assignment-4

September 27, 2023

[1]:
```
#Import the Libraries.
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

[2]:
```
#Importing the dataset.
df=pd.read_csv("Employee-Attrition.csv")
```

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

[3]:

	Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome	Education	EducationField	EmployeeCount	EmployeeNumber	…	RelationshipSatisfaction	StandardHours	StockOptionLevel	TotalWorkingYears	TrainingTimesLastYear	WorkLifeBalance	YearsAtCompany
0	41	Yes	Travel_Rarely	1102	Sales	1	2	Life Sciences	1	1	…	1	80	0	8	0	1	6
1	49	No	Travel_Frequently	279	Research & Development	8	1	Life Sciences	1	2	…	4	80	1	10	3	3	10
2	37	Yes	Travel_Rarely	1373	Research & Development	2	2	Other	1	4	…	2	80	0	7	3	3	0
3	33	No	Travel_Frequently	1392	Research & Development	3	4	Life Sciences	1	5	…	3	80	0	8	3	3	8
4	27	No	Travel_Rarely	591	Research & Development	2	1	Medical	1	7	…	4	80	1				

```
4                    6                         3                3                2

  YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
0                  4                        0                     5
1                  7                        1                     7
2                  0                        0                     0
3                  7                        3                     0
4                  2                        2                     2

[5 rows x 35 columns]
```

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

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

[5]:
```
df.Attrition.value_counts()
```

[5]:
```
No     1233
Yes     237
Name: Attrition, dtype: int64
```

[6]:
```
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
```

[7]:
```
df.describe()
```

[7]:

	Age	DailyRate	DistanceFromHome	Education	EmployeeCount	\
count	1470.000000	1470.000000	1470.000000	1470.000000	1470.0	
mean	36.923810	802.485714	9.192517	2.912925	1.0	
std	9.135373	403.509100	8.106864	1.024165	0.0	
min	18.000000	102.000000	1.000000	1.000000	1.0	
25%	30.000000	465.000000	2.000000	2.000000	1.0	
50%	36.000000	802.000000	7.000000	3.000000	1.0	
75%	43.000000	1157.000000	14.000000	4.000000	1.0	
max	60.000000	1499.000000	29.000000	5.000000	1.0	

	EmployeeNumber	EnvironmentSatisfaction	HourlyRate	JobInvolvement	\
count	1470.000000	1470.000000	1470.000000	1470.000000	
mean	1024.865306	2.721769	65.891156	2.729932	
std	602.024335	1.093082	20.329428	0.711561	
min	1.000000	1.000000	30.000000	1.000000	
25%	491.250000	2.000000	48.000000	2.000000	
50%	1020.500000	3.000000	66.000000	3.000000	
75%	1555.750000	4.000000	83.750000	3.000000	
max	2068.000000	4.000000	100.000000	4.000000	

	JobLevel	…	RelationshipSatisfaction	StandardHours	\
count	1470.000000	…	1470.000000	1470.0	
mean	2.063946	…	2.712245	80.0	
std	1.106940	…	1.081209	0.0	
min	1.000000	…	1.000000	80.0	
25%	1.000000	…	2.000000	80.0	

```
50%       2.000000  …                 3.000000           80.0
75%       3.000000  …                 4.000000           80.0
max       5.000000  …                 4.000000           80.0

       StockOptionLevel  TotalWorkingYears  TrainingTimesLastYear  \
count       1470.000000        1470.000000            1470.000000
mean           0.793878          11.279592               2.799320
std            0.852077           7.780782               1.289271
min            0.000000           0.000000               0.000000
25%            0.000000           6.000000               2.000000
50%            1.000000          10.000000               3.000000
75%            1.000000          15.000000               3.000000
max            3.000000          40.000000               6.000000

       WorkLifeBalance  YearsAtCompany  YearsInCurrentRole  \
count      1470.000000     1470.000000         1470.000000
mean          2.761224        7.008163            4.229252
std           0.706476        6.126525            3.623137
min           1.000000        0.000000            0.000000
25%           2.000000        3.000000            2.000000
50%           3.000000        5.000000            3.000000
75%           3.000000        9.000000            7.000000
max           4.000000       40.000000           18.000000

       YearsSinceLastPromotion  YearsWithCurrManager
count              1470.000000           1470.000000
mean                  2.187755              4.123129
std                   3.222430              3.568136
min                   0.000000              0.000000
25%                   0.000000              2.000000
50%                   1.000000              3.000000
75%                   3.000000              7.000000
max                  15.000000             17.000000

[8 rows x 26 columns]
```

[8]:
```
#Checking for Null Values.
df.isnull().any()
```

[8]:
```
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
```

[9]:
```
df.isnull().sum()
```

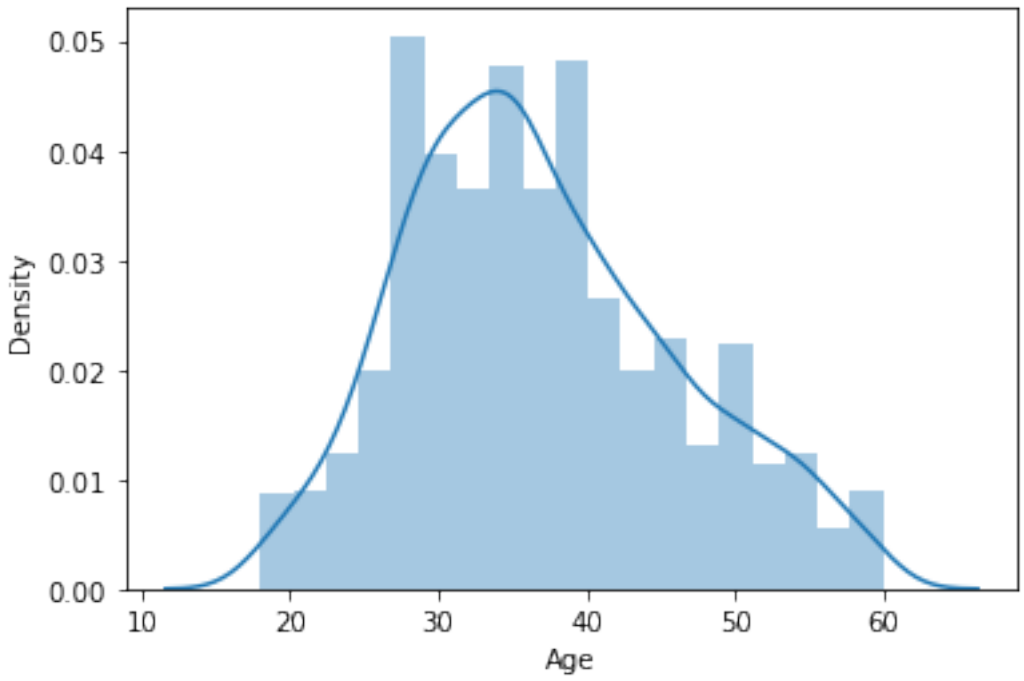
[9]:
```
Age                         0
Attrition                   0
BusinessTravel              0
DailyRate                   0
Department                  0
DistanceFromHome            0
Education                   0
EducationField              0
EmployeeCount               0
EmployeeNumber              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
```

[10]:
```
#Data Visualization.
sns.distplot(df["Age"])
```

