog. The...	0
12	kisha they cnt get over u til they get out frm...	0
13	@nicolerichie Yes i remember that band, It was...	0
14	I really love reflections and shadows	0

In [10]:

```
# Checking for missing values
df.isna().sum()
```

Out[10]:

```
Tweets      0
Polarity    0
dtype: int64
```

In [11]:

```
# We see that there are no missing values thus we carry on with the preprocessing

# Preprocess data
import re
import nltk
from nltk.corpus import stopwords
from wordcloud import WordCloud, STOPWORDS
import spacy

nltk.download('stopwords')
```

```
# Convert Text to lower case
df['Tweets'] = df['Tweets'].str.strip().str.lower()

# Initialize Spacy 'en' model
nlp = spacy.load('en', disable = ['parser', 'ner'])

# Remove usernames and links
def remove_usernames_links(tweet):
    tweet = re.sub('@[^\s]+','',tweet)
    tweet = re.sub('http[^\s]+','',tweet)
    return tweet

df['Tweets'] = df['Tweets'].apply(remove_usernames_links)

# Remove punctuations
def remove_punctuation(tweet):
  tweet = re.sub('[^\w\s]', '', tweet)
  return tweet

df['Tweets'] = df['Tweets'].apply(remove_punctuation)

# Remove Stopwords
stop = stopwords.words('english')
df['Tweets'] = df['Tweets'].apply(lambda x: " ".join(x for x in x.split(' ') if x not in
stop))

# Lemmatization
def space(comment):
  doc = nlp(comment)
  return " ".join([token.lemma_ for token in doc])

df['Tweets'] = df['Tweets'].apply(space)

df.head(15)
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
```

Out[11]:

	Tweets	Polarity
0	real good moment missssssssss much	0
1	read manga	0
2		0
3	need send -PRON- accountant tomorrow oddly b...	0
4	add myspace myspacecomlookthunder	0
5	sleepy good time tonight though	0
6	nbn someone already say fiber home mean leas...	0
7	23 24ï½c possible today nice	0
8	nite twitterville workout ciao	0
9	night darlin sweet dream	0
10	good morning everybody	0
11	finally create wordpress blog there s already ...	0
12	kisha cnt get u til get frm u remember ur top	0
13	yes remember band awesome please reply	0
14	really love reflection shadow	0

In [12]:

```
# Outputting last 15 rows with df.tail()
```

```
df.tail(15)
```

Out[12]:

	Tweets	Polarity
10299	engage physical activity decrease people chanc...	1
10300	depression -PRON- be always u darling	1
10301	-PRON- be suffer depression -PRON- be thankful...	1
10302	one 20 us child teen anxiety depression	1
10303	-PRON- be go see next week chicago -PRON- be...	1
10304	reagan bush 43 trump gop use maga slogan r...	1
10305	rt depression could improve vitamin deficiency...	1
10306	actor symptom adult depression naked gteen por...	1
10307	bharatu may book court law provoke s...	1
10308	many sufferer depression be not sad feel nothi...	1
10309	depression g herbo mood -PRON- be do stress pe...	1
10310	depression succumb brain make feel like -PRON-...	1
10311	ketamine nasal spray show promise depression s...	1
10312	do not mistake bad day depression everyone -PRON-	1
10313	0	1

In [13]:

```
# Again checking for invalid rows
(df['Tweets'] == '').sum()
```

Out[13]:

```
25
```

In [14]:

```
df.shape
```

Out[14]:

```
(10314, 2)
```

In [15]:

```
# Checking for rows containing just numbers
def remove_numbers(tweet):
  if tweet.isdigit():
    tweet = ''

  return tweet

df['Tweets'] = df['Tweets'].apply(remove_numbers)

(df['Tweets'] == '').sum()
```

Out[15]:

```
31
```

In [16]:

```
# Thus we see that we have 25 null strings + 6 more that had rows with just numbers and h
ence we must drop them
# This will change the shape of our dataset to (10283, 2)

# Dropping empty strings
```

```
nan_value = float("NaN")
df. replace('', nan_value, inplace=True)
df = df.dropna(axis = 0)
df.shape
```

Out[16]:

```
(10283, 2)
```

In [17]:

```
# Split into training and testing dataset
from sklearn.model_selection import train_test_split

x = df['Tweets']
y = df['Polarity']

X_train, X_test, Y_train, Y_test = train_test_split(x, y, stratify = y, test_size = 0.2,
random_state = 42, shuffle = True)
```

