Importing Libs

In [1]:
```
import pandas as pd
import numpy as np
# To Split Dataset
from sklearn.model_selection import train_test_split
# To convert data into numerical value to make it more meaningful
from sklearn.feature_extraction.text import TfidfVectorizer
# Machine Learning Model
from sklearn.linear_model import LogisticRegression
# To test accuracy of the trained model
from sklearn.metrics import accuracy_score
from sklearn.naive_bayes import GaussianNB
from sklearn.naive_bayes import MultinomialNB
from sklearn.pipeline import make_pipeline
from sklearn.ensemble import StackingClassifier
from sklearn.svm import SVC
from sklearn.metrics import precision_recall_fscore_support as score
from sklearn.model_selection import cross_val_score
from sklearn import metrics
import matplotlib.pyplot as plt
```

Loading the Dataset (mail_data.csv)

In [2]:
```
data = pd.read_csv('mail_data.csv')
```

In [3]:
```
data.head()
```

Out[3]:

	Category	Message
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...

EDA

In [4]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5572 entries, 0 to 5571
Data columns (total 2 columns):
 #   Column    Non-Null Count  Dtype 
---  ------    --------------  ----- 
 0   Category  5572 non-null   object
 1   Message   5572 non-null   object
dtypes: object(2)
memory usage: 87.2+ KB
```

In [5]:
```
data.describe()
```

Out[5]:

	Category	Message
count	5572	5572
unique	2	5157
top	ham	Sorry, I'll call later
freq	4825	30

In [6]:
```
data.shape
```

Out[6]:
```
(5572, 2)
```

In [7]:
```
# To check for the Null values
data.isnull().values.any()
```

Out[7]:
```
False
```

Data Preprocessing

Label Encoding

Spam = 1

Ham = 0

In [8]:
```
data['Category'] = data['Category'].map(lambda x : 1 if(x == 'spam') else 0)
```

In [9]:
```
data.head()
```

Out[9]:

	Category	Message
0	0	Go until jurong point, crazy.. Available only ...
1	0	Ok lar... Joking wif u oni...
2	1	Free entry in 2 a wkly comp to win FA Cup fina...
3	0	U dun say so early hor... U c already then say...
4	0	Nah I don't think he goes to usf, he lives aro...

Feature and Label

In [10]:
```
X = data['Message']
Y = data['Category']
```

Train Test Split

In [11]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2, random_state=
# random state 3 will train data in the same manner
```

In [12]:
```
X_train.shape , X_test.shape
```

Out[12]:
```
((4457,), (1115,))
```

In [13]:
```
Y_train.shape , Y_test.shape
```

Out[13]:
```
((4457,), (1115,))
```

Feature Extraction

In [14]:
```
# Transfroming text data to feature vectors
# minimum document frequency >= 1 i.e min_df = 1
feature_ext = TfidfVectorizer(min_df = 1, stop_words = 'english', lowercase='True' )

# Converting X_train and X_test into features
X_train_features = feature_ext.fit_transform(X_train)
# Converting X_test into features
X_test_features = feature_ext.transform(X_test) # Note: not fit transform (using only
```

In [15]:
```
# Converting Y_train and Y_test as integar
Y_train = Y_train.astype('int')
Y_test = Y_test.astype('int')
```

