In [1]:

```
import pandas as pd
```

In [3]:

```
housing = pd.read_csv("/Users/moizzah/Desktop/housing/housing.csv")
```

The usual missing value imputation routine please

In [4]:

```
housing_df = housing[['housing_median_age', 'total_rooms',
       'total_bedrooms', 'population', 'households', 'median_income',
       'median_house_value','ocean_proximity']].copy()
median = housing_df['total_bedrooms'].median()
housing_df['total_bedrooms'].fillna(median, inplace = True)
```

Label Encoding

instead of mapping the categorical variable
use label encoder from sklearn

In [5]:

```
from sklearn import preprocessing
```

In [6]:

```
lab_enc = preprocessing.LabelEncoder()
```

In [7]:

```
lab_enc.fit(housing['ocean_proximity'].unique())
```

Out[7]:

```
LabelEncoder()
```

In [23]:

```
housing_df['ocean_proximity'].unique()
```

Out[23]:

```
array(['NEAR BAY', '<1H OCEAN', 'INLAND', 'NEAR OCEAN', 'ISLAND'],
      dtype=object)
```

In [9]:

```
list(lab_enc.classes_)
```

Out[9]:

```
['<1H OCEAN', 'INLAND', 'ISLAND', 'NEAR BAY', 'NEAR OCEAN']
```

In [24]:

```
housing_df['ocean_proximity'].head()
```

Out[24]:

```
0    NEAR BAY
1    NEAR BAY
2    NEAR BAY
3    NEAR BAY
4    NEAR BAY
Name: ocean_proximity, dtype: object
```

In [25]:

```
housing_df['ocean_proximity'].tail()
```

Out[25]:

```
20635    INLAND
20636    INLAND
20637    INLAND
20638    INLAND
20639    INLAND
Name: ocean_proximity, dtype: object
```

In [27]:

```
housing_df['ocean_proximity'] = lab_enc.transform(housing_df['ocean_proximity'])
```

In [13]:

```
housing['ocean_proximity'].head()
```

Out[13]:

```
0    3
1    3
2    3
3    3
4    3
Name: ocean_proximity, dtype: int64
```

In [28]:

```
housing_df['ocean_proximity'].tail()
```

Out[28]:

```
20635    1
20636    1
20637    1
20638    1
20639    1
Name: ocean_proximity, dtype: int64
```

Now the usual scaling routine please

In [29]:

```
from sklearn.preprocessing import StandardScaler as ss
temp = housing_df[['housing_median_age', 'total_rooms',
       'total_bedrooms', 'population', 'households', 'median_income',
       'median_house_value']].copy()
temp = ss().fit_transform(temp)
housing_df[['housing_median_age', 'total_rooms',
       'total_bedrooms', 'population', 'households', 'median_income',
       'median_house_value']] = temp
housing_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 20640 entries, 0 to 20639
Data columns (total 8 columns):
housing_median_age    20640 non-null float64
total_rooms           20640 non-null float64
total_bedrooms        20640 non-null float64
population            20640 non-null float64
households            20640 non-null float64
median_income         20640 non-null float64
median_house_value    20640 non-null float64
ocean_proximity       20640 non-null int64
dtypes: float64(7), int64(1)
memory usage: 1.3 MB
```

Create the feature set
that is: train and test splits

note: Do not create separate dataframes from predictor variables and target variables
just provide the indices in train_Test_split method

In [16]:

```
from sklearn.model_selection import train_test_split
```

In [31]:

```
x_housing_train, x_housing_test, y_housing_train, y_housing_test = train_test_sp
lit(housing_df.iloc[:, [0,1,2,3,4,5,7]],

housing_df.iloc[:,[6]],

test_size = 0.3, random_state = 123)
```

now repeat for titanic dataset
remember to use label encoder

Also, try using pandas method drop to drop columns

In [43]:

```
titanic = pd.read_csv('/Users/moizzah/Desktop/titanic/titanic.csv')
titanic.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 891 entries, 0 to 890
Data columns (total 12 columns):
PassengerId    891 non-null int64
Survived       891 non-null int64
Pclass         891 non-null int64
Name           891 non-null object
Sex            891 non-null object
Age            714 non-null float64
SibSp          891 non-null int64
Parch          891 non-null int64
Ticket         891 non-null object
Fare           891 non-null float64
Cabin          204 non-null object
Embarked       889 non-null object
dtypes: float64(2), int64(5), object(5)
memory usage: 83.7+ KB
```

