Name : Pampana Chathurya

Data Collection. o Collect the dataset or Create the dataset • Data Preprocessing. o Import the Libraries. o Importing the dataset. o Checking for Null Values. o Data Visualization. o Outlier Detection o Splitting Dependent and Independent variables o- Encoding o Feature Scaling. o Splitting Data into Train and Test. • Model Building o Import the model building Libraries o Initializing the model o Training and testing the model o Evaluation of Model o Save the Model

Data Preprocessing.

o Import the Libraries. o Importing the dataset. o Checking for Null Values. o Data Visualization. o Outlier Detection o Splitting Dependent and Independent variables o- Encoding o Feature Scaling. o Splitting Data into Train and Test.

1.Import the Libraries.

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

2.Importing the dataset.

In [2]:
```
df=pd.read_csv("WA_Fn-UseC_-HR-Employee-Attrition.csv")
```

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

Out[3]:

	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField	EmployeeCount	EmployeeNumber
0	41	Yes	Travel_Rarely	1102	Sales	1	2	Life Sciences	1	1
1	49	No	Travel_Frequently	279	Research & Development	8	1	Life Sciences	1	2
2	37	Yes	Travel_Rarely	1373	Research & Development	2	2	Other	1	4
3	33	No	Travel_Frequently	1392	Research & Development	3	4	Life Sciences	1	5
4	27	No	Travel_Rarely	591	Research & Development	2	1	Medical	1	7

5 rows × 35 columns

In [4]:
```
df.shape
```

Out[4]:
```
(1470, 35)
```

In [5]:
```
df.EmployeeCount.value_counts()
```

Out[5]:
```
1    1470
Name: EmployeeCount, dtype: int64
```

In [6]:
```
df.StockOptionLevel.value_counts()
```

Out[6]:
```
0    631
1    596
2    158
3     85
Name: StockOptionLevel, dtype: int64
```

In [7]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1470 entries, 0 to 1469
Data columns (total 35 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   Age                       1470 non-null   int64
 1   Attrition                 1470 non-null   object
 2   BusinessTravel            1470 non-null   object
 3   DailyRate                 1470 non-null   int64
 4   Department                1470 non-null   object
 5   DistanceFromHome          1470 non-null   int64
 6   Education                 1470 non-null   int64
 7   EducationField            1470 non-null   object
 8   EmployeeCount             1470 non-null   int64
 9   EmployeeNumber            1470 non-null   int64
 10  EnvironmentSatisfaction   1470 non-null   int64
 11  Gender                    1470 non-null   object
 12  HourlyRate                1470 non-null   int64
 13  JobInvolvement            1470 non-null   int64
 14  JobLevel                  1470 non-null   int64
 15  JobRole                   1470 non-null   object
 16  JobSatisfaction           1470 non-null   int64
 17  MaritalStatus             1470 non-null   object
 18  MonthlyIncome             1470 non-null   int64
 19  MonthlyRate               1470 non-null   int64
 20  NumCompaniesWorked        1470 non-null   int64
 21  Over18                    1470 non-null   object
 22  OverTime                  1470 non-null   object
 23  PercentSalaryHike         1470 non-null   int64
 24  PerformanceRating         1470 non-null   int64
 25  RelationshipSatisfaction  1470 non-null   int64
 26  StandardHours             1470 non-null   int64
 27  StockOptionLevel          1470 non-null   int64
 28  TotalWorkingYears         1470 non-null   int64
 29  TrainingTimesLastYear     1470 non-null   int64
 30  WorkLifeBalance           1470 non-null   int64
 31  YearsAtCompany            1470 non-null   int64
 32  YearsInCurrentRole        1470 non-null   int64
 33  YearsSinceLastPromotion   1470 non-null   int64
 34  YearsWithCurrManager      1470 non-null   int64
dtypes: int64(26), object(9)
memory usage: 402.1+ KB
```

In [8]:
```
df.describe()
```

Out[8]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	EmployeeNumber	EnvironmentSatisfaction	HourlyRate
count	1470.000000	1470.000000	1470.000000	1470.000000	1470.0	1470.000000	1470.000000	1470.000000
mean	36.923810	802.485714	9.192517	2.912925	1.0	1024.865306	2.721769	65.891156
std	9.135373	403.509100	8.106864	1.024165	0.0	602.024335	1.093082	20.329428
min	18.000000	102.000000	1.000000	1.000000	1.0	1.000000	1.000000	30.000000
25%	30.000000	465.000000	2.000000	2.000000	1.0	491.250000	2.000000	48.000000
50%	36.000000	802.000000	7.000000	3.000000	1.0	1020.500000	3.000000	66.000000
75%	43.000000	1157.000000	14.000000	4.000000	1.0	1555.750000	4.000000	83.750000
max	60.000000	1499.000000	29.000000	5.000000	1.0	2068.000000	4.000000	100.000000

8 rows × 26 columns

3.Checking for Null Values.

In [9]:
```
df.isnull().any()
```

Out[9]:
```
Age                         False
Attrition                   False
BusinessTravel              False
DailyRate                   False
Department                  False
DistanceFromHome            False
Education                   False
EducationField              False
EmployeeCount               False
EmployeeNumber              False
EnvironmentSatisfaction     False
Gender                      False
HourlyRate                  False
JobInvolvement              False
JobLevel                    False
JobRole                     False
JobSatisfaction             False
MaritalStatus               False
MonthlyIncome               False
MonthlyRate                 False
NumCompaniesWorked          False
Over18                      False
OverTime                    False
PercentSalaryHike           False
PerformanceRating           False
RelationshipSatisfaction    False
StandardHours               False
StockOptionLevel            False
TotalWorkingYears           False
TrainingTimesLastYear       False
WorkLifeBalance             False
YearsAtCompany              False
YearsInCurrentRole          False
YearsSinceLastPromotion     False
YearsWithCurrManager        False
dtype: bool
```

In [10]:
```
df.isnull().sum()
```

Out[10]:
```
Age                         0
Attrition                   0
BusinessTravel              0
DailyRate                   0
Department                  0
DistanceFromHome            0
Education                   0
EducationField              0
EmployeeCount               0
EmployeeNumber              0
EnvironmentSatisfaction     0
Gender                      0
HourlyRate                  0
JobInvolvement              0
JobLevel                    0
JobRole                     0
JobSatisfaction             0
MaritalStatus               0
MonthlyIncome               0
MonthlyRate                 0
NumCompaniesWorked          0
Over18                      0
OverTime                    0
PercentSalaryHike           0
PerformanceRating           0
RelationshipSatisfaction    0
StandardHours               0
StockOptionLevel            0
TotalWorkingYears           0
TrainingTimesLastYear       0
WorkLifeBalance             0
YearsAtCompany              0
YearsInCurrentRole          0
YearsSinceLastPromotion     0
YearsWithCurrManager        0
dtype: int64
```

4.Data Visualization.

In [11]:
```
sns.distplot(df["WorkLifeBalance"])
```

```
C:\Users\ASUS\AppData\Local\Temp\ipykernel_12124\1982600552.py:2: UserWarning:

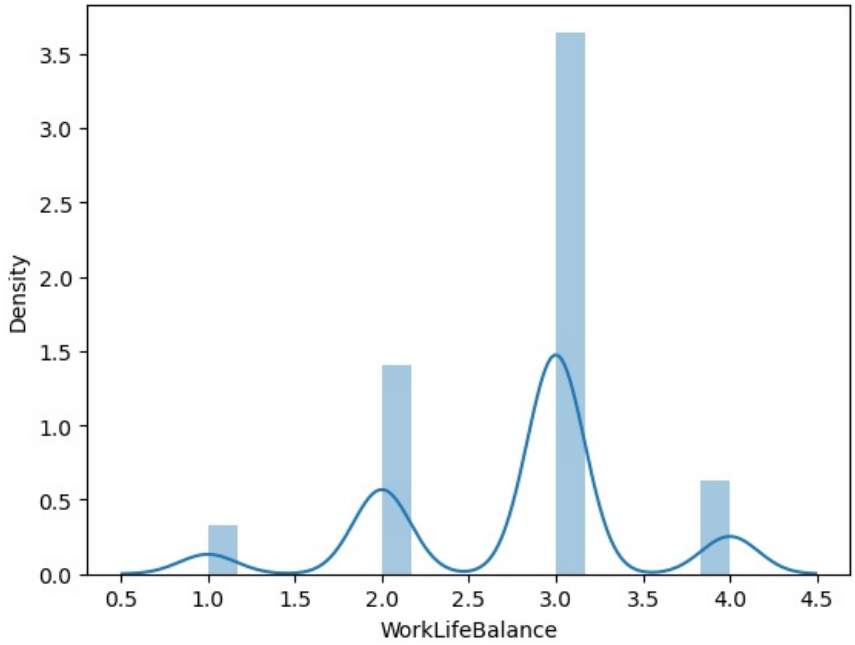
`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(df["WorkLifeBalance"])
```

Out[11]:
```
<Axes: xlabel='WorkLifeBalance', ylabel='Density'>
```



In [12]:
```
sns.distplot(df["Age"])
```

```
C:\Users\ASUS\AppData\Local\Temp\ipykernel_12124\2732350774.py:1: UserWarning:

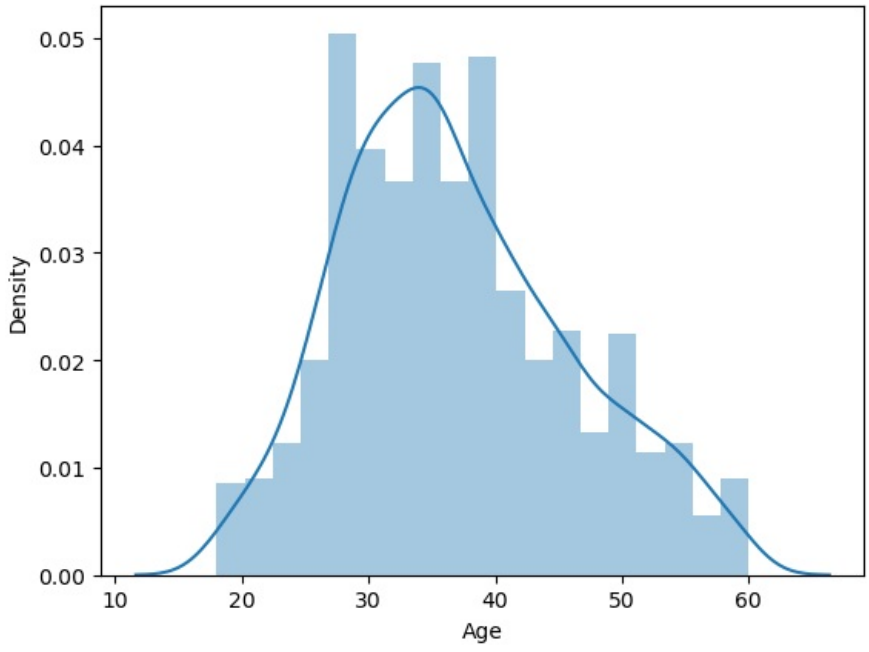
`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(df["Age"])
```

Out[12]:
```
<Axes: xlabel='Age', ylabel='Density'>
```



In [13]:
```
df.corr()
```

