```
#Import all libraries
import pandas as pd
import numpy as np
import statsmodels.api as sm
import matplotlib.pyplot as plt
import seaborn as sns
import warnings

from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import LogisticRegression
from sklearn import metrics
from sklearn import preprocessing
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import OneHotEncoder
warnings.filterwarnings('ignore')
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import confusion_matrix
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report
from sklearn.tree import plot_tree
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.model_selection import GridSearchCV
```

```
/usr/local/lib/python3.7/dist-packages/statsmodels/tools/_testing.py:19: FutureWarning:
  import pandas.util.testing as tm
```

```
#load in data from excel/csv
data = pd.read_csv(r'/content/Telco_Churn_Dataset.csv')


#Ensure the object has the correct data
data.head(5)
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Multip
0	7590-VHVEG	Female	0	Yes	No	1	No	N
1	5575-GNVDE	Male	0	No	No	34	Yes	

```
#Determine the number of columns and rows within dataset
data.shape
```

```
(7043, 21)
```

```
data.index
```

```
RangeIndex(start=0, stop=7043, step=1)
```

```
#List the column names
data.columns
```

```
Index(['customerID', 'gender', 'SeniorCitizen', 'Partner', 'Dependents',
       'tenure', 'PhoneService', 'MultipleLines', 'InternetService',
       'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport',
       'StreamingTV', 'StreamingMovies', 'Contract', 'PaperlessBilling',
       'PaymentMethod', 'MonthlyCharges', 'TotalCharges', 'Churn'],
      dtype='object')
```

```
#Determine the types of data
data.dtypes
```

```
customerID           object
gender               object
SeniorCitizen         int64
Partner              object
Dependents           object
tenure                int64
PhoneService         object
MultipleLines        object
InternetService      object
OnlineSecurity       object
OnlineBackup         object
DeviceProtection     object
TechSupport          object
StreamingTV          object
StreamingMovies      object
Contract             object
PaperlessBilling     object
PaymentMethod        object
MonthlyCharges      float64
TotalCharges         object
Churn                object
dtype: object
```

```
#Check data for any missing values
data.isnull().sum()
```

```
customerID          0
gender              0
SeniorCitizen       0
Partner             0
Dependents          0
tenure              0
PhoneService        0
MultipleLines       0
InternetService     0
OnlineSecurity      0
OnlineBackup        0
DeviceProtection    0
TechSupport         0
StreamingTV         0
StreamingMovies     0
Contract            0
PaperlessBilling    0
PaymentMethod       0
MonthlyCharges      0
TotalCharges        0
Churn               0
dtype: int64
```

```
#No missing values
data1=data.copy()
```

```
X = data1.iloc[ : , :-1].values
```

```
X
```

```
array([['7590-VHVEG', 'Female', 0, ..., 'Electronic check', 29.85,
        '29.85'],
       ['5575-GNVDE', 'Male', 0, ..., 'Mailed check', 56.95, '1889.5'],
       ['3668-QPYBK', 'Male', 0, ..., 'Mailed check', 53.85, '108.15'],
       ...,
       ['4801-JZAZL', 'Female', 0, ..., 'Electronic check', 29.6,
        '346.45'],
       ['8361-LTMKD', 'Male', 1, ..., 'Mailed check', 74.4, '306.6'],
       ['3186-AJIEK', 'Male', 0, ..., 'Bank transfer (automatic)',
        105.65, '6844.5']], dtype=object)
```

```
label_encoder = LabelEncoder()
```

```
X[ : ,0] = label_encoder.fit_transform(X[ :, 0])
```

```
X
```

```
array([[5375, 'Female', 0, ..., 'Electronic check', 29.85, '29.85'],
       [3962, 'Male', 0, ..., 'Mailed check', 56.95, '1889.5'],
       [2564, 'Male', 0, ..., 'Mailed check', 53.85, '108.15'],
       ...,
       [3367, 'Female', 0, ..., 'Electronic check', 29.6, '346.45'],
       [5934, 'Male', 1, ..., 'Mailed check', 74.4, '306.6'],
       [2226, 'Male', 0, ..., 'Bank transfer (automatic)', 105.65,
        '6844.5']], dtype=object)
```

```
#Replace every 'Yes' in data with a '1' and every 'No' with a '0'
data1.Partner.replace(('Yes', 'No'), (1,0), inplace=True)
data1.Dependents.replace(('Yes', 'No'), (1,0), inplace=True)
data1.PhoneService.replace(('Yes', 'No'), (1, 0), inplace=True)
data1.MultipleLines.replace(('Yes', 'No phone service', 'No'), (1,0,0), inplace=True)
data1.OnlineSecurity.replace(('Yes', 'No', 'No internet service'), (1, 0,0), inplace = True)
data1.OnlineBackup.replace(('Yes', 'No'), (1,0), inplace=True)
data1.DeviceProtection.replace(('Yes', 'No', 'No internet service'), (1,0,0), inplace=True)
data1.TechSupport.replace(('Yes', 'No', 'No internet service'), (1,0,0), inplace=True)
data1.StreamingTV.replace(('Yes', 'No', 'No internet service'), (1,0,0), inplace=True)
data1.StreamingMovies.replace(('Yes', 'No', 'No internet service'), (1,0,0), inplace = True)
data1.PaperlessBilling.replace(('Yes', 'No'), (1,0), inplace=True)
data1.Churn.replace(('Yes', 'No'), (1,0), inplace = True)
```

```
data1
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Mul
0	7590-VHVEG	Female	0	1	0	1	0	
1	5575-GNVDE	Male	0	0	0	34	1	
2	3668-QPYBK	Male	0	0	0	2	1	

```
# Split all Categorical Columns into Multiples
data2=data1.drop(['gender'],axis=1)
```

4 9237-HQITU Female 0 0 0 2 1

```
#Make a new column showing Female_Gender and Male_Gender
#Remove Original "Gender" column
dummy=pd.get_dummies(data1['gender'],prefix="Gender")
dummy
data2=pd.concat([data2,dummy], axis=1)
```

7029 2234- Female 0 1 1 72 1

```
#Make a new column showing the different internet services as columns starting with "Internet
#Remove original column named "InternetService"
data3=data2.drop(['InternetService'],axis=1)
dummy=pd.get_dummies(data2["InternetService"],prefix="InternetService")
dummy
data3=pd.concat([data3,dummy],axis=1)
```

7042 3186-AJIEK Male 0 0 0 66 1

```
#Make a new column showing different contract types starting with "Contract"
#Remove original column named "Contract"
data4=data3.drop(['Contract'],axis=1)
dummy=pd.get_dummies(data3["Contract"],prefix="Contract")
dummy
data4=pd.concat([data4, dummy],axis=1)


#Do the same thing with "PaymentMethod" as we did for "Gender", "InternetServices", and "Cont
data5=data4.drop(['PaymentMethod'],axis=1)
dummy=pd.get_dummies(data4["PaymentMethod"],prefix="PaymentMethod")
dummy
data5=pd.concat([data5,dummy],axis=1)
data5
```

	customerID	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLin
0	7590-VHVEG	0	1	0	1	0	
1	5575-GNVDE	0	0	0	34	1	
2	3668-QPYBK	0	0	0	2	1	
3	7795-CFOCW	0	0	0	45	0	
4	9237-HQITU	0	0	0	2	1	
...	...	...	...	...	...	...	
7038	6840-RESVB	0	1	1	24	1	
7039	2234-XADUH	0	1	1	72	1	
7040	4801-JZAZL	0	1	1	11	0	
7041	8361-LTMKD	1	1	0	4	1	

```
#create dummies for the following columns:
data5=pd.get_dummies(data5,columns=['MultipleLines'])
data5=pd.get_dummies(data5,columns=['OnlineSecurity'])
data5=pd.get_dummies(data5,columns=['OnlineBackup'])
data5=pd.get_dummies(data5,columns=['DeviceProtection'])

data5
```

	customerID	SeniorCitizen	Partner	Dependents	tenure	PhoneService	TechSupport
0	7590-VHVEG	0	1	0	1	0	0
1	5575-GNVDE	0	0	0	34	1	0
2	3668-QPYBK	0	0	0	2	1	0
3	7795-CFOCW	0	0	0	45	0	1
4	9237-HQITU	0	0	0	2	1	0
...	...	...	...	...	...	...	...

```
#remove the column labeled "customerID"
data6=data5.drop(['customerID'], axis =1)
data6
```

	SeniorCitizen	Partner	Dependents	tenure	PhoneService	TechSupport	StreamingT
0	0	1	0	1	0	0	
1	0	0	0	34	1	0	
2	0	0	0	2	1	0	
3	0	0	0	45	0	1	
4	0	0	0	2	1	0	
...	...	...	...	...	...	...	.
7038	0	1	1	24	1	1	
7039	0	1	1	72	1	0	
7040	0	1	1	11	0	0	
7041	1	1	0	4	1	0	
7042	0	0	0	66	1	1	