In [44]:

```
titanic.dropna(subset = ['Embarked'], inplace = True)
titanic = titanic.drop(['Cabin'], axis=1)
titanic.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 889 entries, 0 to 890
Data columns (total 11 columns):
PassengerId    889 non-null int64
Survived       889 non-null int64
Pclass         889 non-null int64
Name           889 non-null object
Sex            889 non-null object
Age            712 non-null float64
SibSp          889 non-null int64
Parch          889 non-null int64
Ticket         889 non-null object
Fare           889 non-null float64
Embarked       889 non-null object
dtypes: float64(2), int64(5), object(4)
memory usage: 83.3+ KB
```

In [45]:

```
mean_age = titanic['Age'].mean()
titanic['Age'].fillna(mean_age, inplace = True)
titanic.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 889 entries, 0 to 890
Data columns (total 11 columns):
PassengerId    889 non-null int64
Survived       889 non-null int64
Pclass         889 non-null int64
Name           889 non-null object
Sex            889 non-null object
Age            889 non-null float64
SibSp          889 non-null int64
Parch          889 non-null int64
Ticket         889 non-null object
Fare           889 non-null float64
Embarked       889 non-null object
dtypes: float64(2), int64(5), object(4)
memory usage: 83.3+ KB
```

In [48]:

```
lab_enc.fit(titanic['Sex'].unique())
```

Out[48]:

```
LabelEncoder()
```

In [49]:

```
list(lab_enc.classes_)
```

Out[49]:

```
['female', 'male']
```

In [51]:

```
titanic['Sex'] = lab_enc.transform(titanic['Sex'])
titanic.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 889 entries, 0 to 890
Data columns (total 11 columns):
PassengerId    889 non-null int64
Survived       889 non-null int64
Pclass         889 non-null int64
Name           889 non-null object
Sex            889 non-null int64
Age            889 non-null float64
SibSp          889 non-null int64
Parch          889 non-null int64
Ticket         889 non-null object
Fare           889 non-null float64
Embarked       889 non-null object
dtypes: float64(2), int64(6), object(3)
memory usage: 83.3+ KB
```

In [52]:

```
lab_enc.fit(titanic['Embarked'].unique())
```

Out[52]:

```
LabelEncoder()
```

In [53]:

```
list(lab_enc.classes_)
```

Out[53]:

```
['C', 'Q', 'S']
```

In [54]:

```
titanic['Embarked'] = lab_enc.transform(titanic['Embarked'])
titanic.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 889 entries, 0 to 890
Data columns (total 11 columns):
PassengerId    889 non-null int64
Survived       889 non-null int64
Pclass         889 non-null int64
Name           889 non-null object
Sex            889 non-null int64
Age            889 non-null float64
SibSp          889 non-null int64
Parch          889 non-null int64
Ticket         889 non-null object
Fare           889 non-null float64
Embarked       889 non-null int64
dtypes: float64(2), int64(7), object(2)
memory usage: 83.3+ KB
```

In [55]:

```
x_titanic_train, x_titanic_test, y_titanic_train, y_titanic_test = train_test_sp
lit(titanic.iloc[:, [2,4,5,6,7,10]],

titanic.iloc[:,[1]],

test_size = 0.3, random_state = 123)
```

Naive Bayes Classifiers

In [20]:

```
from sklearn.naive_bayes import MultinomialNB, GaussianNB, BernoulliNB
```

In [58]:

```
#x_titanic_train.info()
G_nb = GaussianNB().fit(x_titanic_train, y_titanic_train)
```

```
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/utils/validation.py:724: DataConversionWarning: A
column-vector y was passed when a 1d array was expected. Please chan
ge the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
```

In [59]:

```
G_nb.class_prior_
```

Out[59]:

```
array([0.62379421, 0.37620579])
```

In [60]:

```
G_nb.class_count_
```

Out[60]:

```
array([388., 234.])
```

In [61]:

```
G_nb.classes_
```

Out[61]:

```
array([0, 1])
```

In [63]:

```
G_nb_pred = G_nb.predict(x_titanic_test)
G_nb_pred
```

Out[63]:

```
array([0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 1,
1, 0,
       0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0,
1, 1,
       1, 1, 0, 0, 1, 0, 1, 0, 0, 0, 1, 1, 0, 0, 1, 0, 1, 1, 1, 1,
1, 1,
       0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 0, 1, 1, 1, 0, 0, 0, 1, 1,
0, 0,
       0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 0, 0,
0, 1,
       1, 0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0,
0, 0,
       0, 0, 1, 0, 1, 1, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0,
1, 0,
       0, 0, 1, 1, 1, 1, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 1, 0,
1, 0,
       1, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0,
1, 0,
       0, 0, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0,
0, 0,
       0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1,
0, 0,
       1, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1,
0, 1,
       0, 0, 1])
```