```
C:\Users\ASUS\AppData\Local\Temp\ipykernel_12124\1134722465.py:1: FutureWarning: The default value of numeric_only in DataFrame.corr is deprecated. In a future version, it will default to False. Select only valid columns or specify the value of numeric_only to silence this warning.
  df.corr()
```

Out[13]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	EmployeeNumber	EnvironmentSatisfaction	H
Age	1.000000	0.010661	-0.001686	0.208034	NaN	-0.010145	0.010146	
DailyRate	0.010661	1.000000	-0.004985	-0.016806	NaN	-0.050990	0.018355	
DistanceFromHome	-0.001686	-0.004985	1.000000	0.021042	NaN	0.032916	-0.016075	
Education	0.208034	-0.016806	0.021042	1.000000	NaN	0.042070	-0.027128	
EmployeeCount	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
EmployeeNumber	-0.010145	-0.050990	0.032916	0.042070	NaN	1.000000	0.017621	
EnvironmentSatisfaction	0.010146	0.018355	-0.016075	-0.027128	NaN	0.017621	1.000000	
HourlyRate	0.024287	0.023381	0.031131	0.016775	NaN	0.035179	-0.049857	
JobInvolvement	0.029820	0.046135	0.008783	0.042438	NaN	-0.006888	-0.008278	
JobLevel	0.509604	0.002966	0.005303	0.101589	NaN	-0.018519	0.001212	
JobSatisfaction	-0.004892	0.030571	-0.003669	-0.011296	NaN	-0.046247	-0.006784	
MonthlyIncome	0.497855	0.007707	-0.017014	0.094961	NaN	-0.014829	-0.006259	
MonthlyRate	0.028051	-0.032182	0.027473	-0.026084	NaN	0.012648	0.037600	
NumCompaniesWorked	0.299635	0.038153	-0.029251	0.126317	NaN	-0.001251	0.012594	
PercentSalaryHike	0.003634	0.022704	0.040235	-0.011111	NaN	-0.012944	-0.031701	
PerformanceRating	0.001904	0.000473	0.027110	-0.024539	NaN	-0.020359	-0.029548	
RelationshipSatisfaction	0.053535	0.007846	0.006557	-0.009118	NaN	-0.069861	0.007665	
StandardHours	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
StockOptionLevel	0.037510	0.042143	0.044872	0.018422	NaN	0.062227	0.003432	
TotalWorkingYears	0.680381	0.014515	0.004628	0.148280	NaN	-0.014365	-0.002693	
TrainingTimesLastYear	-0.019621	0.002453	-0.036942	-0.025100	NaN	0.023603	-0.019359	
WorkLifeBalance	-0.021490	-0.037848	-0.026556	0.009819	NaN	0.010309	0.027627	
YearsAtCompany	0.311309	-0.034055	0.009508	0.069114	NaN	-0.011240	0.001458	
YearsInCurrentRole	0.212901	0.009932	0.018845	0.060236	NaN	-0.008416	0.018007	
YearsSinceLastPromotion	0.216513	-0.033229	0.010029	0.054254	NaN	-0.009019	0.016194	
YearsWithCurrManager	0.202089	-0.026363	0.014406	0.069065	NaN	-0.009197	-0.004999	

26 rows × 26 columns

In [14]:
```
df.head()
```

Out[14]:

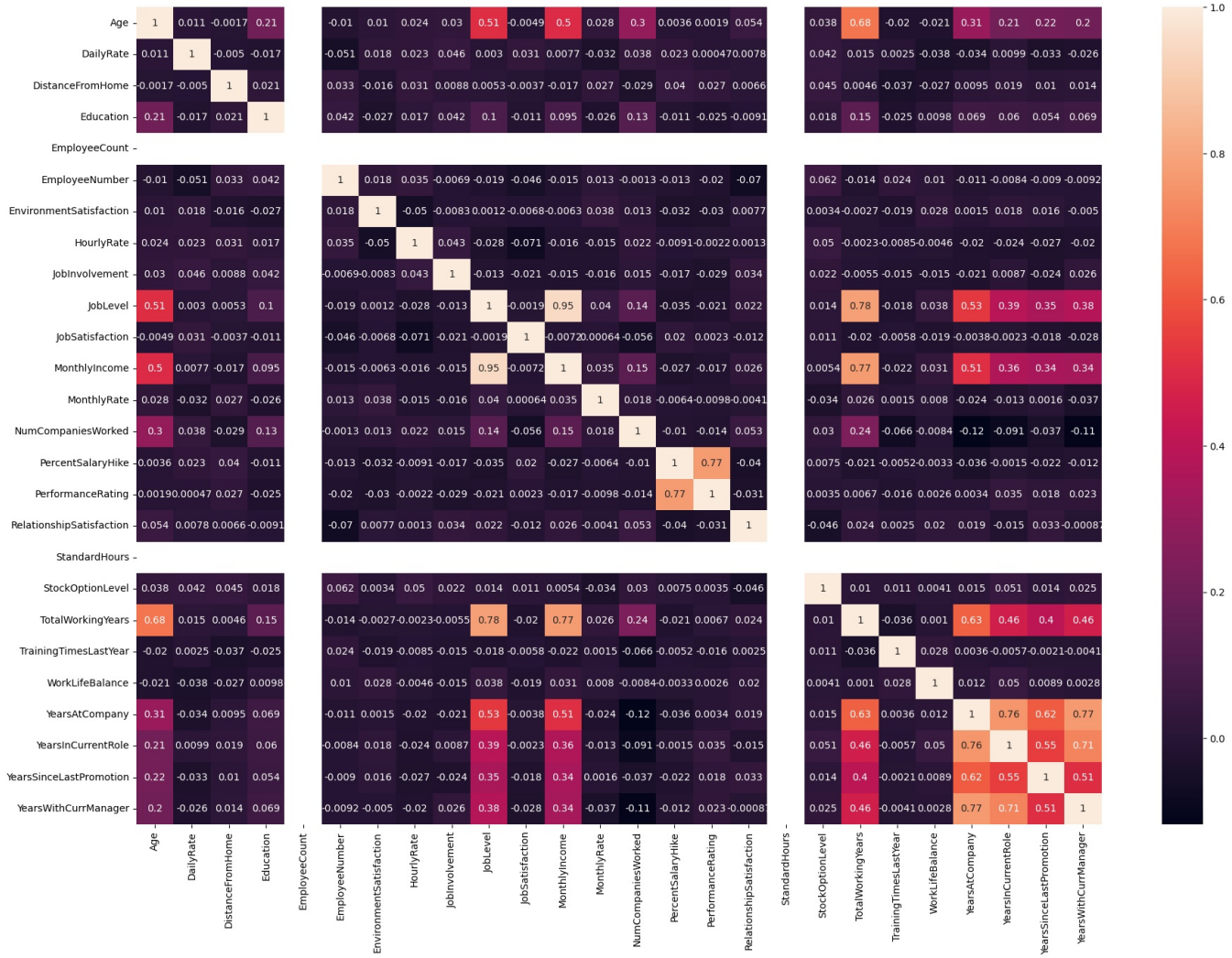
	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField	EmployeeCount	EmployeeNumber
0	41	Yes	Travel_Rarely	1102	Sales	1	2	Life Sciences	1	1
1	49	No	Travel_Frequently	279	Research & Development	8	1	Life Sciences	1	2
2	37	Yes	Travel_Rarely	1373	Research & Development	2	2	Other	1	4
3	33	No	Travel_Frequently	1392	Research & Development	3	4	Life Sciences	1	5
4	27	No	Travel_Rarely	591	Research & Development	2	1	Medical	1	7

5 rows × 35 columns

In [15]:
```
plt.subplots(figsize=(22,15))
sns.heatmap(df.corr(),annot=True)
```