7043 rows × 33 columns

```
#list columns to ensure CustomerID is off of the dataset
data6.columns
```

```
Index(['SeniorCitizen', 'Partner', 'Dependents', 'tenure', 'PhoneService',
       'TechSupport', 'StreamingTV', 'StreamingMovies', 'PaperlessBilling',
       'MonthlyCharges', 'TotalCharges', 'Churn', 'Gender_Female',
       'Gender_Male', 'InternetService_DSL', 'InternetService_Fiber optic',
       'InternetService_No', 'Contract_Month-to-month', 'Contract_One year',
       'Contract_Two year', 'PaymentMethod_Bank transfer (automatic)',
       'PaymentMethod_Credit card (automatic)',
       'PaymentMethod_Electronic check', 'PaymentMethod_Mailed check',
       'MultipleLines_0', 'MultipleLines_1', 'OnlineSecurity_0',
       'OnlineSecurity_1', 'OnlineBackup_0', 'OnlineBackup_1',
       'OnlineBackup_No internet service', 'DeviceProtection_0',
       'DeviceProtection_1'],
      dtype='object')
```

```
#change "MonthlyCharges" to an integer type
data6['MonthlyCharges'] = data6.MonthlyCharges.astype(int)
```

```
#change "TotalCharges" to an integer type
data6['TotalCharges'] = data6.MonthlyCharges.astype(int)
```

```
#list all datatypes within data6 dataset
data6.dtypes
```

```
SeniorCitizen                              int64
Partner                                    int64
Dependents                                 int64
tenure                                     int64
PhoneService                               int64
TechSupport                                int64
StreamingTV                                int64
StreamingMovies                            int64
PaperlessBilling                           int64
MonthlyCharges                             int64
TotalCharges                               int64
Churn                                      int64
Gender_Female                              uint8
Gender_Male                                uint8
InternetService_DSL                        uint8
InternetService_Fiber optic                uint8
InternetService_No                         uint8
Contract_Month-to-month                    uint8
Contract_One year                          uint8
Contract_Two year                          uint8
PaymentMethod_Bank transfer (automatic)    uint8
PaymentMethod_Credit card (automatic)      uint8
PaymentMethod_Electronic check             uint8
PaymentMethod_Mailed check                 uint8
MultipleLines_0                            uint8
MultipleLines_1                            uint8
OnlineSecurity_0                           uint8
OnlineSecurity_1                           uint8
OnlineBackup_0                             uint8
```

```
OnlineBackup_1                          uint8
OnlineBackup_No internet service        uint8
DeviceProtection_0                      uint8
DeviceProtection_1                      uint8
dtype: object
```

```
#split data
#identify x as all columns except Churn
x = data6.loc[:,['SeniorCitizen', 'Partner', 'Dependents', 'tenure', 'PhoneService',
       'TechSupport', 'StreamingTV', 'StreamingMovies', 'PaperlessBilling',
       'MonthlyCharges', 'TotalCharges', 'Gender_Female',
       'Gender_Male', 'InternetService_DSL', 'InternetService_Fiber optic',
       'InternetService_No', 'Contract_Month-to-month', 'Contract_One year',
       'Contract_Two year', 'PaymentMethod_Bank transfer (automatic)',
       'PaymentMethod_Credit card (automatic)',
       'PaymentMethod_Electronic check', 'PaymentMethod_Mailed check',
       'MultipleLines_0', 'MultipleLines_1', 'OnlineSecurity_0',
       'OnlineSecurity_1', 'OnlineBackup_0', 'OnlineBackup_1',
       'OnlineBackup_No internet service', 'DeviceProtection_0',
       'DeviceProtection_1']]
#identify y as "Churn" columns
y = data6.loc[:, ["Churn"]]
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(x, y, test_size = 0.2, random_state=0)
```

```
#show X_train
X_train
```

	SeniorCitizen	Partner	Dependents	tenure	PhoneService	TechSupport	StreamingT
2920	0	1	0	72	1	1	

```
#Show X_test
X_test
```

	SeniorCitizen	Partner	Dependents	tenure	PhoneService	TechSupport	StreamingT
2200	0	0	0	19	1	0	
4627	0	0	0	60	1	1	
3225	0	0	0	13	1	0	
2828	0	0	0	1	1	0	
3768	0	1	0	55	1	0	
...	...	...	...	...	...	...	.
2631	1	1	0	7	1	0	
5333	0	1	1	13	1	0	
6972	1	0	0	56	1	1	
4598	0	0	0	18	1	0	
3065	0	0	0	1	1	0	

1409 rows × 32 columns

```
#Show y_train
y_train
```

	Churn
2920	0
2966	0
6099	0
5482	1
2012	1

```
#Show y_test
y_test
```

	Churn
2200	0
4627	0
3225	0
2828	0
3768	0
...	...
2631	1
5333	1
6972	1
4598	0
3065	0

1409 rows × 1 columns

```
from sklearn.preprocessing import StandardScaler
standard_X=StandardScaler()


#transform the data for X_train to be reidentified
X_train = standard_X.fit_transform(X_train)


#transform data for X_test to be reidentified
X_test = standard_X.fit_transform(X_test)


#print X_train
X_train
```

```
array([[-0.4397627 ,  1.03247596, -0.65321536, ..., -0.52628119,
        -1.37989989,  1.37989989],
       [ 2.27395367, -0.96854556, -0.65321536, ..., -0.52628119,
         0.72469025, -0.72469025],
       [-0.4397627 ,  1.03247596,  1.53088869, ...,  1.9001249 ,
         0.72469025, -0.72469025],
       ...,
       [-0.4397627 ,  1.03247596, -0.65321536, ...,  1.9001249 ,
         0.72469025, -0.72469025],
       [ 2.27395367, -0.96854556, -0.65321536, ..., -0.52628119,
         0.72469025, -0.72469025],
       [-0.4397627 , -0.96854556,  1.53088869, ...,  1.9001249 ,
         0.72469025, -0.72469025]])
```

```
#print X_test
X_test
```

```
array([[-0.44053127, -0.95896743, -0.65719903, ..., -0.52451227,
         0.72108034, -0.72108034],
       [-0.44053127, -0.95896743, -0.65719903, ..., -0.52451227,
        -1.38680803,  1.38680803],
       [-0.44053127, -0.95896743, -0.65719903, ..., -0.52451227,
         0.72108034, -0.72108034],
       ...,
       [ 2.26998644, -0.95896743, -0.65719903, ..., -0.52451227,
        -1.38680803,  1.38680803],
       [-0.44053127, -0.95896743, -0.65719903, ..., -0.52451227,
         0.72108034, -0.72108034],
       [-0.44053127, -0.95896743, -0.65719903, ..., -0.52451227,
         0.72108034, -0.72108034]])
```

```
#print y_train for viewing
y_train
```

	Churn
2920	0

```
#print y_test
y_test
```

	Churn
2200	0
4627	0
3225	0
2828	0
3768	0
...	...
2631	1
5333	1
6972	1
4598	0
3065	0

1409 rows × 1 columns

```
# Calculating Descriptive Statistics
data6.describe(include='all')
```

	SeniorCitizen	Partner	Dependents	tenure	PhoneService	TechSupport	S
count	7043.000000	7043.000000	7043.000000	7043.000000	7043.000000	7043.000000	

```
#find the correlation for all columns
data6.corr()
```

	SeniorCitizen	Partner	Dependents	tenure	PhoneService	Te
SeniorCitizen	1.000000	0.016479	-0.211185	0.016567	0.008576	
Partner	0.016479	1.000000	0.452676	0.379697	0.017706	
Dependents	-0.211185	0.452676	1.000000	0.159712	-0.001762	
tenure	0.016567	0.379697	0.159712	1.000000	0.008448	
PhoneService	0.008576	0.017706	-0.001762	0.008448	1.000000	
TechSupport	-0.060625	0.119999	0.063268	0.324221	-0.096340	
StreamingTV	0.105378	0.124666	-0.016558	0.279756	-0.022574	
StreamingMovies	0.120176	0.117412	-0.039741	0.286111	-0.032959	
PaperlessBilling	0.156530	-0.014877	-0.111377	0.006152	0.016505	
MonthlyCharges	0.220129	0.096913	-0.113910	0.247917	0.247277	
TotalCharges	0.220129	0.096913	-0.113910	0.247917	0.247277	
Churn	0.150889	-0.150448	-0.164221	-0.352229	0.011942	

```
#find the covariance for all columns
data6.cov()
```