In [64]:

```
from sklearn.metrics import confusion_matrix, accuracy_score, precision_score, r
ecall_score, f1_score
```

In [65]:

```
confusion_matrix(y_titanic_test, G_nb_pred)
```

Out[65]:

```
array([[135,  26],
       [ 31,  75]])
```

In [66]:

```
accuracy_score(y_titanic_test, G_nb_pred)
```

Out[66]:

```
0.7865168539325843
```

In [67]:

```
precision_score(y_titanic_test, G_nb_pred)
```

Out[67]:

```
0.7425742574257426
```

In [68]:

```
recall_score(y_titanic_test, G_nb_pred)
```

Out[68]:

```
0.7075471698113207
```

In [69]:

```
f1_score(y_titanic_test, G_nb_pred)
```

Out[69]:

```
0.7246376811594202
```

Now, from the titanic dataset, pick only those predictor variables,
which can be used to train multinomial Naive Bayes
use the same train test split, make copies, add a suffix _mnb wherever appropriate
compare this mnb classifier with G_nb classifier

Bagging

First Apply on Decision Tree classifier

In [72]:

```
from sklearn.ensemble import BaggingClassifier
from sklearn.tree import DecisionTreeClassifier
```

base_estimator
The base estimator to fit on random subsets of the dataset. If None, then the base estimator is a decision tree.

In [73]:

```
tree_restricted = DecisionTreeClassifier(criterion = 'entropy', random_state = 1
23, max_depth = 4)
```

In [74]:

```
bagging = BaggingClassifier(tree_restricted, n_estimators=100, max_samples=0.8,
                        random_state=198)
```

In [75]:

```
bagging.fit(x_titanic_train, y_titanic_train)
```

```
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/ensemble/bagging.py:623: DataConversionWarning: A
column-vector y was passed when a 1d array was expected. Please chan
ge the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
```

Out[75]:

```
BaggingClassifier(base_estimator=DecisionTreeClassifier(class_weight
=None,
                                                        criterion='e
ntropy',
                                                        max_depth=4,
                                                        max_features
=None,
                                                        max_leaf_nod
es=None,
                                                        min_impurity
_decrease=0.0,
                                                        min_impurity
_split=None,
                                                        min_samples_
leaf=1,
                                                        min_samples_
split=2,
                                                        min_weight_f
raction_leaf=0.0,
                                                        presort=Fals
e,
                                                        random_state
=123,
                                                        splitter='be
st'),
                  bootstrap=True, bootstrap_features=False, max_feat
ures=1.0,
                  max_samples=0.8, n_estimators=100, n_jobs=None,
                  oob_score=False, random_state=198, verbose=0,
                  warm_start=False)
```

In [76]:

```
bagging.base_estimator_
```

Out[76]:

```
DecisionTreeClassifier(class_weight=None, criterion='entropy', max_d
epth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split
=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=123, splitter='best')
```

In [77]:

```
bagging.n_features_
```

Out[77]:

```
6
```

In [78]:

```
bagging.estimators_
```

Out[78]:

```
[DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1511094012, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1492618134, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1489790253, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=215994538, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1049357520, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1086753958, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=631037180, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1137172324, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1491004505, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=231221994, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1152921957, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1550519296, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1413460195, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=554749366, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1882573037, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_spli
t=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=1470386578, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_spli
t=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=1361166231, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_spli
t=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=484371728, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_spli
t=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=874145041, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_spli
t=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=1458501657, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_spli
t=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=2033873965, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_spli
t=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=1894172727, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_spli
t=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=91268423, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                       max_features=None, max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_spli
t=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, presort=False,
                       random_state=62078030, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
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                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=632471792, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1637909726, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
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                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1017279060, splitter='best'),
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depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=1599810166, splitter='best'),
 DecisionTreeClassifier(class_weight=None, criterion='entropy', max_
depth=4,
                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
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                        min_weight_fraction_leaf=0.0, presort=False,
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depth=4,
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t=None,
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depth=4,
                        max_features=None, max_leaf_nodes=None,
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                        min_weight_fraction_leaf=0.0, presort=False,
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depth=4,
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                        min_impurity_decrease=0.0, min_impurity_spli
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                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=703936783, splitter='best'),
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                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=810911689, splitter='best'),
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                        max_features=None, max_leaf_nodes=None,
                        min_impurity_decrease=0.0, min_impurity_spli
t=None,
                        min_samples_leaf=1, min_samples_split=2,
                        min_weight_fraction_leaf=0.0, presort=False,
                        random_state=284863514, splitter='best')]
```