In [16]:
```
#print(X_train_features)
```

Training ML Models

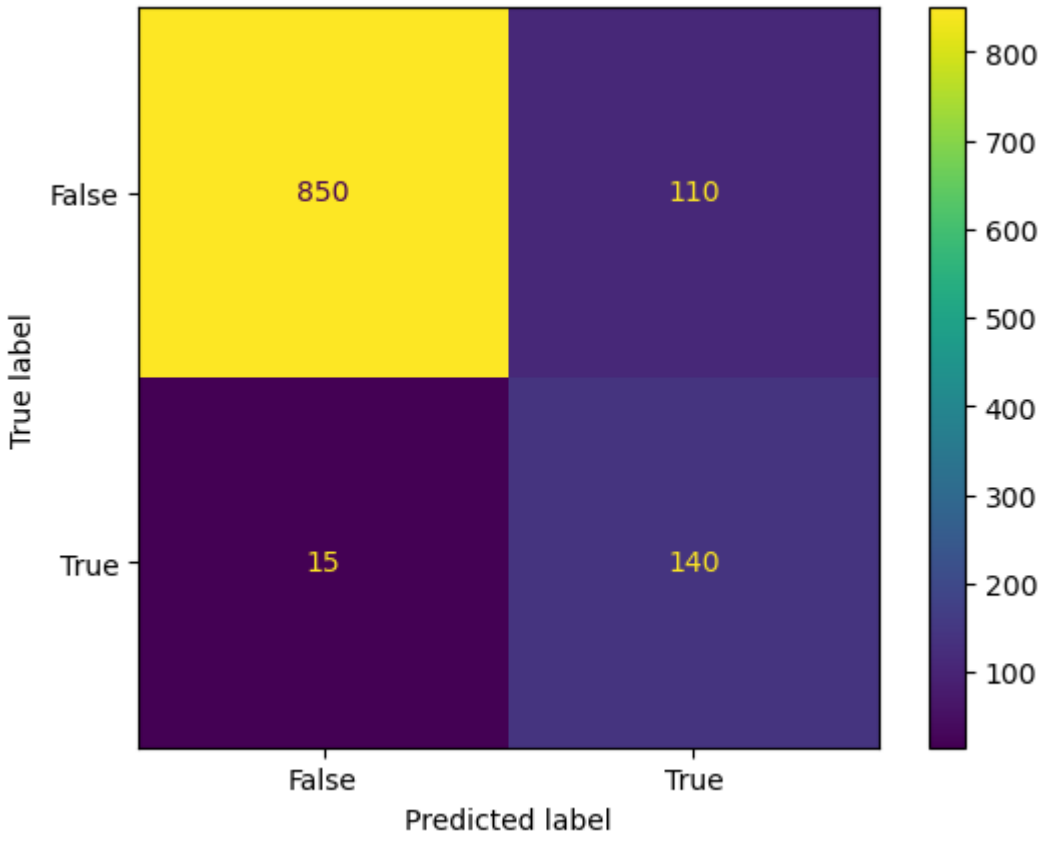
Naive Bayes

In [17]:
```
summary = {'Model':[], 'Accuracy':[], 'precision':[], 'recall':[], 'fscore':[], 'suppo

# Build a Gaussian Classifier
NBmodel = GaussianNB()

# Model training
NBmodel.fit(X_train_features.toarray(), Y_train)

# Evaluation
prediction = NBmodel.predict(X_test_features.toarray())
accuracy   =  accuracy_score(Y_test, prediction)
```

```
precision, recall, fscore, support = score(Y_test,prediction)

summary['Model'].append('Naive Bayes')

summary['Accuracy'].append(accuracy)
summary['recall'].append(recall)
summary['fscore'].append(fscore)
summary['support'].append(support)
summary['precision'].append(precision)

print(f'Accuracy of Naive Bayes Model : {accuracy}')
```

```
Accuracy of Naive Bayes Model : 0.8878923766816144
```

In [18]:
```
confusion_matrix = metrics.confusion_matrix(Y_test, prediction)
cm_display = metrics.ConfusionMatrixDisplay(confusion_matrix = confusion_matrix, displ
cm_display.plot()
plt.show()
```