	SeniorCitizen	Partner	Dependents	tenure	PhoneService
SeniorCitizen	0.135875	0.003036	-0.035662	0.149978	0.000935
Partner	0.003036	0.249748	0.103635	4.660232	0.002617
Dependents	-0.035662	0.103635	0.209865	1.796915	-0.000239
tenure	0.149978	4.660232	1.796915	603.168108	0.061364
PhoneService	0.000935	0.002617	-0.000239	0.061364	0.087469
TechSupport	-0.010143	0.027220	0.013156	3.614225	-0.012933
StreamingTV	0.018896	0.030308	-0.003690	3.342417	-0.003248
StreamingMovies	0.021587	0.028593	-0.008872	3.424172	-0.004750
PaperlessBilling	0.028356	-0.003654	-0.025076	0.074260	0.002399
MonthlyCharges	2.441790	1.457450	-1.570341	183.225863	2.200767
TotalCharges	2.441790	1.457450	-1.570341	183.225863	2.200767
Churn	0.024559	-0.033199	-0.033219	-3.819750	0.001560
Gender_Female	0.000345	0.000452	-0.002409	-0.062705	0.000959
Gender_Male	-0.000345	-0.000452	0.002409	0.062705	-0.000959
InternetService_DSL	-0.018966	-0.000202	0.011317	0.154849	-0.063557
InternetService_Fiber optic	0.046719	0.000075	-0.037706	0.240404	0.042573
InternetService_No	-0.027753	0.000127	0.026389	-0.395253	0.020984
Contract_Month-to-month	0.025374	-0.069831	-0.052812	-7.887845	-0.000109
Contract_One year	-0.006936	0.016827	0.012739	2.023473	-0.000336
Contract_Two year	-0.018438	0.053005	0.040074	5.864371	0.000445
PaymentMethod_Bank transfer (automatic)	-0.002464	0.022891	0.009860	2.474431	0.000925
PaymentMethod_Credit card (automatic)	-0.003662	0.016874	0.011364	2.355455	-0.000940
[illegible]	-0.023769	-0.019973	0.011369	-2.412992	-0.000412

```
#Save the depedent feature "Churn" in a variable called "Y" and independent features in "X"
Y = data6["Churn"]
X = data6.drop("Churn",axis=1)
```

```
X_train, X_valid, Y_train, Y_valid = train_test_split(X,Y, train_size = 0.8, random_state = 1
```

```
#Create the X_scaled meaning the data has been preprocessed
X_scaled = preprocessing.scale(X_train, axis =1)
```

```
#create the linear model summary (the OLS Regression)
X2_train = sm.add_constant(X_train)
linearModel = sm.OLS(Y_train, X_train).fit()
print(linearModel.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  Churn   R-squared:                       0.286
Model:                            OLS   Adj. R-squared:                  0.283
Method:                 Least Squares   F-statistic:                     101.9
Date:                Mon, 02 May 2022   Prob (F-statistic):               0.00
Time:                        03:37:49   Log-Likelihood:                -2477.9
No. Observations:                5634   AIC:                             5002.
Df Residuals:                    5611   BIC:                             5155.
Df Model:                          22
Covariance Type:            nonrobust
================================================================================================
                                           coef    std err          t      P>|t|
------------------------------------------------------------------------------------------------
SeniorCitizen                             0.0360      0.015      2.465      0.014
Partner                                  -0.0115      0.012     -0.950      0.342
Dependents                               -0.0105      0.013     -0.813      0.416
tenure                                   -0.0044      0.000    -12.870      0.000
PhoneService                             -0.0136      0.096     -0.141      0.888
TechSupport                              -0.0609      0.027     -2.231      0.026
StreamingTV                               0.0308      0.049      0.634      0.526
StreamingMovies                           0.0503      0.049      1.032      0.302
PaperlessBilling                          0.0520      0.011      4.623      0.000
MonthlyCharges                           -0.0008      0.002     -0.354      0.723
TotalCharges                             -0.0008      0.002     -0.354      0.723
Gender_Female                             0.0645      0.025      2.566      0.010
Gender_Male                               0.0616      0.025      2.446      0.014
InternetService_DSL                      -0.0051      0.013     -0.389      0.697
InternetService_Fiber optic               0.1784      0.107      1.673      0.094
InternetService_No                       -0.0471      0.047     -1.002      0.316
Contract_Month-to-month                   0.0942      0.019      4.974      0.000
Contract_One year                        -0.0073      0.019     -0.389      0.697
Contract_Two year                         0.0393      0.020      2.000      0.046
PaymentMethod_Bank transfer (automatic)   0.0197      0.016      1.266      0.205
PaymentMethod_Credit card (automatic)     0.0099      0.016      0.632      0.527
PaymentMethod_Electronic check            0.0991      0.015      6.491      0.000
PaymentMethod_Mailed check               -0.0026      0.016     -0.163      0.870
MultipleLines_0                           0.0419      0.014      3.025      0.003
MultipleLines_1                           0.0842      0.037      2.269      0.023
OnlineSecurity_0                          0.0952      0.014      6.586      0.000
OnlineSecurity_1                          0.0309      0.037      0.836      0.403
OnlineBackup_0                            0.1035      0.036      2.841      0.005
OnlineBackup_1                            0.0697      0.060      1.164      0.244
OnlineBackup_No internet service         -0.0471      0.047     -1.002      0.316
DeviceProtection_0                        0.0702      0.014      4.894      0.000
DeviceProtection_1                        0.0559      0.037      1.510      0.131
==============================================================================
Omnibus:                      303.151   Durbin-Watson:                   2.006
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              287.812
```

```
Skew:                          0.501   Prob(JB):                     3.18e-63
Kurtosis:                      2.527   Cond. No.                     1.12e+16
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly spec
[2] The smallest eigenvalue is 5.01e-25. This might indicate that there are
```

```
#include all columns that have a P value of above 0.05
cols = ['SeniorCitizen', 'Partner', 'Dependents', 'tenure', 'PhoneService',
       'TechSupport', 'StreamingTV', 'StreamingMovies', 'PaperlessBilling',
       'MonthlyCharges', 'TotalCharges', 'Gender_Female',
       'Gender_Male', 'InternetService_DSL', 'InternetService_Fiber optic',
       'InternetService_No', 'Contract_Month-to-month', 'Contract_One year',
       'Contract_Two year', 'PaymentMethod_Bank transfer (automatic)',
       'PaymentMethod_Credit card (automatic)',
       'PaymentMethod_Electronic check', 'PaymentMethod_Mailed check',
       'MultipleLines_0', 'MultipleLines_1', 'OnlineSecurity_0',
       'OnlineSecurity_1', 'OnlineBackup_0', 'OnlineBackup_1',
       'OnlineBackup_No internet service', 'DeviceProtection_0',
       'DeviceProtection_1']

#drop all of these columns
X3_train=X2_train.drop(cols, axis=1)

#create a new linear model with this new information
linearModel2=sm.OLS(Y_train, X3_train).fit()
print(linearModel2.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  Churn   R-squared:                       0.000
Model:                            OLS   Adj. R-squared:                  0.000
Method:                 Least Squares   F-statistic:                       inf
Date:                Mon, 02 May 2022   Prob (F-statistic):                nan
Time:                        03:37:49   Log-Likelihood:                -3425.0
No. Observations:                5634   AIC:                             6852.
Df Residuals:                    5633   BIC:                             6859.
Df Model:                           0
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.2709      0.006     45.744      0.000       0.259       0.282
==============================================================================
Omnibus:                     1620.346   Durbin-Watson:                   2.002
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1204.498
Skew:                           1.031   Prob(JB):                    2.80e-262
Kurtosis:                       2.063   Cond. No.                         1.00
==============================================================================
```

```
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specifi
```

```
#lr_model=sm.Logit(Y_train, X_train)
#results=lr_model.fit()
#print(results.summary())
```

```
#create logistic regression
lr_model=LogisticRegression(max_iter=100)
lr_model.fit(X_train, Y_train)
```

```
LogisticRegression()
```

```
#create a linear model for prediction to find the accuracy score for the Y trains
from sklearn.metrics import accuracy_score, confusion_matrix
Y_Pred_Train = lr_model.predict(X_train)
accuracy_score(Y_train, Y_Pred_Train)
```

```
0.8031593894213702
```

```
#find accuracy for the actual values of y train vs the predicted values of y train
ac = pd.DataFrame({'Actual Value': Y_train, 'Predicted Value': Y_Pred_Train})
ac.head()
```

	Actual Value	Predicted Value
1182	0	0
4328	0	0
6091	1	1
4870	0	0
4683	0	1

```
#do the same for test
Y_Pred_Test = lr_model.predict(X_valid)

accuracy_score(Y_valid, Y_Pred_Test)
```

```
0.8055358410220014
```

```
# Create decision tree model
tree_model_1= DecisionTreeClassifier(max_leaf_nodes=3)
tree_model_1.fit(X_train, Y_train)

DecisionTreeClassifier(max_leaf_nodes=3)
```

```
DecisionTreeClassifier(max_leaf_nodes=3)
```

```
#evaluate the model
confusion_matrix(Y_train, tree_model_1.predict(X_train))
```

```
array([[3343,  765],
       [ 566,  960]])
```

```
#accuracy score of decision tee
accuracy_score(Y_train, tree_model_1.predict(X_train))
```

```
0.7637557685481008
```

```
leaf_range = np.arange(2,51)
leaf_range
```

```
array([ 2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16, 17, 18,
       19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
       36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50])
```

```
leaf_score=pd.DataFrame(columns = ['NoLeaves','TrainScore','ValidScore'])
leaf_score
```

	NoLeaves	TrainScore	ValidScore

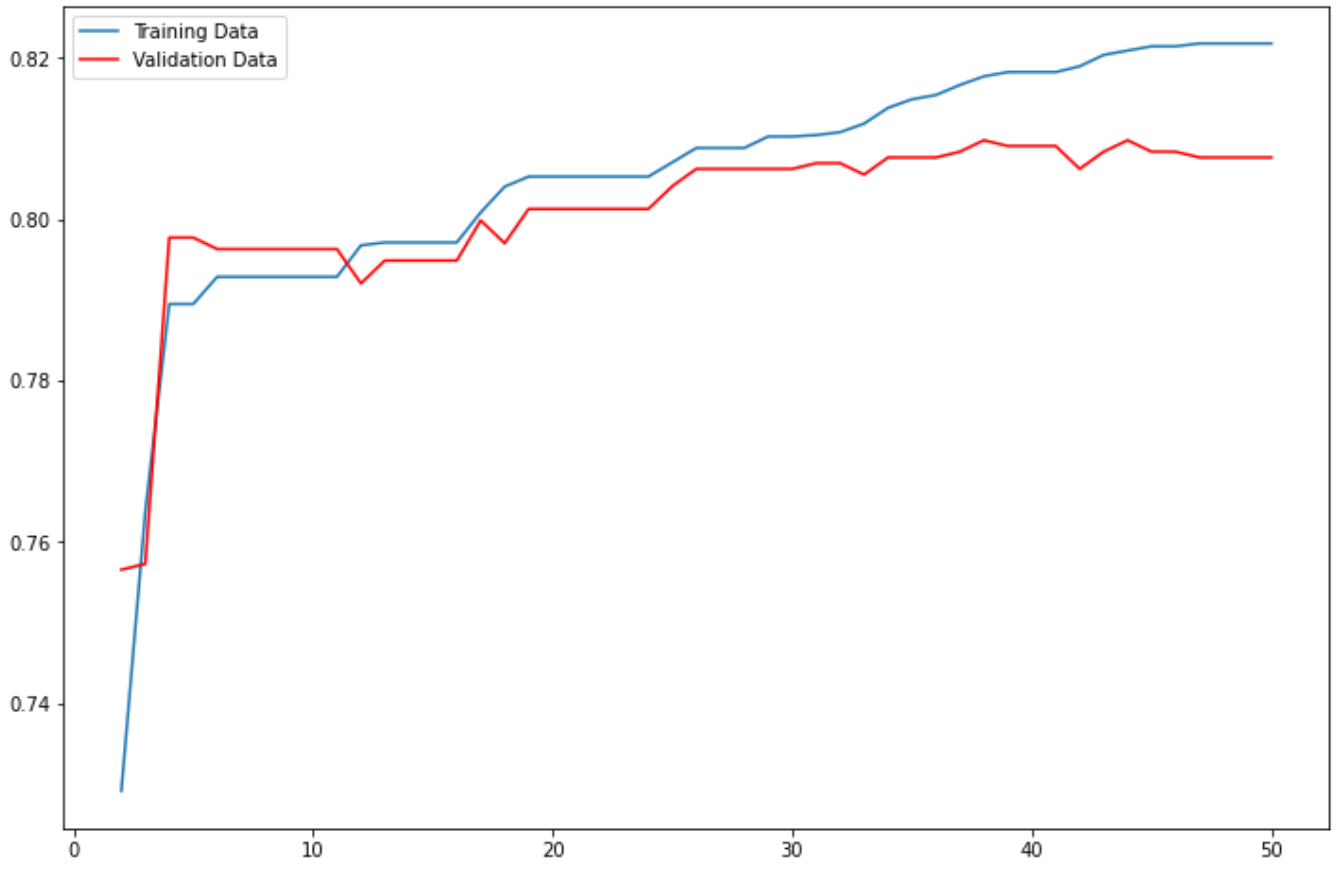
```
for i in leaf_range:
  tree_model=DecisionTreeClassifier(max_leaf_nodes=i)
  tree_model.fit(X_train, Y_train)
  accTrain=accuracy_score(Y_train, tree_model.predict(X_train))
  accValid=accuracy_score(Y_valid, tree_model.predict(X_valid))
  leaf_score=leaf_score.append({'NoLeaves':i, 'TrainScore':accTrain,'ValidScore':accValid}, i
```

```
leaf_score
```