```
C:\Users\kavya\anaconda3\lib\site-packages\seaborn\distributions.py:2557:
FutureWarning: `distplot` is a deprecated function and will be removed in a
future version. Please adapt your code to use either `displot` (a figure-level
function with similar flexibility) or `histplot` (an axes-level function for
histograms).
  warnings.warn(msg, FutureWarning)
```

[10]:
```
<AxesSubplot:xlabel='Age', ylabel='Density'>
```



[11]:
```
df.corr()
```

[11]:

	Age	DailyRate	DistanceFromHome	Education
Age	1.000000	0.010661	-0.001686	0.208034
DailyRate	0.010661	1.000000	-0.004985	-0.016806
DistanceFromHome	-0.001686	-0.004985	1.000000	0.021042
Education	0.208034	-0.016806	0.021042	1.000000
EmployeeCount	NaN	NaN	NaN	NaN
EmployeeNumber	-0.010145	-0.050990	0.032916	0.042070
EnvironmentSatisfaction	0.010146	0.018355	-0.016075	-0.027128
HourlyRate	0.024287	0.023381	0.031131	0.016775
JobInvolvement	0.029820	0.046135	0.008783	0.042438
JobLevel	0.509604	0.002966	0.005303	0.101589
JobSatisfaction	-0.004892	0.030571	-0.003669	-0.011296
MonthlyIncome	0.497855	0.007707	-0.017014	0.094961
MonthlyRate	0.028051	-0.032182	0.027473	-0.026084
NumCompaniesWorked	0.299635	0.038153	-0.029251	0.126317
PercentSalaryHike	0.003634	0.022704	0.040235	-0.011111
PerformanceRating	0.001904	0.000473	0.027110	-0.024539
RelationshipSatisfaction	0.053535	0.007846	0.006557	-0.009118
StandardHours	NaN	NaN	NaN	NaN
StockOptionLevel	0.037510	0.042143	0.044872	0.018422
TotalWorkingYears	0.680381	0.014515	0.004628	0.148280
TrainingTimesLastYear	-0.019621	0.002453	-0.036942	-0.025100
WorkLifeBalance	-0.021490	-0.037848	-0.026556	0.009819

YearsAtCompany	0.311309	-0.034055	0.009508	0.069114
YearsInCurrentRole	0.212901	0.009932	0.018845	0.060236
YearsSinceLastPromotion	0.216513	-0.033229	0.010029	0.054254
YearsWithCurrManager	0.202089	-0.026363	0.014406	0.069065

	EmployeeCount	EmployeeNumber
Age	NaN	-0.010145
DailyRate	NaN	-0.050990
DistanceFromHome	NaN	0.032916
Education	NaN	0.042070
EmployeeCount	NaN	NaN
EmployeeNumber	NaN	1.000000
EnvironmentSatisfaction	NaN	0.017621
HourlyRate	NaN	0.035179
JobInvolvement	NaN	-0.006888
JobLevel	NaN	-0.018519
JobSatisfaction	NaN	-0.046247
MonthlyIncome	NaN	-0.014829
MonthlyRate	NaN	0.012648
NumCompaniesWorked	NaN	-0.001251
PercentSalaryHike	NaN	-0.012944
PerformanceRating	NaN	-0.020359
RelationshipSatisfaction	NaN	-0.069861
StandardHours	NaN	NaN
StockOptionLevel	NaN	0.062227
TotalWorkingYears	NaN	-0.014365
TrainingTimesLastYear	NaN	0.023603
WorkLifeBalance	NaN	0.010309
YearsAtCompany	NaN	-0.011240
YearsInCurrentRole	NaN	-0.008416
YearsSinceLastPromotion	NaN	-0.009019
YearsWithCurrManager	NaN	-0.009197

	EnvironmentSatisfaction	HourlyRate	JobInvolvement
Age	0.010146	0.024287	0.029820
DailyRate	0.018355	0.023381	0.046135
DistanceFromHome	-0.016075	0.031131	0.008783
Education	-0.027128	0.016775	0.042438
EmployeeCount	NaN	NaN	NaN
EmployeeNumber	0.017621	0.035179	-0.006888
EnvironmentSatisfaction	1.000000	-0.049857	-0.008278
HourlyRate	-0.049857	1.000000	0.042861
JobInvolvement	-0.008278	0.042861	1.000000
JobLevel	0.001212	-0.027853	-0.012630
JobSatisfaction	-0.006784	-0.071335	-0.021476
MonthlyIncome	-0.006259	-0.015794	-0.015271
MonthlyRate	0.037600	-0.015297	-0.016322

NumCompaniesWorked	0.012594	0.022157	0.015012
PercentSalaryHike	-0.031701	-0.009062	-0.017205
PerformanceRating	-0.029548	-0.002172	-0.029071
RelationshipSatisfaction	0.007665	0.001330	0.034297
StandardHours	NaN	NaN	NaN
StockOptionLevel	0.003432	0.050263	0.021523
TotalWorkingYears	-0.002693	-0.002334	-0.005533
TrainingTimesLastYear	-0.019359	-0.008548	-0.015338
WorkLifeBalance	0.027627	-0.004607	-0.014617
YearsAtCompany	0.001458	-0.019582	-0.021355
YearsInCurrentRole	0.018007	-0.024106	0.008717
YearsSinceLastPromotion	0.016194	-0.026716	-0.024184
YearsWithCurrManager	-0.004999	-0.020123	0.025976

	JobLevel	…	RelationshipSatisfaction	\
Age	0.509604	…	0.053535	
DailyRate	0.002966	…	0.007846	
DistanceFromHome	0.005303	…	0.006557	
Education	0.101589	…	-0.009118	
EmployeeCount	NaN	…	NaN	
EmployeeNumber	-0.018519	…	-0.069861	
EnvironmentSatisfaction	0.001212	…	0.007665	
HourlyRate	-0.027853	…	0.001330	
JobInvolvement	-0.012630	…	0.034297	
JobLevel	1.000000	…	0.021642	
JobSatisfaction	-0.001944	…	-0.012454	
MonthlyIncome	0.950300	…	0.025873	
MonthlyRate	0.039563	…	-0.004085	
NumCompaniesWorked	0.142501	…	0.052733	
PercentSalaryHike	-0.034730	…	-0.040490	
PerformanceRating	-0.021222	…	-0.031351	
RelationshipSatisfaction	0.021642	…	1.000000	
StandardHours	NaN	…	NaN	
StockOptionLevel	0.013984	…	-0.045952	
TotalWorkingYears	0.782208	…	0.024054	
TrainingTimesLastYear	-0.018191	…	0.002497	
WorkLifeBalance	0.037818	…	0.019604	
YearsAtCompany	0.534739	…	0.019367	
YearsInCurrentRole	0.389447	…	-0.015123	
YearsSinceLastPromotion	0.353885	…	0.033493	
YearsWithCurrManager	0.375281	…	-0.000867	

	StandardHours	StockOptionLevel	TotalWorkingYears	\
Age	NaN	0.037510	0.680381	
DailyRate	NaN	0.042143	0.014515	
DistanceFromHome	NaN	0.044872	0.004628	
Education	NaN	0.018422	0.148280	

EmployeeCount	NaN	NaN	NaN
EmployeeNumber	NaN	0.062227	-0.014365
EnvironmentSatisfaction	NaN	0.003432	-0.002693
HourlyRate	NaN	0.050263	-0.002334
JobInvolvement	NaN	0.021523	-0.005533
JobLevel	NaN	0.013984	0.782208
JobSatisfaction	NaN	0.010690	-0.020185
MonthlyIncome	NaN	0.005408	0.772893
MonthlyRate	NaN	-0.034323	0.026442
NumCompaniesWorked	NaN	0.030075	0.237639
PercentSalaryHike	NaN	0.007528	-0.020608
PerformanceRating	NaN	0.003506	0.006744
RelationshipSatisfaction	NaN	-0.045952	0.024054
StandardHours	NaN	NaN	NaN
StockOptionLevel	NaN	1.000000	0.010136
TotalWorkingYears	NaN	0.010136	1.000000
TrainingTimesLastYear	NaN	0.011274	-0.035662
WorkLifeBalance	NaN	0.004129	0.001008
YearsAtCompany	NaN	0.015058	0.628133
YearsInCurrentRole	NaN	0.050818	0.460365
YearsSinceLastPromotion	NaN	0.014352	0.404858
YearsWithCurrManager	NaN	0.024698	0.459188

	TrainingTimesLastYear	WorkLifeBalance	\
Age	-0.019621	-0.021490	
DailyRate	0.002453	-0.037848	
DistanceFromHome	-0.036942	-0.026556	
Education	-0.025100	0.009819	
EmployeeCount	NaN	NaN	
EmployeeNumber	0.023603	0.010309	
EnvironmentSatisfaction	-0.019359	0.027627	
HourlyRate	-0.008548	-0.004607	
JobInvolvement	-0.015338	-0.014617	
JobLevel	-0.018191	0.037818	
JobSatisfaction	-0.005779	-0.019459	
MonthlyIncome	-0.021736	0.030683	
MonthlyRate	0.001467	0.007963	
NumCompaniesWorked	-0.066054	-0.008366	
PercentSalaryHike	-0.005221	-0.003280	
PerformanceRating	-0.015579	0.002572	
RelationshipSatisfaction	0.002497	0.019604	
StandardHours	NaN	NaN	
StockOptionLevel	0.011274	0.004129	
TotalWorkingYears	-0.035662	0.001008	
TrainingTimesLastYear	1.000000	0.028072	
WorkLifeBalance	0.028072	1.000000	
YearsAtCompany	0.003569	0.012089	

YearsInCurrentRole	-0.005738	0.049856
YearsSinceLastPromotion	-0.002067	0.008941
YearsWithCurrManager	-0.004096	0.002759

	YearsAtCompany	YearsInCurrentRole	\
Age	0.311309	0.212901	
DailyRate	-0.034055	0.009932	
DistanceFromHome	0.009508	0.018845	
Education	0.069114	0.060236	
EmployeeCount	NaN	NaN	
EmployeeNumber	-0.011240	-0.008416	
EnvironmentSatisfaction	0.001458	0.018007	
HourlyRate	-0.019582	-0.024106	
JobInvolvement	-0.021355	0.008717	
JobLevel	0.534739	0.389447	
JobSatisfaction	-0.003803	-0.002305	
MonthlyIncome	0.514285	0.363818	
MonthlyRate	-0.023655	-0.012815	
NumCompaniesWorked	-0.118421	-0.090754	
PercentSalaryHike	-0.035991	-0.001520	
PerformanceRating	0.003435	0.034986	
RelationshipSatisfaction	0.019367	-0.015123	
StandardHours	NaN	NaN	
StockOptionLevel	0.015058	0.050818	
TotalWorkingYears	0.628133	0.460365	
TrainingTimesLastYear	0.003569	-0.005738	
WorkLifeBalance	0.012089	0.049856	
YearsAtCompany	1.000000	0.758754	
YearsInCurrentRole	0.758754	1.000000	
YearsSinceLastPromotion	0.618409	0.548056	
YearsWithCurrManager	0.769212	0.714365	

	YearsSinceLastPromotion	YearsWithCurrManager
Age	0.216513	0.202089
DailyRate	-0.033229	-0.026363
DistanceFromHome	0.010029	0.014406
Education	0.054254	0.069065
EmployeeCount	NaN	NaN
EmployeeNumber	-0.009019	-0.009197
EnvironmentSatisfaction	0.016194	-0.004999
HourlyRate	-0.026716	-0.020123
JobInvolvement	-0.024184	0.025976
JobLevel	0.353885	0.375281
JobSatisfaction	-0.018214	-0.027656
MonthlyIncome	0.344978	0.344079
MonthlyRate	0.001567	-0.036746
NumCompaniesWorked	-0.036814	-0.110319

```
PercentSalaryHike                -0.022154             -0.011985
PerformanceRating                 0.017896              0.022827
RelationshipSatisfaction          0.033493             -0.000867
StandardHours                          NaN                   NaN
StockOptionLevel                  0.014352              0.024698
TotalWorkingYears                 0.404858              0.459188
TrainingTimesLastYear            -0.002067             -0.004096
WorkLifeBalance                   0.008941              0.002759
YearsAtCompany                    0.618409              0.769212
YearsInCurrentRole                0.548056              0.714365
YearsSinceLastPromotion           1.000000              0.510224
YearsWithCurrManager              0.510224              1.000000

[26 rows x 26 columns]
```

[12]:
```
df.head()
```

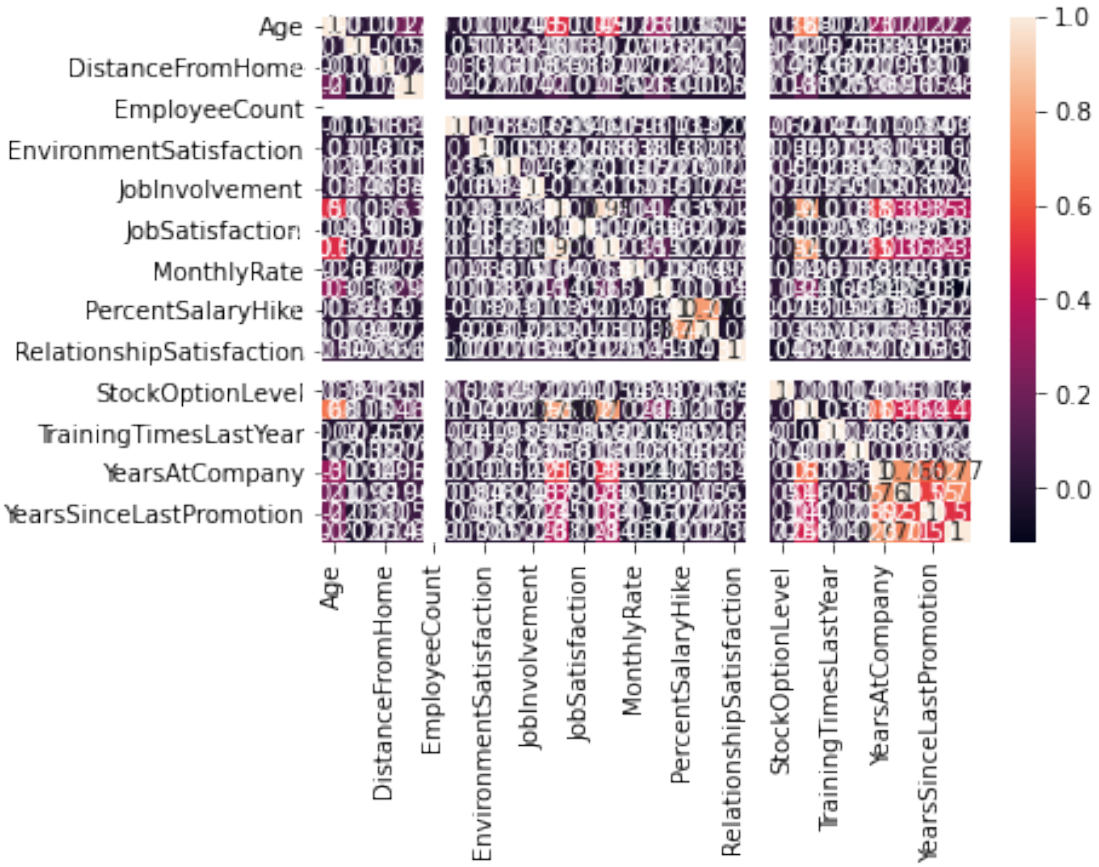
[12]:
```
   Age Attrition     BusinessTravel  DailyRate              Department  \
0   41       Yes      Travel_Rarely       1102                   Sales
1   49        No  Travel_Frequently        279  Research & Development
2   37       Yes      Travel_Rarely       1373  Research & Development
3   33        No  Travel_Frequently       1392  Research & Development
4   27        No      Travel_Rarely        591  Research & Development

   DistanceFromHome  Education EducationField  EmployeeCount  EmployeeNumber  \
0                 1          2  Life Sciences              1               1
1                 8          1  Life Sciences              1               2
2                 2          2          Other              1               4
3                 3          4  Life Sciences              1               5
4                 2          1        Medical              1               7