```
C:\Users\ASUS\AppData\Local\Temp\ipykernel_12124\919060229.py:2: FutureWarning: The default value of numeric_only in DataFrame.corr is deprecated. In a future version, it will default to False. Select only valid columns or specify the value of numeric_only to silence this warning.
  sns.heatmap(df.corr(),annot=True)
```

Out[15]:
```
<Axes: >
```

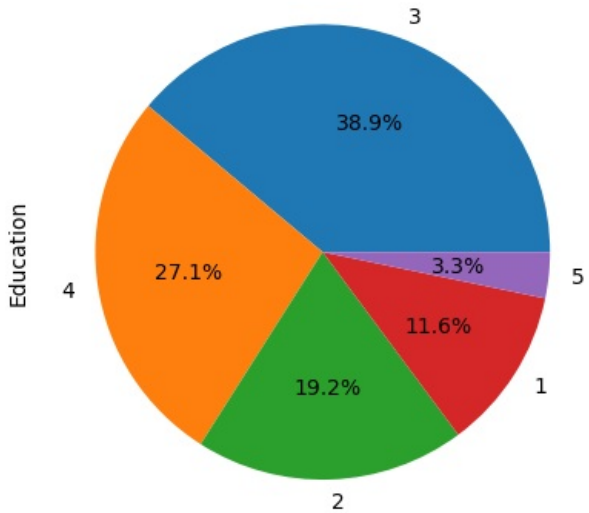


In [16]:
```
sns.pairplot(df)
```

Out[16]:
```
<seaborn.axisgrid.PairGrid at 0x25e0f7b68d0>
```

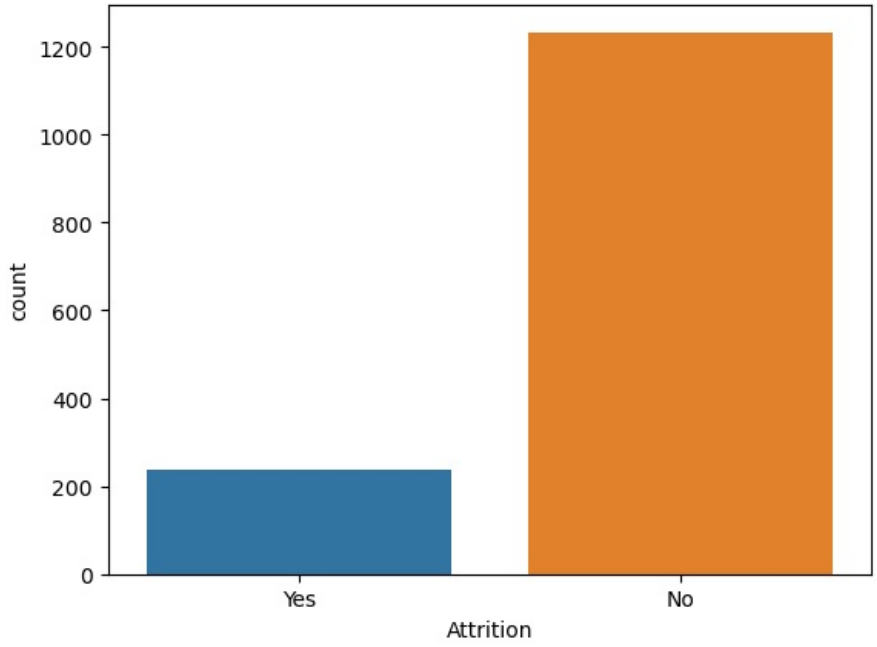
In [17]:
```
df.Education.value_counts().plot(kind="pie",autopct="%1.1f%%")
```

Out[17]:
```
<Axes: ylabel='Education'>
```



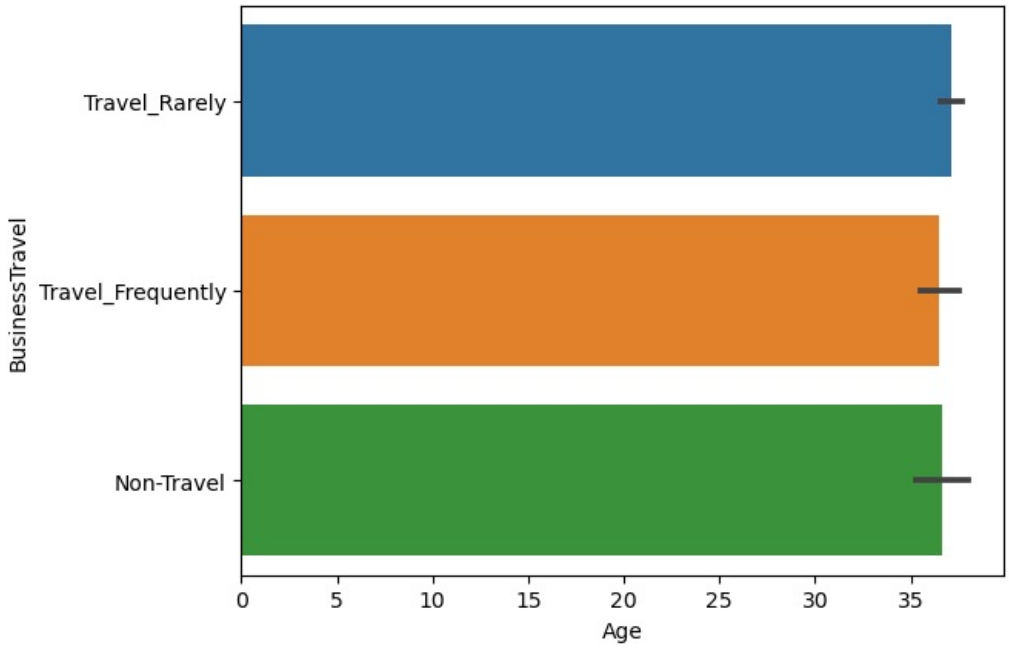
In [18]:
```
sns.countplot(x="Attrition",data=df)
```

Out[18]:
```
<Axes: xlabel='Attrition', ylabel='count'>
```



In [19]:
```
sns.barplot(x="Age",y="BusinessTravel",data=df)
```

Out[19]:
```
<Axes: xlabel='Age', ylabel='BusinessTravel'>
```



In [20]:
```
df.head()
```

Out[20]:

	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField	EmployeeCount	EmployeeNumber
0	41	Yes	Travel_Rarely	1102	Sales	1	2	Life Sciences	1	1
1	49	No	Travel_Frequently	279	Research & Development	8	1	Life Sciences	1	2
2	37	Yes	Travel_Rarely	1373	Research & Development	2	2	Other	1	4
3	33	No	Travel_Frequently	1392	Research & Development	3	4	Life Sciences	1	5
4	27	No	Travel_Rarely	591	Research & Development	2	1	Medical	1	7

5 rows × 35 columns

5.Outlier Detection

In [21]:
```
df.head()
```

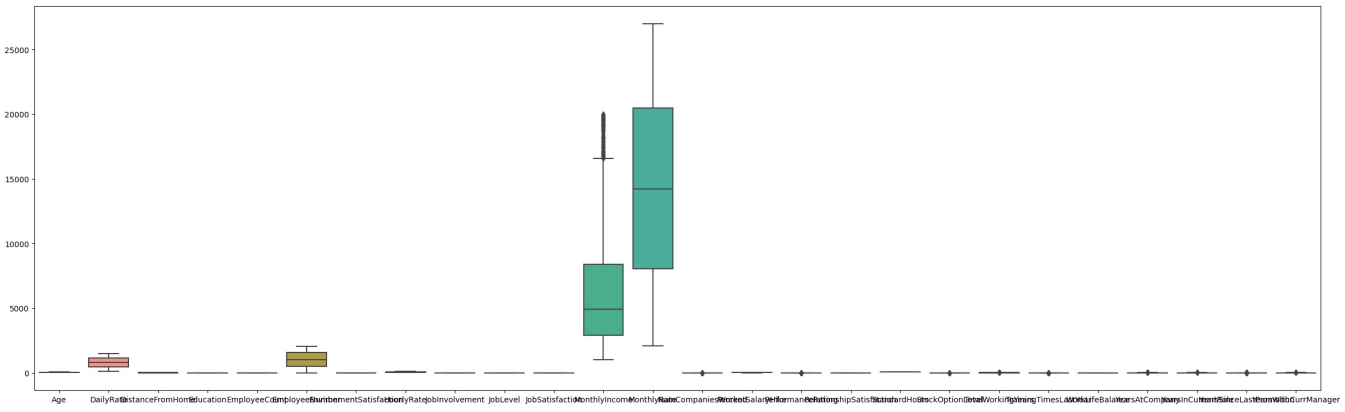
Out[21]:

	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField	EmployeeCount	EmployeeNumber
0	41	Yes	Travel_Rarely	1102	Sales	1	2	Life Sciences	1	1
1	49	No	Travel_Frequently	279	Research & Development	8	1	Life Sciences	1	2
2	37	Yes	Travel_Rarely	1373	Research & Development	2	2	Other	1	4
3	33	No	Travel_Frequently	1392	Research & Development	3	4	Life Sciences	1	5
4	27	No	Travel_Rarely	591	Research & Development	2	1	Medical	1	7

5 rows × 35 columns

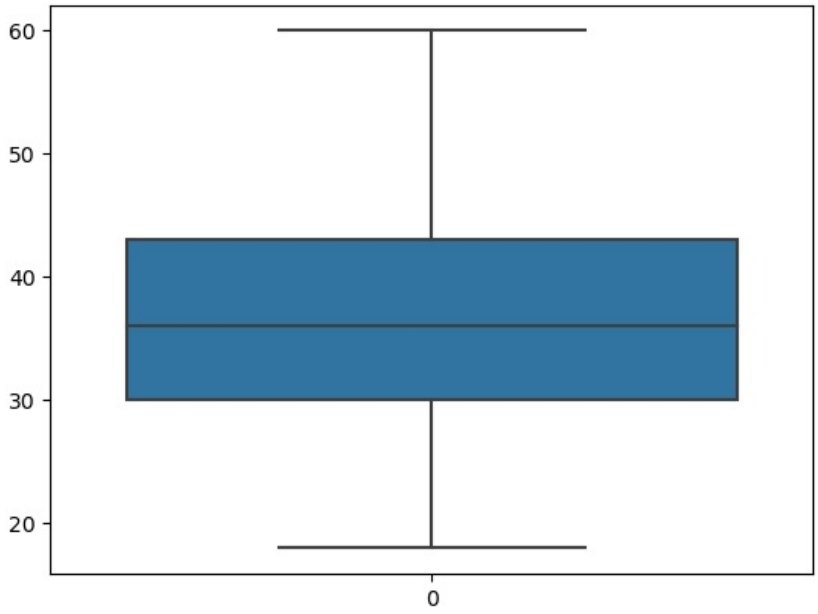
In [22]:
```
plt.figure(figsize=(30,9))
sns.boxplot(df)
```

Out[22]:
```
<Axes: >
```



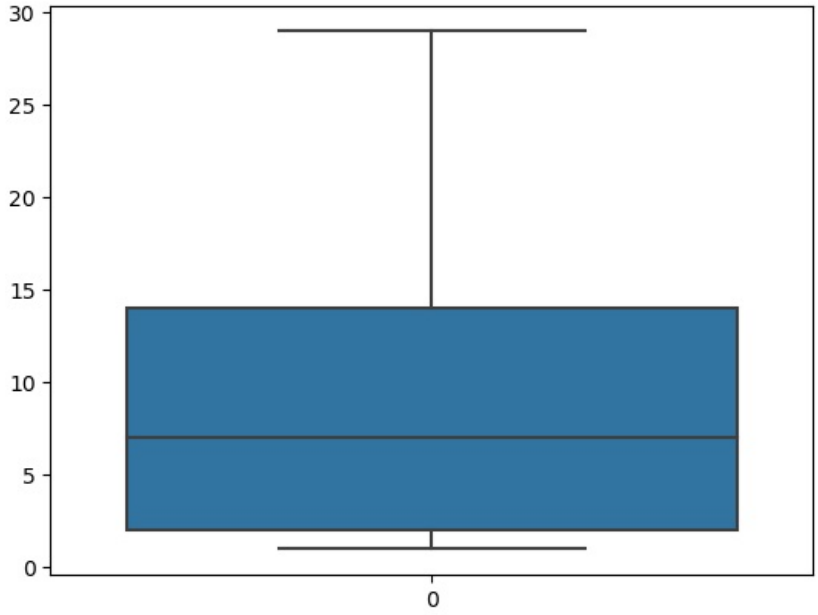
In [23]:
```
sns.boxplot(df["Age"])
```

Out[23]:
```
<Axes: >
```



In [24]:
```
sns.boxplot(df["DistanceFromHome"])
```

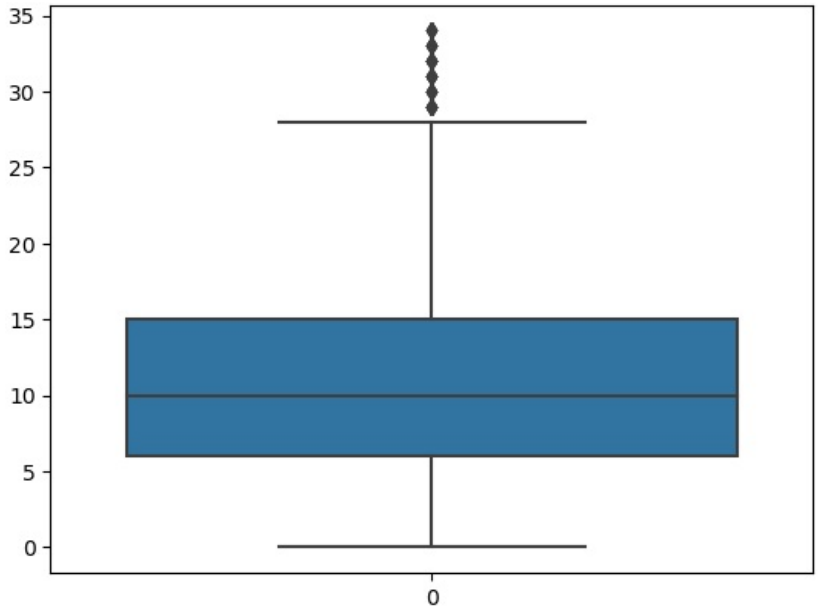
Out[24]:
```
<Axes: >
```



In [25]:
```
from scipy import stats
z_scores = stats.zscore(df['TotalWorkingYears'])
df_cleaned = df[(np.abs(z_scores) <=3)]
```

In [26]:
```
sns.boxplot(df_cleaned['TotalWorkingYears'])
```

Out[26]:
```
<Axes: >
```



6.Splitting Dependent and Independent variables

In [27]:
```
x=df.drop(columns=["Attrition"],axis=1)
x.head()
```

Out[27]:

	Age	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField	EmployeeCount	EmployeeNumber	Environ
0	41	Travel_Rarely	1102	Sales	1	2	Life Sciences	1	1	
1	49	Travel_Frequently	279	Research & Development	8	1	Life Sciences	1	2	
2	37	Travel_Rarely	1373	Research & Development	2	2	Other	1	4	
3	33	Travel_Frequently	1392	Research & Development	3	4	Life Sciences	1	5	
4	27	Travel_Rarely	591	Research & Development	2	1	Medical	1	7	

5 rows × 34 columns

In [28]:
```
type(x)
```

Out[28]:
```
pandas.core.frame.DataFrame
```

In [29]:
```
y=df["Attrition"]
y.head()
```

Out[29]:
```
0    Yes
1     No
2    Yes
3     No
4     No
Name: Attrition, dtype: object
```

In [30]:
```
type(y)
```

Out[30]:
```
pandas.core.series.Series
```

7.label encoding

In [31]:
```
from sklearn.preprocessing import LabelEncoder
le=LabelEncoder()
categorical_features = x.select_dtypes(include=['object']).columns.tolist()
x_encoded = pd.get_dummies(x, columns=categorical_features,drop_first=True)
x_encoded.head()
```

Out[31]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	EmployeeNumber	EnvironmentSatisfaction	HourlyRate	JobInvolvement	J
0	41	1102	1	2	1	1	2	94	3	
1	49	279	8	1	1	2	3	61	2	
2	37	1373	2	2	1	4	4	92	2	
3	33	1392	3	4	1	5	4	56	3	
4	27	591	2	1	1	7	1	40	3	

5 rows × 47 columns

8.Feature Scaling

In [32]:
```
from sklearn.preprocessing import StandardScaler
s=StandardScaler()
x_scaled=pd.DataFrame(s.fit_transform(x_encoded),columns=x_encoded.columns)
```

In [33]:
```
x_scaled.head()
```

Out[33]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	EmployeeNumber	EnvironmentSatisfaction	HourlyRate	JobInvolveme
0	0.446350	0.742527	-1.010909	-0.891688	0.0	-1.701283	-0.660531	1.383138	0.3796
1	1.322365	-1.297775	-0.147150	-1.868426	0.0	-1.699621	0.254625	-0.240677	-1.0261
2	0.008343	1.414363	-0.887515	-0.891688	0.0	-1.696298	1.169781	1.284725	-1.0261
3	-0.429664	1.461466	-0.764121	1.061787	0.0	-1.694636	1.169781	-0.486709	0.3796
4	-1.086676	-0.524295	-0.887515	-1.868426	0.0	-1.691313	-1.575686	-1.274014	0.3796

5 rows × 47 columns

9.Splitting Data into Train and Test

In [34]:
```
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x_scaled,y,test_size=0.2,random_state=0)
x_train.shape,x_test.shape,y_train.shape,y_test.shape
```

Out[34]:
```
((1176, 47), (294, 47), (1176,), (294,))
```

In [35]:
```
x_train.head()
```

Out[35]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	EmployeeNumber	EnvironmentSatisfaction	HourlyRate	JobInvolv
1374	2.307882	-0.489587	1.456975	0.085049	0.0	1.517290	1.169781	0.300595	0.3
1092	0.884358	0.365703	2.320735	0.085049	0.0	0.865932	1.169781	1.530758	0.3
768	0.336849	-1.245713	2.073946	0.085049	0.0	0.068351	0.254625	0.399008	0.3
569	-0.101159	1.565588	-0.147150	1.061787	0.0	-0.391920	-1.575686	0.497421	-1.0
911	-1.305679	-0.504462	1.827158	-1.868426	0.0	0.412307	0.254625	0.349801	-2.4

5 rows × 47 columns

Model Building o Import the model building Libraries o Initializing the model o Training and testing the model o Evaluation of Model o Save the Model

Logistic Regression

1.import the model building Libraries

In [36]:
```
from sklearn.linear_model import LogisticRegression
```

2.Initializing the model

In [37]:
```
lr=LogisticRegression()
```

3.Training and testing the model

In [38]:
```
lr.fit(x_train,y_train)
```

Out[38]:
```
▾ LogisticRegression
LogisticRegression()
```

In [39]:
```
y_pred=lr.predict(x_test)
```

In [40]:
```
y_pred
```

Out[40]:
```
array(['No', 'No', 'Yes', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'Yes', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No',
       'No', 'No', 'Yes', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'Yes', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'Yes', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'Yes',
       'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes',
       'No', 'No', 'No', 'No', 'Yes', 'Yes', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No'], dtype=object)
```

In [41]:
```
y_test
```

Out[41]:
```
442      No
1091     No
981     Yes
785      No
1332    Yes
       ...
1439     No
481      No
124     Yes
198      No
1229     No
Name: Attrition, Length: 294, dtype: object
```

In [42]:
```
df.head()
```

Out[42]:

	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField	EmployeeCount	EmployeeNumber
0	41	Yes	Travel_Rarely	1102	Sales	1	2	Life Sciences	1	1
1	49	No	Travel_Frequently	279	Research & Development	8	1	Life Sciences	1	2
2	37	Yes	Travel_Rarely	1373	Research & Development	2	2	Other	1	4
3	33	No	Travel_Frequently	1392	Research & Development	3	4	Life Sciences	1	5
4	27	No	Travel_Rarely	591	Research & Development	2	1	Medical	1	7

5 rows × 35 columns

Evaluation of classification model

In [43]:
```
#Accuracy score
from sklearn.metrics import accuracy_score,confusion_matrix,classification_report,roc_auc_score,roc_curve
```

In [44]:
```
accuracy_score(y_test,y_pred)
```

Out[44]:
```
0.8775510204081632
```

In [45]:
```
confusion_matrix(y_test,y_pred)
```

Out[45]:
```
array([[238,   7],
       [ 29,  20]], dtype=int64)
```

In [46]:
```
pd.crosstab(y_test,y_pred)
```

Out[46]:

col_0	No	Yes
Attrition		
No	238	7
Yes	29	20

In [47]:
```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