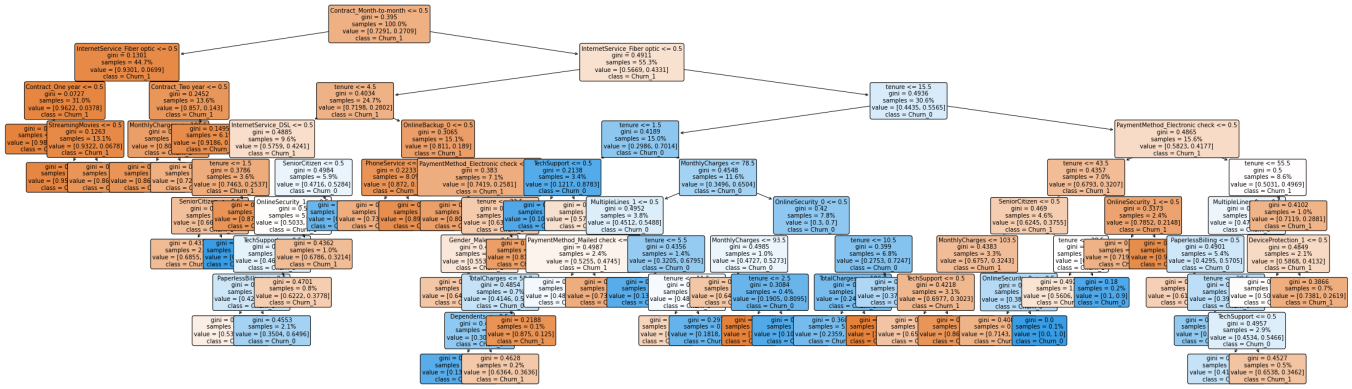
	NoLeaves	TrainScore	ValidScore
0	2.0	0.729144	0.756565
1	3.0	0.763756	0.757275
2	4.0	0.789492	0.797729
3	5.0	0.789492	0.797729
4	6.0	0.792865	0.796309
5	7.0	0.792865	0.796309
6	8.0	0.792865	0.796309
7	9.0	0.792865	0.796309
8	10.0	0.792865	0.796309
9	11.0	0.792865	0.796309
10	12.0	0.796770	0.792051
11	13.0	0.797125	0.794890
12	14.0	0.797125	0.794890
13	15.0	0.797125	0.794890
14	16.0	0.797125	0.794890
15	17.0	0.800852	0.799858
16	18.0	0.804047	0.797019
17	19.0	0.805289	0.801278
18	20.0	0.805289	0.801278
19	21.0	0.805289	0.801278
20	22.0	0.805289	0.801278
21	23.0	0.805289	0.801278
22	24.0	0.805289	0.801278
23	25.0	0.807064	0.804116
24	26.0	0.808839	0.806246
25	27.0	0.808839	0.806246
26	28.0	0.808839	0.806246
27	29.0	0.810259	0.806246
28	30.0	0.810259	0.806246
29	31.0	0.810437	0.806955

30	32.0	0.810792	0.806955
31	33.0	0.811857	0.805536
32	34.0	0.813809	0.807665
33	35.0	0.814874	0.807665
34	36.0	0.815406	0.807665
35	37.0	0.816649	0.808375
36	38.0	0.817714	0.809794
37	39.0	0.818246	0.809084
38	40.0	0.818246	0.809084
39	41.0	0.818246	0.809084
40	42.0	0.818956	0.806246
41	43.0	0.820376	0.808375

```
plt.figure(figsize=(12,8))
plt.plot(leaf_score['NoLeaves'], leaf_score['TrainScore'], label='Training Data')
plt.plot(leaf_score['NoLeaves'],leaf_score['ValidScore'], label = 'Validation Data', color =
plt.legend()
plt.show()
```



```
plt.figure(figsize=(40,12))
dec_tree = plot_tree(decision_tree = tree_model, feature_names = X_valid.columns,
                     class_names = ["Churn_1","Churn_0"], filled = True, precision = 4, round
plt.show()
```



```
# Random Forest Classifier
tree_model_2= RandomForestClassifier(max_depth=2, random_state = 0)
tree_model_2.fit(X_train, y_train)

RandomForestClassifier(max_depth=2, random_state=0)
```

```
RandomForestClassifier(max_depth=2, random_state=0)
```

```
#evaluate the model
confusion_matrix(Y_train, tree_model_2.predict(X_train))
```

```
array([[4108,    0],
       [1526,    0]])
```

```
confusion_matrix(Y_valid, tree_model_2.predict(X_valid))
```

```
array([[1066,    0],
       [ 343,    0]])
```

```
#random forest accuracy score y train
```

```
accuracy_score(Y_train, tree_model_2.predict(X_train))
```

```
0.729144479943202
```

```
#random forest accuracy score y test/valid
accuracy_score(Y_valid, tree_model_2.predict(X_valid))
```

```
0.7565649396735273
```

```
leaf_range = np.arange(2,51)
leaf_range
```

```
array([ 2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16, 17, 18,
       19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
       36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50])
```

```
leaf_score=pd.DataFrame(columns = ['NoLeaves','TrainScore','ValidScore'])
leaf_score
```

NoLeaves	TrainScore	ValidScore

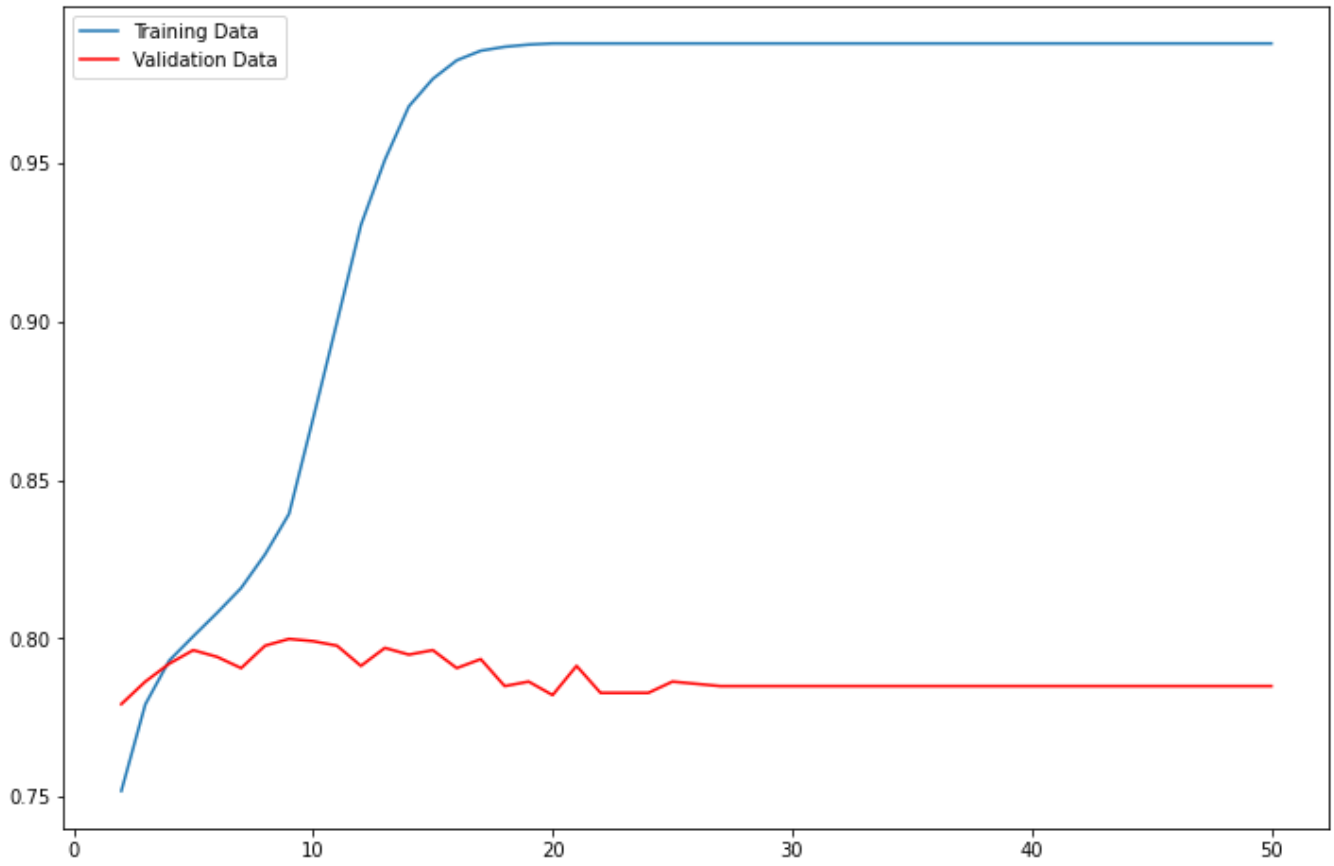
```
for i in leaf_range:
  tree_model=RandomForestClassifier(max_depth=i, random_state=0)
  tree_model.fit(X_train, Y_train)
  accTrain=accuracy_score(Y_train, tree_model.predict(X_train))
  accValid=accuracy_score(Y_valid, tree_model.predict(X_valid))
  leaf_score=leaf_score.append({'NoLeaves':i, 'TrainScore':accTrain,'ValidScore':accValid}, i
```

```
leaf_score
```

	NoLeaves	TrainScore	ValidScore
0	2.0	0.751864	0.779276
1	3.0	0.779198	0.786373
2	4.0	0.793042	0.792051
3	5.0	0.800674	0.796309
4	6.0	0.808129	0.794180
5	7.0	0.815939	0.790632
6	8.0	0.826589	0.797729
7	9.0	0.839368	0.799858
8	10.0	0.869365	0.799148
9	11.0	0.899894	0.797729
10	12.0	0.930600	0.791341
11	13.0	0.951189	0.797019
12	14.0	0.968051	0.794890
13	15.0	0.976748	0.796309
14	16.0	0.982606	0.790632
15	17.0	0.985623	0.793471
16	18.0	0.986865	0.784954
17	19.0	0.987575	0.786373
18	20.0	0.987930	0.782115
19	21.0	0.987930	0.791341
20	22.0	0.987930	0.782825
21	23.0	0.987930	0.782825
22	24.0	0.987930	0.782825
23	25.0	0.987930	0.786373
24	26.0	0.987930	0.785664
25	27.0	0.987930	0.784954
26	28.0	0.987930	0.784954
27	29.0	0.987930	0.784954
28	30.0	0.987930	0.784954
29	31.0	0.987930	0.784954