   …  RelationshipSatisfaction StandardHours  StockOptionLevel  \
0  …                         1            80                 0
1  …                         4            80                 1
2  …                         2            80                 0
3  …                         3            80                 0
4  …                         4            80                 1

   TotalWorkingYears  TrainingTimesLastYear WorkLifeBalance  YearsAtCompany  \
0                  8                      0               1               6
1                 10                      3               3              10
2                  7                      3               3               0
3                  8                      3               3               8
4                  6                      3               3               2

  YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
0                  4                        0                     5
```

1	7	1	7
2	0	0	0
3	7	3	0
4	2	2	2

[5 rows x 35 columns]

[13]:
```
sns.heatmap(df.corr(),annot=True)
```

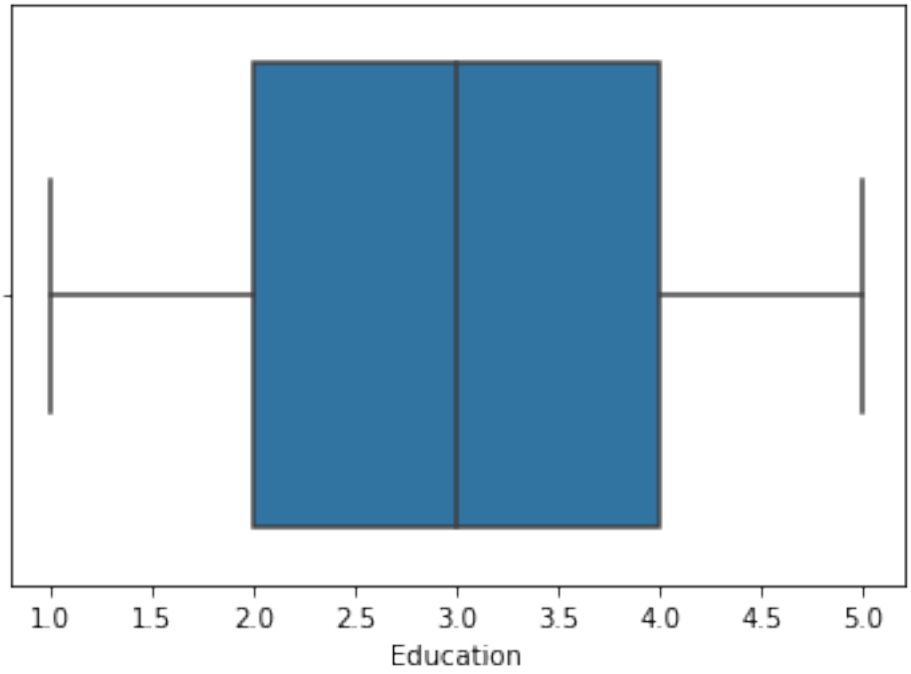
[13]: <AxesSubplot:>



[14]:
```
sns.boxplot(df.Education)
#sns.boxplot(df["EstimatedSalary"])
```

```
C:\Users\kavya\anaconda3\lib\site-packages\seaborn\_decorators.py:36:
FutureWarning: Pass the following variable as a keyword arg: x. From version
0.12, the only valid positional argument will be `data`, and passing other
arguments without an explicit keyword will result in an error or
misinterpretation.
  warnings.warn(
```

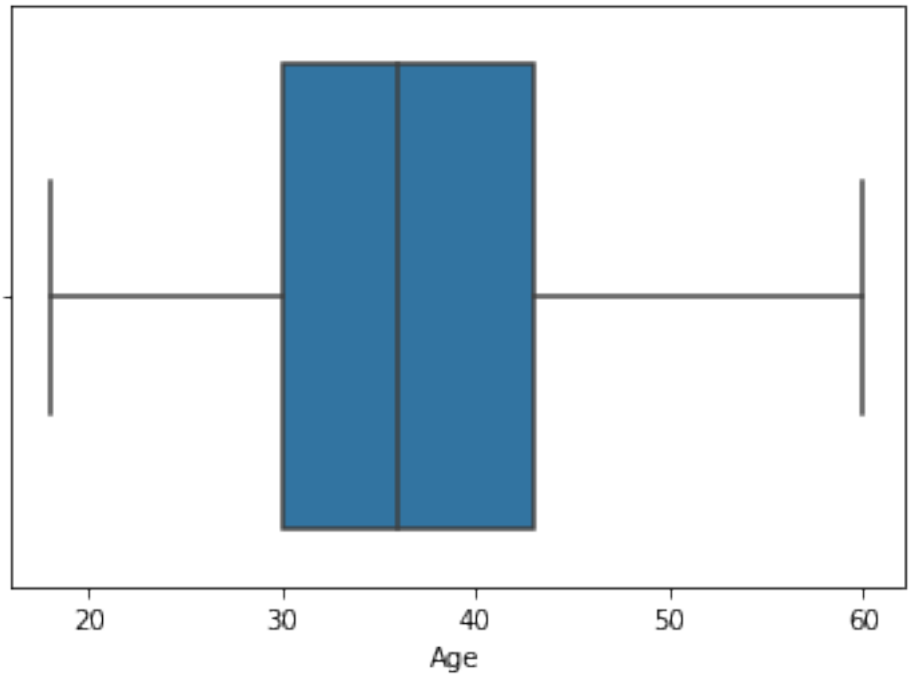
[14]: <AxesSubplot:xlabel='Education'>



[15]:
```
sns.boxplot(df.Age)
```

```
C:\Users\kavya\anaconda3\lib\site-packages\seaborn\_decorators.py:36:
FutureWarning: Pass the following variable as a keyword arg: x. From version
0.12, the only valid positional argument will be `data`, and passing other
arguments without an explicit keyword will result in an error or
misinterpretation.
  warnings.warn(
```

[15]: <AxesSubplot:xlabel='Age'>



[16]:
```
df.head()
```

[16]:

	Age	Attrition	BusinessTravel	DailyRate	Department	\
0	41	Yes	Travel_Rarely	1102	Sales	
1	49	No	Travel_Frequently	279	Research & Development	
2	37	Yes	Travel_Rarely	1373	Research & Development	
3	33	No	Travel_Frequently	1392	Research & Development	
4	27	No	Travel_Rarely	591	Research & Development	

	DistanceFromHome	Education	EducationField	EmployeeCount	EmployeeNumber	\
0	1	2	Life Sciences	1	1	
1	8	1	Life Sciences	1	2	
2	2	2	Other	1	4	
3	3	4	Life Sciences	1	5	
4	2	1	Medical	1	7	

	…	RelationshipSatisfaction	StandardHours	StockOptionLevel	\
0	…	1	80	0	
1	…	4	80	1	
2	…	2	80	0	
3	…	3	80	0	
4	…	4	80	1	

	TotalWorkingYears	TrainingTimesLastYear	WorkLifeBalance	YearsAtCompany	\
0	8	0	1	6	

```
1                 10                         3                 3                10
2                  7                         3                 3                 0
3                  8                         3                 3                 8
4                  6                         3                 3                 2

  YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
0                  4                        0                     5
1                  7                        1                     7
2                  0                        0                     0
3                  7                        3                     0
4                  2                        2                     2

[5 rows x 35 columns]
```

[17]:
```
#Splitting Dependent and Independent variables
x=df.iloc[:,2:]
x.head()
```

[17]:
```
      BusinessTravel  DailyRate              Department  DistanceFromHome  \
0      Travel_Rarely       1102                   Sales                 1
1  Travel_Frequently        279  Research & Development                 8
2      Travel_Rarely       1373  Research & Development                 2
3  Travel_Frequently       1392  Research & Development                 3
4      Travel_Rarely        591  Research & Development                 2

   Education EducationField  EmployeeCount  EmployeeNumber  \
0          2  Life Sciences              1               1
1          1  Life Sciences              1               2
2          2          Other              1               4
3          4  Life Sciences              1               5
4          1        Medical              1               7

   EnvironmentSatisfaction  Gender  …  RelationshipSatisfaction  \
0                        2  Female  …                         1
1                        3    Male  …                         4
2                        4    Male  …                         2
3                        4  Female  …                         3
4                        1    Male  …                         4

   StandardHours  StockOptionLevel  TotalWorkingYears  TrainingTimesLastYear  \
0             80                 0                  8                      0
1             80                 1                 10                      3
2             80                 0                  7                      3
3             80                 0                  8                      3
4             80                 1                  6                      3

  WorkLifeBalance  YearsAtCompany  YearsInCurrentRole  \
```

```
0                1               6                    4
1                3              10                    7
2                3               0                    0
3                3               8                    7
4                3               2                    2

   YearsSinceLastPromotion YearsWithCurrManager
0                        0                    5
1                        1                    7
2                        0                    0
3                        3                    0
4                        2                    2

[5 rows x 33 columns]
```

[18]:
```
y=df.Attrition
y.head()
```

[18]:
```
0    Yes
1     No
2    Yes
3     No
4     No
Name: Attrition, dtype: object
```

[19]:
```
#label encoding
from sklearn.preprocessing import LabelEncoder
le=LabelEncoder()
x.Gender=le.fit_transform(x.Gender)
x.BusinessTravel=le.fit_transform(x.BusinessTravel)
x.Department=le.fit_transform(x.Department)
x.EducationField=le.fit_transform(x.EducationField)
x.JobRole=le.fit_transform(x.JobRole)
x.MaritalStatus=le.fit_transform(x.MaritalStatus)
x.Over18=le.fit_transform(x.Over18)
x.OverTime=le.fit_transform(x.OverTime)
x.head()
```

[19]:
```
   BusinessTravel  DailyRate  Department  DistanceFromHome  Education  \
0               2       1102           2                 1          2
1               1        279           1                 8          1
2               2       1373           1                 2          2
3               1       1392           1                 3          4
4               2        591           1                 2          1

   EducationField  EmployeeCount  EmployeeNumber  EnvironmentSatisfaction  \
0               1              1               1                        2
```

```
1              1              1              2                        3
2              4              1              4                        4
3              1              1              5                        4
4              3              1              7                        1

   Gender  …  RelationshipSatisfaction  StandardHours  StockOptionLevel  \
0       0  …                         1             80                 0
1       1  …                         4             80                 1
2       1  …                         2             80                 0
3       0  …                         3             80                 0
4       1  …                         4             80                 1

   TotalWorkingYears  TrainingTimesLastYear  WorkLifeBalance  YearsAtCompany  \
0                  8                      0                1               6
1                 10                      3                3              10
2                  7                      3                3               0
3                  8                      3                3               8
4                  6                      3                3               2

   YearsInCurrentRole  YearsSinceLastPromotion  YearsWithCurrManager
0                   4                        0                     5
1                   7                        1                     7
2                   0                        0                     0
3                   7                        3                     0
4                   2                        2                     2

[5 rows x 33 columns]
```

[20]:
```
from sklearn.preprocessing import MinMaxScaler
ms=MinMaxScaler()
x_scaled=pd.DataFrame(ms.fit_transform(x),columns=x.columns)
```

[21]:
```
x_scaled
```

[21]:
```
      BusinessTravel  DailyRate  Department  DistanceFromHome  Education  \
0                1.0   0.715820         1.0          0.000000       0.25
1                0.5   0.126700         0.5          0.250000       0.00
2                1.0   0.909807         0.5          0.035714       0.25
3                0.5   0.923407         0.5          0.071429       0.75
4                1.0   0.350036         0.5          0.035714       0.00
…                …          …           …                …          …
1465             0.5   0.559771         0.5          0.785714       0.25
1466             1.0   0.365784         0.5          0.178571       0.00
1467             1.0   0.037938         0.5          0.107143       0.50
1468             0.5   0.659270         1.0          0.035714       0.50
1469             1.0   0.376521         0.5          0.250000       0.50
```