In [18]:

```
print('Xtrain: ', X_train.shape, 'Ytrain: ', Y_train.shape)
print('Xtest: ', X_test.shape, 'Ytest: ', Y_test.shape)
```

```
Xtrain:  (8226,) Ytrain:  (8226,)
Xtest:  (2057,) Ytest:  (2057,)
```

In [20]:

```
print(Y_train.value_counts())
print(Y_test.value_counts())
```

```
0    6380
1    1846
Name: Polarity, dtype: int64
0    1595
1     462
Name: Polarity, dtype: int64
```

In [21]:

```
from sklearn.feature_extraction.text import CountVectorizer

# Vectorize text reviews to encoded numbers
vector = CountVectorizer(stop_words = 'english')
X_train = vector.fit_transform(X_train).toarray()
X_test = vector.transform(X_test).toarray()
```

In [22]:

```
# Model Generation

# Multinomial NB
from sklearn.naive_bayes import MultinomialNB
model1 = MultinomialNB()
model1.fit(X_train, Y_train)
```

Out[22]:

```
MultinomialNB()
```

In [23]:

```
# Evaluating Training score
model1.score(X_train, Y_train)
```

Out[23]:

```
0.9912472647702407
```

In [24]:

```
# Function to generate metrics
def metrics(labels, predictions):
    true_pos, true_neg, false_pos, false_neg = 0, 0, 0, 0
    for i in range(len(labels)):
        true_pos += int(labels.iloc[i] == 1 and predictions[i] == 1)
        true_neg += int(labels.iloc[i] == 0 and predictions[i] == 0)
        false_pos += int(labels.iloc[i] == 0 and predictions[i] == 1)
        false_neg += int(labels.iloc[i] == 1 and predictions[i] == 0)
    precision = true_pos / (true_pos + false_pos)
    recall = true_pos / (true_pos + false_neg)
    Fscore = 2 * precision * recall / (precision + recall)
    accuracy = (true_pos + true_neg) / (true_pos + true_neg + false_pos + false_neg)
    return true_pos, true_neg, false_pos, false_neg, accuracy, precision, recall, Fscore
```

In [25]:

```
# Testing our own calculations
predictions1 = model1.predict(X_test)
true_pos1, true_neg1, false_pos1, false_neg1, a1, p1, r1, f1 = metrics(Y_test, predictio
ns1)

print("Accuracy: ", a1)
print("Precision: ", p1)
print("Recall: ", r1)
print("F-score: ", f1)
```

```
Accuracy:  0.9795819154107924
Precision:  0.9356846473029046
Recall:  0.9761904761904762
F-score:  0.9555084745762712
```

In [33]:

```
# Print Confusion Matrix
matrix1 = np.zeros((2, 2))
matrix1[0, 0] = int(true_neg1)
matrix1[0, 1] = int(false_pos1)
matrix1[1, 0] = int(false_neg1)
matrix1[1, 1] = int(true_pos1)

print(matrix1)
```

```
[[1564.   31.]
 [  11.  451.]]
```

In [34]:

```
# Pitting our values against sklearn values
from sklearn.metrics import confusion_matrix, accuracy_score, recall_score, precision_sco
re, f1_score

check_matrix1 = confusion_matrix(Y_test, predictions1)
cm1 = pd.DataFrame(check_matrix1, index=['0', '1'], columns=['0', '1'])
print(cm1)
```

```
      0    1
0  1564   31
1    11  451
```

In [35]:

```
chk_acc1 = accuracy_score(Y_test, predictions1)
chk_prc1 = precision_score(Y_test, predictions1)
chk_rec1 = recall_score(Y_test, predictions1)
chk_f1 = f1_score(Y_test, predictions1)

print("Sklearn Accuracy: ", chk_acc1)
print("Sklearn Precision: ", chk_prc1)
print("Sklearn Recall: ", chk_rec1)
print("Sklearn F-score: ", chk_f1)
```

```
Sklearn Accuracy:  0.9795819154107924
```

```
Sklearn Precision:  0.9356846473029046
Sklearn Recall:  0.9761904761904762
Sklearn F-score:  0.9555084745762712
```

In [36]:

```
# Evaluating Testing score as output by sklearn
model1.score(X_test, Y_test)
```