30	32.0	0.987930	0.784954
31	33.0	0.987930	0.784954
32	34.0	0.987930	0.784954
33	35.0	0.987930	0.784954
34	36.0	0.987930	0.784954
35	37.0	0.987930	0.784954
36	38.0	0.987930	0.784954
37	39.0	0.987930	0.784954

```
plt.figure(figsize=(12,8))
plt.plot(leaf_score['NoLeaves'], leaf_score['TrainScore'], label='Training Data')
plt.plot(leaf_score['NoLeaves'],leaf_score['ValidScore'], label = 'Validation Data', color =
plt.legend()
plt.show()
```




```
from sklearn import tree
plot_tree(tree_model.estimators_[0],
          feature_names=X_train.columns,
          filled=True, impurity= True,
          rounded=True)
```

```
[Text(0.7154925859591477, 0.9814814814814815, 'InternetService_No <= 0.5\ngini = 0.401\n
 Text(0.47829732891818777, 0.9444444444444444, 'PaymentMethod_Electronic check <= 0.5\ng
 Text(0.29654692207844613, 0.9074074074074074, 'OnlineSecurity_1 <= 0.5\ngini = 0.341\ns
 Text(0.1964243079468417, 0.8703703703703703, 'Partner <= 0.5\ngini = 0.438\nsamples = 9
 Text(0.12221732755837728, 0.8333333333333334, 'TechSupport <= 0.5\ngini = 0.477\nsample
 Text(0.08533640912514796, 0.7962962962962963, 'OnlineBackup_1 <= 0.5\ngini = 0.498\nsam
 Text(0.047246583449908536, 0.7592592592592593, 'MonthlyCharges <= 69.5\ngini = 0.498\ns
 Text(0.022221026579145594, 0.7222222222222222, 'Gender_Male <= 0.5\ngini = 0.479\nsampl
 Text(0.00817819864414075, 0.6851851851851852, 'Contract_Month-to-month <= 0.5\ngini = 0
 Text(0.00731733562896804, 0.6481481481481481, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]
 Text(0.009039061659313462, 0.6481481481481481, 'DeviceProtection_0 <= 0.5\ngini = 0.499
 Text(0.0034434520606908426, 0.6111111111111112, 'tenure <= 38.0\ngini = 0.473\nsamples
 Text(0.002582589045518132, 0.5740740740740741, 'tenure <= 17.0\ngini = 0.32\nsamples =
 Text(0.0017217260303454213, 0.5370370370370371, 'TotalCharges <= 54.5\ngini = 0.444\nsa
 Text(0.0008608630151727107, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.002582589045518132, 0.5, 'StreamingMovies <= 0.5\ngini = 0.5\nsamples = 2\nvalue
 Text(0.0017217260303454213, 0.46296296296296297, 'gini = 0.0\nsamples = 1\nvalue = [1,
 Text(0.0034434520606908426, 0.46296296296296297, 'gini = 0.0\nsamples = 1\nvalue = [0,
 Text(0.0034434520606908426, 0.5370370370370371, 'gini = 0.0\nsamples = 6\nvalue = [7, 0
 Text(0.004304315075863553, 0.5740740740740741, 'gini = 0.0\nsamples = 2\nvalue = [0, 3]
 Text(0.01463467125793608, 0.6111111111111112, 'PaperlessBilling <= 0.5\ngini = 0.5\nsam
 Text(0.007747767136554395, 0.5740740740740741, 'InternetService_DSL <= 0.5\ngini = 0.39
 Text(0.006886904121381685, 0.5370370370370371, 'gini = 0.0\nsamples = 2\nvalue = [0, 3]
 Text(0.008608630151727106, 0.5370370370370371, 'MonthlyCharges <= 34.0\ngini = 0.287\ns
 Text(0.006026041106208974, 0.5, 'TotalCharges <= 24.5\ngini = 0.48\nsamples = 3\nvalue
 Text(0.005165178091036264, 0.46296296296296297, 'gini = 0.0\nsamples = 1\nvalue = [2, 0
 Text(0.006886904121381685, 0.46296296296296297, 'PaymentMethod_Bank transfer (automatic
 Text(0.006026041106208974, 0.42592592592592593, 'gini = 0.0\nsamples = 1\nvalue = [0, 2
 Text(0.007747767136554395, 0.42592592592592593, 'gini = 0.0\nsamples = 1\nvalue = [1, 0
 Text(0.011191219197245238, 0.5, 'StreamingTV <= 0.5\ngini = 0.198\nsamples = 12\nvalue
 Text(0.010330356182072528, 0.46296296296296297, 'Dependents <= 0.5\ngini = 0.231\nsampl
 Text(0.009469493166899818, 0.42592592592592593, 'gini = 0.0\nsamples = 6\nvalue = [9, 0
 Text(0.011191219197245238, 0.42592592592592593, 'MultipleLines_0 <= 0.5\ngini = 0.444\n
 Text(0.010330356182072528, 0.3888888888888889, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]
 Text(0.012052082212417948, 0.3888888888888889, 'PaymentMethod_Mailed check <= 0.5\ngini
 Text(0.011191219197245238, 0.35185185185185186, 'gini = 0.0\nsamples = 1\nvalue = [3, 0
 Text(0.01291294522759066, 0.35185185185185186, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]
 Text(0.012052082212417948, 0.46296296296296297, 'gini = 0.0\nsamples = 2\nvalue = [3, 0
 Text(0.021521575379317766, 0.5740740740740741, 'PaymentMethod_Credit card (automatic) <
 Text(0.019799849348972345, 0.5370370370370371, 'StreamingTV <= 0.5\ngini = 0.43\nsample
 Text(0.018938986333799635, 0.5, 'tenure <= 6.0\ngini = 0.437\nsamples = 19\nvalue = [10
 Text(0.01721726030345421, 0.46296296296296297, 'MultipleLines_1 <= 0.5\ngini = 0.308\ns
 Text(0.0163563972882815, 0.42592592592592593, 'InternetService_Fiber optic <= 0.5\ngini
 Text(0.01549553427310879, 0.3888888888888889, 'TotalCharges <= 45.5\ngini = 0.408\nsamp
 Text(0.01463467125793608, 0.35185185185185186, 'tenure <= 3.0\ngini = 0.444\nsamples =
 Text(0.01377380824276337, 0.3148148148148148, 'PaymentMethod_Bank transfer (automatic)
 Text(0.01291294522759066, 0.2777777777777778, 'SeniorCitizen <= 0.5\ngini = 0.494\nsamp
 Text(0.012052082212417948, 0.24074074074074073, 'tenure <= 1.5\ngini = 0.49\nsamples =
 Text(0.011191219197245238, 0.2037037037037037, 'MonthlyCharges <= 44.5\ngini = 0.5\nsam
 Text(0.010330356182072528, 0.16666666666666666, 'MonthlyCharges <= 34.5\ngini = 0.48\ns
 Text(0.009469493166899818, 0.12962962962962962, 'gini = 0.5\nsamples = 2\nvalue = [1, 1
 Text(0.011191219197245238, 0.12962962962962962, 'gini = 0.444\nsamples = 2\nvalue = [2,
 Text(0.012052082212417948, 0.16666666666666666, 'gini = 0.0\nsamples = 1\nvalue = [0, 1
 Text(0.01291294522759066, 0.2037037037037037, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]
 Text(0.01377380824276337, 0.24074074074074073, 'gini = 0.0\nsamples = 1\nvalue = [0, 2]
 Text(0.01463467125793608, 0.2777777777777778, 'gini = 0.0\nsamples = 1\nvalue = [0, 2]
```

```
Text(0.01549553427310879, 0.3148148148148148, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]
Text(0.0163563972882815, 0.35185185185185186, 'gini = 0.0\nsamples = 1\nvalue = [0, 2]
Text(0.01721726030345421, 0.3888888888888889, 'gini = 0.0\nsamples = 2\nvalue = [0, 6]
Text(0.018078123318626925, 0.42592592592592593, 'gini = 0.0\nsamples = 1\nvalue = [0, 1
Text(0.020660712364145056, 0.46296296296296297, 'MultipleLines_1 <= 0.5\ngini = 0.48\ns
Text(0.019799849348972345, 0.42592592592592593, 'gini = 0.0\nsamples = 2\nvalue = [2, 0
Text(0.021521575379317766, 0.42592592592592593, 'tenure <= 17.5\ngini = 0.5\nsamples =
Text(0.020660712364145056, 0.3888888888888889, 'gini = 0.0\nsamples = 2\nvalue = [3, 0]
Text(0.022382438394490476, 0.3888888888888889, 'MonthlyCharges <= 55.5\ngini = 0.32\nsa
Text(0.021521575379317766, 0.35185185185185186, 'gini = 0.0\nsamples = 1\nvalue = [1, 0
Text(0.023243301409663186, 0.35185185185185186, 'gini = 0.0\nsamples = 1\nvalue = [0, 4
Text(0.020660712364145056, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.023243301409663186, 0.5370370370370371, 'PhoneService <= 0.5\ngini = 0.444\nsamp
Text(0.022382438394490476, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.024104164424835896, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [2, 0]'),
Text(0.036263854514150436, 0.6851851851851852, 'PaymentMethod_Mailed check <= 0.5\ngini
Text(0.03013020553104487, 0.6481481481481481, 'TotalCharges <= 58.0\ngini = 0.31\nsampl
Text(0.02840847950069945, 0.6111111111111112, 'DeviceProtection_1 <= 0.5\ngini = 0.188\
Text(0.02754761648552674, 0.5740740740740741, 'StreamingMovies <= 0.5\ngini = 0.219\nsa
Text(0.02668675347035403, 0.5370370370370371, 'SeniorCitizen <= 0.5\ngini = 0.231\nsamp
Text(0.02582589045518132, 0.5, 'PaperlessBilling <= 0.5\ngini = 0.185\nsamples = 15\nva
Text(0.024104164424835896, 0.46296296296296297, 'tenure <= 6.0\ngini = 0.408\nsamples =
Text(0.023243301409663186, 0.42592592592592593, 'gini = 0.0\nsamples = 2\nvalue = [0, 2
Text(0.02496502744000861, 0.42592592592592593, 'gini = 0.0\nsamples = 3\nvalue = [5, 0]
Text(0.02754761648552674, 0.46296296296296297, 'MultipleLines_0 <= 0.5\ngini = 0.087\ns
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Text(0.10631658237382977, 0.46296296296296297, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]
Text(0.10717744538900248, 0.5, 'gini = 0.0\nsamples = 3\nvalue = [7, 0]'),
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Text(0.10889917141934789, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
Text(0.11062089744969332, 0.5, 'MonthlyCharges <= 52.5\ngini = 0.496\nsamples = 17\nval
Text(0.10825352415796836, 0.46296296296296297, 'TotalCharges <= 49.5\ngini = 0.397\nsam
Text(0.10610136662003658, 0.42592592592592593, 'PaymentMethod_Mailed check <= 0.5\ngini
Text(0.10437964058969117, 0.3888888888888889, 'tenure <= 10.0\ngini = 0.5\nsamples = 2\
Text(0.10351877757451845, 0.35185185185185186, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]
Text(0.10524050360486388, 0.35185185185185186, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]
Text(0.10782309265038201, 0.3888888888888889, 'Gender_Female <= 0.5\ngini = 0.444\nsamp
Text(0.1069622296352093, 0.35185185185185186, 'gini = 0.0\nsamples = 1\nvalue = [2, 0]
Text(0.10868395566555472, 0.35185185185185186, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]
```

```
Text(0.11040568169590013, 0.42592592592592593, 'StreamingTV <= 0.5\ngini = 0.278\nsampl
Text(0.10954481868072743, 0.3888888888888889, 'gini = 0.0\nsamples = 2\nvalue = [4, 0]
Text(0.11126654471107285, 0.3888888888888889, 'MonthlyCharges <= 50.5\ngini = 0.5\nsamp
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Text(0.11212740772624556, 0.42592592592592593, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]
Text(0.11384913375659098, 0.42592592592592593, 'MonthlyCharges <= 57.0\ngini = 0.494\ns
Text(0.11298827074141828, 0.3888888888888889, 'gini = 0.0\nsamples = 2\nvalue = [0, 4]
Text(0.11470999677176369, 0.3888888888888889, 'DeviceProtection_1 <= 0.5\ngini = 0.32\n
Text(0.11384913375659098, 0.35185185185185186, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]
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Text(0.11406434951038416, 0.5740740740740741, 'InternetService_Fiber optic <= 0.5\ngini
Text(0.11320348649521145, 0.5370370370370371, 'tenure <= 57.0\ngini = 0.375\nsamples =
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Text(0.11406434951038416, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [3, 0]'),
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Text(0.12030560637038631, 0.5740740740740741, 'Contract_Month-to-month <= 0.5\ngini = 0
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Text(0.11643172280210912, 0.46296296296296297, 'tenure <= 27.0\ngini = 0.5\nsamples = 2
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Text(0.11901431184762724, 0.42592592592592593, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]
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Text(0.1233186269234908, 0.46296296296296297, 'tenure <= 23.0\ngini = 0.219\nsamples =
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Text(0.12159690089314538, 0.3888888888888889, 'gini = 0.0\nsamples = 1\nvalue = [0, 3]
Text(0.1233186269234908, 0.3888888888888889, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]')
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Text(0.12977509953728614, 0.6481481481481481, 'PaperlessBilling <= 0.5\ngini = 0.492\ns
Text(0.1280533735069407, 0.6111111111111112, 'InternetService_Fiber optic <= 0.5\ngini
Text(0.127192510491768, 0.5740740740740741, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
Text(0.12891423652211342, 0.5740740740740741, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]
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Text(0.13063596255245885, 0.5740740740740741, 'Contract_One year <= 0.5\ngini = 0.494\n
Text(0.12977509953728614, 0.5370370370370371, 'InternetService_Fiber optic <= 0.5\ngini
```

```
Text(0.12891423652211342, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
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Text(0.12977509953728614, 0.46296296296296297, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]
Text(0.13149682556763156, 0.46296296296296297, 'tenure <= 8.5\ngini = 0.32\nsamples = 3
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Text(0.13321855159797696, 0.6481481481481481, 'gini = 0.0\nsamples = 19\nvalue = [29, 0
Text(0.1349402776283224, 0.6481481481481481, 'Gender_Male <= 0.5\ngini = 0.375\nsamples
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Text(0.15909824599160657, 0.7962962962962963, 'Contract_Month-to-month <= 0.5\ngini = 0
Text(0.14397933928763584, 0.7592592592592593, 'TotalCharges <= 103.5\ngini = 0.179\nsam
Text(0.14096631873453136, 0.7222222222222222, 'Dependents <= 0.5\ngini = 0.078\nsamples
Text(0.13924459270418596, 0.6851851851851852, 'MonthlyCharges <= 65.5\ngini = 0.045\nsa
Text(0.13838372968901325, 0.6481481481481481, 'tenure <= 30.0\ngini = 0.137\nsamples =
Text(0.13752286667384053, 0.6111111111111112, 'gini = 0.0\nsamples = 8\nvalue = [14, 0]
Text(0.13924459270418596, 0.6111111111111112, 'MultipleLines_1 <= 0.5\ngini = 0.26\nsam
Text(0.13838372968901325, 0.5740740740740741, 'Gender_Female <= 0.5\ngini = 0.32\nsampl
Text(0.13666200365866782, 0.5370370370370371, 'PaymentMethod_Mailed check <= 0.5\ngini
Text(0.1358011406434951, 0.5, 'gini = 0.0\nsamples = 4\nvalue = [6, 0]'),
Text(0.13752286667384053, 0.5, 'tenure <= 53.0\ngini = 0.5\nsamples = 2\nvalue = [1, 1]
Text(0.13666200365866782, 0.46296296296296297, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]
Text(0.13838372968901325, 0.46296296296296297, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]
Text(0.14010545571935865, 0.5370370370370371, 'PaymentMethod_Credit card (automatic) <=
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Text(0.14010545571935865, 0.5740740740740741, 'gini = 0.0\nsamples = 2\nvalue = [3, 0]
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Text(0.14268804476487680, 0.6851851851851852, 'MonthlyCharges <= 87.0\ngini = 0.26\nsamp
Text(0.14182718174970407, 0.6481481481481481, 'gini = 0.0\nsamples = 5\nvalue = [9, 0]
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Text(0.14268804476487680, 0.6111111111111112, 'gini = 0.0\nsamples = 1\nvalue = [0, 2]')
Text(0.14440977079522221, 0.6111111111111112, 'gini = 0.0\nsamples = 1\nvalue = [2, 0]
Text(0.14699235984074036, 0.7222222222222222, 'Gender_Male <= 0.5\ngini = 0.463\nsample
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Text(0.14785322285591304, 0.6851851851851852, 'tenure <= 70.5\ngini = 0.397\nsamples =
Text(0.14699235984074036, 0.6481481481481481, 'DeviceProtection_0 <= 0.5\ngini = 0.198\
Text(0.14613149682556764, 0.6111111111111112, 'gini = 0.0\nsamples = 3\nvalue = [0, 4]
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Text(0.14699235984074036, 0.5740740740740741, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]
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Text(0.15603142150005380, 0.6851851851851852, 'PaperlessBilling <= 0.5\ngini = 0.428\nsa
Text(0.15301840940694932, 0.6481481481481481, 'OnlineBackup_1 <= 0.5\ngini = 0.463\nsam
Text(0.15215753793177660, 0.6111111111111112, 'MonthlyCharges <= 29.0\ngini = 0.444\nsam
Text(0.15129667491660390, 0.5740740740740741, 'gini = 0.0\nsamples = 1\nvalue = [0, 2]')
Text(0.15301840940694932, 0.5740740740740741, 'tenure <= 3.0\ngini = 0.388\nsamples = 1
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Text(0.1512966749166039, 0.46296296296296297, 'MonthlyCharges <= 50.0\ngini = 0.444\nsa
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Text(0.159905305068331, 0.5370370370370371, 'gini = 0.0\nsamples = 2\nvalue = [0, 5]'),
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Text(0.16851393522005811, 0.6481481481481481, 'Gender_Female <= 0.5\ngini = 0.486\nsamp
Text(0.1667922091897127, 0.6111111111111112, 'PaymentMethod_Mailed check <= 0.5\ngini =
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Text(0.16593134617453997, 0.5370370370370371, 'PhoneService <= 0.5\ngini = 0.5\nsamples
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Text(0.1762617023566125, 0.5740740740740741, 'gini = 0.0\nsamples = 1\nvalue = [2, 0]')
```

```
Text(0.17798342838695794, 0.5740740740740741, 'gini = 0.0\nsamples = 1\nvalue = [0, 3]
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Text(0.18357903798558053, 0.6851851851851852, 'gini = 0.0\nsamples = 6\nvalue = [9, 0]
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Text(0.17884429140213062, 0.5370370370370371, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]
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Text(0.18745292155385773, 0.6111111111111112, 'PhoneService <= 0.5\ngini = 0.32\nsample
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Text(0.19347896266006673, 0.5370370370370371, 'InternetService_Fiber optic <= 0.5\ngini
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Text(0.19520068869041213, 0.42592592592592593, 'gini = 0.0\nsamples = 1\nvalue = [2, 0]
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Text(0.19864414075110298, 0.3888888888888889, 'TechSupport <= 0.5\ngini = 0.278\nsample
Text(0.19778327773593027, 0.35185185185185186, 'gini = 0.0\nsamples = 4\nvalue = [5, 0]
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Text(0.20294845582696652, 0.5370370370370371, 'MonthlyCharges <= 60.0\ngini = 0.245\nsa
Text(0.20208759281179384, 0.5, 'TotalCharges <= 47.5\ngini = 0.375\nsamples = 3\nvalue
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Text(0.2072527709028301, 0.5740740740740741, 'Contract_One year <= 0.5\ngini = 0.298\ns
Text(0.20639190788765738, 0.5370370370370371, 'DeviceProtection_0 <= 0.5\ngini = 0.408\
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Text(0.21758312708490263, 0.5740740740740741, 'PaymentMethod_Bank transfer (automatic)
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Text(0.21930485311524803, 0.42592592592592593, 'tenure <= 20.5\ngini = 0.5\nsamples = 2
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```

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Text(0.24685246960077478, 0.42592592592592593, 'TotalCharges <= 92.0\ngini = 0.48\nsamp
Text(0.24599160658560207, 0.3888888888888889, 'MonthlyCharges <= 80.5\ngini = 0.375\nsa
Text(0.24513074357042935, 0.3518518518518186, 'Dependents <= 0.5\ngini = 0.5\nsamples
```