```
      EducationField  EmployeeCount  EmployeeNumber  EnvironmentSatisfaction  \
0                0.2            0.0        0.000000                 0.333333
1                0.2            0.0        0.000484                 0.666667
2                0.8            0.0        0.001451                 1.000000
3                0.2            0.0        0.001935                 1.000000
4                0.6            0.0        0.002903                 0.000000
…                …              …          …                        …
1465             0.6            0.0        0.996613                 0.666667
1466             0.6            0.0        0.997097                 1.000000
1467             0.2            0.0        0.998065                 0.333333
1468             0.6            0.0        0.998549                 1.000000
1469             0.6            0.0        1.000000                 0.333333

      Gender  …  RelationshipSatisfaction  StandardHours  StockOptionLevel  \
0        0.0  …                  0.000000            0.0          0.000000
1        1.0  …                  1.000000            0.0          0.333333
2        1.0  …                  0.333333            0.0          0.000000
3        0.0  …                  0.666667            0.0          0.000000
4        1.0  …                  1.000000            0.0          0.333333
…       …  …                     …                  …            …
1465     1.0  …                  0.666667            0.0          0.333333
1466     1.0  …                  0.000000            0.0          0.333333
1467     1.0  …                  0.333333            0.0          0.333333
1468     1.0  …                  1.000000            0.0          0.000000
1469     1.0  …                  0.000000            0.0          0.000000

      TotalWorkingYears  TrainingTimesLastYear  WorkLifeBalance  \
0                 0.200               0.000000         0.000000
1                 0.250               0.500000         0.666667
2                 0.175               0.500000         0.666667
3                 0.200               0.500000         0.666667
4                 0.150               0.500000         0.666667
…                 …                    …               …
1465              0.425               0.500000         0.666667
1466              0.225               0.833333         0.666667
1467              0.150               0.000000         0.666667
1468              0.425               0.500000         0.333333
1469              0.150               0.500000         1.000000

      YearsAtCompany  YearsInCurrentRole  YearsSinceLastPromotion  \
0              0.150            0.222222                 0.000000
1              0.250            0.388889                 0.066667
2              0.000            0.000000                 0.000000
3              0.200            0.388889                 0.200000
4              0.050            0.111111                 0.133333
…              …                 …                       …
1465           0.125            0.111111                 0.000000
```

```
1466           0.175           0.388889                  0.066667
1467           0.150           0.111111                  0.000000
1468           0.225           0.333333                  0.000000
1469           0.100           0.166667                  0.066667

      YearsWithCurrManager
0                 0.294118
1                 0.411765
2                 0.000000
3                 0.000000
4                 0.117647
…                      …
1465              0.176471
1466              0.411765
1467              0.176471
1468              0.470588
1469              0.117647

[1470 rows x 33 columns]
```

[22]:
```
#Splitting Data into Train and Test.
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)
```

[23]:
```
x_train.shape,x_test.shape,y_train.shape,y_test.shape
```

[23]:
```
((1176, 33), (294, 33), (1176,), (294,))
```

[24]:
```
x_train.head()
```

[24]:
```
      BusinessTravel  DailyRate  Department  DistanceFromHome  Education  \
1374             1.0   0.360057         1.0          0.714286       0.50
1092             1.0   0.607015         0.5          0.964286       0.50
768              1.0   0.141732         1.0          0.892857       0.50
569              0.0   0.953472         1.0          0.250000       0.75
911              0.5   0.355762         1.0          0.821429       0.00

      EducationField  EmployeeCount  EmployeeNumber  EnvironmentSatisfaction  \
1374             0.2            0.0        0.937107                 1.000000
1092             1.0            0.0        0.747460                 1.000000
768              0.4            0.0        0.515239                 0.666667
569              0.2            0.0        0.381229                 0.000000
911              0.2            0.0        0.615385                 0.666667

      Gender  …  RelationshipSatisfaction  StandardHours  StockOptionLevel  \
1374     0.0  …                  0.666667            0.0          0.333333
```

```
1092     1.0  …                1.000000            0.0          0.333333
768      1.0  …                0.333333            0.0          0.333333
569      1.0  …                0.333333            0.0          0.000000
911      1.0  …                1.000000            0.0          0.000000

      TotalWorkingYears  TrainingTimesLastYear  WorkLifeBalance  \
1374              0.725               0.333333         0.333333
1092              0.200               0.500000         0.666667
768               0.200               0.500000         0.333333
569               0.250               0.166667         0.666667
911               0.025               0.666667         0.666667

      YearsAtCompany  YearsInCurrentRole  YearsSinceLastPromotion  \
1374           0.025            0.000000                 0.000000
1092           0.125            0.222222                 0.000000
768            0.175            0.388889                 0.466667
569            0.250            0.388889                 0.000000
911            0.025            0.000000                 0.066667

      YearsWithCurrManager
1374              0.000000
1092              0.176471
768               0.294118
569               0.529412
911               0.000000

[5 rows x 33 columns]
```

1 • Model Building

[25]:
```
from sklearn.linear_model import LogisticRegression
model=LogisticRegression()
```

[26]:
```
model.fit(x_train,y_train)
```

[26]:
```
LogisticRegression()
```

[27]:
```
pred=model.predict(x_test)
```

[28]:
```
pred
```

[28]:
```
array(['No', 'No', 'No', 'No', 'Yes', 'No', 'Yes', 'No', 'No', 'Yes',
       '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', 'Yes', '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', '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', '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', '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', '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', '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', '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', 'Yes', 'No', 'No'],
      dtype=object)
```

[29]:
```
y_test
```

[29]:
```
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
```

[30]:
```
df
```

[30]:

	Age	Attrition	BusinessTravel	DailyRate	Department	\
0	41	Yes	Travel_Rarely	1102	Sales	
1	49	No	Travel_Frequently	279	Research & Development	
2	37	Yes	Travel_Rarely	1373	Research & Development	
3	33	No	Travel_Frequently	1392	Research & Development	
4	27	No	Travel_Rarely	591	Research & Development	

```
…    …       …                 …         …                       …
1465   36        No  Travel_Frequently       884  Research & Development
1466   39        No      Travel_Rarely       613  Research & Development
1467   27        No      Travel_Rarely       155  Research & Development
1468   49        No  Travel_Frequently      1023                   Sales
1469   34        No      Travel_Rarely       628  Research & Development

      DistanceFromHome  Education EducationField  EmployeeCount  \
0                    1          2  Life Sciences              1
1                    8          1  Life Sciences              1
2                    2          2          Other              1
3                    3          4  Life Sciences              1
4                    2          1        Medical              1
…                  …          …            …              …
1465                23          2        Medical              1
1466                 6          1        Medical              1
1467                 4          3  Life Sciences              1
1468                 2          3        Medical              1
1469                 8          3        Medical              1

      EmployeeNumber  …  RelationshipSatisfaction StandardHours  \
0                  1  …                         1            80
1                  2  …                         4            80
2                  4  …                         2            80
3                  5  …                         3            80
4                  7  …                         4            80
…                …  …                       …           …
1465            2061  …                         3            80
1466            2062  …                         1            80
1467            2064  …                         2            80
1468            2065  …                         4            80
1469            2068  …                         1            80

      StockOptionLevel  TotalWorkingYears  TrainingTimesLastYear  \
0                    0                  8                      0
1                    1                 10                      3
2                    0                  7                      3
3                    0                  8                      3
4                    1                  6                      3
…                  …                …                    …
1465                 1                 17                      3
1466                 1                  9                      5
1467                 1                  6                      0
1468                 0                 17                      3
1469                 0                  6                      3

     WorkLifeBalance  YearsAtCompany YearsInCurrentRole  \
```

```
0                    1                6                    4
1                    3               10                    7
2                    3                0                    0
3                    3                8                    7
4                    3                2                    2
…                  …                  …                  …
1465                 3                5                    2
1466                 3                7                    7
1467                 3                6                    2
1468                 2                9                    6
1469                 4                4                    3

      YearsSinceLastPromotion  YearsWithCurrManager
0                           0                     5
1                           1                     7
2                           0                     0
3                           3                     0
4                           2                     2
…                         …                     …
1465                        0                     3
1466                        1                     7
1467                        0                     3
1468                        0                     8
1469                        1                     2

[1470 rows x 35 columns]
```

[31]:
```
#model.predict(ms.transform([[1,19,19000]]))
model.predict(ms.fit_transform(x))
```

[31]:
```
array(['Yes', 'No', 'Yes', …, 'No', 'No', 'No'], dtype=object)
```

2 Evaluation of classification model

[32]:
```
#Accuracy score
from sklearn.metrics import␣
 ↪accuracy_score,confusion_matrix,classification_report,roc_auc_score,roc_curve
```

[33]:
```
accuracy_score(y_test,pred)
```

[33]:
```
0.8843537414965986
```

[34]:
```
confusion_matrix(y_test,pred)
```

[34]:
```
array([[241,   4],
       [ 30,  19]], dtype=int64)
```

[35]:
```
pd.crosstab(y_test,pred)
```

[35]:
```
col_0       No  Yes
Attrition
No         241    4
Yes         30   19
```

[36]:
```
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

          No       0.89      0.98      0.93       245
         Yes       0.83      0.39      0.53        49