In [79]:

```
bagging.estimators_features_
```

Out[79]:

```
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 array([0, 1, 2, 3, 4, 5]),
 array([0, 1, 2, 3, 4, 5]),
 array([0, 1, 2, 3, 4, 5])]
```

In [80]:

```
bagging.score(x_titanic_train, y_titanic_train)
```

Out[80]:

```
0.8488745980707395
```

In [82]:

```
bagging.score(x_titanic_test, y_titanic_test)
```

Out[82]:

```
0.8089887640449438
```

extract feature importance
then plot a bar graph

In [86]:

```
import numpy as np
feature_importances = np.mean([
    tree.feature_importances_ for tree in bagging.estimators_
], axis=0)
feature_importances
```

Out[86]:

```
array([0.21931641, 0.46901014, 0.19808952, 0.06888841, 0.01381123,
       0.03088428])
```

In [88]:

```
import matplotlib.pyplot as plt
%matplotlib inline
```

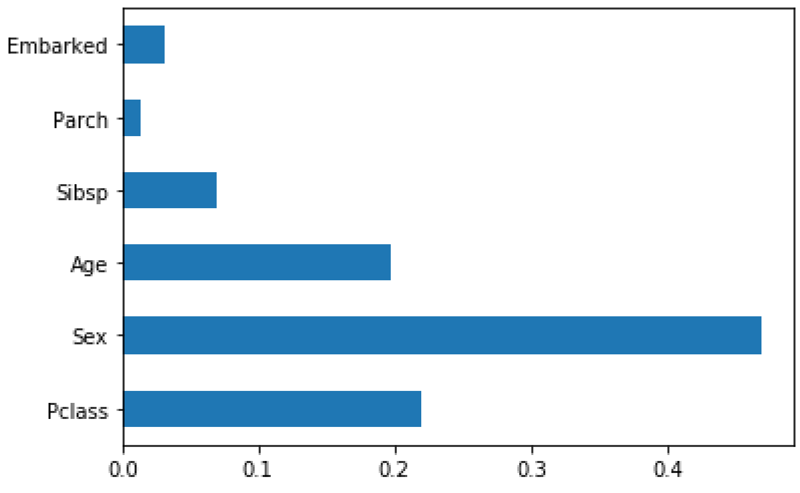
In [92]:

```
feature_importances_series = pd.Series(feature_importances,
                                       index = ['Pclass', 'Sex','Age','Sibsp','P
arch', 'Embarked'])
feature_importances_series.plot(kind = 'barh')

# plt.figure()
# plt.title("Mean Feature importances")
# plt.barh(y = feature_importances, width =
#         color="r", align="center")
# plt.show()
```

Out[92]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fcda045db80>
```



Random Forest

In [93]:

```
from sklearn.ensemble import RandomForestClassifier
```

In [94]:

```
rf = RandomForestClassifier(random_state = 198, verbose = 1, )
```

In [96]:

```
rf.fit(x_titanic_train, y_titanic_train)
```

```
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/ensemble/forest.py:244: FutureWarning: The default
value of n_estimators will change from 10 in version 0.20 to 100 in
0.22.
  warn("The default value of n_estimators will change from "
<ipython-input-96-163ff23db28a>:1: DataConversionWarning: A column-v
ector y was passed when a 1d array was expected. Please change the s
hape of y to (n_samples,), for example using ravel().
  rf.fit(x_titanic_train, y_titanic_train)
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurr
ent workers.
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed:    0.0s finishe
d
```

Out[96]:

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion
='gini',
                       max_depth=None, max_features='auto', max_leaf
_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split
=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=1
0,
                       n_jobs=None, oob_score=False, random_state=19
8,
                       verbose=1, warm_start=False)
```

rf.n_features_

In [99]:

```
rf.feature_importances_
```

Out[99]:

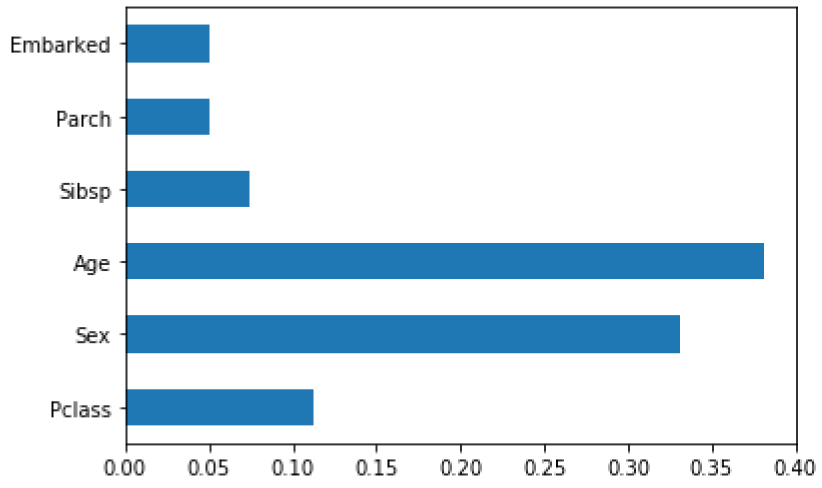
```
array([0.11203241, 0.3309911 , 0.3810256 , 0.07413389, 0.0508831 ,
       0.0509339 ])
```

In [103]:

```
rf_feature_importances = pd.Series(rf.feature_importances_,
                                   index = ['Pclass', 'Sex','Age','Sibsp','Parc
h', 'Embarked'])
rf_feature_importances.plot(kind = 'barh')
```

Out[103]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fcd807b31f0>
```



In [104]:

```
rf.score(x_titanic_train, y_titanic_train)
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurr
ent workers.
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed:    0.0s finishe
d
```

Out[104]:

```
0.927652733118971
```

In [105]:

```
rf.score(x_titanic_test, y_titanic_test)
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurr
ent workers.
[Parallel(n_jobs=1)]: Done  10 out of  10 | elapsed:    0.0s finishe
d
```

Out[105]:

```
0.8014981273408239
```

now change the values for following parameters of random forest and create model rf2
criterion to entropy
max_features to 4
n_estimators to 50
max_depth to 4

Support Vector Machines

In [113]:

```
import nltk
sms = pd.read_csv("/Users/moizzah/Desktop/spam.csv", encoding = 'latin')
sms.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5572 entries, 0 to 5571
Data columns (total 5 columns):
v1            5572 non-null object
v2            5572 non-null object
Unnamed: 2    50 non-null object
Unnamed: 3    12 non-null object
Unnamed: 4    6 non-null object
dtypes: object(5)
memory usage: 217.8+ KB
```

In [114]:

```
sms.head()
```

Out[114]:

	v1	v2	Unnamed: 2	Unnamed: 3	Unnamed: 4
0	ham	Go until jurong point, crazy.. Available only ...	NaN	NaN	NaN
1	ham	Ok lar... Joking wif u oni...	NaN	NaN	NaN
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...	NaN	NaN	NaN
3	ham	U dun say so early hor... U c already then say...	NaN	NaN	NaN
4	ham	Nah I don't think he goes to usf, he lives aro...	NaN	NaN	NaN

In [115]:

```
sms = sms.loc[:, 'v1':'v2']
sms.head()
```

Out[115]:

	v1	v2
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...

In [117]:

```
sms.columns = ['cat', 'text']
sms.columns
```

Out[117]:

```
Index(['cat', 'text'], dtype='object')
```

In [122]:

```
sms['cat'].value_counts()
```

Out[122]:

```
ham     4825
spam     747
Name: cat, dtype: int64
```

In [123]:

```
lab_enc.fit(sms['cat'].unique())
```

Out[123]:

```
LabelEncoder()
```

In [124]:

```
sms['cat'] = lab_enc.transform(sms['cat'])
```

In [125]:

```
sms.head()
```

Out[125]:

	cat	text
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...

extract the frequency/count of each word
use CountVectorizer class

In [126]:

```
from sklearn.feature_extraction.text import CountVectorizer
```

In [127]:

```
CV = CountVectorizer(ngram_range=(1,2), analyzer = 'word')
```

In [135]:

```
ngrams = CV.fit_transform(sms['text'])
ngrams_id = CV.get_feature_names()
```

In [138]:

```
ngrams_id
```

Out[138]:

```
['00',
 '00 in',
 '00 per',
 '00 sub',
 '00 subs',
 '000',
 '000 bonus',
 '000 cash',
 '000 homeowners',
 '000 pounds',
 '000 price',
 '000 prize',
 '000 xmas',
 '000pes',
 '000pes so',
 '008704050406',
 '008704050406 sp',
 '0089',
 '0089 my',
 '0121',
 '0121 2025050',
 '01223585236',
 '01223585236 xx',
 '01223585334',
 '01223585334 to',
 '0125698789',
 '0125698789 ring',
 '02',
 '02 06',
 '02 09',
 '02 claimcode',
 '02 user',
 '0207',
 '0207 083',
 '0207 153',
 '02072069400',
 '02072069400 bx',
 '02073162414',
 '02073162414 now',
 '02085076972',
 '02085076972 reply',
 '021',
 '021 3680',
 '03',
 '03 05',
 '03 is',
 '03 our',
 '03 this',
 '04',
 '04 call',
 '0430',
 '0430 jul',
 '05',
 '05 05',
 '05 or',
 '050703',
 '050703 csbcm4235wc1n3xx',
 '0578',
 '0578 now',
 '06',
 '06 03',
 '06 05',
 '06 11',
 '06 good',
 '07',
 '07 11',
 '07008009200',
 '07046744435',
 '07046744435 now',
 '07090201529',
 '07090298926',
 '07090298926 to',
 '07099833605',
 '07099833605 to',
 '07123456789',
 '07123456789 to',
 '0721072',
 '0721072 to',
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 '07732584351 rodger',
 '07734396839',
 '07734396839 ibh',
 '07742676969',
 '07742676969 shows',
 '07753741225',
 '07753741225 shows',
 '0776xxxxxxx',
 '0776xxxxxxx ve',
 '07781482378',
 '07781482378 com',
 '07786200117',
 '077xxx',
 '077xxx won',
 '078',
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 '07808726822',
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 '07821230901',
 '078498',
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 '07880867867',
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 '07946746291',
 '07946746291 07880867867',
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 '0800 169',
 '0800 18',
 '0800 195',
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 '087123002209am 7pm',
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 '08712400602450p provided',
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 '2309',
 '23f',
 '23f for',
 '23g',
 ...]
```

In [143]:

```
len(ngrams_id)
```

Out[143]:

```
50326
```

In [131]:

```
type(ngrams)
```

Out[131]:

```
scipy.sparse.csr.csr_matrix
```

In [146]:

```
ngrams = ngrams.toarray()
```

In [147]:

```
type(ngrams)
```

Out[147]:

```
numpy.ndarray
```

In [148]:

```
ngrams.shape
```

Out[148]:

```
(5572, 50326)
```

In [149]:

```
sms.shape
```

Out[149]:

```
(5572, 2)
```

In [152]:

```
ngrams_df = pd.DataFrame(data = ngrams, columns = ngrams_id)
ngrams_df.shape
```

Out[152]:

```
(5572, 50326)
```

In [154]:

```
ngrams_df.iloc[:,1:5].head()
```

Out[154]:

	00 in	00 per	00 sub	00 subs
0	0	0	0	0
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0

In [155]:

```
x_sms_train, x_sms_test, y_sms_train, y_sms_test = train_test_split(ngrams_df,
                                                                     sms['cat'],
                                                                     test_size =
0.3,
                                                                     random_state
= 198)
```

Apply SVM
first linear kernel
then polynomial kernel

In [156]:

```
from sklearn.svm import SVC
```

In [157]:

```
svm_linear = SVC(kernel='linear')

svm_linear.fit( x_sms_train , y_sms_train)
```

Out[157]:

```
SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
    decision_function_shape='ovr', degree=3, gamma='auto_deprecate
d',
    kernel='linear', max_iter=-1, probability=False, random_state=No
ne,
    shrinking=True, tol=0.001, verbose=False)
```

In [158]:

```
svm_linear.support_vectors_
```

Out[158]:

```
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.]])
```

In [159]:

```
svm_linear.n_support_
```

Out[159]:

```
array([715, 271], dtype=int32)
```

In [161]:

```
svm_linear_pred = svm_linear.predict(x_sms_test)
```

In [162]:

```
confusion_matrix(y_sms_test, svm_linear_pred)
```

Out[162]:

```
array([[1461,    0],
       [  30,  181]])
```

In [163]:

```
accuracy_score(y_sms_test, svm_linear_pred)
```

Out[163]:

```
0.9820574162679426
```

In [164]:

```
precision_score(y_sms_test, svm_linear_pred)
```

Out[164]:

```
1.0
```

In [165]:

```
recall_score(y_sms_test, svm_linear_pred)
```

Out[165]:

```
0.8578199052132701
```

In [166]:

```
svm_poly = SVC(kernel = 'poly', degree = 3)
svm_poly.fit( x_sms_train , y_sms_train)
```