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Text(0.2546002367373292, 0.3888888888888889, 'gini = 0.0\nsamples = 3\nvalue = [0, 7]')
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Text(0.27009577101043797, 0.5, 'InternetService_DSL <= 0.5\ngini = 0.42\nsamples = 14\n
Text(0.2692349079952652, 0.46296296296296297, 'Gender_Female <= 0.5\ngini = 0.388\nsamp
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Text(0.27870440116216505, 0.5740740740740741, 'gini = 0.0\nsamples = 1\nvalue = [0, 2]
```

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Text(0.27784353814699236, 0.5, 'tenure <= 26.5\ngini = 0.5\nsamples = 2\nvalue = [1, 1]
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Text(0.29075648337458304, 0.6111111111111112, 'tenure <= 20.0\ngini = 0.172\nsamples =
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Text(0.2924782094049284, 0.6111111111111112, 'gini = 0.0\nsamples = 11\nvalue = [20, 0]
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Text(0.2950607984504466, 0.5, 'DeviceProtection_1 <= 0.5\ngini = 0.486\nsamples = 5\nva
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Text(0.307112880662864 5, 0.7962962962962963, 'StreamingMovies <= 0.5\ngini = 0.139\nsam
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Text(0.302808565587001, 0.6851851851851852, 'StreamingTV <= 0.5\ngini = 0.024\nsamples
Text(0.30194770257182824, 0.6481481481481481, 'tenure <= 53.0\ngini = 0.153\nsamples =
Text(0.30108683955665555, 0.6111111111111112, 'InternetService_DSL <= 0.5\ngini = 0.444
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Text(0.3071128806628645, 0.6481481481481481, 'TotalCharges <= 105.0\ngini = 0.48\nsampl
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Text(0.3148606477994189, 0.5740740740740741, 'gini = 0.0\nsamples = 5\nvalue = [11, 0]
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Text(0.31572151081459165, 0.5370370370370371, 'Gender_Male <= 0.5\ngini = 0.375\nsample
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Text(0.32712794576563003, 0.6481481481481481, 'PaymentMethod_Credit card (automatic) <=
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Text(0.3432691273001184, 0.6481481481481481, 'gini = 0.0\nsamples = 39\nvalue = [63, 0]
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Text(0.3484343053911546, 0.5370370370370371, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]')
```

```
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Text(0.3690950177552997, 0.6111111111111112, 'gini = 0.0\nsamples = 2\nvalue = [6, 0]')
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Text(0.3699558807704724, 0.5740740740740741, 'OnlineBackup_0 <= 0.5\ngini = 0.298\nsamp
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Text(0.37253846981599054, 0.6111111111111112, 'gini = 0.0\nsamples = 1\nvalue = [2, 0]
Text(0.37426019584633596, 0.6111111111111112, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]
Text(0.37727321639944045, 0.6851851851851852, 'TotalCharges <= 104.5\ngini = 0.219\nsam
```

```
Text(0.3764123533842677, 0.6481481481481481, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]')
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Text(0.37727321639944045, 0.6111111111111112, 'MonthlyCharges <= 116.5\ngini = 0.42\nsa
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Text(0.3733993328311632, 0.5, 'gini = 0.0\nsamples = 6\nvalue = [8, 0]'),
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Text(0.3863122780587539, 0.5370370370370371, 'gini = 0.0\nsamples = 1\nvalue = [2, 0]')
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Text(0.3854514150435812, 0.42592592592592593, 'PhoneService <= 0.5\ngini = 0.227\nsampl
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```