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

[37]:
```
probability=model.predict_proba(x_test)[:,1]
```

[38]:
```
probability
```

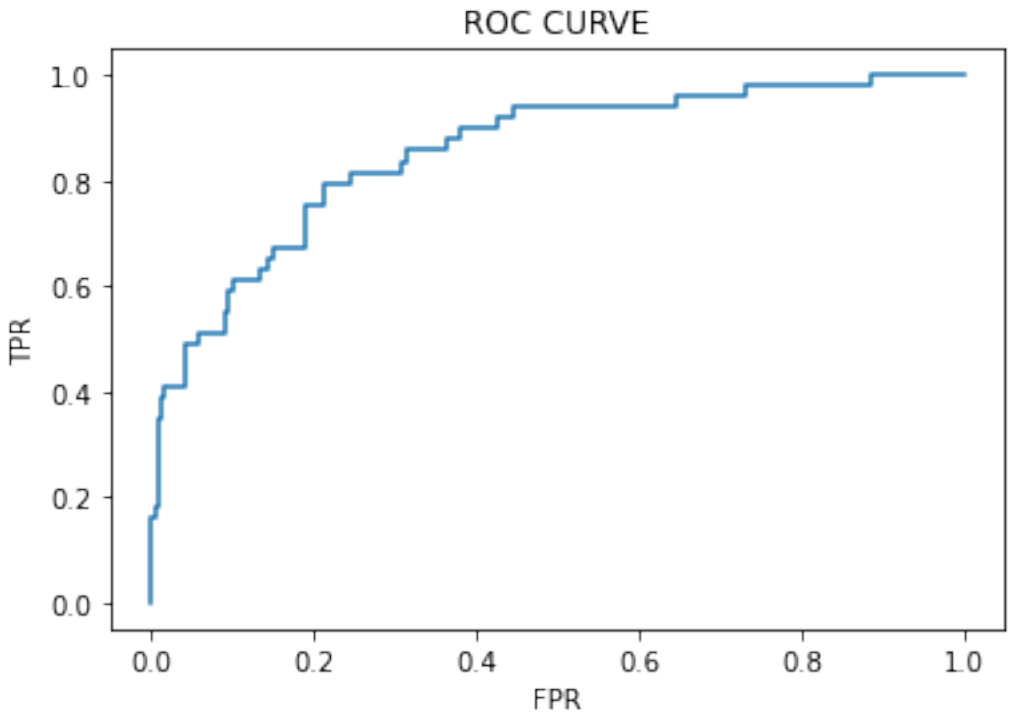
[38]:
```
array([0.15891475, 0.21511559, 0.32432557, 0.08886681, 0.63303258,
       0.06182676, 0.60116073, 0.06129281, 0.01244633, 0.52894224,
       0.05911797, 0.40055503, 0.01774956, 0.61600177, 0.19536204,
       0.03097475, 0.11993564, 0.14259998, 0.0441882 , 0.28487654,
       0.18435044, 0.01360069, 0.06054637, 0.0644042 , 0.50468314,
       0.43046476, 0.10822989, 0.05258899, 0.63461419, 0.08664196,
       0.01485371, 0.03713133, 0.06832962, 0.20850356, 0.09852004,
       0.03286342, 0.082464  , 0.05914568, 0.05256949, 0.05318322,
       0.05700568, 0.01903842, 0.01641415, 0.01302266, 0.02503352,
       0.50677165, 0.36259837, 0.00234831, 0.66839676, 0.44671953,
       0.13405863, 0.56997014, 0.07936646, 0.28134011, 0.69621889,
       0.24937791, 0.01621117, 0.38833096, 0.02564579, 0.17550708,
       0.02883122, 0.18284739, 0.14299095, 0.02734075, 0.34548398,
       0.04414777, 0.31497096, 0.14558263, 0.1235461 , 0.09541113,
       0.09102041, 0.2608112 , 0.07637309, 0.07676458, 0.10931979,
       0.05017179, 0.08388532, 0.10813308, 0.1900822 , 0.03545992,
       0.0091634 , 0.02462897, 0.16628409, 0.02543071, 0.03139766,
       0.07830403, 0.00499672, 0.07289363, 0.03522334, 0.12782832,
       0.1997292 , 0.14301624, 0.2646213 , 0.24404641, 0.01720617,
       0.20455338, 0.34599494, 0.25017011, 0.09201517, 0.05121543,
       0.2112655 , 0.72467912, 0.35414797, 0.02786452, 0.09955845,
       0.04508169, 0.06873754, 0.15215574, 0.10096503, 0.15594135,
       0.08245439, 0.04400721, 0.04334864, 0.14834368, 0.05975021,
       0.04272249, 0.04574552, 0.11551546, 0.00941756, 0.01223489,
```

```
0.22613438, 0.04843507, 0.08376676, 0.80373244, 0.04366118,
0.027391  , 0.01291323, 0.13356578, 0.17716949, 0.04168438,
0.01438738, 0.30332401, 0.56809177, 0.26727437, 0.05807149,
0.42124429, 0.56577335, 0.24697458, 0.06163264, 0.22610041,
0.08386132, 0.07842809, 0.08930405, 0.17701088, 0.29890668,
0.03919743, 0.13828096, 0.0033842 , 0.11208064, 0.13953154,
0.05557145, 0.14898315, 0.05451647, 0.11730045, 0.0341553 ,
0.04390226, 0.06912775, 0.07821587, 0.01381096, 0.01241026,
0.38855565, 0.01307225, 0.11239813, 0.80343597, 0.1942669 ,
0.33130457, 0.16264036, 0.13382165, 0.03038525, 0.00542577,
0.03733729, 0.17353554, 0.17097854, 0.08239189, 0.0161542 ,
0.11497677, 0.09675853, 0.09017036, 0.04375561, 0.09275858,
0.02416675, 0.11140631, 0.00530973, 0.81022589, 0.06321252,
0.04128112, 0.53764442, 0.04502352, 0.73399774, 0.0824389 ,
0.34750978, 0.32974373, 0.31554156, 0.05230788, 0.07749644,
0.21347688, 0.04652234, 0.01956346, 0.25828489, 0.05695346,
0.15536   , 0.17308441, 0.63309302, 0.0554643 , 0.23351402,
0.041376  , 0.4338105 , 0.00331211, 0.12265664, 0.02913167,
0.11640111, 0.18765739, 0.09235799, 0.08987611, 0.24930837,
0.0231433 , 0.01520841, 0.08704603, 0.0228926 , 0.12615554,
0.09957933, 0.23980335, 0.67402732, 0.18515948, 0.35788124,
0.02958548, 0.15886055, 0.16351833, 0.28564987, 0.02851941,
0.03820667, 0.35638525, 0.05565143, 0.02953751, 0.16095279,
0.28425   , 0.20774611, 0.01027417, 0.07141752, 0.01208132,
0.19008834, 0.26995358, 0.01436142, 0.16016645, 0.05334459,
0.03607947, 0.40769009, 0.4200565 , 0.0318672 , 0.10361636,
0.4059028 , 0.35236182, 0.73182365, 0.04756796, 0.2262603 ,
0.0848035 , 0.00518662, 0.62543897, 0.3014179 , 0.35547649,
0.35354735, 0.0335931 , 0.19246384, 0.05074979, 0.05413504,
0.15366914, 0.00781302, 0.212933  , 0.37675336, 0.06984907,
0.10237479, 0.00992434, 0.1386785 , 0.05692345, 0.03202143,
0.03304906, 0.06063555, 0.35044495, 0.35817183, 0.17578989,
0.20989673, 0.01532338, 0.12868418, 0.08311898, 0.03062858,
0.21635223, 0.00706043, 0.24320165, 0.00281585, 0.0253744 ,
0.24037253, 0.67469459, 0.06700778, 0.26604659])
```

[39]:
```
import numpy as np
from sklearn.metrics import roc_curve

# Assuming 'y_test' contains 'No' and 'Yes'
y_test_binary = np.where(y_test == 'Yes', 1, 0)
fpr, tpr, thresholds = roc_curve(y_test_binary, probability)
```

[40]:
```
plt.plot(fpr,tpr)
plt.xlabel('FPR')
plt.ylabel('TPR')
plt.title('ROC CURVE')
```

```
plt.show()
```



3 Decision Tree

[41]:
```
from sklearn.tree import DecisionTreeClassifier
dtc=DecisionTreeClassifier()
```

[42]:
```
dtc.fit(x_train,y_train)
```

[42]:
```
DecisionTreeClassifier()
```

[43]:
```
pred=dtc.predict(x_test)
```

[44]:
```
pred
```

[44]:
```
array(['No', 'No', 'Yes', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No',
       'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No',
       'No', 'No', 'Yes', 'No', 'No', 'No', 'Yes', 'No', 'Yes', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'Yes', 'Yes', 'Yes', 'Yes', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No',
       'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No',
```

```
       'Yes', 'Yes', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No',
       'No', 'Yes', 'Yes', 'No', 'No', 'Yes', 'No', 'No', 'Yes', 'No',
       'No', 'No', 'No', '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', 'Yes', 'Yes', 'Yes', 'No', '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', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No',
       'No', 'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes',
       'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'Yes', 'No', 'No',
       'Yes', 'No', 'No', 'Yes', 'No', 'No', 'Yes', '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',
       'Yes', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
       'No', 'No', 'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No',
       'Yes', 'No', 'No', 'No'], dtype=object)
```

[45]:
```
y_test
```

[45]:
```
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
```

[46]:
```
model.predict(ms.fit_transform(x))
```

[46]:
```
array(['Yes', 'No', 'Yes', ..., 'No', 'No', 'No'], dtype=object)
```

[47]:
```
from sklearn.metrics import␣
 ↪accuracy_score,confusion_matrix,classification_report,roc_auc_score,roc_curve
```

[48]:
```
accuracy_score(y_test,pred)
```

[48]:
```
0.7721088435374149
```

[49]:
```
confusion_matrix(y_test,pred)
```

[49]:
```
array([[211,  34],
       [ 33,  16]], dtype=int64)
```

[50]:
```
pd.crosstab(y_test,pred)
```

[50]:

col_0	No	Yes
Attrition		
No	211	34
Yes	33	16

[51]:
```
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

          No       0.86      0.86      0.86       245
         Yes       0.32      0.33      0.32        49

    accuracy                           0.77       294
   macro avg       0.59      0.59      0.59       294
weighted avg       0.77      0.77      0.77       294
```

[52]:
```
from sklearn import tree
plt.figure(figsize=(25,15))
tree.plot_tree(dtc,filled=True)
```