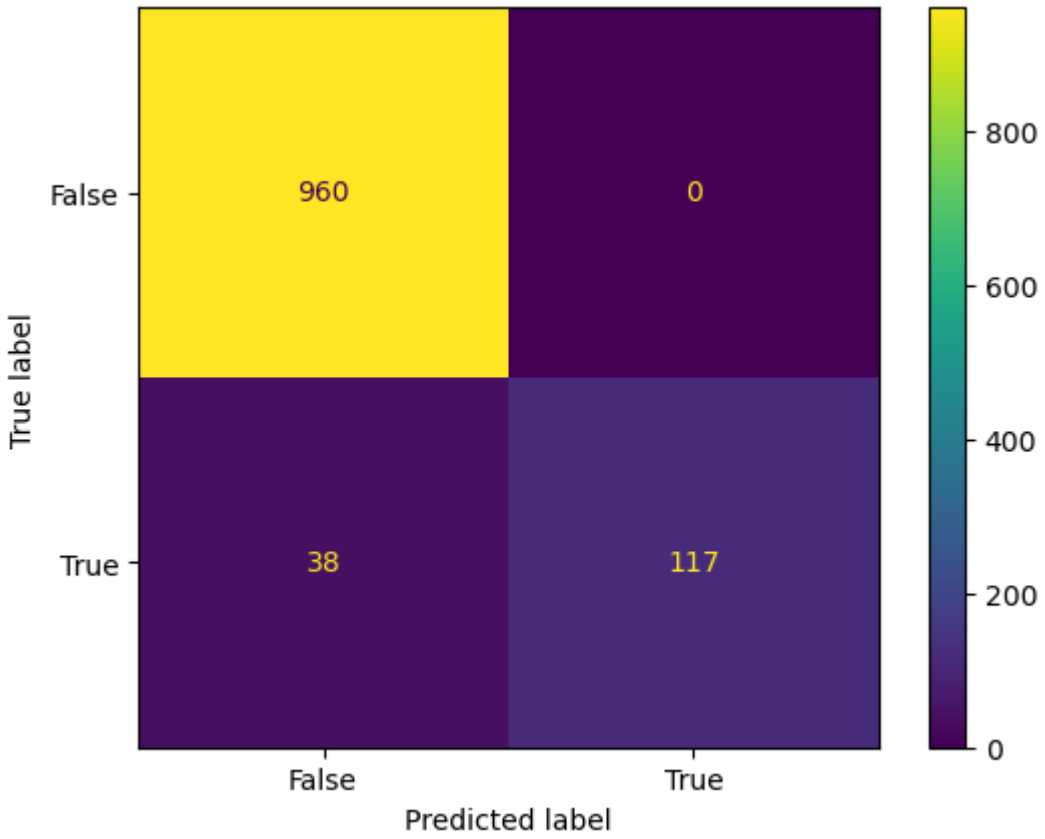
Logistic Regression Model

In [19]:
```
# Build a LogisticRegression Classifier
LR_model = LogisticRegression()


LR_model.fit(X_train_features, Y_train)

# Evaluation
prediction =  LR_model.predict(X_test_features)
accuracy   =  accuracy_score(Y_test, prediction)
precision, recall, fscore, support = score(Y_test,prediction)
```

```
summary['Model'].append('Logistic Regression')
summary['Accuracy'].append(accuracy)
summary['recall'].append(recall)
summary['fscore'].append(fscore)
summary['support'].append(support)
summary['precision'].append(precision)


print(f'Accuracy of Logistic Redression Model : {accuracy}')
```

```
Accuracy of Logistic Redression Model : 0.9659192825112107
```

In [20]:
```
confusion_matrix = metrics.confusion_matrix(Y_test, prediction)
cm_display = metrics.ConfusionMatrixDisplay(confusion_matrix = confusion_matrix, displ
cm_display.plot()
plt.show()
```