```
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Text(0.39233831916496287, 0.3888888888888889, 'InternetService_DSL <= 0.5\ngini = 0.245
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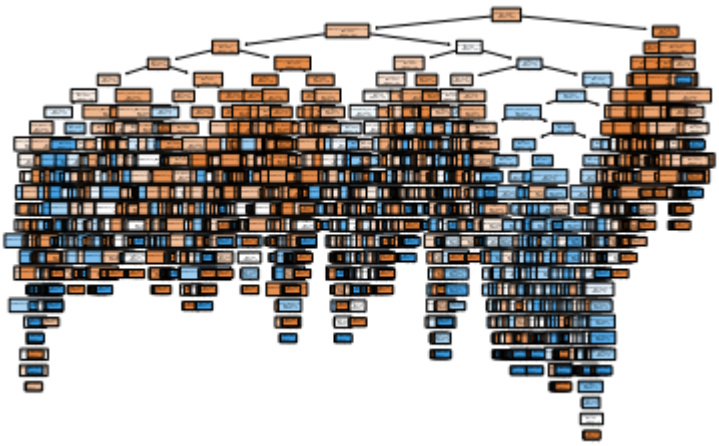
Text(0.40525126439255355, 0.46296296296296297, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]
...]
```



```
# SVM
xTrain, xValid, yTrain, yValid = train_test_split(X, Y, test_size = 0.2, random_state = 1)


SVModel = SVC(kernel = 'linear', C=10, gamma = 'auto')
SVModel.fit(xTrain, yTrain)
```

```
     SVC(C=10, gamma='auto', kernel='linear')
```

```
confusion_matrix(yTrain, SVModel.predict(xTrain))
```

```
confusion_matrix(yTrain, SVModel.predict(xTrain))
```

```
array([[3689,  424],
       [ 692,  829]])
```

```
#accuracy score SVM for Y train
accuracy_score(yTrain, SVModel.predict(xTrain))
```

```
0.8019169329073482
```

```
confusion_matrix(yValid, SVModel.predict(xValid))
```

```
array([[936, 125],
       [151, 197]])
```

```
#accuracy score SVM for y test
accuracy_score(yValid, SVModel.predict(xValid))
```

```
0.8041163946061036
```

```
krn = ['linear', 'poly','rbf','sigmoid']
rng_C = np.arange(1, 15, 5)
rng_deg = np.arange(2, 5)
```

```
param = {'kernel' :krn,
         'C' :rng_C,
       'degree' :rng_deg}
```

```
SVModel = SVC()
GridS = GridSearchCV(SVModel,param, cv=5)
GridS.fit(xTrain, yTrain)
```

```
GridSearchCV(cv=5, estimator=SVC(),
             param_grid={'C': array([ 1,  6, 11]), 'degree': array([2, 3, 4]),
                         'kernel': ['linear', 'poly', 'rbf', 'sigmoid']})
```

```
GridS.best_params_
```

```
{'C': 1, 'degree': 2, 'kernel': 'linear'}
```

```
SVModel = SVC(kernel='linear', C=1, degree=2)
SVModel.fit(xTrain,yTrain)
accuracy_score(yValid, SVModel.predict(xValid))
```

```
0.8048261178140526
```

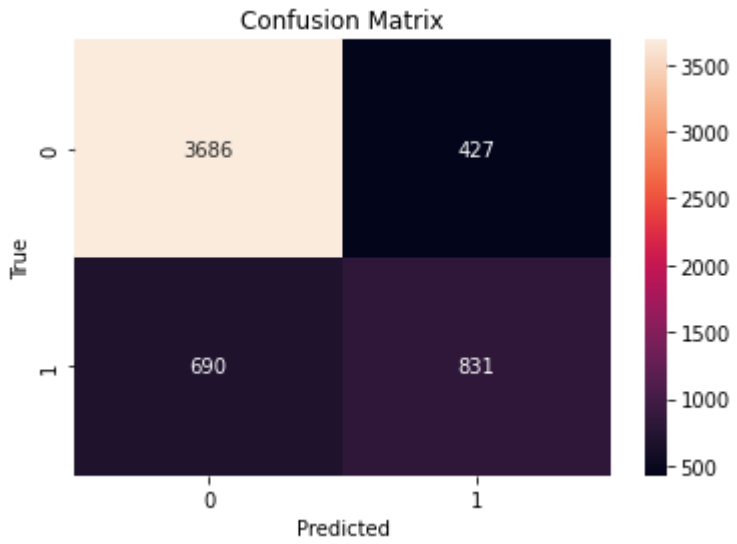
```
y_pred_test = SVModel.predict(xValid)
```

```
matrix = confusion_matrix(yTrain, SVModel.predict(xTrain))
sns.heatmap(matrix, annot = True, fmt='d')
plt.title('Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')
print(classification_report(yValid, y_pred_test))
```

```
                  precision    recall  f1-score   support

               0       0.86      0.88      0.87      1061
               1       0.61      0.57      0.59       348

        accuracy                           0.80      1409
       macro avg       0.74      0.73      0.73      1409
    weighted avg       0.80      0.80      0.80      1409
```




```
#KNN Redifining
x = data6.drop(['Churn'], axis=1)
y = data6['Churn']


#print y
y
```

```
0       0
1       0
2       1
3       0
4       1
       ..
7038    0
7039    0
7040    0
7041    1
7042    0
Name: Churn, Length: 7043, dtype: int64
```

```
#print x
x
```

	SeniorCitizen	Partner	Dependents	tenure	PhoneService	TechSupport	StreamingT
0	0	1	0	1	0	0	
1	0	0	0	34	1	0	
2	0	0	0	2	1	0	
3	0	0	0	45	0	1	
4	0	0	0	2	1	0	
...	...	...	...	...	...	...	.
7038	0	1	1	24	1	1	
7039	0	1	1	72	1	0	
7040	0	1	1	11	0	0	
7041	1	1	0	4	1	0	
7042	0	0	0	66	1	1	

7043 rows × 32 columns

```
#KNN re-preprocessing to double-check everything
from sklearn import preprocessing
x = preprocessing.StandardScaler().fit(x).transform(x.astype(float))


#splitting
xTrain, xTest, yTrain, yTest = train_test_split(x, y, test_size = 0.2, random_state = 1)