[52]:
```
[Text(448.3566497093023, 792.75, 'X[26] <= 0.038\ngini = 0.269\nsamples =
1176\nvalue = [988, 188]'),
 Text(101.96013289036544, 747.45, 'X[15] <= 0.75\ngini = 0.5\nsamples =
78\nvalue = [39, 39]'),
 Text(60.24916943521594, 702.15, 'X[3] <= 0.554\ngini = 0.426\nsamples =
39\nvalue = [27, 12]'),
 Text(37.07641196013289, 656.85, 'X[14] <= 0.167\ngini = 0.312\nsamples =
31\nvalue = [25, 6]'),
 Text(18.538205980066444, 611.55, 'X[8] <= 0.5\ngini = 0.49\nsamples = 7\nvalue
= [3, 4]'),
 Text(9.269102990033222, 566.25, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(27.807308970099665, 566.25, 'X[16] <= 0.045\ngini = 0.375\nsamples =
4\nvalue = [3, 1]'),
 Text(18.538205980066444, 520.95, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(37.07641196013289, 520.95, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
 Text(55.61461794019933, 611.55, 'X[18] <= 0.056\ngini = 0.153\nsamples =
24\nvalue = [22, 2]'),
 Text(46.345514950166105, 566.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(64.88372093023256, 566.25, 'X[8] <= 0.167\ngini = 0.083\nsamples =
```

```
23\nvalue = [22, 1]'),
 Text(55.61461794019933, 520.95, 'X[5] <= 0.4\ngini = 0.5\nsamples = 2\nvalue =
[1, 1]'),
 Text(46.345514950166105, 475.65, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(64.88372093023256, 475.65, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(74.15282392026577, 520.95, 'gini = 0.0\nsamples = 21\nvalue = [21, 0]'),
 Text(83.42192691029899, 656.85, 'X[21] <= 0.679\ngini = 0.375\nsamples =
8\nvalue = [2, 6]'),
 Text(74.15282392026577, 611.55, 'gini = 0.0\nsamples = 6\nvalue = [0, 6]'),
 Text(92.69102990033221, 611.55, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
 Text(143.67109634551494, 702.15, 'X[10] <= 0.364\ngini = 0.426\nsamples =
39\nvalue = [12, 27]'),
 Text(120.49833887043188, 656.85, 'X[16] <= 0.1\ngini = 0.133\nsamples =
14\nvalue = [1, 13]'),
 Text(111.22923588039866, 611.55, 'gini = 0.0\nsamples = 13\nvalue = [0, 13]'),
 Text(129.7674418604651, 611.55, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(166.84385382059799, 656.85, 'X[7] <= 0.105\ngini = 0.493\nsamples =
25\nvalue = [11, 14]'),
 Text(148.30564784053155, 611.55, 'X[20] <= 0.5\ngini = 0.278\nsamples =
6\nvalue = [5, 1]'),
 Text(139.03654485049833, 566.25, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
 Text(157.57475083056477, 566.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(185.38205980066442, 611.55, 'X[14] <= 0.5\ngini = 0.432\nsamples =
19\nvalue = [6, 13]'),
 Text(176.1129568106312, 566.25, 'gini = 0.0\nsamples = 7\nvalue = [0, 7]'),
 Text(194.65116279069767, 566.25, 'X[5] <= 0.4\ngini = 0.5\nsamples = 12\nvalue
= [6, 6]'),
 Text(176.1129568106312, 520.95, 'X[11] <= 0.167\ngini = 0.278\nsamples =
6\nvalue = [5, 1]'),
 Text(166.84385382059799, 475.65, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(185.38205980066442, 475.65, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
 Text(213.1893687707641, 520.95, 'X[7] <= 0.249\ngini = 0.278\nsamples =
6\nvalue = [1, 5]'),
 Text(203.9202657807309, 475.65, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(222.45847176079732, 475.65, 'gini = 0.0\nsamples = 5\nvalue = [0, 5]'),
 Text(794.7531665282391, 747.45, 'X[20] <= 0.5\ngini = 0.235\nsamples =
1098\nvalue = [949, 149]'),
 Text(446.5100705980066, 702.15, 'X[28] <= 0.167\ngini = 0.162\nsamples =
798\nvalue = [727, 71]'),
 Text(240.99667774086376, 656.85, 'X[7] <= 0.445\ngini = 0.38\nsamples =
47\nvalue = [35, 12]'),
 Text(222.45847176079732, 611.55, 'X[15] <= 0.75\ngini = 0.1\nsamples =
19\nvalue = [18, 1]'),
 Text(213.1893687707641, 566.25, 'gini = 0.0\nsamples = 18\nvalue = [18, 0]'),
 Text(231.72757475083054, 566.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(259.5348837209302, 611.55, 'X[16] <= 0.094\ngini = 0.477\nsamples =
28\nvalue = [17, 11]'),
```

```
 Text(250.26578073089698, 566.25, 'gini = 0.0\nsamples = 4\nvalue = [0, 4]'),
 Text(268.80398671096344, 566.25, 'X[7] <= 0.524\ngini = 0.413\nsamples =
24\nvalue = [17, 7]'),
 Text(259.5348837209302, 520.95, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(278.07308970099666, 520.95, 'X[32] <= 0.324\ngini = 0.351\nsamples =
22\nvalue = [17, 5]'),
 Text(259.5348837209302, 475.65, 'X[1] <= 0.025\ngini = 0.133\nsamples =
14\nvalue = [13, 1]'),
 Text(250.26578073089698, 430.35, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(268.80398671096344, 430.35, 'gini = 0.0\nsamples = 13\nvalue = [13, 0]'),
 Text(296.6112956810631, 475.65, 'X[1] <= 0.329\ngini = 0.5\nsamples = 8\nvalue
= [4, 4]'),
 Text(287.3421926910299, 430.35, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(305.8803986710963, 430.35, 'X[11] <= 0.333\ngini = 0.32\nsamples =
5\nvalue = [4, 1]'),
 Text(296.6112956810631, 385.05, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(315.14950166112953, 385.05, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
 Text(652.0234634551495, 656.85, 'X[26] <= 0.975\ngini = 0.145\nsamples =
751\nvalue = [692, 59]'),
 Text(642.7543604651162, 611.55, 'X[29] <= 0.113\ngini = 0.143\nsamples =
750\nvalue = [692, 58]'),
 Text(457.3723006644518, 566.25, 'X[8] <= 0.167\ngini = 0.218\nsamples =
257\nvalue = [225, 32]'),
 Text(414.7923588039867, 520.95, 'X[32] <= 0.147\ngini = 0.355\nsamples =
65\nvalue = [50, 15]'),
 Text(384.6677740863787, 475.65, 'X[32] <= 0.029\ngini = 0.303\nsamples =
59\nvalue = [48, 11]'),
 Text(352.2259136212624, 430.35, 'X[11] <= 0.5\ngini = 0.463\nsamples =
22\nvalue = [14, 8]'),
 Text(333.68770764119597, 385.05, 'X[10] <= 0.179\ngini = 0.198\nsamples =
9\nvalue = [8, 1]'),
 Text(324.41860465116275, 339.75, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(342.9568106312292, 339.75, 'gini = 0.0\nsamples = 8\nvalue = [8, 0]'),
 Text(370.76411960132884, 385.05, 'X[10] <= 0.4\ngini = 0.497\nsamples =
13\nvalue = [6, 7]'),
 Text(361.4950166112956, 339.75, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
 Text(380.0332225913621, 339.75, 'X[3] <= 0.286\ngini = 0.346\nsamples =
9\nvalue = [2, 7]'),
 Text(370.76411960132884, 294.45000000000005, 'X[26] <= 0.15\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
 Text(361.4950166112956, 249.14999999999998, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(380.0332225913621, 249.14999999999998, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(389.30232558139534, 294.45000000000005, 'gini = 0.0\nsamples = 6\nvalue =
[0, 6]'),
 Text(417.109634551495, 430.35, 'X[14] <= 0.167\ngini = 0.149\nsamples =
```

```
37\nvalue = [34, 3]'),
 Text(407.8405315614618, 385.05, 'X[29] <= 0.088\ngini = 0.5\nsamples = 6\nvalue
= [3, 3]'),
 Text(398.57142857142856, 339.75, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(417.109634551495, 339.75, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
 Text(426.3787375415282, 385.05, 'gini = 0.0\nsamples = 31\nvalue = [31, 0]'),
 Text(444.91694352159465, 475.65, 'X[7] <= 0.065\ngini = 0.444\nsamples =
6\nvalue = [2, 4]'),
 Text(435.6478405315614, 430.35, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
 Text(454.18604651162786, 430.35, 'gini = 0.0\nsamples = 4\nvalue = [0, 4]'),
 Text(499.9522425249169, 520.95, 'X[1] <= 0.006\ngini = 0.161\nsamples =
192\nvalue = [175, 17]'),
 Text(490.68313953488365, 475.65, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(509.22134551495014, 475.65, 'X[28] <= 0.5\ngini = 0.154\nsamples =
191\nvalue = [175, 16]'),
 Text(472.7242524916943, 430.35, 'X[10] <= 0.629\ngini = 0.339\nsamples =
37\nvalue = [29, 8]'),
 Text(463.4551495016611, 385.05, 'X[11] <= 0.5\ngini = 0.488\nsamples =
19\nvalue = [11, 8]'),
 Text(444.91694352159465, 339.75, 'X[5] <= 0.3\ngini = 0.375\nsamples = 8\nvalue
= [2, 6]'),
 Text(435.6478405315614, 294.45000000000005, 'X[5] <= 0.1\ngini = 0.444\nsamples
= 3\nvalue = [2, 1]'),
 Text(426.3787375415282, 249.14999999999998, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(444.91694352159465, 249.14999999999998, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(454.18604651162786, 294.45000000000005, 'gini = 0.0\nsamples = 5\nvalue =
[0, 5]'),
 Text(481.9933554817275, 339.75, 'X[27] <= 0.75\ngini = 0.298\nsamples =
11\nvalue = [9, 2]'),
 Text(472.7242524916943, 294.45000000000005, 'X[26] <= 0.15\ngini =
0.18\nsamples = 10\nvalue = [9, 1]'),
 Text(463.4551495016611, 249.14999999999998, 'X[26] <= 0.113\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
 Text(454.18604651162786, 203.85000000000002, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
 Text(472.7242524916943, 203.85000000000002, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(481.9933554817275, 249.14999999999998, 'gini = 0.0\nsamples = 7\nvalue =
[7, 0]'),
 Text(491.26245847176074, 294.45000000000005, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(481.9933554817275, 385.05, 'gini = 0.0\nsamples = 18\nvalue = [18, 0]'),
 Text(545.718438538206, 430.35, 'X[7] <= 0.022\ngini = 0.098\nsamples =
154\nvalue = [146, 8]'),
 Text(514.4352159468438, 385.05, 'X[13] <= 0.5\ngini = 0.5\nsamples = 4\nvalue =
```

```
[2, 2]'),
 Text(505.1661129568106, 339.75, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
 Text(523.704318936877, 339.75, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(577.0016611295681, 385.05, 'X[1] <= 0.943\ngini = 0.077\nsamples =
150\nvalue = [144, 6]'),
 Text(542.2425249169435, 339.75, 'X[4] <= 0.875\ngini = 0.055\nsamples =
142\nvalue = [138, 4]'),
 Text(519.0697674418604, 294.45000000000005, 'X[17] <= 0.966\ngini =
0.029\nsamples = 135\nvalue = [133, 2]'),
 Text(500.53156146179396, 249.14999999999998, 'X[26] <= 0.063\ngini =
0.015\nsamples = 132\nvalue = [131, 1]'),
 Text(491.26245847176074, 203.85000000000002, 'X[7] <= 0.83\ngini =
0.18\nsamples = 10\nvalue = [9, 1]'),
 Text(481.9933554817275, 158.55000000000007, 'gini = 0.0\nsamples = 9\nvalue =
[9, 0]'),
 Text(500.53156146179396, 158.55000000000007, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(509.8006644518272, 203.85000000000002, 'gini = 0.0\nsamples = 122\nvalue =
[122, 0]'),
 Text(537.6079734219269, 249.14999999999998, 'X[4] <= 0.625\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
 Text(528.3388704318936, 203.85000000000002, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(546.87707641196, 203.85000000000002, 'gini = 0.0\nsamples = 2\nvalue = [2,
0]'),
 Text(565.4152823920265, 294.45000000000005, 'X[3] <= 0.446\ngini =
0.408\nsamples = 7\nvalue = [5, 2]'),
 Text(556.1461794019933, 249.14999999999998, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
 Text(574.6843853820598, 249.14999999999998, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(611.7607973421926, 339.75, 'X[26] <= 0.163\ngini = 0.375\nsamples =
8\nvalue = [6, 2]'),
 Text(602.4916943521595, 294.45000000000005, 'X[11] <= 0.5\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(593.2225913621262, 249.14999999999998, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(611.7607973421926, 249.14999999999998, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(621.0299003322259, 294.45000000000005, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
 Text(828.1364202657807, 566.25, 'X[29] <= 0.787\ngini = 0.1\nsamples =
493\nvalue = [467, 26]'),
 Text(780.3426079734219, 520.95, 'X[14] <= 0.5\ngini = 0.094\nsamples =
486\nvalue = [462, 24]'),
 Text(712.5622923588039, 475.65, 'X[13] <= 0.938\ngini = 0.154\nsamples =
191\nvalue = [175, 16]'),
```