```
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/svm/base.py:189: FutureWarning: The default value
of gamma will change from 'auto' to 'scale' in version 0.22 to accou
nt better for unscaled features. Set gamma explicitly to 'auto' or
'scale' to avoid this warning.
  warnings.warn("The default value of gamma will change "
```

Out[166]:

```
SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
    decision_function_shape='ovr', degree=3, gamma='auto_deprecate
d',
    kernel='poly', max_iter=-1, probability=False, random_state=Non
e,
    shrinking=True, tol=0.001, verbose=False)
```

In [167]:

```
svm_poly.n_support_
```

Out[167]:

```
array([536, 536], dtype=int32)
```

In [168]:

```
svm_poly_pred = svm_poly.predict(x_sms_test)
```

In [ ]:

```
confusion_matrix(y_sms_test, svm_poly_pred)
```

In [ ]:

```
accuracy_score(y_sms_test, svm_poly_pred)
```

In [ ]:

```
precision_score(y_sms_test, svm_poly_pred)
```

In [ ]:

```
recall_score(y_sms_test, svm_poly_pred)
```

Now try grid search to hyper tune polynomial svm's parameter (hyperparameters)
possible parameteres include
degree
gamma
C(regularisation parameter)
kernel

In [169]:

```
from sklearn.model_selection import GridSearchCV

param_grid = [
    {'kernel': ['poly','rbf'], 'degree': [2,3,4,7,8]}
]

grid = GridSearchCV(SVC(), param_grid, cv = 3)
```

In [170]:

```
grid.fit(x_sms_train, y_sms_train)
```

```
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/svm/base.py:189: FutureWarning: The default value
of gamma will change from 'auto' to 'scale' in version 0.22 to accou
nt better for unscaled features. Set gamma explicitly to 'auto' or
'scale' to avoid this warning.
  warnings.warn("The default value of gamma will change "
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/svm/base.py:189: FutureWarning: The default value
of gamma will change from 'auto' to 'scale' in version 0.22 to accou
nt better for unscaled features. Set gamma explicitly to 'auto' or
'scale' to avoid this warning.
  warnings.warn("The default value of gamma will change "
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/svm/base.py:189: FutureWarning: The default value
of gamma will change from 'auto' to 'scale' in version 0.22 to accou
nt better for unscaled features. Set gamma explicitly to 'auto' or
'scale' to avoid this warning.
  warnings.warn("The default value of gamma will change "
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/svm/base.py:189: FutureWarning: The default value
of gamma will change from 'auto' to 'scale' in version 0.22 to accou
nt better for unscaled features. Set gamma explicitly to 'auto' or
'scale' to avoid this warning.
  warnings.warn("The default value of gamma will change "
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/svm/base.py:189: FutureWarning: The default value
of gamma will change from 'auto' to 'scale' in version 0.22 to accou
nt better for unscaled features. Set gamma explicitly to 'auto' or
'scale' to avoid this warning.
  warnings.warn("The default value of gamma will change "
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/svm/base.py:189: FutureWarning: The default value
of gamma will change from 'auto' to 'scale' in version 0.22 to accou
nt better for unscaled features. Set gamma explicitly to 'auto' or
'scale' to avoid this warning.
  warnings.warn("The default value of gamma will change "
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/svm/base.py:189: FutureWarning: The default value
of gamma will change from 'auto' to 'scale' in version 0.22 to accou
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```
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```

```
nt better for unscaled features. Set gamma explicitly to 'auto' or
'scale' to avoid this warning.
  warnings.warn("The default value of gamma will change "
```

Out[170]:

```
GridSearchCV(cv=3, error_score='raise-deprecating',
             estimator=SVC(C=1.0, cache_size=200, class_weight=None,
coef0=0.0,
                           decision_function_shape='ovr', degree=3,
                           gamma='auto_deprecated', kernel='rbf', ma
x_iter=-1,
                           probability=False, random_state=None, shr
inking=True,
                           tol=0.001, verbose=False),
             iid='warn', n_jobs=None,
             param_grid=[{'degree': [2, 3, 4, 7, 8],
                          'kernel': ['poly', 'rbf']}],
             pre_dispatch='2*n_jobs', refit=True, return_train_score
=False,
             scoring=None, verbose=0)
```