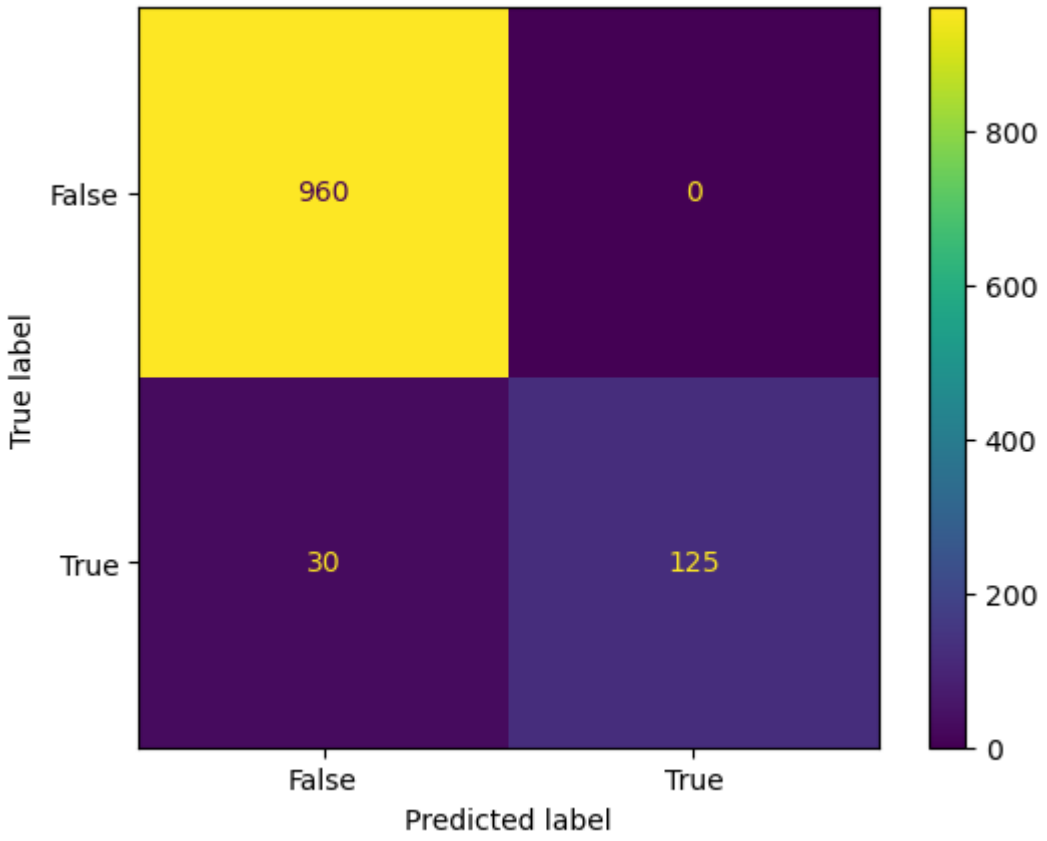
MultinomialNB Model

In [21]:
```
# Build a MultinomialNB Classifier
MNBmodel = MultinomialNB()

# Model training
MNBmodel.fit(X_train_features, Y_train)

# Evaluation
prediction = MNBmodel.predict(X_test_features)
accuracy   =  accuracy_score(Y_test, prediction)

precision, recall, fscore, support = score(Y_test,prediction)
```

```
summary['Model'].append('MultinomialNB')
summary['Accuracy'].append(accuracy)
summary['recall'].append(recall)
summary['fscore'].append(fscore)
summary['support'].append(support)
summary['precision'].append(precision)


print(f'Accuracy of MultinomialNB Model : {accuracy}')
```

```
Accuracy of MultinomialNB Model : 0.9730941704035875
```

In [22]:
```
confusion_matrix = metrics.confusion_matrix(Y_test, prediction)
cm_display = metrics.ConfusionMatrixDisplay(confusion_matrix = confusion_matrix, displ
cm_display.plot()
plt.show()
```



Stack (Naive bayes + LogisticRegression + MultinomialNB Model)