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 Text(703.2931893687708, 430.35, 'X[17] <= 0.481\ngini = 0.145\nsamples =
190\nvalue = [175, 15]'),
 Text(678.9617940199334, 385.05, 'X[17] <= 0.47\ngini = 0.221\nsamples =
95\nvalue = [83, 12]'),
 Text(669.6926910299003, 339.75, 'X[32] <= 0.794\ngini = 0.207\nsamples =
94\nvalue = [83, 11]'),
 Text(660.423588039867, 294.45000000000005, 'X[4] <= 0.375\ngini =
0.192\nsamples = 93\nvalue = [83, 10]'),
 Text(630.2990033222591, 249.14999999999998, 'X[5] <= 0.9\ngini = 0.363\nsamples
= 21\nvalue = [16, 5]'),
 Text(621.0299003322259, 203.85000000000002, 'X[16] <= 0.413\ngini =
0.266\nsamples = 19\nvalue = [16, 3]'),
 Text(602.4916943521595, 158.55000000000007, 'X[7] <= 0.215\ngini =
0.117\nsamples = 16\nvalue = [15, 1]'),
 Text(593.2225913621262, 113.25, 'X[21] <= 0.179\ngini = 0.5\nsamples = 2\nvalue
= [1, 1]'),
 Text(583.9534883720929, 67.95000000000005, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(602.4916943521595, 67.95000000000005, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(611.7607973421926, 113.25, 'gini = 0.0\nsamples = 14\nvalue = [14, 0]'),
 Text(639.5681063122923, 158.55000000000007, 'X[31] <= 0.6\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(630.2990033222591, 113.25, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(648.8372093023255, 113.25, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(639.5681063122923, 203.85000000000002, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(690.5481727574751, 249.14999999999998, 'X[30] <= 0.139\ngini =
0.129\nsamples = 72\nvalue = [67, 5]'),
 Text(667.3754152823919, 203.85000000000002, 'X[7] <= 0.68\ngini =
0.444\nsamples = 6\nvalue = [4, 2]'),
 Text(658.1063122923588, 158.55000000000007, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
 Text(676.6445182724252, 158.55000000000007, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(713.7209302325581, 203.85000000000002, 'X[1] <= 0.958\ngini =
0.087\nsamples = 66\nvalue = [63, 3]'),
 Text(695.1827242524917, 158.55000000000007, 'X[27] <= 0.583\ngini =
0.061\nsamples = 64\nvalue = [62, 2]'),
 Text(685.9136212624584, 113.25, 'gini = 0.0\nsamples = 52\nvalue = [52, 0]'),
 Text(704.4518272425248, 113.25, 'X[2] <= 0.75\ngini = 0.278\nsamples =
12\nvalue = [10, 2]'),
 Text(695.1827242524917, 67.95000000000005, 'gini = 0.0\nsamples = 9\nvalue =
[9, 0]'),
 Text(713.7209302325581, 67.95000000000005, 'X[26] <= 0.3\ngini = 0.444\nsamples
= 3\nvalue = [1, 2]'),
 Text(704.4518272425248, 22.649999999999977, 'gini = 0.0\nsamples = 2\nvalue =
```

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[0, 2]'),
 Text(722.9900332225913, 22.649999999999977, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(732.2591362126245, 158.55000000000007, 'X[2] <= 0.75\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
 Text(722.9900332225913, 113.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(741.5282392026577, 113.25, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(678.9617940199334, 294.45000000000005, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(688.2308970099667, 339.75, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(727.624584717608, 385.05, 'X[18] <= 0.5\ngini = 0.061\nsamples = 95\nvalue
= [92, 3]'),
 Text(718.3554817275747, 339.75, 'gini = 0.0\nsamples = 76\nvalue = [76, 0]'),
 Text(736.8936877076411, 339.75, 'X[7] <= 0.161\ngini = 0.266\nsamples =
19\nvalue = [16, 3]'),
 Text(718.3554817275747, 294.45000000000005, 'X[5] <= 0.5\ngini = 0.444\nsamples
= 3\nvalue = [1, 2]'),
 Text(709.0863787375415, 249.14999999999998, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
 Text(727.624584717608, 249.14999999999998, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(755.4318936877075, 294.45000000000005, 'X[32] <= 0.059\ngini =
0.117\nsamples = 16\nvalue = [15, 1]'),
 Text(746.1627906976744, 249.14999999999998, 'X[13] <= 0.438\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(736.8936877076411, 203.85000000000002, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(755.4318936877075, 203.85000000000002, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(764.7009966777408, 249.14999999999998, 'gini = 0.0\nsamples = 14\nvalue =
[14, 0]'),
 Text(721.8313953488372, 430.35, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(848.1229235880398, 475.65, 'X[21] <= 0.036\ngini = 0.053\nsamples =
295\nvalue = [287, 8]'),
 Text(815.6810631229235, 430.35, 'X[31] <= 0.7\ngini = 0.159\nsamples =
46\nvalue = [42, 4]'),
 Text(806.4119601328903, 385.05, 'X[11] <= 0.167\ngini = 0.124\nsamples =
45\nvalue = [42, 3]'),
 Text(783.2392026578073, 339.75, 'X[10] <= 0.193\ngini = 0.5\nsamples = 2\nvalue
= [1, 1]'),
 Text(773.970099667774, 294.45000000000005, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(792.5083056478404, 294.45000000000005, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(829.5847176079734, 339.75, 'X[26] <= 0.688\ngini = 0.089\nsamples =
43\nvalue = [41, 2]'),
 Text(811.0465116279069, 294.45000000000005, 'X[13] <= 0.062\ngini =
```

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0.048\nsamples = 41\nvalue = [40, 1]'),
 Text(801.7774086378737, 249.14999999999998, 'X[1] <= 0.487\ngini =
0.375\nsamples = 4\nvalue = [3, 1]'),
 Text(792.5083056478404, 203.85000000000002, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(811.0465116279069, 203.85000000000002, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
 Text(820.3156146179401, 249.14999999999998, 'gini = 0.0\nsamples = 37\nvalue =
[37, 0]'),
 Text(848.1229235880398, 294.45000000000005, 'X[15] <= 0.25\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
 Text(838.8538205980066, 249.14999999999998, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(857.392026578073, 249.14999999999998, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(824.9501661129567, 385.05, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(880.564784053156, 430.35, 'X[16] <= 0.056\ngini = 0.032\nsamples =
249\nvalue = [245, 4]'),
 Text(857.392026578073, 385.05, 'X[7] <= 0.33\ngini = 0.32\nsamples = 5\nvalue =
[4, 1]'),
 Text(848.1229235880398, 339.75, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(866.6611295681063, 339.75, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
 Text(903.7375415282391, 385.05, 'X[1] <= 0.015\ngini = 0.024\nsamples =
244\nvalue = [241, 3]'),
 Text(885.1993355481727, 339.75, 'X[3] <= 0.875\ngini = 0.278\nsamples =
6\nvalue = [5, 1]'),
 Text(875.9302325581394, 294.45000000000005, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
 Text(894.4684385382059, 294.45000000000005, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(922.2757475083056, 339.75, 'X[23] <= 0.167\ngini = 0.017\nsamples =
238\nvalue = [236, 2]'),
 Text(913.0066445182723, 294.45000000000005, 'X[28] <= 0.833\ngini =
0.073\nsamples = 53\nvalue = [51, 2]'),
 Text(894.4684385382059, 249.14999999999998, 'X[32] <= 0.088\ngini =
0.041\nsamples = 48\nvalue = [47, 1]'),
 Text(885.1993355481727, 203.85000000000002, 'X[17] <= 0.824\ngini =
0.245\nsamples = 7\nvalue = [6, 1]'),
 Text(875.9302325581394, 158.55000000000007, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
 Text(894.4684385382059, 158.55000000000007, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(903.7375415282391, 203.85000000000002, 'gini = 0.0\nsamples = 41\nvalue =
[41, 0]'),
 Text(931.5448504983387, 249.14999999999998, 'X[21] <= 0.357\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
 Text(922.2757475083056, 203.85000000000002, 'gini = 0.0\nsamples = 4\nvalue =
```

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[4, 0]'),
 Text(940.813953488372, 203.85000000000002, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
 Text(931.5448504983387, 294.45000000000005, 'gini = 0.0\nsamples = 185\nvalue =
[185, 0]'),
 Text(875.9302325581394, 520.95, 'X[9] <= 0.5\ngini = 0.408\nsamples = 7\nvalue
= [5, 2]'),
 Text(866.6611295681063, 475.65, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(885.1993355481727, 475.65, 'gini = 0.0\nsamples = 5\nvalue = [5, 0]'),
 Text(661.2925664451826, 611.55, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(1142.9962624584716, 702.15, 'X[16] <= 0.157\ngini = 0.385\nsamples =
300\nvalue = [222, 78]'),
 Text(1014.9667774086378, 656.85, 'X[25] <= 0.167\ngini = 0.5\nsamples =
96\nvalue = [49, 47]'),
 Text(963.986710963455, 611.55, 'X[3] <= 0.161\ngini = 0.459\nsamples =
42\nvalue = [15, 27]'),
 Text(931.5448504983387, 566.25, 'X[7] <= 0.415\ngini = 0.499\nsamples =
23\nvalue = [12, 11]'),
 Text(913.0066445182723, 520.95, 'X[17] <= 0.561\ngini = 0.355\nsamples =
13\nvalue = [3, 10]'),
 Text(903.7375415282391, 475.65, 'gini = 0.0\nsamples = 8\nvalue = [0, 8]'),
 Text(922.2757475083056, 475.65, 'X[27] <= 0.583\ngini = 0.48\nsamples =
5\nvalue = [3, 2]'),
 Text(913.0066445182723, 430.35, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
 Text(931.5448504983387, 430.35, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(950.0830564784052, 520.95, 'X[2] <= 0.75\ngini = 0.18\nsamples = 10\nvalue
= [9, 1]'),
 Text(940.813953488372, 475.65, 'gini = 0.0\nsamples = 8\nvalue = [8, 0]'),
 Text(959.3521594684385, 475.65, 'X[21] <= 0.357\ngini = 0.5\nsamples = 2\nvalue
= [1, 1]'),
 Text(950.0830564784052, 430.35, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(968.6212624584717, 430.35, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(996.4285714285713, 566.25, 'X[12] <= 0.125\ngini = 0.266\nsamples =
19\nvalue = [3, 16]'),
 Text(987.1594684385382, 520.95, 'X[10] <= 0.2\ngini = 0.198\nsamples =
18\nvalue = [2, 16]'),
 Text(977.8903654485049, 475.65, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(996.4285714285713, 475.65, 'X[30] <= 0.306\ngini = 0.111\nsamples =
17\nvalue = [1, 16]'),
 Text(987.1594684385382, 430.35, 'gini = 0.0\nsamples = 15\nvalue = [0, 15]'),
 Text(1005.6976744186046, 430.35, 'X[28] <= 0.5\ngini = 0.5\nsamples = 2\nvalue
= [1, 1]'),
 Text(996.4285714285713, 385.05, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(1014.9667774086378, 385.05, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(1005.6976744186046, 520.95, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(1065.9468438538206, 611.55, 'X[16] <= 0.08\ngini = 0.466\nsamples =
54\nvalue = [34, 20]'),
```