Out[36]:

```
0.9795819154107924
```

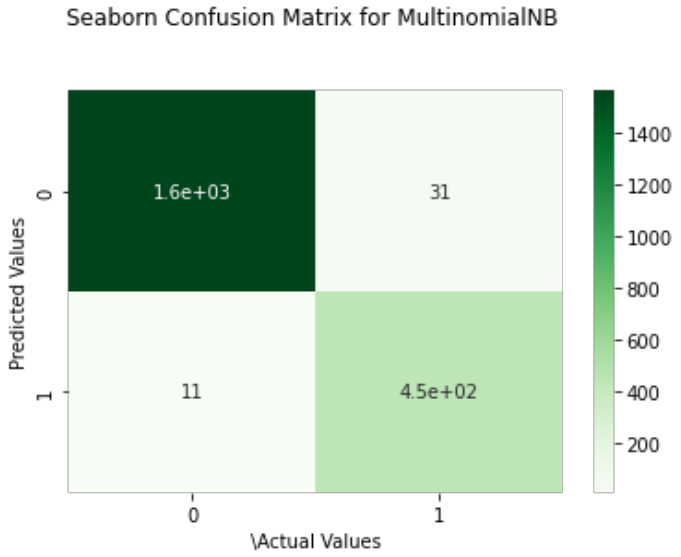
In [42]:

```
# Creating heatmap of confusion matrix
import seaborn as sns
import matplotlib.pyplot as plt

ax1 = sns.heatmap(check_matrix1, annot = True, cmap = 'Greens')
ax1.set_title('Seaborn Confusion Matrix for MultinomialNB \n\n')
ax1.set_xlabel('\Actual Values')
ax1.set_ylabel('Predicted Values')

ax1.set_xticklabels(['0', '1'])
ax1.set_yticklabels(['0', '1'])

plt.show()
```



In [43]:

```
# Gaussian NB
from sklearn.naive_bayes import GaussianNB
model2 = GaussianNB()
model2.fit(X_train, Y_train)
```

Out[43]:

```
GaussianNB()
```

In [44]:

```
# Evaluating Training score
model2.score(X_train, Y_train)
```

Out[44]:

```
0.8334548991004134
```

In [45]:

```
# Testing our own calculations
predictions2 = model2.predict(X_test)
```

```
true_pos2, true_neg2, false_pos2, false_neg2, a2, p2, r2, f2 = metrics(Y_test, predictio
ns2)

print("Accuracy: ", a2)
print("Precision: ", p2)
print("Recall: ", r2)
print("F-score: ", f2)
```

```
Accuracy:  0.6140009722897424
Precision:  0.3628099173553719
Recall:  0.9502164502164502
F-score:  0.5251196172248803
```

In [46]:

```
# Print Confusion Matrix
matrix2 = np.zeros((2, 2))
matrix2[0, 0] = int(true_neg2)
matrix2[0, 1] = int(false_pos2)
matrix2[1, 0] = int(false_neg2)
matrix2[1, 1] = int(true_pos2)

print(matrix2)
```

```
[[824. 771.]
 [ 23. 439.]]
```

In [47]:

```
# Pitting our values against sklearn values
check_matrix2 = confusion_matrix(Y_test, predictions2)
cm2 = pd.DataFrame(check_matrix2, index=['0', '1'], columns=['0', '1'])
print(cm2)
```

```
     0    1
0  824  771
1   23  439
```

In [48]:

```
chk_acc2 = accuracy_score(Y_test, predictions2)
chk_prc2 = precision_score(Y_test, predictions2)
chk_rec2 = recall_score(Y_test, predictions2)
chk_f2 = f1_score(Y_test, predictions2)

print("Sklearn Accuracy: ", chk_acc2)
print("Sklearn Precision: ", chk_prc2)
print("Sklearn Recall: ", chk_rec2)
print("Sklearn F-score: ", chk_f2)
```

```
Sklearn Accuracy:  0.6140009722897424
Sklearn Precision:  0.3628099173553719
Sklearn Recall:  0.9502164502164502
Sklearn F-score:  0.5251196172248803
```