          No       0.89      0.97      0.93       245
         Yes       0.74      0.41      0.53        49

    accuracy                           0.88       294
   macro avg       0.82      0.69      0.73       294
weighted avg       0.87      0.88      0.86       294
```

In [48]:
```
probability=lr.predict_proba(x_test)[:,1]
```

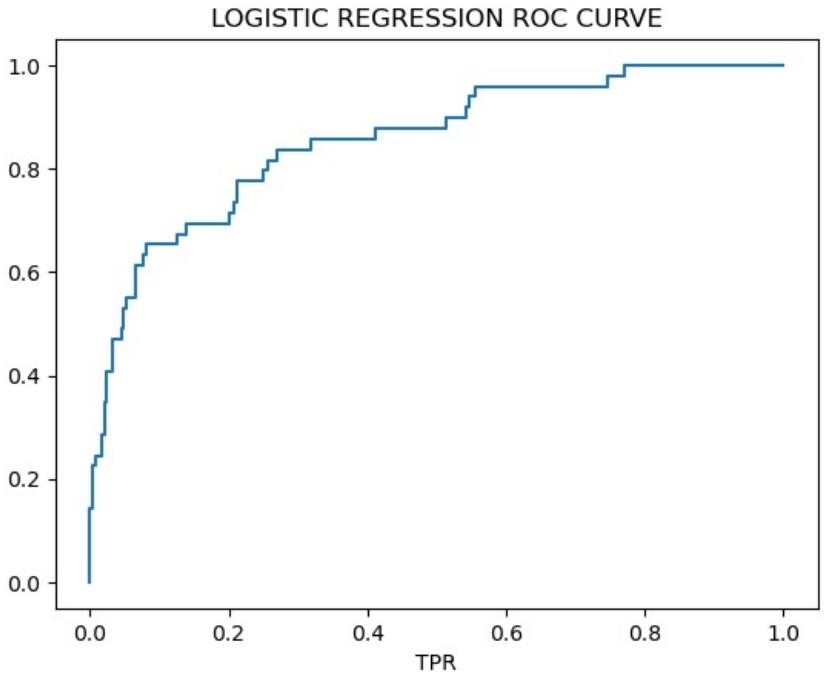
In [49]:
```
probability
```

Out[49]:
```
array([6.61367680e-02, 8.06198087e-02, 5.95640954e-01, 1.42633628e-01,
       7.84184536e-01, 4.42409704e-02, 4.90141163e-01, 3.64319554e-02,
       8.44925839e-04, 4.30164151e-01, 3.70048030e-02, 1.96283567e-01,
       1.51964558e-02, 5.39471444e-01, 5.88816107e-02, 1.18804547e-02,
       1.13489514e-01, 3.82574810e-02, 2.32011787e-02, 2.66149260e-01,
       1.31568762e-01, 9.99913247e-03, 1.30286201e-02, 3.88975456e-02,
       7.51582081e-01, 4.58920880e-01, 6.43869830e-02, 2.97280577e-02,
       6.90209855e-01, 3.77607239e-02, 5.59306642e-03, 3.05902665e-01,
       3.65028773e-02, 3.90288488e-02, 2.27899092e-02, 5.90358760e-03,
       2.32731579e-01, 5.29386349e-02, 1.38241033e-02, 1.13353905e-01,
       3.42777217e-02, 8.33820691e-03, 1.07151981e-03, 5.52578825e-03,
       8.80282261e-03, 5.59254552e-01, 4.21978392e-01, 5.99712843e-04,
       4.00447399e-01, 3.68527002e-01, 3.55627577e-02, 8.16716675e-01,
       1.58976261e-02, 3.55101528e-01, 4.94410470e-01, 2.54453615e-01,
       1.03880530e-02, 4.22173742e-01, 2.22235299e-02, 2.95631863e-01,
       1.26998325e-02, 1.53660325e-01, 1.65718568e-01, 2.37981819e-02,
       1.13922041e-01, 2.33156457e-02, 3.48112915e-01, 1.78088100e-01,
       1.21220858e-01, 1.82213934e-01, 3.38118048e-02, 1.58551253e-01,
       9.58027931e-02, 3.08386596e-02, 7.44773642e-02, 4.13402445e-02,
       1.92788840e-02, 2.80415152e-02, 4.93838215e-01, 1.65502835e-02,
       3.08277540e-03, 1.74647710e-02, 2.61191408e-01, 1.97665118e-02,
       1.95892874e-02, 7.95183218e-02, 6.72183840e-04, 1.32195797e-02,
       1.24777389e-02, 6.32250258e-02, 5.79625808e-02, 7.28350500e-02,
       3.24892323e-01, 1.73612641e-01, 8.28152031e-04, 7.99639374e-02,
       4.97002372e-01, 6.41780395e-01, 5.52704989e-02, 7.62263342e-02,
       1.32740233e-01, 5.87050953e-01, 5.91342152e-01, 5.08443347e-03,
       1.06560968e-01, 6.69002781e-03, 6.09068154e-02, 2.11328359e-01,
       3.68701854e-02, 3.96643551e-01, 2.94309518e-02, 5.18292700e-02,
       3.44618460e-03, 2.96577876e-01, 2.24618906e-02, 2.45843670e-02,
       9.84944236e-03, 2.82977886e-02, 2.36629032e-03, 4.89083971e-03,
       1.06593614e-01, 3.22277227e-02, 8.43908260e-02, 8.89755562e-01,
       1.01655842e-02, 2.07510840e-03, 3.14944475e-03, 9.91294127e-02,
       1.39271996e-01, 1.05763678e-02, 4.62491869e-03, 3.29517891e-01,
       7.00654301e-01, 1.96667235e-01, 9.97786091e-03, 3.85631608e-01,
       6.96550561e-01, 2.28516613e-01, 1.82557187e-01, 4.88667496e-01,
       2.73199468e-02, 3.53431498e-02, 3.17068584e-02, 3.13677515e-01,
       4.71792593e-01, 3.75527841e-02, 2.67239299e-01, 3.83012181e-03,
       7.37038139e-02, 1.24740256e-01, 4.07667992e-03, 1.71768746e-01,
       7.20048951e-02, 1.75320014e-01, 7.13178095e-03, 2.39429405e-02,
       1.98658569e-01, 3.20547275e-01, 3.96927966e-03, 9.49330798e-03,
       7.45555587e-01, 3.12330244e-03, 3.32408074e-02, 9.19392780e-01,
       1.48852250e-02, 2.57190744e-01, 1.73014525e-01, 1.51785386e-01,
       1.86931379e-02, 8.28851842e-04, 2.54342547e-01, 4.56483830e-02,
       3.99204597e-02, 1.25490112e-01, 1.70919482e-02, 8.25299901e-02,
       4.38992386e-02, 4.31506741e-02, 3.39152219e-02, 5.12964217e-02,
       2.12219051e-02, 1.57474151e-01, 2.44952859e-03, 8.22895146e-01,
       5.98438753e-02, 8.69783952e-02, 5.40701108e-01, 8.54091278e-03,
       5.57078600e-01, 2.31232882e-01, 2.11246138e-01, 2.75461703e-01,
       1.33154014e-01, 1.82199815e-02, 3.32865074e-02, 1.09429647e-01,
       1.86460970e-02, 7.81476677e-03, 2.65574308e-01, 1.69272765e-02,
       3.86686532e-01, 2.20988923e-01, 8.08612471e-01, 2.03966645e-02,
       1.28650474e-01, 1.77680007e-02, 3.57289398e-01, 5.30474583e-04,
       1.67105418e-01, 1.00764993e-02, 8.58290380e-02, 3.05739812e-01,
       6.81826517e-02, 3.81711531e-01, 1.10859745e-01, 4.71842280e-03,
       1.86894274e-02, 5.45048658e-02, 4.72421338e-02, 9.34489342e-02,
       8.33653672e-02, 4.44029727e-01, 5.18663398e-01, 1.79271982e-01,
       2.87090882e-01, 2.67710024e-03, 1.09509162e-01, 2.65241921e-01,
       7.65032998e-01, 4.64180665e-02, 1.97677279e-01, 2.06495230e-01,
       3.00475823e-02, 4.28680929e-02, 9.01257179e-02, 1.16204269e-01,
       2.66591825e-01, 9.07332777e-04, 7.47052094e-02, 1.49451887e-03,
       1.41520152e-01, 2.92363790e-01, 5.07029822e-03, 1.26501783e-01,
       3.79539275e-02, 1.77150306e-02, 1.54456455e-01, 3.43384106e-01,
       4.27481928e-02, 3.44423944e-02, 2.93165700e-01, 7.16660273e-02,
       5.38151329e-01, 1.63749013e-02, 1.23951727e-01, 6.52278702e-02,
       2.45783680e-03, 6.25002778e-01, 6.25608255e-01, 3.74616723e-01,
       1.41256456e-01, 2.84604841e-02, 2.91843045e-01, 5.95069780e-02,
       3.21045151e-02, 6.99486994e-02, 1.15155181e-03, 4.47317458e-01,
       5.39084197e-01, 2.55697184e-02, 2.85616158e-02, 8.43094503e-03,
       6.55595901e-02, 2.48427612e-02, 9.60265542e-03, 5.93422188e-03,
       8.58521685e-02, 3.64680251e-01, 1.20449475e-01, 1.84226608e-01,
       6.91761349e-01, 3.24455148e-03, 4.85788438e-02, 7.34675868e-02,
       5.35355633e-02, 7.58287245e-02, 2.30602991e-04, 1.53563842e-01,
       1.43056931e-03, 9.15060156e-03, 1.08956580e-01, 6.50047900e-01,
       2.36548949e-02, 7.52606168e-02])
```

In [50]:
```
from sklearn.preprocessing import LabelEncoder
le=LabelEncoder()
y_test = le.fit_transform(y_test)
```

In [51]:
```
fpr,tpr,threshsholds=roc_curve(y_test,probability)
```

In [52]:
```
plt.plot(fpr,tpr)
plt.xlabel('FPR')
plt.xlabel('TPR')
plt.title('LOGISTIC REGRESSION ROC CURVE')
plt.show()
```



Decision Tree

In [53]:
```
from sklearn.tree import DecisionTreeClassifier
dtc=DecisionTreeClassifier()
```

In [54]:
```
dtc.fit(x_train, y_train)
```

Out[54]:
```
▾ DecisionTreeClassifier
DecisionTreeClassifier()
```

In [55]:
```
y_pred1=dtc.predict(x_test)
```

In [56]:
```
y_pred1
```

Out[56]:
```
array(['No', 'No', 'Yes', 'No', 'No', 'Yes', 'Yes', 'No', 'No', 'No',
       'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No',
       'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'Yes', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'Yes',
       'Yes', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No',
       'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'Yes', 'Yes', 'No', 'No', 'No', 'No',
       'Yes', 'No', 'No', 'No', 'Yes', 'Yes', 'No', 'No', 'Yes', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'Yes', 'No', 'No', 'No',
       'No', 'No', 'No', 'Yes', 'Yes', 'Yes', 'Yes', 'No', 'No', 'No',
       'Yes', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'Yes',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'Yes', 'No', 'No',
       'No', 'No', 'Yes', 'No', 'No', 'Yes', 'No', 'Yes', 'No', 'No',
       'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'Yes', 'No',
       'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'Yes', 'No', 'Yes',
       'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No',
       'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No'], dtype=object)
```

In [57]:
```
y_test
```

Out[57]:
```
array([0, 0, 1, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0,
       0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1,
       0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0,
       1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0,
       0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
       0, 1, 0, 0, 0, 1, 0, 0])
```

In [58]:
```
#Accuracy score
from sklearn.metrics import accuracy_score,confusion_matrix,classification_report,roc_auc_score,roc_curve
```

In [59]:
```
# Convert integer labels to string labels
y_test = ['No' if label == 0 else 'Yes' for label in y_test]