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 Text(1033.5049833887042, 566.25, 'X[1] <= 0.563\ngini = 0.488\nsamples =
19\nvalue = [8, 11]'),
 Text(1024.235880398671, 520.95, 'gini = 0.0\nsamples = 8\nvalue = [0, 8]'),
 Text(1042.7740863787374, 520.95, 'X[4] <= 0.625\ngini = 0.397\nsamples =
11\nvalue = [8, 3]'),
 Text(1033.5049833887042, 475.65, 'gini = 0.0\nsamples = 7\nvalue = [7, 0]'),
 Text(1052.0431893687708, 475.65, 'X[17] <= 0.505\ngini = 0.375\nsamples =
4\nvalue = [1, 3]'),
 Text(1042.7740863787374, 430.35, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(1061.312292358804, 430.35, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(1098.3887043189368, 566.25, 'X[14] <= 0.5\ngini = 0.382\nsamples =
35\nvalue = [26, 9]'),
 Text(1079.8504983388702, 520.95, 'X[21] <= 0.821\ngini = 0.133\nsamples =
14\nvalue = [13, 1]'),
 Text(1070.581395348837, 475.65, 'gini = 0.0\nsamples = 13\nvalue = [13, 0]'),
 Text(1089.1196013289036, 475.65, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(1116.9269102990033, 520.95, 'X[31] <= 0.267\ngini = 0.472\nsamples =
21\nvalue = [13, 8]'),
 Text(1107.65780730897, 475.65, 'X[17] <= 0.648\ngini = 0.401\nsamples =
18\nvalue = [13, 5]'),
 Text(1098.3887043189368, 430.35, 'gini = 0.0\nsamples = 9\nvalue = [9, 0]'),
 Text(1116.9269102990033, 430.35, 'X[16] <= 0.09\ngini = 0.494\nsamples =
9\nvalue = [4, 5]'),
 Text(1107.65780730897, 385.05, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
 Text(1126.1960132890365, 385.05, 'X[4] <= 0.875\ngini = 0.278\nsamples =
6\nvalue = [1, 5]'),
 Text(1116.9269102990033, 339.75, 'gini = 0.0\nsamples = 5\nvalue = [0, 5]'),
 Text(1135.4651162790697, 339.75, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(1126.1960132890365, 475.65, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(1271.0257475083056, 656.85, 'X[15] <= 0.75\ngini = 0.258\nsamples =
204\nvalue = [173, 31]'),
 Text(1207.300664451827, 611.55, 'X[16] <= 0.992\ngini = 0.138\nsamples =
147\nvalue = [136, 11]'),
 Text(1198.031561461794, 566.25, 'X[3] <= 0.482\ngini = 0.128\nsamples =
146\nvalue = [136, 10]'),
 Text(1172.5415282392025, 520.95, 'X[29] <= 0.063\ngini = 0.038\nsamples =
104\nvalue = [102, 2]'),
 Text(1163.2724252491694, 475.65, 'X[10] <= 0.193\ngini = 0.32\nsamples =
10\nvalue = [8, 2]'),
 Text(1154.0033222591362, 430.35, 'X[26] <= 0.475\ngini = 0.444\nsamples =
3\nvalue = [1, 2]'),
 Text(1144.7342192691028, 385.05, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(1163.2724252491694, 385.05, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(1172.5415282392025, 430.35, 'gini = 0.0\nsamples = 7\nvalue = [7, 0]'),
 Text(1181.8106312292357, 475.65, 'gini = 0.0\nsamples = 94\nvalue = [94, 0]'),
 Text(1223.5215946843853, 520.95, 'X[8] <= 0.167\ngini = 0.308\nsamples =
42\nvalue = [34, 8]'),
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 Text(1200.3488372093022, 475.65, 'X[17] <= 0.194\ngini = 0.375\nsamples =
4\nvalue = [1, 3]'),
 Text(1191.079734219269, 430.35, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(1209.6179401993354, 430.35, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(1246.6943521594683, 475.65, 'X[18] <= 0.722\ngini = 0.229\nsamples =
38\nvalue = [33, 5]'),
 Text(1228.156146179402, 430.35, 'X[13] <= 0.812\ngini = 0.157\nsamples =
35\nvalue = [32, 3]'),
 Text(1218.8870431893686, 385.05, 'gini = 0.0\nsamples = 29\nvalue = [29, 0]'),
 Text(1237.4252491694351, 385.05, 'X[30] <= 0.25\ngini = 0.5\nsamples = 6\nvalue
= [3, 3]'),
 Text(1228.156146179402, 339.75, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(1246.6943521594683, 339.75, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
 Text(1265.2325581395348, 430.35, 'X[10] <= 0.579\ngini = 0.444\nsamples =
3\nvalue = [1, 2]'),
 Text(1255.9634551495014, 385.05, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(1274.501661129568, 385.05, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(1216.5697674418604, 566.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(1334.7508305647839, 611.55, 'X[13] <= 0.812\ngini = 0.456\nsamples =
57\nvalue = [37, 20]'),
 Text(1293.0398671096345, 566.25, 'X[7] <= 0.071\ngini = 0.238\nsamples =
29\nvalue = [25, 4]'),
 Text(1274.501661129568, 520.95, 'X[17] <= 0.558\ngini = 0.444\nsamples =
3\nvalue = [1, 2]'),
 Text(1265.2325581395348, 475.65, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(1283.7707641196012, 475.65, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(1311.5780730897009, 520.95, 'X[31] <= 0.4\ngini = 0.142\nsamples =
26\nvalue = [24, 2]'),
 Text(1302.3089700996677, 475.65, 'gini = 0.0\nsamples = 23\nvalue = [23, 0]'),
 Text(1320.847176079734, 475.65, 'X[21] <= 0.286\ngini = 0.444\nsamples =
3\nvalue = [1, 2]'),
 Text(1311.5780730897009, 430.35, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(1330.1162790697674, 430.35, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
 Text(1376.4617940199334, 566.25, 'X[31] <= 0.1\ngini = 0.49\nsamples =
28\nvalue = [12, 16]'),
 Text(1367.1926910299003, 520.95, 'X[3] <= 0.804\ngini = 0.48\nsamples =
20\nvalue = [12, 8]'),
 Text(1357.923588039867, 475.65, 'X[29] <= 0.013\ngini = 0.415\nsamples =
17\nvalue = [12, 5]'),
 Text(1348.6544850498337, 430.35, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
 Text(1367.1926910299003, 430.35, 'X[23] <= 0.5\ngini = 0.32\nsamples =
15\nvalue = [12, 3]'),
 Text(1357.923588039867, 385.05, 'X[31] <= 0.033\ngini = 0.5\nsamples = 6\nvalue
= [3, 3]'),
 Text(1348.6544850498337, 339.75, 'X[1] <= 0.907\ngini = 0.375\nsamples =
4\nvalue = [1, 3]'),
 Text(1339.3853820598006, 294.45000000000005, 'gini = 0.0\nsamples = 3\nvalue =
```

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[0, 3]'),
 Text(1357.923588039867, 294.45000000000005, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
 Text(1367.1926910299003, 339.75, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
 Text(1376.4617940199334, 385.05, 'gini = 0.0\nsamples = 9\nvalue = [9, 0]'),
 Text(1376.4617940199334, 475.65, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
 Text(1385.7308970099666, 520.95, 'gini = 0.0\nsamples = 8\nvalue = [0, 8]')]
```

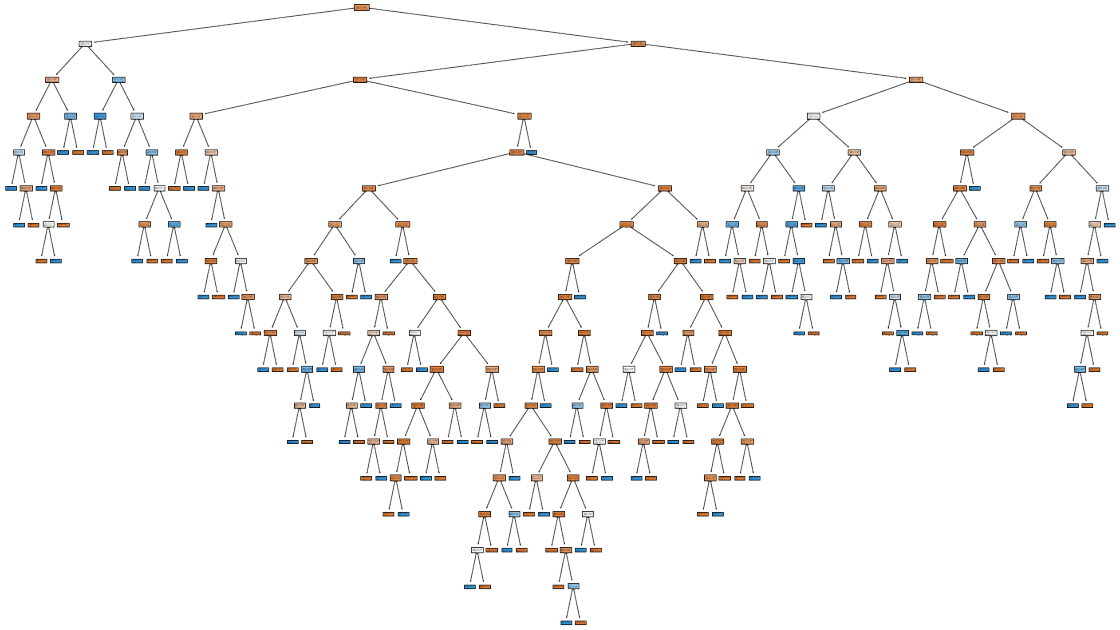

[53]:
```
from sklearn.model_selection import GridSearchCV
parameter={
 'criterion':['gini','entropy'],
  'splitter':['best','random'],
  'max_depth':[1,2,3,4,5],
  'max_features':['auto', 'sqrt', 'log2']

}
```

[54]:
```
grid_search=GridSearchCV(estimator=dtc,param_grid=parameter,cv=5,scoring="accuracy")
```

[55]:
```
grid_search.fit(x_train,y_train)
```

[55]:
```
GridSearchCV(cv=5, estimator=DecisionTreeClassifier(),
             param_grid={'criterion': ['gini', 'entropy'],
                         'max_depth': [1, 2, 3, 4, 5],
                         'max_features': ['auto', 'sqrt', 'log2'],
                         'splitter': ['best', 'random']},
```

```
                 scoring='accuracy')
```

[56]:
```python
grid_search.best_params_
```

[56]:
```
{'criterion': 'gini',
 'max_depth': 3,
 'max_features': 'auto',
 'splitter': 'random'}
```

[57]:
```python
dtc_cv=DecisionTreeClassifier(criterion= 'entropy',
 max_depth=3,
 max_features='sqrt',
 splitter='best')
dtc_cv.fit(x_train,y_train)
```

[57]:
```
DecisionTreeClassifier(criterion='entropy', max_depth=3, max_features='sqrt')
```

[58]:
```python
pred=dtc_cv.predict(x_test)
```

[59]:
```python
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

          No       0.83      1.00      0.91       245
         Yes       0.00      0.00      0.00        49

    accuracy                           0.83       294
   macro avg       0.42      0.50      0.45       294
weighted avg       0.69      0.83      0.76       294


C:\Users\kavya\anaconda3\lib\site-
packages\sklearn\metrics\_classification.py:1245: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
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  _warn_prf(average, modifier, msg_start, len(result))
```

4 Random Forest

[60]:
```
from sklearn.ensemble import RandomForestClassifier
rfc=RandomForestClassifier()
```

[61]:
```
forest_params = [{'max_depth': list(range(10, 15)), 'max_features':␣
 ↪list(range(0,14))}]
```

[62]:
```
rfc_cv= GridSearchCV(rfc,param_grid=forest_params,cv=10,scoring="accuracy")
```

[63]:
```
rfc_cv.fit(x_train,y_train)
```

```
C:\Users\kavya\anaconda3\lib\site-
packages\sklearn\model_selection\_validation.py:610: FitFailedWarning: Estimator
fit failed. The score on this train-test partition for these parameters will be
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```
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C:\Users\kavya\anaconda3\lib\site-
packages\sklearn\model_selection\_search.py:918: UserWarning: One or more of the
test scores are non-finite: [       nan 0.84608866 0.84779806 0.85969868
0.8528828  0.85628712
 0.86223381 0.85967695 0.85882949 0.85458496 0.85882949 0.8613936
 0.85800377 0.85459221        nan 0.84693611 0.85289729 0.85375924
 0.85459221 0.86138635 0.85798928 0.85714182 0.85712009 0.85713458
 0.85629436 0.86138635 0.85371578 0.85457772        nan 0.84779082
 0.85459945 0.85629436 0.85543966 0.85971317 0.85797479 0.85629436
 0.85797479 0.85628712 0.85457772 0.85711285 0.86138635 0.86050992
        nan 0.84864552 0.85545415 0.85375924 0.85800377 0.85543242
 0.85798928 0.85544691 0.85458496 0.85543966 0.85289005 0.85372302
 0.85712734 0.85883674        nan 0.85119513 0.85544691 0.85969144
 0.85799652 0.85459221 0.85884398 0.85712734 0.85969868 0.85628712
 0.85969144 0.85542518 0.85627988 0.85289005]
  warnings.warn(
```

[63]:
```
GridSearchCV(cv=10, estimator=RandomForestClassifier(),
             param_grid=[{'max_depth': [10, 11, 12, 13, 14],
                          'max_features': [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
                                           12, 13]}],
             scoring='accuracy')
```

[64]:
```
pred=rfc_cv.predict(x_test)
```

[65]:
```
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

          No       0.85      0.99      0.92       245
         Yes       0.75      0.12      0.21        49

    accuracy                           0.85       294
   macro avg       0.80      0.56      0.56       294
weighted avg       0.83      0.85      0.80       294
```

[67]:
```
rfc_cv.best_params_
```

[67]:
```
{'max_depth': 10, 'max_features': 6}
```

[ ]:
```

```