In [49]:

```
# Evaluating Testing score
model2.score(X_test, Y_test)
```

Out[49]:

```
0.6140009722897424
```

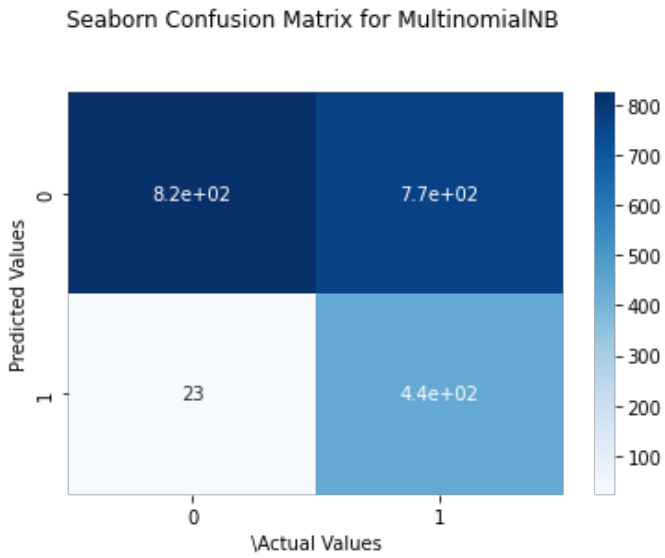
In [50]:

```
ax2 = sns.heatmap(check_matrix2, annot = True, cmap = 'Blues')
ax2.set_title('Seaborn Confusion Matrix for MultinomialNB \n\n')
ax2.set_xlabel('\Actual Values')
ax2.set_ylabel('Predicted Values')

ax2.set_xticklabels(['0', '1'])
```

```
ax2.set_yticklabels(['0', '1'])

plt.show()
```



In [51]:

```
# Complement NB
from sklearn.naive_bayes import ComplementNB
model3 = ComplementNB()
model3.fit(X_train, Y_train)
```

Out[51]:

```
ComplementNB()
```

In [52]:

```
# Evaluating Training score
model3.score(X_train, Y_train)
```

Out[52]:

```
0.973741794310722
```

In [53]:

```
# Testing our own calculations
predictions3 = model3.predict(X_test)
true_pos3, true_neg3, false_pos3, false_neg3, a3, p3, r3, f3 = metrics(Y_test, predictio
ns3)

print("Accuracy: ", a3)
print("Precision: ", p3)
print("Recall: ", r3)
print("F-score: ", f3)
```

```
Accuracy:  0.9470102090422946
Precision:  0.818018018018018
Recall:  0.9826839826839827
F-score:  0.8928220255653884
```

In [54]:

```
# Print Confusion Matrix
matrix3 = np.zeros((2, 2))
matrix3[0, 0] = int(true_neg3)
matrix3[0, 1] = int(false_pos3)
matrix3[1, 0] = int(false_neg3)
matrix3[1, 1] = int(true_pos3)

print(matrix3)
```

```
[[1494.  101.]
 [   8.  454.]]
```

In [55]:

```
# Pitting our values against sklearn values
check_matrix3 = confusion_matrix(Y_test, predictions3)
cm3 = pd.DataFrame(check_matrix3, index=['0', '1'], columns=['0', '1'])
print(cm3)
```

```
      0    1
0  1494  101
1     8  454
```

In [56]:

```
chk_acc3 = accuracy_score(Y_test, predictions3)
chk_prc3 = precision_score(Y_test, predictions3)
chk_rec3 = recall_score(Y_test, predictions3)
chk_f3 = f1_score(Y_test, predictions3)

print("Sklearn Accuracy: ", chk_acc3)
print("Sklearn Precision: ", chk_prc3)
print("Sklearn Recall: ", chk_rec3)
print("Sklearn F-score: ", chk_f3)
```

```
Sklearn Accuracy:  0.9470102090422946
Sklearn Precision:  0.818018018018018
Sklearn Recall:  0.9826839826839827
Sklearn F-score:  0.8928220255653884
```

In [57]:

```
# Evaluating Testing score
model3.score(X_test, Y_test)
```

Out[57]:

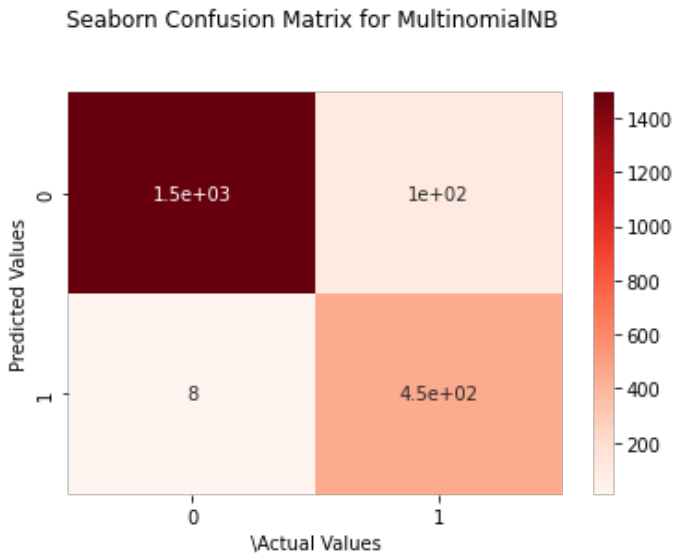
```
0.9470102090422946
```

In [58]:

```
ax3 = sns.heatmap(check_matrix3, annot = True, cmap = 'Reds')
ax3.set_title('Seaborn Confusion Matrix for MultinomialNB \n\n')
ax3.set_xlabel('\Actual Values')
ax3.set_ylabel('Predicted Values')

ax3.set_xticklabels(['0', '1'])
ax3.set_yticklabels(['0', '1'])

plt.show()
```



In [59]:

```
# Bernoulli NB
from sklearn.naive_bayes import BernoulliNB
model4 = BernoulliNB()
model4.fit(X_train, Y_train)
```

Out[59]:

```
BernoulliNB()
```

In [60]:

```
# Evaluating Training score
model4.score(X_train, Y_train)
```

Out[60]:

```
0.987478725990761
```

In [61]:

```
# Testing our own calculations
predictions4 = model4.predict(X_test)
true_pos4, true_neg4, false_pos4, false_neg4, a4, p4, r4, f4 = metrics(Y_test, predictio
ns4)

print("Accuracy: ", a4)
print("Precision: ", p4)
print("Recall: ", r4)
print("F-score: ", f4)
```

```
Accuracy:  0.9708313077297035
Precision:  1.0
Recall:  0.8701298701298701
F-score:  0.9305555555555556
```

In [62]:

```
# Print Confusion Matrix
matrix4 = np.zeros((2, 2))
matrix4[0, 0] = int(true_neg4)
matrix4[0, 1] = int(false_pos4)
matrix4[1, 0] = int(false_neg4)
matrix4[1, 1] = int(true_pos4)

print(matrix4)
```

```
[[1595.    0.]
 [  60.  402.]]
```

In [63]:

```
# Pitting our values against sklearn values
check_matrix4 = confusion_matrix(Y_test, predictions4)
cm4 = pd.DataFrame(check_matrix4, index=['0', '1'], columns=['0', '1'])
print(cm4)
```

```
      0    1
0  1595    0
1    60  402
```

In [64]:

```
chk_acc4 = accuracy_score(Y_test, predictions4)
chk_prc4 = precision_score(Y_test, predictions4)
chk_rec4 = recall_score(Y_test, predictions4)
chk_f4 = f1_score(Y_test, predictions4)

print("Sklearn Accuracy: ", chk_acc4)
print("Sklearn Precision: ", chk_prc4)
print("Sklearn Recall: ", chk_rec4)
print("Sklearn F-score: ", chk_f4)
```

```
Sklearn Accuracy:  0.9708313077297035
```

```
Sklearn Precision:  1.0
Sklearn Recall:  0.8701298701298701
Sklearn F-score:  0.9305555555555556
```

In [65]:

```
# Evaluating Testing score
model4.score(X_test, Y_test)
```

Out[65]:

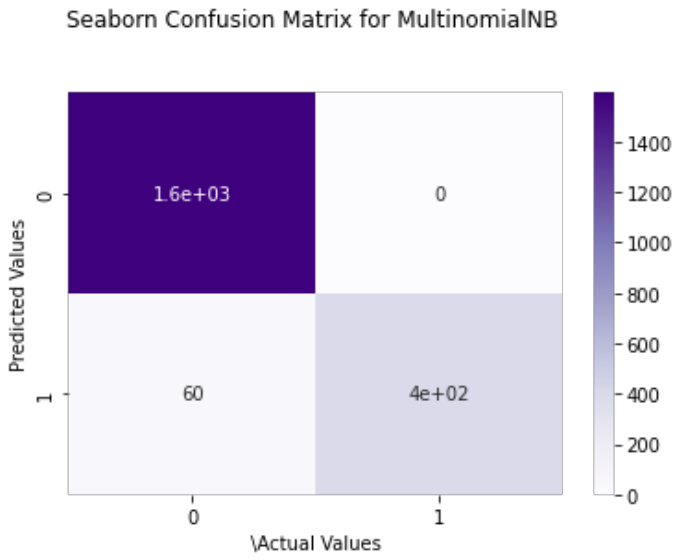
```
0.9708313077297035
```

In [67]:

```
ax4 = sns.heatmap(check_matrix4, annot = True, cmap = 'Purples')
ax4.set_title('Seaborn Confusion Matrix for MultinomialNB \n\n')
ax4.set_xlabel('\Actual Values')
ax4.set_ylabel('Predicted Values')

ax4.set_xticklabels(['0', '1'])
ax4.set_yticklabels(['0', '1'])

plt.show()
```



In [74]:

```
# Let us try to get some assumptions for each model and see
tweet1 = 'I am sad'
tweet2 = 'Today was the best day ever'
tweet3 = 'Everything will be okay'
tweet4 = 'Hello. I am amazing'
tweet5 = 'Is it sad that I am all alone'
tweet6 = 'That is sad but I am happy'
```

In [78]:

```
# Model 1 predictions
p1 = model1.predict(vector.transform([tweet1, tweet2, tweet3, tweet4, tweet5, tweet6]))

print(p1)
print()
for index, i in enumerate(p1):
  if i == 0:
    print('Tweeter ' + str(index + 1) + ' is not depressed')
  else:
    print('Tweeter ' + str(index + 1) + ' is depressed')
```

```
[1 0 0 0 1 0]

Tweeter 1 is depressed
Tweeter 2 is not depressed
Tweeter 3 is not depressed
```

```
Tweeter 4 is not depressed
Tweeter 5 is depressed
Tweeter 6 is not depressed
```

In [80]:

```
# Model 2 predictions
p2 = model2.predict(vector.transform([tweet1, tweet2, tweet3, tweet4, tweet5, tweet6]).t
oarray())

print(p2)
print()
for index, i in enumerate(p2):
  if i == 0:
    print('Tweeter ' + str(index + 1) + ' is not depressed')
  else:
    print('Tweeter ' + str(index + 1) + ' is depressed')
```

```
[1 1 1 1 1 1]

Tweeter 1 is depressed
Tweeter 2 is depressed
Tweeter 3 is depressed
Tweeter 4 is depressed
Tweeter 5 is depressed
Tweeter 6 is depressed
```

In [81]:

```
# Model 3 predictions
p3 = model3.predict(vector.transform([tweet1, tweet2, tweet3, tweet4, tweet5, tweet6]))

print(p3)
print()
for index, i in enumerate(p3):
  if i == 0:
    print('Tweeter ' + str(index + 1) + ' is not depressed')
  else:
    print('Tweeter ' + str(index + 1) + ' is depressed')
```

```
[1 0 0 0 1 1]

Tweeter 1 is depressed
Tweeter 2 is not depressed
Tweeter 3 is not depressed
Tweeter 4 is not depressed
Tweeter 5 is depressed
Tweeter 6 is depressed
```

In [82]:

```
# Model 4 predictions
p4 = model4.predict(vector.transform([tweet1, tweet2, tweet3, tweet4, tweet5, tweet6]))

print(p4)
print()
for index, i in enumerate(p4):
  if i == 0:
    print('Tweeter ' + str(index + 1) + ' is not depressed')
  else:
    print('Tweeter ' + str(index + 1) + ' is depressed')
```

```
[0 0 0 0 0 0]

Tweeter 1 is not depressed
Tweeter 2 is not depressed
Tweeter 3 is not depressed
Tweeter 4 is not depressed
Tweeter 5 is not depressed
Tweeter 6 is not depressed
```

In [85]:

In [85]:

```
# Saving our models:
import joblib
path = 'gdrive/MyDrive/Models/'
name= 'MultinomialNB'
model_path = path + name

_a = joblib.dump(model1, model_path)
```

In [87]:

```
name= 'GaussianNB'
model_path2 = path + name

_b = joblib.dump(model2, model_path2)
```

In [88]:

```
name= 'ComplementNB'
model_path3 = path + name

_c = joblib.dump(model3, model_path3)
```

In [89]:

```
name= 'BernoulliNB'
model_path4 = path + name

_d = joblib.dump(model4, model_path4)
```

In [ ]:

```

```