# Calculate accuracy score
accuracy = accuracy_score(y_test, y_pred1)
```

In [60]:
```
accuracy
```

Out[60]:
```
0.7755102040816326
```

In [61]:
```
confusion_matrix(y_test,y_pred1)
```

Out[61]:
```
array([[210,  35],
       [ 31,  18]], dtype=int64)
```

In [62]:
```
pd.crosstab(y_test,y_pred1)
```

Out[62]:

col_0	No	Yes
row_0		
No	210	35
Yes	31	18

In [63]:
```
print(classification_report(y_test,y_pred1))
```

```
              precision    recall  f1-score   support

          No       0.87      0.86      0.86       245
         Yes       0.34      0.37      0.35        49

    accuracy                           0.78       294
   macro avg       0.61      0.61      0.61       294
weighted avg       0.78      0.78      0.78       294
```

In [64]:
```
probability= dtc.predict_proba(x_test)[:,1]
```

In [65]:
```
probability
```

Out[65]:
```
array([0., 0., 1., 0., 0., 1., 1., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0.,
       0., 0., 1., 0., 0., 0., 0., 1., 0., 0., 0., 1., 0., 0., 0., 0., 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0.,
       1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0.,
       0., 0., 0., 1., 0., 0., 0., 1., 1., 0., 0., 0., 1., 0., 0., 0., 0.,
       0., 1., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 1.,
       1., 0., 0., 0., 0., 1., 0., 0., 0., 1., 1., 0., 0., 1., 0., 0., 0.,
       0., 0., 0., 0., 1., 1., 0., 0., 0., 0., 0., 0., 1., 1., 1., 1., 0.,
       0., 0., 1., 0., 0., 0., 1., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0.,
       0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 1., 0., 0., 0., 0., 0., 0.,
       0., 0., 0., 0., 0., 0., 0., 1., 1., 0., 0., 0., 0., 1., 0., 0., 1.,
       0., 1., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0.,
       0., 1., 0., 0., 0., 0., 1., 0., 0., 0., 1., 0., 1., 0., 0., 0., 0.,
       0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0.,
       0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 1., 0., 1., 0., 0., 0., 0.,
       0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 1., 0., 0., 1., 0., 0., 0.,
       0., 0., 0., 0., 0.])
```

Hyper Parameter Tuning

In [66]:
```
from sklearn import tree
plt.figure(figsize=(25,15))
tree.plot_tree(dtc,filled=True)
```

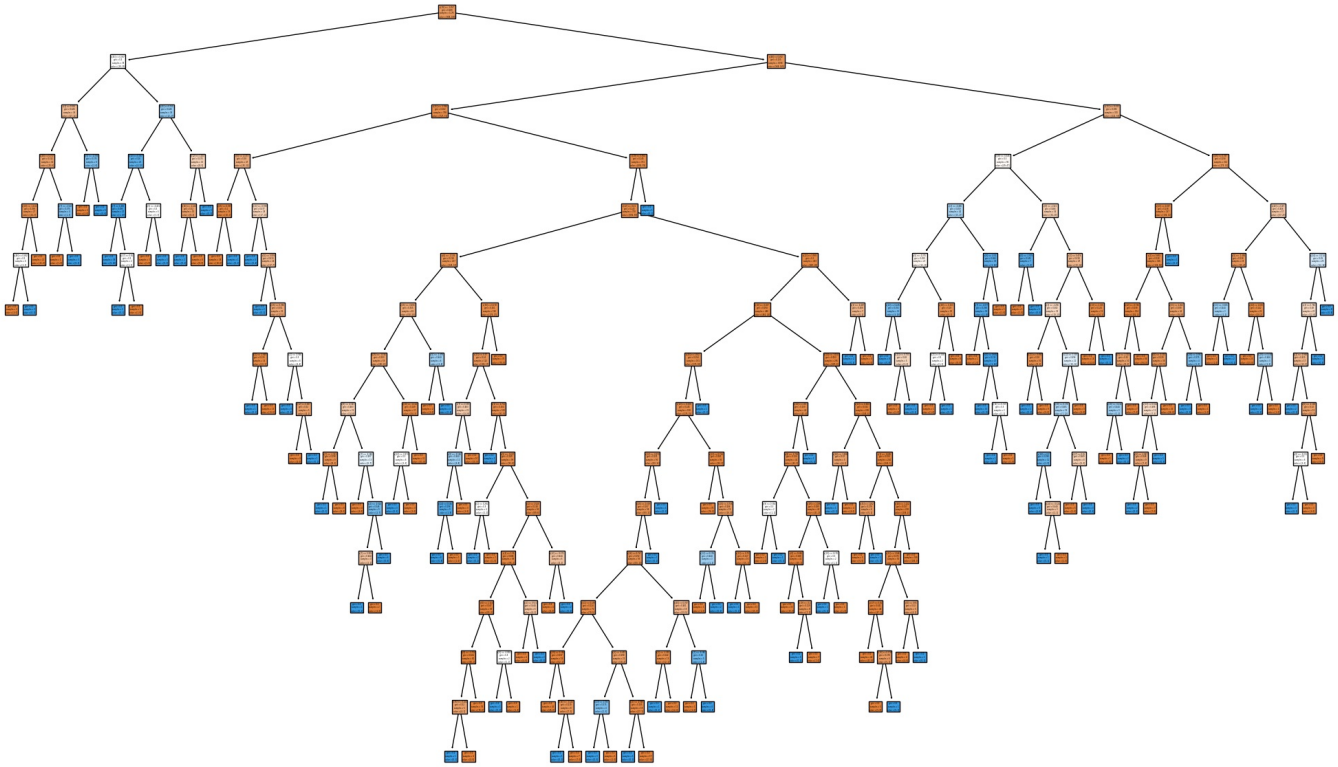
Out[66]:
```
[Text(0.3331301867219917, 0.96875, 'x[19] <= -1.257\ngini = 0.269\nsamples = 1176\nvalue = [988, 188]'),
 Text(0.08630705394190871, 0.90625, 'x[45] <= 0.387\ngini = 0.5\nsamples = 78\nvalue = [39, 39]'),
```

```
Text(0.04979253112033195, 0.84375, 'x[2] <= 0.902\ngini = 0.426\nsamples = 39\nvalue = [27, 12]'),
Text(0.03319502074688797, 0.78125, 'x[26] <= 0.797\ngini = 0.312\nsamples = 31\nvalue = [25, 6]'),
Text(0.01991701244813278, 0.71875, 'x[10] <= -1.114\ngini = 0.198\nsamples = 27\nvalue = [24, 3]'),
Text(0.013278008298755186, 0.65625, 'x[46] <= 0.482\ngini = 0.5\nsamples = 6\nvalue = [3, 3]'),
Text(0.006639004149377593, 0.59375, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
Text(0.01991701244813278, 0.59375, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.026556016597510373, 0.65625, 'gini = 0.0\nsamples = 21\nvalue = [21, 0]'),
Text(0.046473029045643155, 0.71875, 'x[7] <= -1.102\ngini = 0.375\nsamples = 4\nvalue = [1, 3]'),
Text(0.03983402489626556, 0.65625, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.053112033195020746, 0.65625, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.06639004149377593, 0.78125, 'x[5] <= -0.378\ngini = 0.375\nsamples = 8\nvalue = [2, 6]'),
Text(0.05975103734439834, 0.71875, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
Text(0.07302904564315353, 0.71875, 'gini = 0.0\nsamples = 6\nvalue = [0, 6]'),
Text(0.12282157676348547, 0.84375, 'x[41] <= 0.755\ngini = 0.426\nsamples = 39\nvalue = [12, 27]'),
Text(0.0995850622406639, 0.78125, 'x[32] <= 0.397\ngini = 0.26\nsamples = 26\nvalue = [4, 22]'),
Text(0.08630705394190871, 0.71875, 'x[7] <= 1.482\ngini = 0.095\nsamples = 20\nvalue = [1, 19]'),
Text(0.07966804979253111, 0.65625, 'gini = 0.0\nsamples = 18\nvalue = [0, 18]'),
Text(0.09294605809128631, 0.65625, 'x[37] <= 0.85\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.08630705394190871, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.0995850622406639, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.11286307053941909, 0.71875, 'x[5] <= -0.401\ngini = 0.5\nsamples = 6\nvalue = [3, 3]'),
Text(0.10622406639004149, 0.65625, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
Text(0.11950207468879669, 0.65625, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.14605809128630706, 0.78125, 'x[12] <= 1.103\ngini = 0.473\nsamples = 13\nvalue = [8, 5]'),
Text(0.13941908713692946, 0.71875, 'x[16] <= -1.122\ngini = 0.32\nsamples = 10\nvalue = [8, 2]'),
Text(0.13278008298755187, 0.65625, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.14605809128630706, 0.65625, 'gini = 0.0\nsamples = 8\nvalue = [8, 0]'),
Text(0.15269709543568466, 0.71875, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.5799533195020747, 0.90625, 'x[46] <= 0.482\ngini = 0.235\nsamples = 1098\nvalue = [949, 149]'),
Text(0.3279564315352697, 0.84375, 'x[21] <= -1.786\ngini = 0.162\nsamples = 798\nvalue = [727, 71]'),
Text(0.17925311203319502, 0.78125, 'x[5] <= -0.173\ngini = 0.38\nsamples = 47\nvalue = [35, 12]'),
Text(0.16597510373443983, 0.71875, 'x[45] <= 0.387\ngini = 0.1\nsamples = 19\nvalue = [18, 1]'),
Text(0.15933609958506223, 0.65625, 'gini = 0.0\nsamples = 18\nvalue = [18, 0]'),
Text(0.17261410788381742, 0.65625, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.19253112033195022, 0.71875, 'x[11] <= -0.789\ngini = 0.477\nsamples = 28\nvalue = [17, 11]'),
Text(0.18589211618257262, 0.65625, 'gini = 0.0\nsamples = 4\nvalue = [0, 4]'),
Text(0.1991701244813278, 0.65625, 'x[5] <= 0.099\ngini = 0.413\nsamples = 24\nvalue = [17, 7]'),
Text(0.19253112033195022, 0.59375, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.20580912863070538, 0.59375, 'x[25] <= 0.386\ngini = 0.351\nsamples = 22\nvalue = [17, 5]'),
Text(0.19253112033195022, 0.53125, 'x[1] <= -1.649\ngini = 0.133\nsamples = 14\nvalue = [13, 1]'),
Text(0.18589211618257262, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.1991701244813278, 0.46875, 'gini = 0.0\nsamples = 13\nvalue = [13, 0]'),
Text(0.21908713692946058, 0.53125, 'x[1] <= -0.596\ngini = 0.5\nsamples = 8\nvalue = [4, 4]'),
Text(0.21244813278008298, 0.46875, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.22572614107883818, 0.46875, 'x[12] <= 0.897\ngini = 0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.21908713692946058, 0.40625, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.23236514522821577, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.4766597510373444, 0.78125, 'x[19] <= 3.564\ngini = 0.145\nsamples = 751\nvalue = [692, 59]'),
Text(0.4700207468879668, 0.71875, 'x[22] <= -0.41\ngini = 0.143\nsamples = 750\nvalue = [692, 58]'),
Text(0.33443983402489624, 0.65625, 'x[6] <= -1.118\ngini = 0.218\nsamples = 257\nvalue = [225, 32]'),
Text(0.30373443983402487, 0.59375, 'x[25] <= -0.455\ngini = 0.355\nsamples = 65\nvalue = [50, 15]'),
Text(0.2821576763485477, 0.53125, 'x[25] <= -1.016\ngini = 0.303\nsamples = 59\nvalue = [48, 11]'),
Text(0.25892116182572616, 0.46875, 'x[8] <= -0.323\ngini = 0.463\nsamples = 22\nvalue = [14, 8]'),
Text(0.24564315352697094, 0.40625, 'x[7] <= -1.151\ngini = 0.198\nsamples = 9\nvalue = [8, 1]'),
Text(0.23900414937759337, 0.34375, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.25228215767634854, 0.34375, 'gini = 0.0\nsamples = 8\nvalue = [8, 0]'),
Text(0.2721991701244813, 0.40625, 'x[7] <= -0.388\ngini = 0.497\nsamples = 13\nvalue = [6, 7]'),
Text(0.26556016597510373, 0.34375, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.27883817427385893, 0.34375, 'x[2] <= -0.024\ngini = 0.346\nsamples = 9\nvalue = [2, 7]'),
Text(0.2721991701244813, 0.28125, 'x[7] <= 0.399\ngini = 0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.26556016597510373, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.27883817427385893, 0.21875, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
Text(0.2854771784232365, 0.28125, 'gini = 0.0\nsamples = 6\nvalue = [0, 6]'),
Text(0.3053941908713693, 0.46875, 'x[10] <= -1.114\ngini = 0.149\nsamples = 37\nvalue = [34, 3]'),
Text(0.2987551867219917, 0.40625, 'x[22] <= -0.573\ngini = 0.5\nsamples = 6\nvalue = [3, 3]'),
Text(0.2921161825726141, 0.34375, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.3053941908713693, 0.34375, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
Text(0.3120331950207469, 0.40625, 'gini = 0.0\nsamples = 31\nvalue = [31, 0]'),
Text(0.3253112033195021, 0.53125, 'x[5] <= -1.479\ngini = 0.444\nsamples = 6\nvalue = [2, 4]'),
Text(0.31867219917012446, 0.46875, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
Text(0.33195020746887965, 0.46875, 'gini = 0.0\nsamples = 4\nvalue = [0, 4]'),
Text(0.3651452282157676, 0.59375, 'x[30] <= 0.178\ngini = 0.161\nsamples = 192\nvalue = [175, 17]'),
Text(0.35850622406639004, 0.53125, 'x[21] <= -0.37\ngini = 0.24\nsamples = 122\nvalue = [105, 17]'),
Text(0.34522821576763485, 0.46875, 'x[7] <= 0.399\ngini = 0.463\nsamples = 22\nvalue = [14, 8]'),
Text(0.3385892116182573, 0.40625, 'x[0] <= -0.156\ngini = 0.444\nsamples = 12\nvalue = [4, 8]'),
Text(0.33195020746887965, 0.34375, 'x[14] <= 0.626\ngini = 0.198\nsamples = 9\nvalue = [1, 8]'),
Text(0.3253112033195021, 0.28125, 'gini = 0.0\nsamples = 8\nvalue = [0, 8]'),
Text(0.3385892116182573, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.34522821576763485, 0.34375, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
Text(0.35186721991701245, 0.40625, 'gini = 0.0\nsamples = 10\nvalue = [10, 0]'),
Text(0.37178423236514524, 0.46875, 'x[1] <= -1.711\ngini = 0.164\nsamples = 100\nvalue = [91, 9]'),
Text(0.3651452282157676, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.3784232365145228, 0.40625, 'x[5] <= -1.627\ngini = 0.149\nsamples = 99\nvalue = [91, 8]'),
Text(0.35933609958506224, 0.34375, 'x[1] <= 0.265\ngini = 0.5\nsamples = 4\nvalue = [2, 2]'),
Text(0.35269709543568467, 0.28125, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.3659751037344398, 0.28125, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
Text(0.3975103734439834, 0.34375, 'x[1] <= 1.528\ngini = 0.118\nsamples = 95\nvalue = [89, 6]'),
Text(0.379253112033195, 0.28125, 'x[3] <= 1.55\ngini = 0.086\nsamples = 89\nvalue = [85, 4]'),
Text(0.362655601659751, 0.21875, 'x[0] <= 2.144\ngini = 0.047\nsamples = 83\nvalue = [81, 2]'),
```