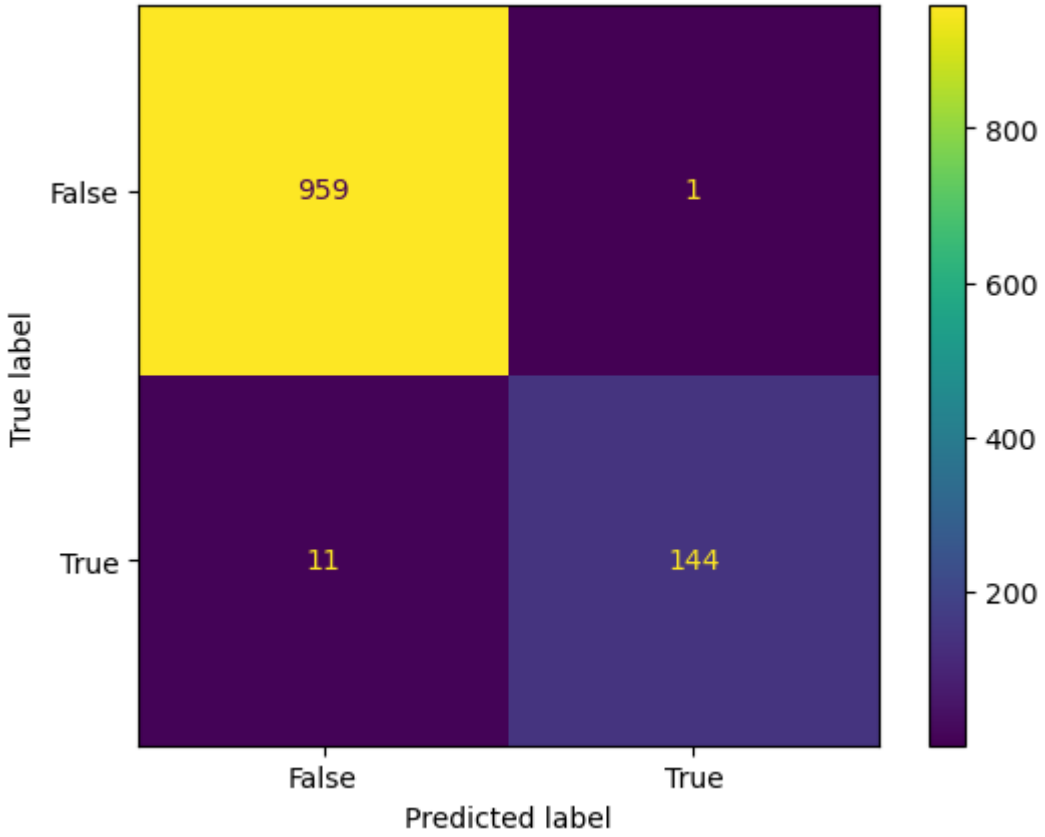
In [23]:
```
MNBmodel = MultinomialNB()
LR_model = LogisticRegression()
NBmodel = GaussianNB()

classifiers = [('lr',LR_model),('mnb',MNBmodel),('nb',NBmodel),] #list of (str, estimc
```

In [24]:
```
stack_model = StackingClassifier( estimators =  classifiers , final_estimator = SVC())
```

In [25]:
```
stack_model.fit(X_train_features.toarray(), Y_train)
prediction = stack_model.predict(X_test_features.toarray())

precision, recall, fscore, support = score(Y_test,prediction)
accuracy   =  accuracy_score(Y_test, prediction)

summary['Model'].append('Stack')
summary['Accuracy'].append(accuracy)
summary['recall'].append(recall)
summary['fscore'].append(fscore)
summary['support'].append(support)
summary['precision'].append(precision)



print(f'Accuracy of Stack Model : {accuracy}')
```

```
Accuracy of Stack Model : 0.989237668161435
```

In [26]:
```
confusion_matrix = metrics.confusion_matrix(Y_test, prediction)
cm_display = metrics.ConfusionMatrixDisplay(confusion_matrix = confusion_matrix, displ
cm_display.plot()
plt.show()
```



Comparison

In [27]:
```
result = pd.DataFrame(summary)
```

In [28]:
```
result
```

Out[28]:

	Model	Accuracy	precision	recall	fscore	support
0	Naive Bayes	0.887892	[0.9826589595375722, 0.56]	[0.8854166666666666, 0.9032258064516129]	[0.9315068493150684, 0.691358024691358]	[960, 155]
1	Logistic Regression	0.965919	[0.9619238476953907, 1.0]	[1.0, 0.7548387096774194]	[0.9805924412665985, 0.8602941176470589]	[960, 155]
2	MultinomialNB	0.973094	[0.9696969696969697, 1.0]	[1.0, 0.8064516129032258]	[0.9846153846153847, 0.8928571428571428]	[960, 155]
3	Stack	0.989238	[0.988659793814433, 0.993103448275862]	[0.9989583333333333, 0.9290322580645162]	[0.993782383419689, 0.9600000000000001]	[960, 155]

Conclusion: Stack is giving better Accuracy