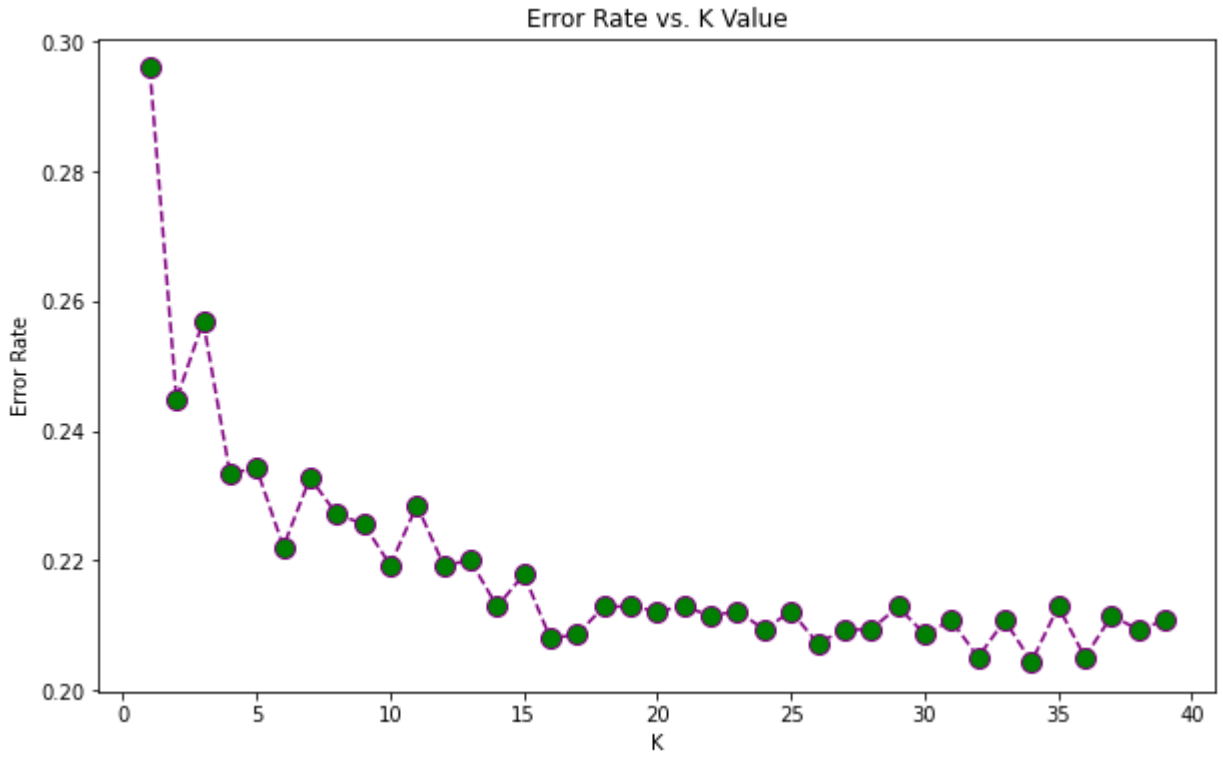

#using KNeighbors classifier to train and predict
from sklearn.neighbors import KNeighborsClassifier
from sklearn import metrics
#Train Model and Predict
k = 4
neigh = KNeighborsClassifier(n_neighbors = k).fit(xTrain,yTrain)
Pred_y = neigh.predict(xTest)
print("Accuracy of model at k = 4 is", metrics.accuracy_score(yTest, Pred_y))
```

```
Accuracy of model at k = 4 is 0.7665010645848119
```

```
#Error Rate
error_rate = []
for i in range (1,40):
  knn = KNeighborsClassifier(n_neighbors=i)
  knn.fit(xTrain, yTrain)
  pred_i = knn.predict(xTest)
  error_rate.append(np.mean(pred_i !=yTest))

plt.figure(figsize=(10,6))
plt.plot(range(1,40),error_rate,color='purple', linestyle='dashed', marker='o', markerfacecol
plt.title('Error Rate vs. K Value')
plt.xlabel('K')
plt.ylabel('Error Rate')
print("Minimum error:-",min(error_rate),"at K =",error_rate.index(min(error_rate)))
```

```
Minimum error:- 0.2044002838892832 at K = 33
```

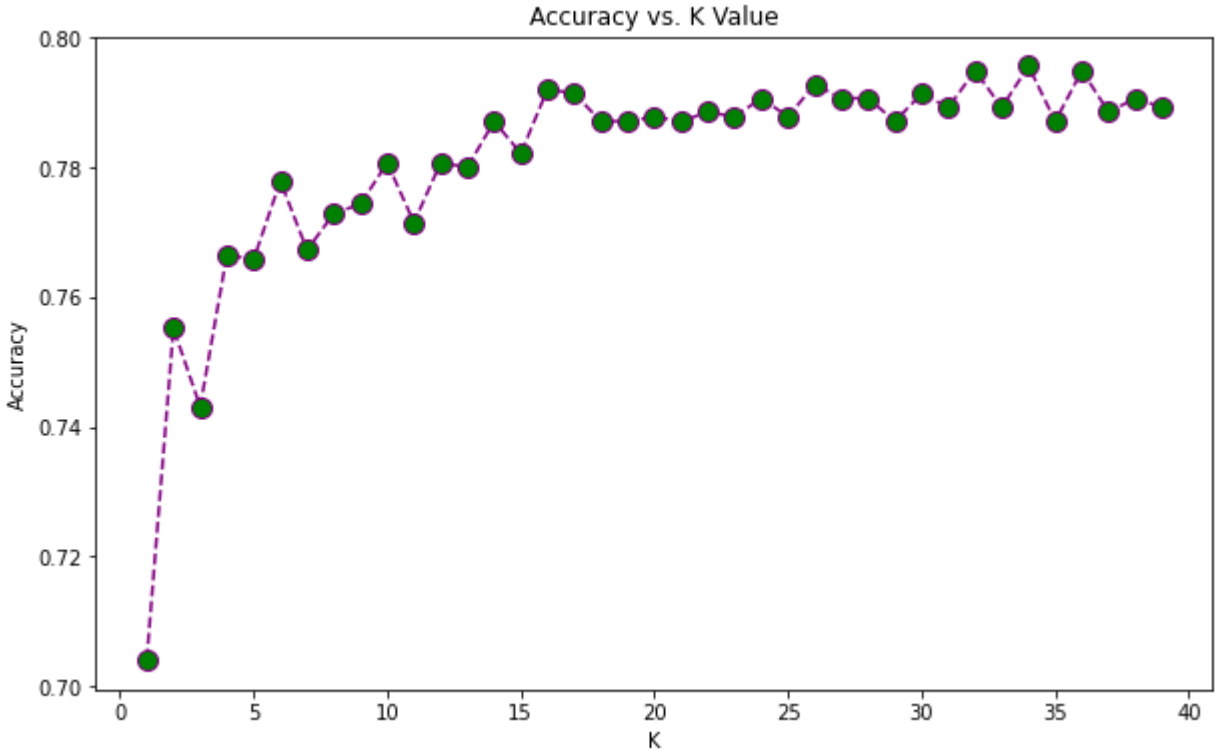



```
#Accuracy and plotting
acc = []
#Will take some time
from sklearn import metrics
for i in range (1,40):
  neigh = KNeighborsClassifier(n_neighbors = i).fit(xTrain,yTrain)
  yhat = neigh.predict(xTest)
  acc.append(metrics.accuracy_score(yTest,yhat))

plt.figure(figsize=(10,6))
plt.plot(range(1,40),acc,color='purple', linestyle='dashed', marker='o', markerfacecolor='gre
plt.title('Accuracy vs. K Value')
```

```
plt.xlabel('K')
plt.ylabel('Accuracy')
print("Maximum Accuracy:-",max(acc),"at K =",acc.index(max(acc)))
```

```
Maximum Accuracy:- 0.7955997161107168 at K = 33
```




```
#Importing More
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
import matplotlib.pyplot as plt
from sklearn.model_selection import GridSearchCV
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report, confusion_matrix, plot_confusion_matrix


#Scaling
scaler = StandardScaler()
scaler.fit(xTrain)
xTrain = scaler.transform(xTrain)
xTest = scaler.transform(xTest)


#Setting up to find the best parameters
n_neighbors = np.arange(1,40)
grid_params = {'n_neighbors' : n_neighbors,
               'leaf_size': [30, 35],
               'algorithm' : ['ball_tree', 'kd_tree']}
gridSearch = GridSearchCV(KNeighborsClassifier(), grid_params, verbose = 1, cv = 3, n_jobs =
gridSearchresults = gridSearch.fit(xTrain, yTrain)
```

```
Fitting 3 folds for each of 156 candidates, totalling 468 fits
```

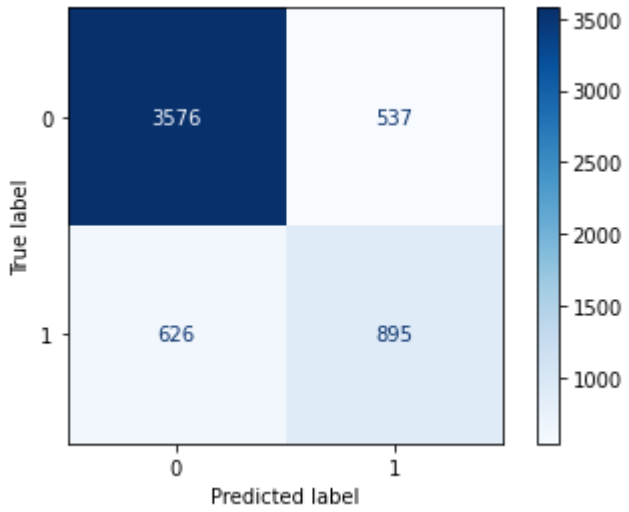
```
#finding the best parameters
gridSearchresults.best_params_
```

```
{'algorithm': 'ball_tree', 'leaf_size': 30, 'n_neighbors': 37}
```

```
#making confusion matrix
Classifier = KNeighborsClassifier(n_neighbors=37, leaf_size=30, algorithm ='ball_tree')
Classifier.fit(xTrain,yTrain)
y_pred_train= Classifier.predict(xTrain)
y_pred_test = Classifier.predict(xTest)
```

```
#plotting train matrix
plot_confusion_matrix(Classifier,xTrain,yTrain, cmap= plt.cm.Blues)
```

```
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x7f332828e090>
```




```
#plotting test matrix
plot_confusion_matrix(Classifier, xTest, yTest, cmap = plt.cm.Blues)
```

```
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x7f33282fa050>
```

```
#classification report for test
from sklearn.metrics import classification_report
print(classification_report(yTest,y_pred_test))
```

```
                  precision    recall  f1-score   support

               0       0.87      0.85      0.86      1061
               1       0.57      0.60      0.58       348

        accuracy                           0.79      1409
       macro avg       0.72      0.73      0.72      1409
    weighted avg       0.79      0.79      0.79      1409
```

```
#classification report for train
print(classification_report(yTrain,y_pred_train))
```

```
                  precision    recall  f1-score   support

               0       0.85      0.87      0.86      4113
               1       0.62      0.59      0.61      1521

        accuracy                           0.79      5634
       macro avg       0.74      0.73      0.73      5634
    weighted avg       0.79      0.79      0.79      5634
```

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