```
Text(0.34937759336099583, 0.15625, 'x[8] <= -1.729\ngini = 0.024\nsamples = 81\nvalue = [80, 1]'),
Text(0.34273858921161826, 0.09375, 'x[35] <= -0.204\ngini = 0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.3360995850622407, 0.03125, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.34937759336099583, 0.03125, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.35601659751037346, 0.09375, 'gini = 0.0\nsamples = 76\nvalue = [76, 0]'),
Text(0.3759336099585062, 0.15625, 'x[9] <= -0.058\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.36929460580912865, 0.09375, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.3825726141078838, 0.09375, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.395850622406639, 0.21875, 'x[2] <= 0.532\ngini = 0.444\nsamples = 6\nvalue = [4, 2]'),
Text(0.3892116182572614, 0.15625, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.4024896265560166, 0.15625, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.4157676348547718, 0.28125, 'x[22] <= -0.573\ngini = 0.444\nsamples = 6\nvalue = [4, 2]'),
Text(0.4091286307053942, 0.21875, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.4224066390041494, 0.21875, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.37178423236514524, 0.53125, 'gini = 0.0\nsamples = 70\nvalue = [70, 0]'),
Text(0.6056016597510373, 0.65625, 'x[22] <= 3.999\ngini = 0.1\nsamples = 493\nvalue = [467, 26]'),
Text(0.5697095435684647, 0.59375, 'x[10] <= -0.207\ngini = 0.094\nsamples = 486\nvalue = [462, 24]'),
Text(0.5178423236514523, 0.53125, 'x[43] <= 1.922\ngini = 0.154\nsamples = 191\nvalue = [175, 16]'),
Text(0.5112033195020746, 0.46875, 'x[12] <= -0.035\ngini = 0.145\nsamples = 190\nvalue = [175, 15]'),
Text(0.4871369294605809, 0.40625, 'x[12] <= -0.073\ngini = 0.221\nsamples = 95\nvalue = [83, 12]'),
Text(0.48049792531120333, 0.34375, 'x[25] <= 2.629\ngini = 0.207\nsamples = 94\nvalue = [83, 11]'),
Text(0.4738589211618257, 0.28125, 'x[26] <= 0.797\ngini = 0.192\nsamples = 93\nvalue = [83, 10]'),
Text(0.43900414937759336, 0.21875, 'x[11] <= 0.439\ngini = 0.124\nsamples = 75\nvalue = [70, 5]'),
Text(0.4157676348547718, 0.15625, 'x[39] <= 1.346\ngini = 0.037\nsamples = 53\nvalue = [52, 1]'),
Text(0.4091286307053942, 0.09375, 'gini = 0.0\nsamples = 45\nvalue = [45, 0]'),
Text(0.4224066390041494, 0.09375, 'x[16] <= -1.122\ngini = 0.219\nsamples = 8\nvalue = [7, 1]'),
Text(0.4157676348547718, 0.03125, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.42904564315352695, 0.03125, 'gini = 0.0\nsamples = 7\nvalue = [7, 0]'),
Text(0.46224066390041496, 0.15625, 'x[3] <= -0.403\ngini = 0.298\nsamples = 22\nvalue = [18, 4]'),
Text(0.44896265560165977, 0.09375, 'x[23] <= 1.593\ngini = 0.375\nsamples = 4\nvalue = [1, 3]'),
Text(0.44232365145228214, 0.03125, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.45560165975103734, 0.03125, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.4755186721991701, 0.09375, 'x[2] <= -0.949\ngini = 0.105\nsamples = 18\nvalue = [17, 1]'),
Text(0.46887966804979253, 0.03125, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.4821576763485477, 0.03125, 'gini = 0.0\nsamples = 17\nvalue = [17, 0]'),
Text(0.5087136929460581, 0.21875, 'x[45] <= 0.387\ngini = 0.401\nsamples = 18\nvalue = [13, 5]'),
Text(0.4954356846473029, 0.15625, 'x[1] <= -1.335\ngini = 0.142\nsamples = 13\nvalue = [12, 1]'),
Text(0.4887966804979253, 0.09375, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.5020746887966805, 0.09375, 'gini = 0.0\nsamples = 12\nvalue = [12, 0]'),
Text(0.5219917012448133, 0.15625, 'x[7] <= -0.585\ngini = 0.32\nsamples = 5\nvalue = [1, 4]'),
Text(0.5153526970954356, 0.09375, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.5286307053941909, 0.09375, 'gini = 0.0\nsamples = 4\nvalue = [0, 4]'),
Text(0.4871369294605809, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.49377593360995853, 0.34375, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.5352697095435685, 0.40625, 'x[13] <= 0.724\ngini = 0.061\nsamples = 95\nvalue = [92, 3]'),
Text(0.5286307053941909, 0.34375, 'gini = 0.0\nsamples = 76\nvalue = [76, 0]'),
Text(0.541908713692946, 0.34375, 'x[25] <= -0.735\ngini = 0.266\nsamples = 19\nvalue = [16, 3]'),
Text(0.5286307053941909, 0.28125, 'x[12] <= 0.578\ngini = 0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.5219917012448133, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.5352697095435685, 0.21875, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.5551867219917013, 0.28125, 'x[11] <= -0.73\ngini = 0.117\nsamples = 16\nvalue = [15, 1]'),
Text(0.5485477178423237, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.5618257261410788, 0.21875, 'gini = 0.0\nsamples = 15\nvalue = [15, 0]'),
Text(0.5244813278008299, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.6215767634854772, 0.53125, 'x[14] <= -1.014\ngini = 0.053\nsamples = 295\nvalue = [287, 8]'),
Text(0.5983402489626556, 0.46875, 'x[24] <= 2.58\ngini = 0.159\nsamples = 46\nvalue = [42, 4]'),
Text(0.591701244813278, 0.40625, 'x[8] <= -1.729\ngini = 0.124\nsamples = 45\nvalue = [42, 3]'),
Text(0.575103734439834, 0.34375, 'x[9] <= 0.394\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.5684647302904564, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.5817427385892117, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.6082987551867219, 0.34375, 'x[19] <= 2.085\ngini = 0.089\nsamples = 43\nvalue = [41, 2]'),
Text(0.5950207468879668, 0.28125, 'x[0] <= 0.665\ngini = 0.048\nsamples = 41\nvalue = [40, 1]'),
Text(0.5883817427385892, 0.21875, 'gini = 0.0\nsamples = 33\nvalue = [33, 0]'),
Text(0.6016597510373444, 0.21875, 'x[19] <= -0.1\ngini = 0.219\nsamples = 8\nvalue = [7, 1]'),
Text(0.5950207468879668, 0.15625, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.6082987551867219, 0.15625, 'gini = 0.0\nsamples = 7\nvalue = [7, 0]'),
Text(0.6215767634854772, 0.28125, 'x[19] <= 2.278\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.6149377593360996, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.6282157676348548, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.6049792531120332, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.6448132780082988, 0.46875, 'x[11] <= -0.943\ngini = 0.032\nsamples = 249\nvalue = [245, 4]'),
Text(0.6282157676348548, 0.40625, 'x[20] <= -1.008\ngini = 0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.6215767634854772, 0.34375, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.6348547717842323, 0.34375, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.6614107883817427, 0.40625, 'x[1] <= -1.685\ngini = 0.024\nsamples = 244\nvalue = [241, 3]'),
Text(0.6481327800829876, 0.34375, 'x[31] <= 1.262\ngini = 0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.64149377593361, 0.28125, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
Text(0.6547717842323652, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.6746887966804979, 0.34375, 'x[16] <= -1.122\ngini = 0.017\nsamples = 238\nvalue = [236, 2]'),
Text(0.6680497925311203, 0.28125, 'x[21] <= 1.046\ngini = 0.073\nsamples = 53\nvalue = [51, 2]'),
Text(0.6547717842323652, 0.21875, 'x[37] <= 0.85\ngini = 0.041\nsamples = 48\nvalue = [47, 1]'),
Text(0.6481327800829876, 0.15625, 'gini = 0.0\nsamples = 42\nvalue = [42, 0]'),
Text(0.6614107883817427, 0.15625, 'x[30] <= 0.178\ngini = 0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.6547717842323652, 0.09375, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
Text(0.6680497925311203, 0.09375, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.6813278008298755, 0.21875, 'x[0] <= 0.83\ngini = 0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.6746887966804979, 0.15625, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.6879668049792531, 0.15625, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.6813278008298755, 0.28125, 'gini = 0.0\nsamples = 185\nvalue = [185, 0]'),
```