In [171]:

```
grid.best_params_
```

Out[171]:

```
{'degree': 2, 'kernel': 'poly'}
```

In [172]:

```
grid.cv_results_
```

Out[172]:

```
{'mean_fit_time': array([ 92.37450782,  97.9618245 , 274.70143954, 5
10.02646112,
        158.80167103, 145.29603648,  87.33926868,  94.94347684,
        705.04820458, 106.51352771]),
 'std_fit_time': array([2.96083596e-01, 1.75040287e+00, 2.63289147e+
02, 4.43279024e+02,
        1.00953928e+02, 7.13039557e+01, 2.61493287e-01, 1.36672163e+
00,
        8.74177963e+02, 9.50814588e-01]),
 'mean_score_time': array([ 44.70128846,  47.63206895, 400.54052504,
793.817662  ,
        797.2882603 ,  45.31920465,  42.75135652,  45.34162696,
         44.96676731,  51.17960437]),
 'std_score_time': array([2.34961420e-01, 8.71806758e-01, 5.05794394
e+02, 1.05843377e+03,
        1.06721127e+03, 1.48485699e-01, 1.18387215e-01, 4.25620832e-
01,
        2.75228631e+00, 4.33852389e-01]),
 'param_degree': masked_array(data=[2, 2, 3, 3, 4, 4, 7, 7, 8, 8],
              mask=[False, False, False, False, False, False, False,
False,
                    False, False],
        fill_value='?',
             dtype=object),
 'param_kernel': masked_array(data=['poly', 'rbf', 'poly', 'rbf', 'p
oly', 'rbf', 'poly',
                    'rbf', 'poly', 'rbf'],
              mask=[False, False, False, False, False, False, False,
False,
                    False, False],
        fill_value='?',
             dtype=object),
 'params': [{'degree': 2, 'kernel': 'poly'},
  {'degree': 2, 'kernel': 'rbf'},
  {'degree': 3, 'kernel': 'poly'},
  {'degree': 3, 'kernel': 'rbf'},
  {'degree': 4, 'kernel': 'poly'},
  {'degree': 4, 'kernel': 'rbf'},
  {'degree': 7, 'kernel': 'poly'},
  {'degree': 7, 'kernel': 'rbf'},
  {'degree': 8, 'kernel': 'poly'},
  {'degree': 8, 'kernel': 'rbf'}],
 'split0_test_score': array([0.86241353, 0.86241353, 0.86241353, 0.8
6241353, 0.86241353,
        0.86241353, 0.86241353, 0.86241353, 0.86241353, 0.8624135
3]),
 'split1_test_score': array([0.86230769, 0.86230769, 0.86230769, 0.8
6230769, 0.86230769,
        0.86230769, 0.86230769, 0.86230769, 0.86230769, 0.8623076
9]),
 'split2_test_score': array([0.86297152, 0.86297152, 0.86297152, 0.8
6297152, 0.86297152,
        0.86297152, 0.86297152, 0.86297152, 0.86297152, 0.8629715
2]),
 'mean_test_score': array([0.8625641, 0.8625641, 0.8625641, 0.862564
1, 0.8625641, 0.8625641,
        0.8625641, 0.8625641, 0.8625641, 0.8625641]),
 'std_test_score': array([0.00029114, 0.00029114, 0.00029114, 0.0002
9114, 0.00029114,
        0.00029114, 0.00029114, 0.00029114, 0.00029114, 0.0002911
4]),
 'rank_test_score': array([1, 1, 1, 1, 1, 1, 1, 1, 1, 1], dtype=int3
2)}
```

In [173]:

```
grid.best_estimator_.degree
```

Out[173]:

```
2
```

In [180]:

```
svm_grid_pred = grid.predict(x_sms_test)
```

In [181]:

```
confusion_matrix(y_sms_test, svm_grid_pred)
```

Out[181]:

```
array([[1461,    0],
       [ 211,    0]])
```

In [182]:

```
accuracy_score(y_sms_test, svm_grid_pred)
```

Out[182]:

```
0.8738038277511961
```

In [177]:

```
precision_score(y_sms_test, svm_grid_pred)
```

```
/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/site
-packages/sklearn/metrics/classification.py:1436: UndefinedMetricWar
ning: Precision is ill-defined and being set to 0.0 due to no predic
ted samples.
  precision = _prf_divide(tp_sum, pred_sum,
```

Out[177]:

```
0.0
```

In [178]:

```
recall_score(y_sms_test, svm_grid_pred)
```

Out[178]:

```
0.0
```

In [179]:

```
recall_score(y_sms_test, svm_grid_pred)
```

Out[179]:

```
0.0
```

This is an interesting confusion matrix, nothing has been predicted positively, not even the actual positive instance.
try to think of the reason.

you are ready to compare NB and SVM

In [ ]:

```
```