```
Text(0.64149377593361, 0.59375, 'x[1] <= -0.467\ngini = 0.408\nsamples = 7\nvalue = [5, 2]'),
Text(0.6348547717842323, 0.53125, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.6481327800829876, 0.53125, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
Text(0.483298755186722, 0.71875, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.8319502074688797, 0.84375, 'x[11] <= -0.533\ngini = 0.385\nsamples = 300\nvalue = [222, 78]'),
Text(0.750207468879668, 0.78125, 'x[18] <= -0.345\ngini = 0.5\nsamples = 96\nvalue = [49, 47]'),
Text(0.7145228215767635, 0.71875, 'x[2] <= -0.456\ngini = 0.459\nsamples = 42\nvalue = [15, 27]'),
Text(0.6879668049792531, 0.65625, 'x[5] <= -0.275\ngini = 0.499\nsamples = 23\nvalue = [12, 11]'),
Text(0.6680497925311203, 0.59375, 'x[12] <= 0.245\ngini = 0.355\nsamples = 13\nvalue = [3, 10]'),
Text(0.6614107883817427, 0.53125, 'gini = 0.0\nsamples = 8\nvalue = [0, 8]'),
Text(0.674688796680498, 0.53125, 'x[11] <= -0.733\ngini = 0.48\nsamples = 5\nvalue = [3, 2]'),
Text(0.6680497925311203, 0.46875, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
Text(0.6813278008298755, 0.46875, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.7078838174273859, 0.59375, 'x[28] <= -0.323\ngini = 0.18\nsamples = 10\nvalue = [9, 1]'),
Text(0.7012448132780082, 0.53125, 'x[21] <= 0.338\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.6946058091286307, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.7078838174273859, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.7145228215767635, 0.53125, 'gini = 0.0\nsamples = 8\nvalue = [8, 0]'),
Text(0.7410788381742739, 0.65625, 'x[9] <= -0.51\ngini = 0.266\nsamples = 19\nvalue = [3, 16]'),
Text(0.7344398340248963, 0.59375, 'x[7] <= -1.077\ngini = 0.198\nsamples = 18\nvalue = [2, 16]'),
Text(0.7278008298755186, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.7410788381742739, 0.53125, 'x[0] <= 0.665\ngini = 0.111\nsamples = 17\nvalue = [1, 16]'),
Text(0.7344398340248963, 0.46875, 'gini = 0.0\nsamples = 15\nvalue = [0, 15]'),
Text(0.7477178423236515, 0.46875, 'x[16] <= 0.729\ngini = 0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.7410788381742739, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.754356846473029, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.7477178423236515, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.7858921161825726, 0.71875, 'x[0] <= -1.141\ngini = 0.466\nsamples = 54\nvalue = [34, 20]'),
Text(0.7676348547717843, 0.65625, 'x[0] <= -1.579\ngini = 0.245\nsamples = 7\nvalue = [1, 6]'),
Text(0.7609958506224066, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.7742738589211619, 0.59375, 'gini = 0.0\nsamples = 6\nvalue = [0, 6]'),
Text(0.804149377593361, 0.65625, 'x[1] <= 0.419\ngini = 0.418\nsamples = 47\nvalue = [33, 14]'),
Text(0.787551867219917, 0.59375, 'x[1] <= -1.236\ngini = 0.482\nsamples = 32\nvalue = [19, 13]'),
Text(0.7742738589211619, 0.53125, 'x[11] <= -0.893\ngini = 0.18\nsamples = 10\nvalue = [9, 1]'),
Text(0.7676348547717843, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.7809128630705394, 0.46875, 'gini = 0.0\nsamples = 9\nvalue = [9, 0]'),
Text(0.8008298755186722, 0.53125, 'x[12] <= 1.329\ngini = 0.496\nsamples = 22\nvalue = [10, 12]'),
Text(0.7941908713692946, 0.46875, 'x[30] <= 0.178\ngini = 0.465\nsamples = 19\nvalue = [7, 12]'),
Text(0.7809128630705394, 0.40625, 'x[10] <= 0.7\ngini = 0.298\nsamples = 11\nvalue = [2, 9]'),
Text(0.7742738589211619, 0.34375, 'gini = 0.0\nsamples = 8\nvalue = [0, 8]'),
Text(0.787551867219917, 0.34375, 'x[24] <= -0.524\ngini = 0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.7809128630705394, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.7941908713692946, 0.28125, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
Text(0.8074688796680498, 0.40625, 'x[37] <= 0.85\ngini = 0.469\nsamples = 8\nvalue = [5, 3]'),
Text(0.8008298755186722, 0.34375, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
Text(0.8141078838174274, 0.34375, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.8074688796680498, 0.46875, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
Text(0.820746887966805, 0.59375, 'x[13] <= 2.325\ngini = 0.124\nsamples = 15\nvalue = [14, 1]'),
Text(0.8141078838174274, 0.53125, 'gini = 0.0\nsamples = 14\nvalue = [14, 0]'),
Text(0.8273858921161825, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.9136929460580913, 0.78125, 'x[45] <= 0.387\ngini = 0.258\nsamples = 204\nvalue = [173, 31]'),
Text(0.870539419087137, 0.71875, 'x[11] <= 2.837\ngini = 0.138\nsamples = 147\nvalue = [136, 11]'),
Text(0.8639004149377594, 0.65625, 'x[2] <= 0.655\ngini = 0.128\nsamples = 146\nvalue = [136, 10]'),
Text(0.8473029045643153, 0.59375, 'x[22] <= -0.736\ngini = 0.038\nsamples = 104\nvalue = [102, 2]'),
Text(0.8406639004149378, 0.53125, 'x[7] <= -1.102\ngini = 0.32\nsamples = 10\nvalue = [8, 2]'),
Text(0.8340248962655602, 0.46875, 'x[20] <= -0.232\ngini = 0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.8273858921161825, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.8406639004149378, 0.40625, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.8473029045643153, 0.46875, 'gini = 0.0\nsamples = 7\nvalue = [7, 0]'),
Text(0.8539419087136929, 0.53125, 'gini = 0.0\nsamples = 94\nvalue = [94, 0]'),
Text(0.8804979253112033, 0.59375, 'x[31] <= 1.262\ngini = 0.308\nsamples = 42\nvalue = [34, 8]'),
Text(0.8672199170124482, 0.53125, 'x[6] <= -0.203\ngini = 0.229\nsamples = 38\nvalue = [33, 5]'),
Text(0.8605809128630706, 0.46875, 'x[13] <= 0.924\ngini = 0.486\nsamples = 12\nvalue = [7, 5]'),
Text(0.8539419087136929, 0.40625, 'x[5] <= -1.067\ngini = 0.346\nsamples = 9\nvalue = [7, 2]'),
Text(0.8473029045643153, 0.34375, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.8605809128630706, 0.34375, 'gini = 0.0\nsamples = 7\nvalue = [7, 0]'),
Text(0.8672199170124482, 0.40625, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.8738589211618257, 0.46875, 'gini = 0.0\nsamples = 26\nvalue = [26, 0]'),
Text(0.8937759336099586, 0.53125, 'x[38] <= 1.695\ngini = 0.375\nsamples = 4\nvalue = [1, 3]'),
Text(0.8871369294605809, 0.46875, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.9004149377593361, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.8771784232365145, 0.65625, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.9568464730290457, 0.71875, 'x[42] <= 0.67\ngini = 0.456\nsamples = 57\nvalue = [37, 20]'),
Text(0.9269709543568465, 0.65625, 'x[5] <= -1.458\ngini = 0.238\nsamples = 29\nvalue = [25, 4]'),
Text(0.9136929460580913, 0.59375, 'x[11] <= -0.365\ngini = 0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.9070539419087137, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.9203319502074688, 0.53125, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.9402489626556016, 0.59375, 'x[24] <= 1.183\ngini = 0.142\nsamples = 26\nvalue = [24, 2]'),
Text(0.9336099585062241, 0.53125, 'gini = 0.0\nsamples = 23\nvalue = [23, 0]'),
Text(0.9468879668049792, 0.53125, 'x[29] <= 0.428\ngini = 0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.9402489626556016, 0.46875, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.9535269709543569, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.9867219917012449, 0.65625, 'x[24] <= -0.214\ngini = 0.49\nsamples = 28\nvalue = [12, 16]'),
Text(0.9800829875518672, 0.59375, 'x[2] <= 1.765\ngini = 0.48\nsamples = 20\nvalue = [12, 8]'),
Text(0.9734439834024896, 0.53125, 'x[2] <= -0.949\ngini = 0.415\nsamples = 17\nvalue = [12, 5]'),
Text(0.966804979253112, 0.46875, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.9800829875518672, 0.46875, 'x[6] <= -1.118\ngini = 0.32\nsamples = 15\nvalue = [12, 3]'),
Text(0.9734439834024896, 0.40625, 'x[0] <= -0.211\ngini = 0.5\nsamples = 6\nvalue = [3, 3]'),
Text(0.966804979253112, 0.34375, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
```

```
Text(0.9800829875518672, 0.34375, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
Text(0.9867219917012449, 0.40625, 'gini = 0.0\nsamples = 9\nvalue = [9, 0]'),
Text(0.9867219917012449, 0.53125, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.9933609958506224, 0.59375, 'gini = 0.0\nsamples = 8\nvalue = [0, 8]')]
```



In [67]:
```
from sklearn.model_selection import GridSearchCV
parameter={
 'criterion':['gini','entropy'],
  'splitter':['best','random'],
  'max_depth':[1,2,3,4,5],
  'max_features':['auto', 'sqrt', 'log2']

}
```

In [68]:
```
grid_search=GridSearchCV(estimator=dtc,param_grid=parameter,cv=5,scoring="accuracy")
```

In [69]:
```
grid_search.fit(x_train,y_train)
```

```
C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\model_selection\_validation.py:425: FitFailedWarning:
100 fits failed out of a total of 300.
The score on these train-test partitions for these parameters will be set to nan.
If these failures are not expected, you can try to debug them by setting error_score='raise'.

Below are more details about the failures:
--------------------------------------------------------------------------------
100 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\model_selection\_validation.py", line 732, in _fit_an
d_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\base.py", line 1144, in wrapper
    estimator._validate_params()
  File "C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\base.py", line 637, in _validate_params
    validate_parameter_constraints(
  File "C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\utils\_param_validation.py", line 95, in validate_par
ameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'max_features' parameter of DecisionTreeClassifier m
ust be an int in the range [1, inf), a float in the range (0.0, 1.0], a str among {'sqrt', 'log2'} or None. Got
'auto' instead.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\model_selection\_search.py:976: UserWarning: One or more of t
he test scores are non-finite: [       nan        nan 0.83758384 0.83588172 0.84013704 0.84013704
        nan        nan 0.83673278 0.84013704 0.83928597 0.84013704
        nan        nan 0.84098089 0.8435449  0.84438514 0.84184277
        nan        nan 0.84522539 0.83502705 0.83673278 0.84524342
        nan        nan 0.83080418 0.83671114 0.81208799 0.83335016
        nan        nan 0.84013704 0.84013704 0.84013704 0.84013704
        nan        nan 0.84013704 0.84013704 0.83077533 0.83843491
        nan        nan 0.83844933 0.83672557 0.83504147 0.83928597
        nan        nan 0.8341832  0.84267941 0.83928958 0.84353768
        nan        nan 0.84098089 0.82312297 0.82992066 0.84268301]
  warnings.warn(
```

Out[69]:

```
GridSearchCV
estimator: DecisionTreeClassifier
DecisionTreeClassifier
```

In [70]:
```
grid_search.best_params_
```

Out[70]:
```
{'criterion': 'gini',
 'max_depth': 4,
 'max_features': 'log2',
 'splitter': 'random'}
```

In [71]:
```
dtc_cv=DecisionTreeClassifier(criterion= 'entropy',
 max_depth=3,
 max_features='sqrt',
 splitter='best')
dtc_cv.fit(x_train,y_train)
```

Out[71]:
```
DecisionTreeClassifier
DecisionTreeClassifier(criterion='entropy', max_depth=3, max_features='sqrt')
```

In [72]:
```
pred=dtc_cv.predict(x_test)
```

In [73]:
```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

          No       0.89      0.97      0.93       245
         Yes       0.74      0.41      0.53        49

    accuracy                           0.88       294
   macro avg       0.82      0.69      0.73       294
weighted avg       0.87      0.88      0.86       294
```

Random Forest

In [74]:
```
from sklearn.ensemble import RandomForestClassifier
rfc=RandomForestClassifier()
```

In [75]:
```
rfc.fit(x_train,y_train)
```

Out[75]:
```
RandomForestClassifier
RandomForestClassifier()
```

In [76]:
```
y_pred2=dtc.predict(x_test)
```

In [77]:
```
y_pred2
```

Out[77]:
```
array(['No', 'No', 'Yes', 'No', 'No', 'Yes', 'Yes', 'No', 'No', 'No',
       'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No',
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       'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No'], dtype=object)
```

In [78]:
```
y_test
```

Out[78]:
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['No',
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```

In [79]:
```
forest_params = [{'max_depth': list(range(10,15)),'max_features': list(range(0,14)) }]
```

In [80]:
```
rfc_cv=GridSearchCV(rfc,param_grid=forest_params,cv=10,scoring="accuracy")
```

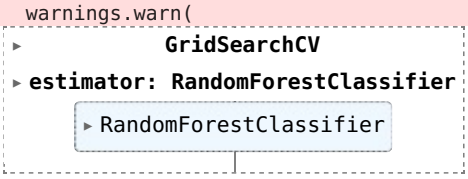
In [81]:
```
rfc_cv.fit(x_train,y_train)
```

```
C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\model_selection\_validation.py:425: FitFailedWarning:
50 fits failed out of a total of 700.
The score on these train-test partitions for these parameters will be set to nan.
If these failures are not expected, you can try to debug them by setting error_score='raise'.

Below are more details about the failures:
--------------------------------------------------------------------------------
50 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\model_selection\_validation.py", line 732, in _fit_an
d_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\base.py", line 1144, in wrapper
    estimator._validate_params()
  File "C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\base.py", line 637, in _validate_params
    validate_parameter_constraints(
  File "C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\utils\_param_validation.py", line 95, in validate_par
ameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'max_features' parameter of RandomForestClassifier m
ust be an int in the range [1, inf), a float in the range (0.0, 1.0], a str among {'sqrt', 'log2'} or None. Got
0 instead.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\ASUS\anaconda3\Lib\site-packages\sklearn\model_selection\_search.py:976: UserWarning: One or more of t
he test scores are non-finite: [       nan 0.84439374 0.85034767 0.85544691 0.85884398 0.8596842
 0.85798928 0.85629436 0.85203535 0.85714907 0.85885122 0.85797479
 0.86053165 0.85798204        nan 0.84779082 0.85120962 0.85628712
 0.85799652 0.85543966 0.85629436 0.85628712 0.85969144 0.86308127
 0.85798928 0.85457772 0.86137911 0.86136462        nan 0.8460959
 0.85460669 0.85628712 0.85629436 0.85627988 0.85459945 0.85800377
 0.85627988 0.85966247 0.8605389  0.85966971 0.85712734 0.85882225
        nan 0.85034043 0.85630161 0.85630161 0.85714182 0.85459221
 0.86308851 0.85969868 0.86223381 0.85713458 0.85627988 0.85712734
 0.85627988 0.85881501        nan 0.84949297 0.85544691 0.85459945
 0.85544691 0.85627988 0.85883674 0.85543966 0.86308127 0.85969144
 0.85798928 0.8596842  0.86477618 0.86053165]
  warnings.warn(
```

Out[81]:



In [82]:
```
y_pred=rfc_cv.predict(x_test)
```

In [83]:
```
#Accuracy score
from sklearn.metrics import accuracy_score,confusion_matrix,classification_report,roc_auc_score,roc_curve
```

In [84]:
```
accuracy_score(y_test,y_pred2)
```

Out[84]:
```
0.7755102040816326
```

In [85]:
```
confusion_matrix(y_test,y_pred2)
```

Out[85]:
```
array([[210,  35],
       [ 31,  18]], dtype=int64)
```

In [86]:
```
pd.crosstab(y_test,y_pred2)
```

Out[86]:

col_0	No	Yes
row_0		
No	210	35
Yes	31	18

In [87]:
```
print(classification_report(y_test,y_pred2))
```

```
              precision    recall  f1-score   support

          No       0.87      0.86      0.86       245
         Yes       0.34      0.37      0.35        49

    accuracy                           0.78       294
   macro avg       0.61      0.61      0.61       294
weighted avg       0.78      0.78      0.78       294
```

In [88]:
```
rfc_cv.best_params_
```

Out[88]:
```
{'max_depth': 14, 'max_features': 12}
```

In [89]:
```
probability= rfc.predict_proba(x_test)[:,1]
```

In [90]:
```
probability
```

Out[90]:
```
array([0.12, 0.04, 0.22, 0.11, 0.66, 0.43, 0.34, 0.13, 0.1 , 0.2 , 0.05,
       0.12, 0.04, 0.44, 0.03, 0.02, 0.08, 0.17, 0.06, 0.13, 0.44, 0.02,
       0.02, 0.06, 0.34, 0.27, 0.1 , 0.04, 0.54, 0.09, 0.04, 0.08, 0.2 ,
       0.1 , 0.09, 0.07, 0.15, 0.07, 0.1 , 0.25, 0.2 , 0.08, 0.07, 0.19,
       0.13, 0.41, 0.34, 0.05, 0.52, 0.4 , 0.17, 0.42, 0.16, 0.11, 0.38,
       0.09, 0.11, 0.08, 0.1 , 0.29, 0.06, 0.16, 0.1 , 0.1 , 0.28, 0.15,
       0.2 , 0.13, 0.06, 0.23, 0.18, 0.35, 0.15, 0.02, 0.14, 0.18, 0.1 ,
       0.12, 0.52, 0.03, 0.05, 0.04, 0.13, 0.09, 0.13, 0.09, 0.04, 0.22,
       0.08, 0.09, 0.57, 0.06, 0.11, 0.23, 0.12, 0.06, 0.14, 0.28, 0.09,
       0.18, 0.1 , 0.19, 0.32, 0.05, 0.07, 0.1 , 0.12, 0.45, 0.21, 0.21,
       0.19, 0.09, 0.08, 0.01, 0.1 , 0.1 , 0.05, 0.2 , 0.06, 0.01, 0.13,
       0.06, 0.08, 0.56, 0.19, 0.12, 0.02, 0.07, 0.09, 0.08, 0.05, 0.26,
       0.46, 0.17, 0.17, 0.15, 0.34, 0.16, 0.13, 0.27, 0.07, 0.17, 0.16,
       0.12, 0.18, 0.13, 0.04, 0.09, 0.12, 0.13, 0.07, 0.2 , 0.08, 0.22,
       0.11, 0.1 , 0.11, 0.2 , 0.13, 0.13, 0.4 , 0.08, 0.24, 0.57, 0.07,
       0.2 , 0.19, 0.08, 0.07, 0.06, 0.13, 0.13, 0.1 , 0.18, 0.14, 0.35,
       0.1 , 0.15, 0.18, 0.12, 0.06, 0.04, 0.03, 0.41, 0.06, 0.03, 0.24,
       0.04, 0.17, 0.29, 0.25, 0.48, 0.2 , 0.04, 0.21, 0.13, 0.09, 0.12,
       0.52, 0.2 , 0.21, 0.15, 0.2 , 0.02, 0.16, 0.18, 0.4 , 0.04, 0.12,
       0.04, 0.06, 0.12, 0.11, 0.26, 0.03, 0.08, 0.06, 0.24, 0.16, 0.27,
       0.13, 0.32, 0.44, 0.21, 0.11, 0.07, 0.04, 0.36, 0.62, 0.17, 0.03,
       0.26, 0.06, 0.13, 0.08, 0.27, 0.22, 0.08, 0.08, 0.08, 0.19, 0.15,
       0.11, 0.1 , 0.08, 0.1 , 0.06, 0.29, 0.1 , 0.16, 0.11, 0.1 , 0.3 ,
       0.08, 0.27, 0.12, 0.04, 0.57, 0.26, 0.24, 0.16, 0.05, 0.2 , 0.06,
       0.07, 0.24, 0.06, 0.24, 0.2 , 0.08, 0.12, 0.06, 0.1 , 0.11, 0.03,
       0.04, 0.09, 0.36, 0.16, 0.32, 0.29, 0.12, 0.14, 0.21, 0.14, 0.18,
       0.  , 0.14, 0.11, 0.15, 0.12, 0.22, 0.06, 0.06])
```

In [92]:
```
# Convert string labels to integer labels
y_test_int = [0 if label == 'No' else 1 for label in y_test]

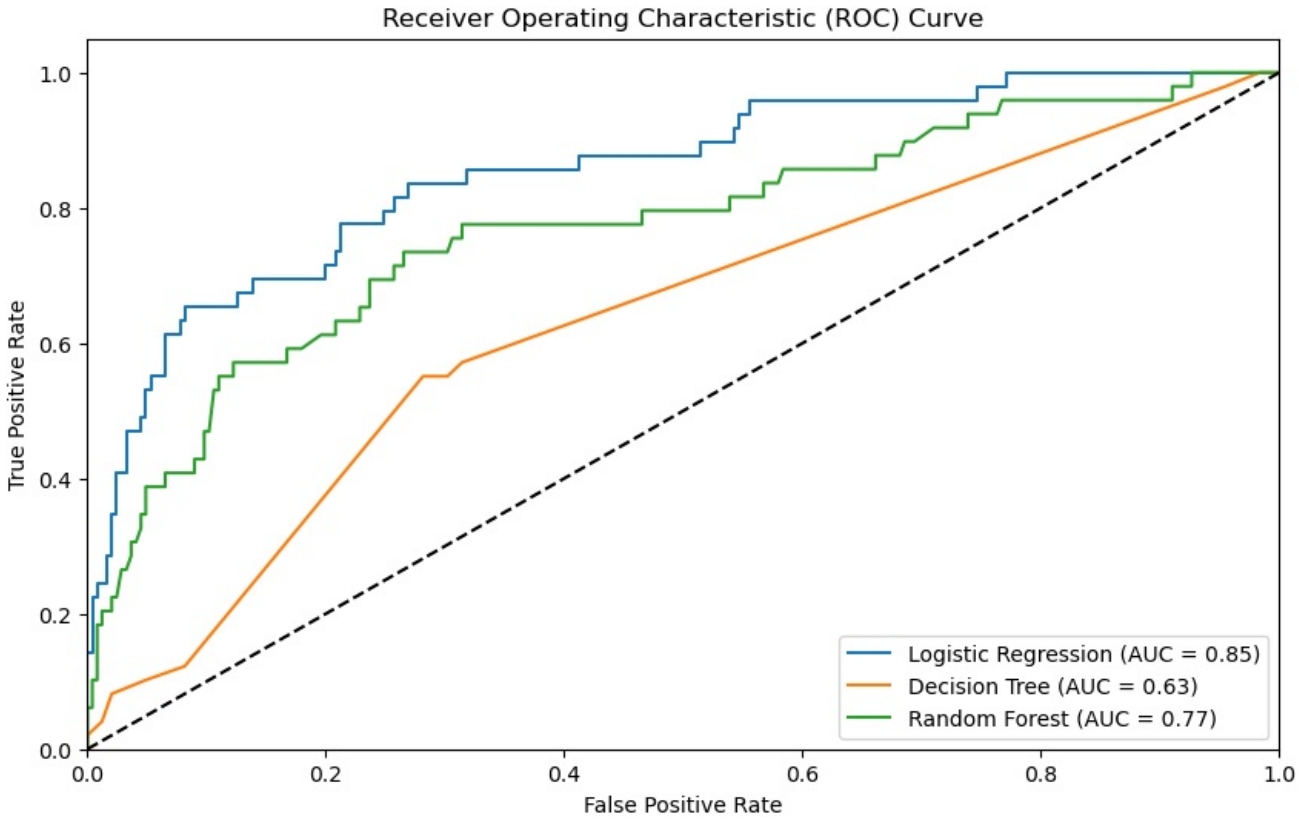
# Compute ROC curve for Logistic Regression
logreg_fpr, logreg_tpr, _ = roc_curve(y_test_int, lr.predict_proba(x_test)[:, 1])
logreg_roc_auc = roc_auc_score(y_test_int, lr.predict_proba(x_test)[:, 1])

# Compute ROC curve for Decision Tree Classifier
dt_fpr, dt_tpr, _ = roc_curve(y_test_int, grid_search.predict_proba(x_test)[:, 1])
dt_roc_auc = roc_auc_score(y_test_int, grid_search.predict_proba(x_test)[:, 1])

# Compute ROC curve for Random Forest
rf_fpr, rf_tpr, _ = roc_curve(y_test_int, rfc_cv.predict_proba(x_test)[:, 1])
rf_roc_auc = roc_auc_score(y_test_int, rfc_cv.predict_proba(x_test)[:, 1])

# Plot ROC AUC curves
plt.figure(figsize=(10, 6))
plt.plot(logreg_fpr, logreg_tpr, label='Logistic Regression (AUC = %0.2f)' % logreg_roc_auc)
plt.plot(dt_fpr, dt_tpr, label='Decision Tree (AUC = %0.2f)' % dt_roc_auc)
plt.plot(rf_fpr, rf_tpr, label='Random Forest (AUC = %0.2f)' % rf_roc_auc)
plt.plot([0, 1], [0, 1], 'k--')
plt.xlim([0.0, 1.0])
```

```
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend(loc='lower right')
plt.show()
```



In [ ]: