KALERU ABHILASH-21BCB7033

ASSIGNMENT-4

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import LabelEncoder
from sklearn.linear_model import LogisticRegression

df = pd.read_csv("Employee-Attrition.csv")
df.head()
```

```
   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]

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

df.describe()

               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]
```

```
df.isnull().any()
```

```
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
```

```
df.isnull().sum()
```

```
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
```

```
corr = df.corr()
corr
```

```
C:\Users\tejos\AppData\Local\Temp\ipykernel_18972\2438084875.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.
  corr = df.corr()
```

```
                               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
```

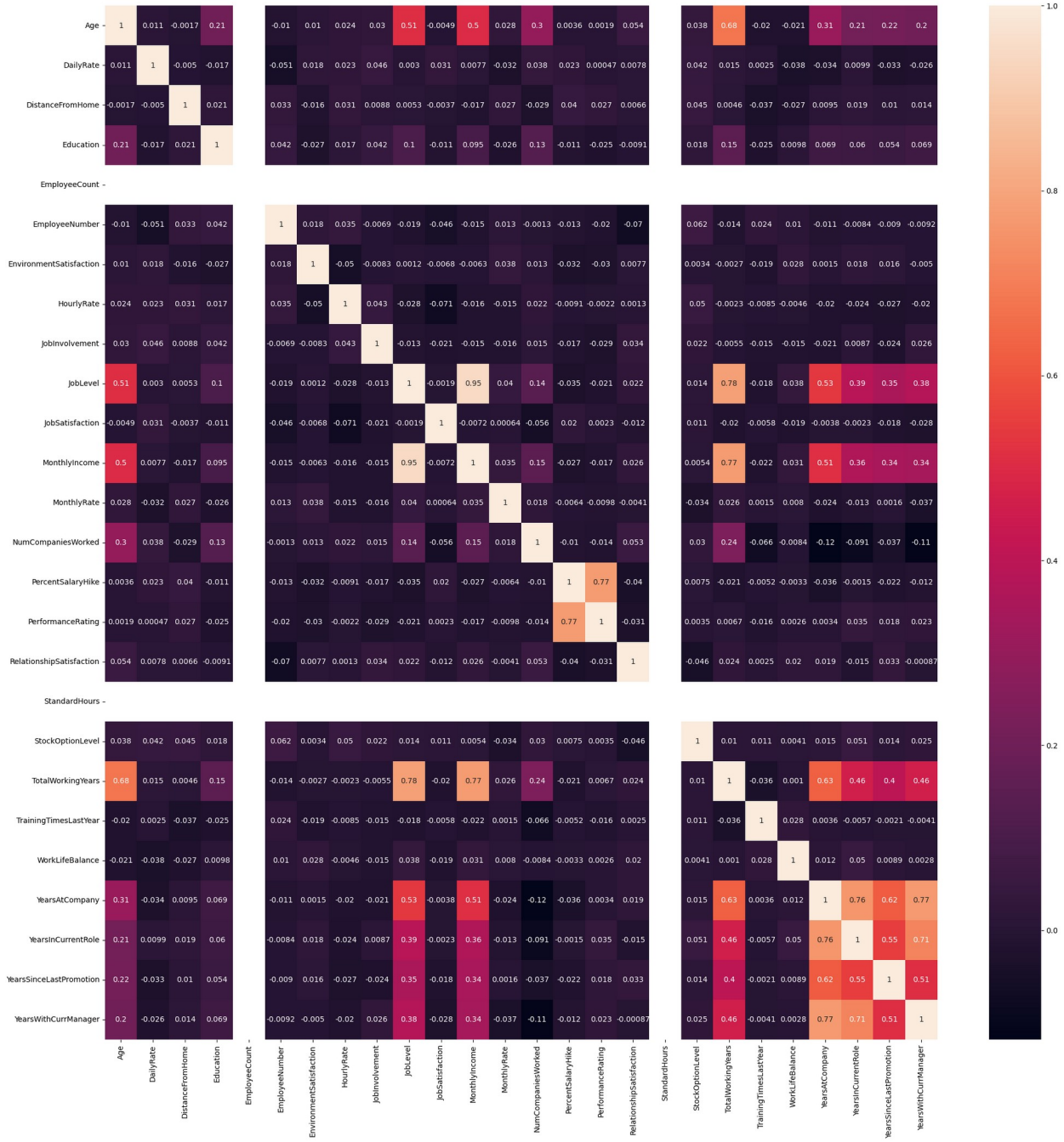
```
0.010136
TotalWorkingYears                   NaN          0.010136
1.000000
TrainingTimesLastYear               NaN          0.011274          -
0.035662
WorkLifeBalance                     NaN          0.004129
0.001008
YearsAtCompany                      NaN          0.015058
0.628133
YearsInCurrentRole                  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]
```

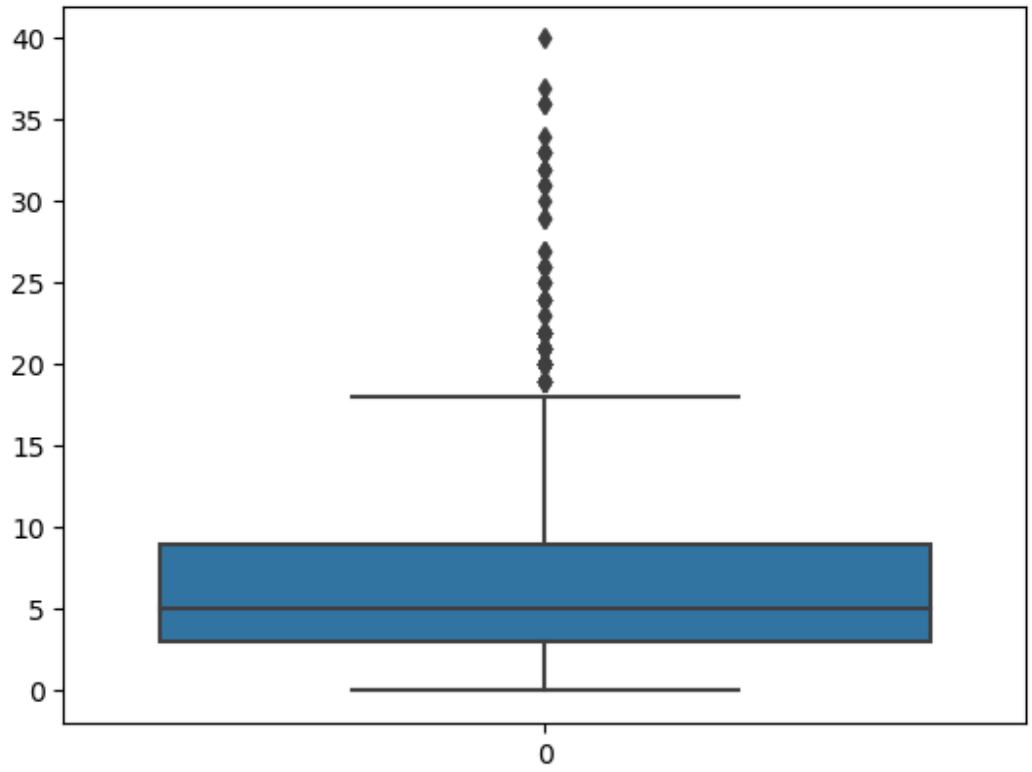
```
plt.subplots(figsize = (25,25))
sns.heatmap(corr,annot = True)
```

```
<Axes: >
```



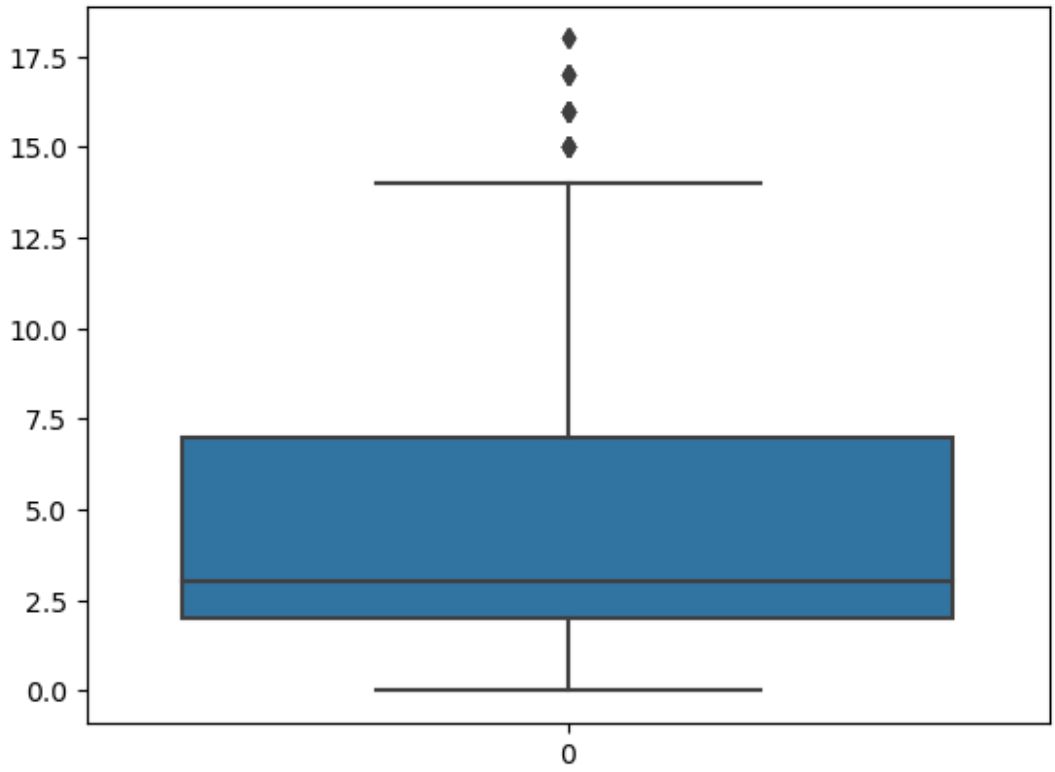

```
sns.boxplot(df.YearsAtCompany)
```

```
<Axes: >
```




```
sns.boxplot(df.YearsInCurrentRole)
```

```
<Axes: >
```




```
q1 = df.YearsInCurrentRole.quantile(0.25)
q3 = df.YearsInCurrentRole.quantile(0.75)
print(q1)
print(q3)
```

```
2.0
7.0
```

```
q3-q1
```

```
5.0
```

```
upperlimit = q3+1.5*(q3-q1)
upperlimit
```

```
14.5
```

```
lowerlimit = q1-1.5*(q3-q1)
lowerlimit
```

```
-5.5
```

```
df.median()
```

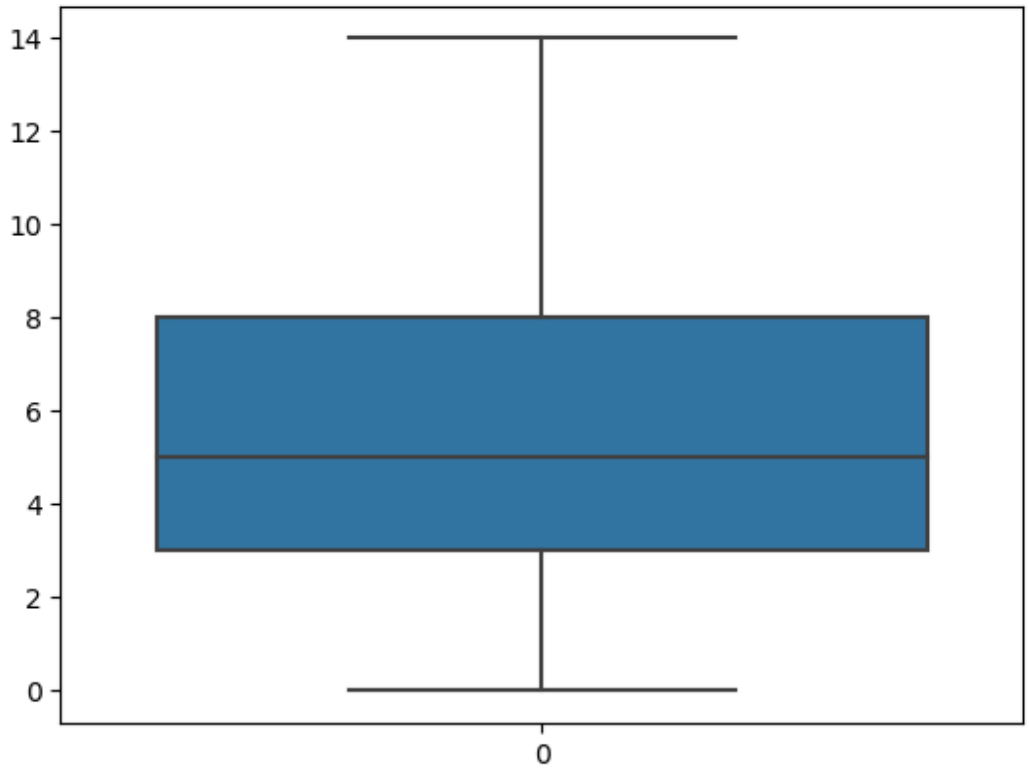
```
C:\Users\tejos\AppData\Local\Temp\ipykernel_18972\530051474.py:1:
FutureWarning: The default value of numeric_only in DataFrame.median
is deprecated. In a future version, it will default to False. In
```

```
addition, specifying 'numeric_only=None' is deprecated. Select only
valid columns or specify the value of numeric_only to silence this
warning.
  df.median()
```

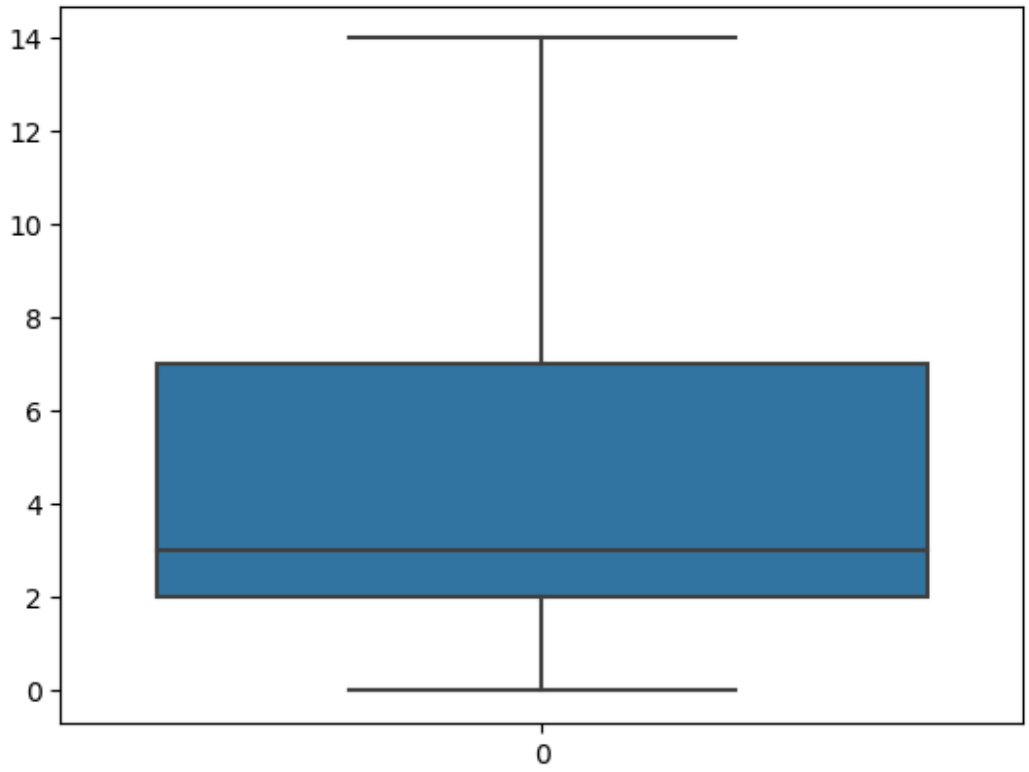
```
Age                         36.0
DailyRate                  802.0
DistanceFromHome             7.0
Education                    3.0
EmployeeCount                1.0
EmployeeNumber            1020.5
EnvironmentSatisfaction      3.0
HourlyRate                  66.0
JobInvolvement               3.0
JobLevel                     2.0
JobSatisfaction              3.0
MonthlyIncome             4919.0
MonthlyRate              14235.5
NumCompaniesWorked           2.0
PercentSalaryHike           14.0
PerformanceRating            3.0
RelationshipSatisfaction     3.0
StandardHours               80.0
StockOptionLevel             1.0
TotalWorkingYears           10.0
TrainingTimesLastYear        3.0
WorkLifeBalance              3.0
YearsAtCompany               5.0
YearsInCurrentRole           3.0
YearsSinceLastPromotion      1.0
YearsWithCurrManager         3.0
dtype: float64
```

```
df["YearsAtCompany"]=np.where(df["YearsAtCompany"]>upperlimit,5,df["Ye
arsAtCompany"])
sns.boxplot(df.YearsAtCompany)
```

```
<Axes: >
```




```
df["YearsInCurrentRole"]=np.where(df["YearsInCurrentRole"]>upperlimit,
5,df["YearsInCurrentRole"])
sns.boxplot(df.YearsInCurrentRole)

<Axes: >
```




```
x = df.drop('Attrition',axis=1)
y = df['Attrition']

x.head()
```

```
   Age     BusinessTravel  DailyRate              Department  \
0   41      Travel_Rarely       1102                   Sales
1   49  Travel_Frequently        279  Research & Development
2   37      Travel_Rarely       1373  Research & Development
3   33  Travel_Frequently       1392  Research & Development
4   27      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

   EnvironmentSatisfaction  ... RelationshipSatisfaction
```

```
StandardHours  \
0                         2  ...                         1
80
1                         3  ...                         4
80
2                         4  ...                         2
80
3                         4  ...                         3
80
4                         1  ...                         4
80

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

  YearsAtCompany  YearsInCurrentRole  YearsSinceLastPromotion  \
0              6                   4                        0
1             10                   7                        1
2              0                   0                        0
3              8                   7                        3
4              2                   2                        2

   YearsWithCurrManager
0                     5
1                     7
2                     0
3                     0
4                     2

[5 rows x 34 columns]
```

```
type(x)
```

```
pandas.core.frame.DataFrame
```

```
type(y)
```

```
pandas.core.series.Series
```

```
le = LabelEncoder()
x.BusinessTravel = le.fit_transform(x.BusinessTravel)
x.head()
```

```
   Age  BusinessTravel  DailyRate              Department
DistanceFromHome  \
0   41               2       1102                   Sales
1
1   49               1        279  Research & Development
8
2   37               2       1373  Research & Development
2
3   33               1       1392  Research & Development
3
4   27               2        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  ... RelationshipSatisfaction
StandardHours  \
0                        2  ...                        1
80
1                        3  ...                        4
80
2                        4  ...                        2
80
3                        4  ...                        3
80
4                        1  ...                        4
80

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

```
  YearsAtCompany  YearsInCurrentRole  YearsSinceLastPromotion  \
0              6                   4                        0
1             10                   7                        1
2              0                   0                        0
3              8                   7                        3
4              2                   2                        2

   YearsWithCurrManager
0                     5
1                     7
2                     0
3                     0
4                     2

[5 rows x 34 columns]
```

```
y = le.fit_transform(y)
y
```

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

```
x.Department = le.fit_transform(x.Department)
x.head()
```

```
   Age  BusinessTravel  DailyRate  Department  DistanceFromHome
Education  \
0   41               2       1102           2                 1
2
1   49               1        279           1                 8
1
2   37               2       1373           1                 2
2
3   33               1       1392           1                 3
4
4   27               2        591           1                 2
1

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

  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 34 columns]
```

```
x.EducationField = le.fit_transform(x.EducationField)
x.head()
```

```
   Age  BusinessTravel  DailyRate  Department  DistanceFromHome
Education  \
0   41               2       1102           2                 1
2
1   49               1        279           1                 8
1
2   37               2       1373           1                 2
2
3   33               1       1392           1                 3
4
4   27               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

   ... 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 34 columns]
```

```
x.Gender = le.fit_transform(x.Gender)
x.head()
```

```
   Age  BusinessTravel  DailyRate  Department  DistanceFromHome
Education  \
0   41               2       1102           2                 1
2
1   49               1        279           1                 8
1
2   37               2       1373           1                 2
2
3   33               1       1392           1                 3
4
4   27               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

   ...  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 34 columns]
```

```
x.MaritalStatus = le.fit_transform(x.MaritalStatus)
x.Over18 = le.fit_transform(x.Over18)
x.OverTime = le.fit_transform(x.OverTime)

x.JobRole = le.fit_transform(x.JobRole)
x.head()
```

```
   Age  BusinessTravel  DailyRate  Department  DistanceFromHome
Education  \
0   41               2       1102           2                 1
2
1   49               1        279           1                 8
1
2   37               2       1373           1                 2
2
3   33               1       1392           1                 3
4
4   27               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

   ...  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 34 columns]
```

```
ms = MinMaxScaler()

x_scaled= pd.DataFrame(ms.fit_transform(x),columns=x.columns)
x_scaled.head()
```

```
        Age  BusinessTravel  DailyRate  Department
DistanceFromHome  \
0  0.547619             1.0   0.715820         1.0          0.000000

1  0.738095             0.5   0.126700         0.5          0.250000

2  0.452381             1.0   0.909807         0.5          0.035714

3  0.357143             0.5   0.923407         0.5          0.071429

4  0.214286             1.0   0.350036         0.5          0.035714


   Education  EducationField  EmployeeCount  EmployeeNumber  \
0       0.25             0.2            0.0        0.000000
1       0.00             0.2            0.0        0.000484
2       0.25             0.8            0.0        0.001451
3       0.75             0.2            0.0        0.001935
4       0.00             0.6            0.0        0.002903

   EnvironmentSatisfaction  ...  RelationshipSatisfaction
StandardHours  \
0                 0.333333  ...                  0.000000
0.0
1                 0.666667  ...                  1.000000
0.0
2                 1.000000  ...                  0.333333
0.0
3                 1.000000  ...                  0.666667
0.0
4                 0.000000  ...                  1.000000
0.0

   StockOptionLevel  TotalWorkingYears  TrainingTimesLastYear  \
0          0.000000              0.200                    0.0
1          0.333333              0.250                    0.5
2          0.000000              0.175                    0.5
3          0.000000              0.200                    0.5
4          0.333333              0.150                    0.5

   WorkLifeBalance  YearsAtCompany  YearsInCurrentRole  \
```

```
0         0.000000        0.428571            0.285714
1         0.666667        0.714286            0.500000
2         0.666667        0.000000            0.000000
3         0.666667        0.571429            0.500000
4         0.666667        0.142857            0.142857

   YearsSinceLastPromotion  YearsWithCurrManager
0                 0.000000              0.294118
1                 0.066667              0.411765
2                 0.000000              0.000000
3                 0.200000              0.000000
4                 0.133333              0.117647

[5 rows x 34 columns]
```

```
x.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1470 entries, 0 to 1469
Data columns (total 34 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   Age                       1470 non-null   int64
 1   BusinessTravel            1470 non-null   int32
 2   DailyRate                 1470 non-null   int64
 3   Department                1470 non-null   int32
 4   DistanceFromHome          1470 non-null   int64
 5   Education                 1470 non-null   int64
 6   EducationField            1470 non-null   int32
 7   EmployeeCount             1470 non-null   int64
 8   EmployeeNumber            1470 non-null   int64
 9   EnvironmentSatisfaction   1470 non-null   int64
 10  Gender                    1470 non-null   int32
 11  HourlyRate                1470 non-null   int64
 12  JobInvolvement            1470 non-null   int64
 13  JobLevel                  1470 non-null   int64
 14  JobRole                   1470 non-null   int32
 15  JobSatisfaction           1470 non-null   int64
 16  MaritalStatus             1470 non-null   int32
 17  MonthlyIncome             1470 non-null   int64
 18  MonthlyRate               1470 non-null   int64
 19  NumCompaniesWorked        1470 non-null   int64
 20  Over18                    1470 non-null   int32
 21  OverTime                  1470 non-null   int32
 22  PercentSalaryHike         1470 non-null   int64
 23  PerformanceRating         1470 non-null   int64
 24  RelationshipSatisfaction  1470 non-null   int64
 25  StandardHours             1470 non-null   int64
 26  StockOptionLevel          1470 non-null   int64
 27  TotalWorkingYears         1470 non-null   int64
```

```
 28  TrainingTimesLastYear     1470 non-null   int64
 29  WorkLifeBalance           1470 non-null   int64
 30  YearsAtCompany            1470 non-null   int64
 31  YearsInCurrentRole        1470 non-null   int64
 32  YearsSinceLastPromotion   1470 non-null   int64
 33  YearsWithCurrManager      1470 non-null   int64
dtypes: int32(8), int64(26)
memory usage: 344.7 KB
```

```
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
```

```
((1176, 34), (294, 34), (1176,), (294,))
```

```
model = LogisticRegression()
```

```
model.fit(x_train,y_train)
pred = model.predict(x_test)
pred
```

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

```
y_test
```

```
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, 1, 0, 0, 0, 0, 1, 0, 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, 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,
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])
```

```
from sklearn.metrics import
accuracy_score,confusion_matrix,classification_report

accuracy_score(y_test,pred)
```

```
0.8843537414965986
```

```
confusion_matrix(y_test,pred)
```

```
array([[242,   3],
       [ 31,  18]], dtype=int64)
```

```
print(classification_report(y_test,pred))
```

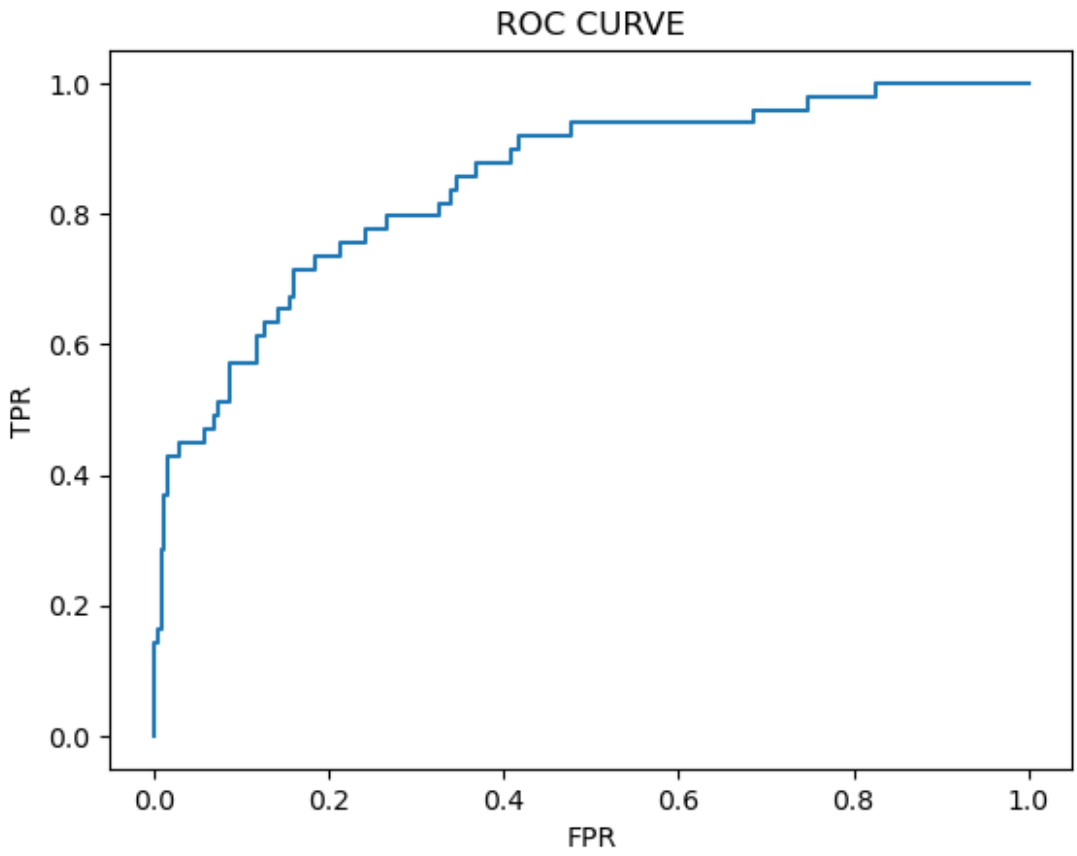
```
              precision    recall  f1-score   support

           0       0.89      0.99      0.93       245
           1       0.86      0.37      0.51        49

    accuracy                           0.88       294
   macro avg       0.87      0.68      0.72       294
weighted avg       0.88      0.88      0.86       294
```

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

probability
```

```
array([0.139689  , 0.19203157, 0.31762872, 0.06821401, 0.66363396,
       0.06679984, 0.6692895 , 0.05667544, 0.00984414, 0.37550747,
       0.0596486 , 0.32040693, 0.01766806, 0.66462849, 0.20449626,
       0.0332682 , 0.10081727, 0.17896119, 0.04726071, 0.19875051,
       0.24840018, 0.02118971, 0.05508412, 0.05624411, 0.59064156,
       0.39773941, 0.05798602, 0.03316344, 0.69770104, 0.06434571,
       0.01241986, 0.02760685, 0.08064678, 0.16501468, 0.08024179,
       0.03300692, 0.08621125, 0.06973968, 0.03323051, 0.05478155,
       0.07302527, 0.01685177, 0.04834498, 0.01790702, 0.02117587,
       0.50177468, 0.42499957, 0.00307051, 0.76272065, 0.52732192,
       0.11573632, 0.48139989, 0.07400635, 0.26197253, 0.68585166,
       0.28810255, 0.01881209, 0.31829355, 0.02780931, 0.17375126,
       0.01940688, 0.22571114, 0.15371747, 0.03446668, 0.40839461,
       0.03541442, 0.24579496, 0.12478435, 0.09620694, 0.0992372 ,
       0.10888532, 0.30043084, 0.06294337, 0.07266611, 0.12445761,
       0.06483562, 0.04834911, 0.07949782, 0.20225966, 0.02831225,
       0.00707532, 0.02164015, 0.14805975, 0.02530552, 0.02966628,
       0.0762403 , 0.01265841, 0.03303401, 0.03693788, 0.13816936,
       0.30154937, 0.16993445, 0.28437979, 0.24647952, 0.01774685,
       0.18495586, 0.35274329, 0.28497481, 0.07620371, 0.04856371,
       0.25508192, 0.75971301, 0.34218794, 0.01902584, 0.09592795,
       0.03063844, 0.04903468, 0.16168169, 0.05179291, 0.1244266 ,
       0.08483899, 0.04678438, 0.02684536, 0.14652185, 0.06109046,
       0.02971224, 0.04444413, 0.12514182, 0.00707973, 0.01073575,
       0.16198959, 0.04615528, 0.06739916, 0.82744548, 0.03365619,
       0.0338438 , 0.0093067 , 0.13406507, 0.17349546, 0.05046873,
       0.01565673, 0.26448719, 0.57952996, 0.32705869, 0.04297303,
       0.39117438, 0.58530873, 0.14395331, 0.07955263, 0.25760428,
       0.11126284, 0.06710735, 0.1009097 , 0.13775765, 0.19696915,
       0.02455285, 0.16436541, 0.01194276, 0.11728467, 0.1690352 ,
       0.06262844, 0.15916042, 0.06067153, 0.13343285, 0.03004275,
       0.02205602, 0.06416646, 0.07854048, 0.01222238, 0.01017505,
       0.46026173, 0.01474059, 0.16278495, 0.82419141, 0.11115106,
       0.28572252, 0.15394052, 0.14151269, 0.03102641, 0.00603303,
       0.03933842, 0.07883446, 0.12642862, 0.10828651, 0.04117055,
       0.14827404, 0.10452404, 0.13470889, 0.05100001, 0.10385795,
       0.03033568, 0.09692069, 0.00629245, 0.77914602, 0.04010393,
       0.03960355, 0.3924741 , 0.04246515, 0.75164761, 0.11066569,
       0.37636118, 0.39834024, 0.27148738, 0.05231632, 0.08634198,
       0.14695653, 0.04196124, 0.0125218 , 0.2799495 , 0.05173187,
       0.14802111, 0.15807771, 0.67948115, 0.06059042, 0.23203306,
       0.03257483, 0.4824282 , 0.00328   , 0.13866045, 0.02494448,
       0.11935202, 0.16602654, 0.05667975, 0.10376776, 0.15815346,
       0.02767992, 0.01908474, 0.07781499, 0.03243343, 0.14721138,
       0.08482637, 0.23384339, 0.74644943, 0.12150511, 0.39423689,
       0.0151262 , 0.12000733, 0.23015731, 0.34321134, 0.0366569 ,
```

```
       0.04065181, 0.32726154, 0.05440085, 0.01691351, 0.16887658,
       0.36840505, 0.24385847, 0.00747131, 0.08292112, 0.00903689,
       0.13802347, 0.27622546, 0.01151549, 0.16852845, 0.03704734,
       0.03618358, 0.43278276, 0.37149071, 0.03522335, 0.10998048,
       0.39416705, 0.31640703, 0.80951128, 0.04966195, 0.19133522,
       0.07099553, 0.005368  , 0.68465104, 0.37811123, 0.367362  ,
       0.36756812, 0.03401359, 0.26248562, 0.05986855, 0.06345854,
       0.10722762, 0.00694377, 0.23640487, 0.46213154, 0.07122532,
       0.09022254, 0.01262613, 0.15422746, 0.04787988, 0.01993732,
       0.02368743, 0.06355887, 0.25322214, 0.26058801, 0.20169548,
       0.28111899, 0.01582808, 0.162111  , 0.09351842, 0.02701473,
       0.19563321, 0.00809015, 0.23963531, 0.00733077, 0.02078013,
       0.20737464, 0.73363449, 0.0803108 , 0.28551904])
```

```python
from sklearn.metrics import roc_curve
fpr,tpr,threshsholds = roc_curve(y_test,probability)

plt.plot(fpr,tpr)
plt.xlabel('FPR')
plt.ylabel('TPR')
plt.title('ROC CURVE')
plt.show()
```



Decision Tree

```
from sklearn.tree import DecisionTreeClassifier
dt = DecisionTreeClassifier()

y_train

array([0, 0, 0, ..., 0, 0, 0])

dt.fit(x_train,y_train)

DecisionTreeClassifier()

pred = dt.predict(x_test)

pred

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

y_test

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, 1, 0, 0, 0, 0, 1, 0, 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])
```

```
accuracy_score(y_test,pred)
```

```
0.7721088435374149
```

```
confusion_matrix(y_test,pred)
```

```
array([[208,  37],
       [ 30,  19]], dtype=int64)
```

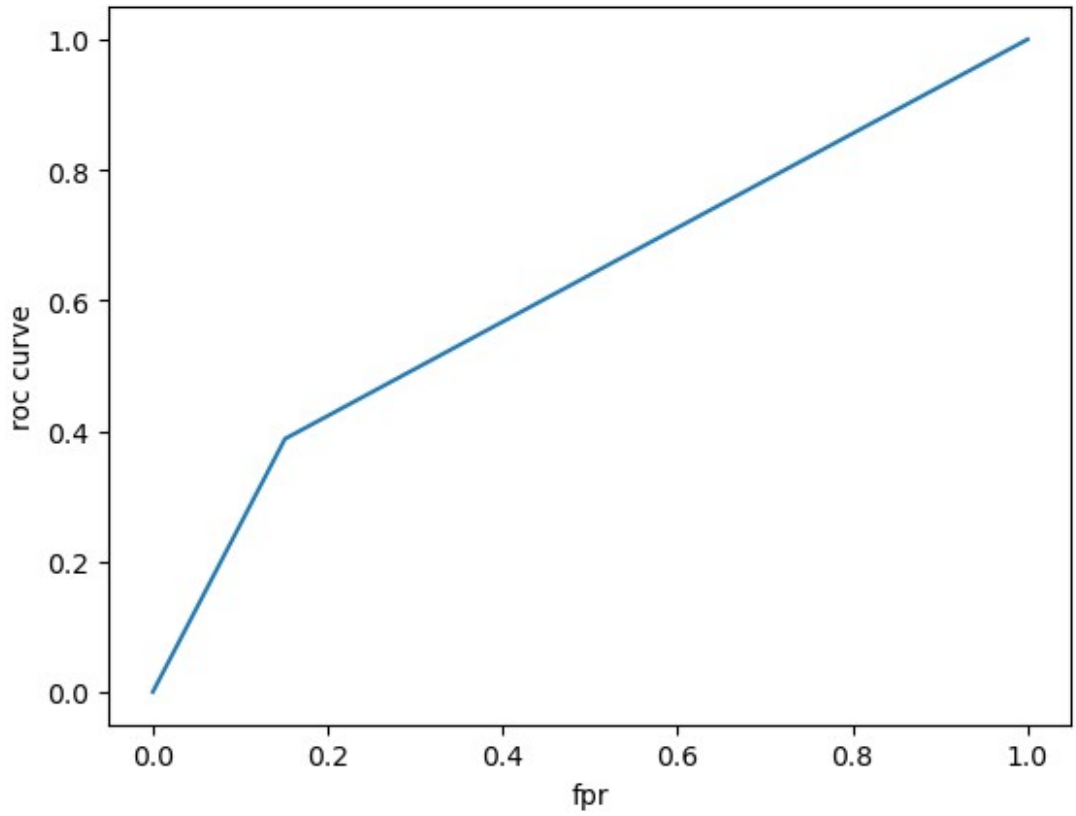
```
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

           0       0.87      0.85      0.86       245
           1       0.34      0.39      0.36        49

    accuracy                           0.77       294
   macro avg       0.61      0.62      0.61       294
weighted avg       0.78      0.77      0.78       294
```

```
probab = dt.predict_proba(x_test)[:,1]
probab
```

```
array([0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 1., 0., 0.,
0.,
       0., 0., 0., 1., 0., 0., 0., 1., 0., 0., 0., 1., 0., 0., 0., 0.,
0.,
```

```
       0., 0., 0., 0., 1., 0., 0., 0., 0., 1., 0., 0., 0., 0., 1., 1.,
0.,
       1., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 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., 1., 0., 0., 0., 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., 1., 0., 0., 0., 0., 0., 0., 0., 1., 1., 1., 0.,
0.,
       0., 0., 1., 0., 0., 0., 0., 0., 1., 0., 0., 1., 0., 0., 0., 0.,
0.,
       0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0.,
0.,
       0., 0., 0., 0., 0., 1., 0., 1., 1., 0., 0., 0., 0., 1., 0., 0.,
1.,
       1., 0., 1., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1.,
0.,
       1., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 1.,
0.,
       0., 1., 0., 0., 0., 0., 1., 1., 0., 0., 1., 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., 1., 0., 0., 1., 0., 1., 0., 0., 0.,
0.,
       0., 0., 0., 0., 1., 0., 0., 1., 0., 0., 1., 1., 0., 1., 0., 0.,
0.,
       0., 0., 0., 0., 0.])

fpr,tpr,threshsholds = roc_curve(y_test,probab)

plt.plot(fpr,tpr)
plt.xlabel('fpr')
plt.ylabel('roc curve')
plt.show()
```




```
from sklearn import tree
plt.figure(figsize = (25,25))
tree.plot_tree(dt,filled= True)
```

```
[Text(0.330265035118525, 0.9705882352941176, 'x[27] <= 0.038\ngini =
0.269\nsamples = 1176\nvalue = [988, 188]'),
 Text(0.08428446005267778, 0.9117647058823529, 'x[16] <= 0.75\ngini =
0.5\nsamples = 78\nvalue = [39, 39]'),
 Text(0.05267778753292362, 0.8529411764705882, 'x[4] <= 0.554\ngini =
0.426\nsamples = 39\nvalue = [27, 12]'),
 Text(0.03511852502194908, 0.7941176470588235, 'x[15] <= 0.167\ngini =
0.312\nsamples = 31\nvalue = [25, 6]'),
 Text(0.021071115013169446, 0.7352941176470589, 'x[16] <= 0.25\ngini =
0.49\nsamples = 7\nvalue = [3, 4]'),
 Text(0.014047410008779631, 0.6764705882352942, 'x[21] <= 0.5\ngini =
0.375\nsamples = 4\nvalue = [3, 1]'),
 Text(0.007023705004389816, 0.6176470588235294, 'gini = 0.0\nsamples =
3\nvalue = [3, 0]'),
 Text(0.021071115013169446, 0.6176470588235294, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.028094820017559263, 0.6764705882352942, 'gini = 0.0\nsamples =
3\nvalue = [0, 3]'),
 Text(0.04916593503072871, 0.7352941176470589, 'x[19] <= 0.056\ngini =
0.153\nsamples = 24\nvalue = [22, 2]'),
```

```
 Text(0.04214223002633889, 0.6764705882352942, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.056189640035118525, 0.6764705882352942, 'x[9] <= 0.167\ngini =
0.083\nsamples = 23\nvalue = [22, 1]'),
 Text(0.04916593503072871, 0.6176470588235294, 'x[28] <= 0.583\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.04214223002633889, 0.5588235294117647, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.056189640035118525, 0.5588235294117647, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.06321334503950835, 0.6176470588235294, 'gini = 0.0\nsamples =
21\nvalue = [21, 0]'),
 Text(0.07023705004389816, 0.7941176470588235, 'x[8] <= 0.385\ngini =
0.375\nsamples = 8\nvalue = [2, 6]'),
 Text(0.06321334503950835, 0.7352941176470589, 'gini = 0.0\nsamples =
2\nvalue = [2, 0]'),
 Text(0.07726075504828797, 0.7352941176470589, 'gini = 0.0\nsamples =
6\nvalue = [0, 6]'),
 Text(0.11589113257243196, 0.8529411764705882, 'x[11] <= 0.364\ngini =
0.426\nsamples = 39\nvalue = [12, 27]'),
 Text(0.09833187006145742, 0.7941176470588235, 'x[0] <= 0.369\ngini =
0.133\nsamples = 14\nvalue = [1, 13]'),
 Text(0.0913081650570676, 0.7352941176470589, 'gini = 0.0\nsamples =
13\nvalue = [0, 13]'),
 Text(0.10535557506584724, 0.7352941176470589, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.1334503950834065, 0.7941176470588235, 'x[8] <= 0.105\ngini =
0.493\nsamples = 25\nvalue = [11, 14]'),
 Text(0.11940298507462686, 0.7352941176470589, 'x[22] <= 0.464\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
 Text(0.11237928007023705, 0.6764705882352942, 'gini = 0.0\nsamples =
5\nvalue = [5, 0]'),
 Text(0.1264266900790167, 0.6764705882352942, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.14749780509218613, 0.7352941176470589, 'x[15] <= 0.5\ngini =
0.432\nsamples = 19\nvalue = [6, 13]'),
 Text(0.14047410008779632, 0.6764705882352942, 'gini = 0.0\nsamples =
7\nvalue = [0, 7]'),
 Text(0.15452151009657594, 0.6764705882352942, 'x[6] <= 0.4\ngini =
0.5\nsamples = 12\nvalue = [6, 6]'),
 Text(0.14047410008779632, 0.6176470588235294, 'x[14] <= 0.875\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
 Text(0.1334503950834065, 0.5588235294117647, 'gini = 0.0\nsamples =
5\nvalue = [5, 0]'),
 Text(0.14749780509218613, 0.5588235294117647, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.16856892010535557, 0.6176470588235294, 'x[8] <= 0.249\ngini =
0.278\nsamples = 6\nvalue = [1, 5]'),
 Text(0.16154521510096576, 0.5588235294117647, 'gini = 0.0\nsamples =
```

```
1\nvalue = [1, 0]'),
 Text(0.17559262510974538, 0.5588235294117647, 'gini = 0.0\nsamples =
5\nvalue = [0, 5]'),
 Text(0.5762456101843723, 0.9117647058823529, 'x[21] <= 0.5\ngini =
0.235\nsamples = 1098\nvalue = [949, 149]'),
 Text(0.3377414398595259, 0.8529411764705882, 'x[29] <= 0.167\ngini =
0.162\nsamples = 798\nvalue = [727, 71]'),
 Text(0.18964003511852504, 0.7941176470588235, 'x[8] <= 0.445\ngini =
0.38\nsamples = 47\nvalue = [35, 12]'),
 Text(0.17559262510974538, 0.7352941176470589, 'x[16] <= 0.75\ngini =
0.1\nsamples = 19\nvalue = [18, 1]'),
 Text(0.16856892010535557, 0.6764705882352942, 'gini = 0.0\nsamples =
18\nvalue = [18, 0]'),
 Text(0.1826163301141352, 0.6764705882352942, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.20368744512730466, 0.7352941176470589, 'x[17] <= 0.094\ngini =
0.477\nsamples = 28\nvalue = [17, 11]'),
 Text(0.19666374012291485, 0.6764705882352942, 'gini = 0.0\nsamples =
4\nvalue = [0, 4]'),
 Text(0.21071115013169447, 0.6764705882352942, 'x[8] <= 0.524\ngini =
0.413\nsamples = 24\nvalue = [17, 7]'),
 Text(0.20368744512730466, 0.6176470588235294, 'gini = 0.0\nsamples =
2\nvalue = [0, 2]'),
 Text(0.2177348551360843, 0.6176470588235294, 'x[33] <= 0.324\ngini =
0.351\nsamples = 22\nvalue = [17, 5]'),
 Text(0.20368744512730466, 0.5588235294117647, 'x[2] <= 0.025\ngini =
0.133\nsamples = 14\nvalue = [13, 1]'),
 Text(0.19666374012291485, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0,
1]'),
 Text(0.21071115013169447, 0.5, 'gini = 0.0\nsamples = 13\nvalue =
[13, 0]'),
 Text(0.2317822651448639, 0.5588235294117647, 'x[2] <= 0.329\ngini =
0.5\nsamples = 8\nvalue = [4, 4]'),
 Text(0.2247585601404741, 0.5, 'gini = 0.0\nsamples = 3\nvalue = [0,
3]'),
 Text(0.23880597014925373, 0.5, 'x[12] <= 0.333\ngini = 0.32\nsamples
= 5\nvalue = [4, 1]'),
 Text(0.2317822651448639, 0.4411764705882353, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.24582967515364354, 0.4411764705882353, 'gini = 0.0\nsamples =
4\nvalue = [4, 0]'),
 Text(0.4858428446005268, 0.7941176470588235, 'x[27] <= 0.975\ngini =
0.145\nsamples = 751\nvalue = [692, 59]'),
 Text(0.47881913959613 7, 0.7352941176470589, 'x[30] <= 0.321\ngini =
0.143\nsamples = 750\nvalue = [692, 58]'),
 Text(0.36479367866549606, 0.6764705882352942, 'x[9] <= 0.167\ngini =
0.218\nsamples = 257\nvalue = [225, 32]'),
 Text(0.32133450395083407, 0.6176470588235294, 'x[33] <= 0.147\ngini =
0.355\nsamples = 65\nvalue = [50, 15]'),
```

```
 Text(0.29850746268656714, 0.5588235294117647, 'x[33] <= 0.029\ngini =
0.303\nsamples = 59\nvalue = [48, 11]'),
 Text(0.2739244951712028, 0.5, 'x[12] <= 0.5\ngini = 0.463\nsamples =
22\nvalue = [14, 8]'),
 Text(0.2598770851624232, 0.4411764705882353, 'x[11] <= 0.179\ngini =
0.198\nsamples = 9\nvalue = [8, 1]'),
 Text(0.2528533801580334, 0.38235294117647056, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.266900790166813, 0.38235294117647056, 'gini = 0.0\nsamples =
8\nvalue = [8, 0]'),
 Text(0.28797190517998245, 0.4411764705882353, 'x[11] <= 0.4\ngini =
0.497\nsamples = 13\nvalue = [6, 7]'),
 Text(0.28094820017559263, 0.38235294117647056, 'gini = 0.0\nsamples =
4\nvalue = [4, 0]'),
 Text(0.29499561018437226, 0.38235294117647056, 'x[4] <= 0.286\ngini =
0.346\nsamples = 9\nvalue = [2, 7]'),
 Text(0.28797190517998245, 0.3235294117647059, 'x[19] <= 0.944\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
 Text(0.28094820017559263, 0.2647058823529412, 'gini = 0.0\nsamples =
2\nvalue = [2, 0]'),
 Text(0.29499561018437226, 0.2647058823529412, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.30201931518876207, 0.3235294117647059, 'gini = 0.0\nsamples =
6\nvalue = [0, 6]'),
 Text(0.3230904302019315, 0.5, 'x[15] <= 0.167\ngini = 0.149\nsamples
= 37\nvalue = [34, 3]'),
 Text(0.3160667251975417, 0.4411764705882353, 'x[29] <= 0.5\ngini =
0.5\nsamples = 6\nvalue = [3, 3]'),
 Text(0.3090430201931519, 0.38235294117647056, 'gini = 0.0\nsamples =
3\nvalue = [3, 0]'),
 Text(0.3230904302019315, 0.38235294117647056, 'gini = 0.0\nsamples =
3\nvalue = [0, 3]'),
 Text(0.3301141352063213, 0.4411764705882353, 'gini = 0.0\nsamples =
31\nvalue = [31, 0]'),
 Text(0.34416154521510095, 0.5588235294117647, 'x[8] <= 0.065\ngini =
0.444\nsamples = 6\nvalue = [2, 4]'),
 Text(0.33713784021071114, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [2,
0]'),
 Text(0.35118525021949076, 0.5, 'gini = 0.0\nsamples = 4\nvalue = [0,
4]'),
 Text(0.40825285338015804, 0.6176470588235294, 'x[0] <= 0.321\ngini =
0.161\nsamples = 192\nvalue = [175, 17]'),
 Text(0.3722563652326602, 0.5588235294117647, 'x[6] <= 0.1\ngini =
0.294\nsamples = 67\nvalue = [55, 12]'),
 Text(0.3652326602282704, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0,
2]'),
 Text(0.37928007023705007, 0.5, 'x[29] <= 0.5\ngini = 0.26\nsamples =
65\nvalue = [55, 10]'),
 Text(0.3617208077260755, 0.4411764705882353, 'x[11] <= 0.679\ngini =
```

```
0.469\nsamples = 16\nvalue = [10, 6]'),
 Text(0.3546971027216857, 0.38235294117647056, 'x[4] <= 0.018\ngini =
0.444\nsamples = 9\nvalue = [3, 6]'),
 Text(0.3476733977172959, 0.3235294117647059, 'gini = 0.0\nsamples =
2\nvalue = [2, 0]'),
 Text(0.3617208077260755, 0.3235294117647059, 'x[1] <= 0.25\ngini =
0.245\nsamples = 7\nvalue = [1, 6]'),
 Text(0.3546971027216857, 0.2647058823529412, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.3687445127304653, 0.2647058823529412, 'gini = 0.0\nsamples =
6\nvalue = [0, 6]'),
 Text(0.3687445127304653, 0.38235294117647056, 'gini = 0.0\nsamples =
7\nvalue = [7, 0]'),
 Text(0.3968393327480246, 0.4411764705882353, 'x[2] <= 0.037\ngini =
0.15\nsamples = 49\nvalue = [45, 4]'),
 Text(0.38981562774363476, 0.38235294117647056, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.4038630377524144, 0.38235294117647056, 'x[2] <= 0.938\ngini =
0.117\nsamples = 48\nvalue = [45, 3]'),
 Text(0.3968393327480246, 0.3235294117647059, 'x[5] <= 0.875\ngini =
0.081\nsamples = 47\nvalue = [45, 2]'),
 Text(0.38279192273924495, 0.2647058823529412, 'x[12] <= 0.167\ngini =
0.043\nsamples = 45\nvalue = [44, 1]'),
 Text(0.37576821773485514, 0.20588235294117646, 'x[14] <= 0.625\ngini
= 0.444\nsamples = 3\nvalue = [2, 1]'),
 Text(0.3687445127304653, 0.14705882352941177, 'gini = 0.0\nsamples =
2\nvalue = [2, 0]'),
 Text(0.38279192273924495, 0.14705882352941177, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.38981562774363476, 0.20588235294117646, 'gini = 0.0\nsamples =
42\nvalue = [42, 0]'),
 Text(0.4108867427568042, 0.2647058823529412, 'x[27] <= 0.125\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.4038630377524144, 0.20588235294117646, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.417910447761194, 0.20588235294117646, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.4108867427568042, 0.3235294117647059, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.4442493415276558, 0.5588235294117647, 'x[8] <= 0.022\ngini =
0.077\nsamples = 125\nvalue = [120, 5]'),
 Text(0.42493415276558383, 0.5, 'x[2] <= 0.578\ngini = 0.5\nsamples =
4\nvalue = [2, 2]'),
 Text(0.417910447761194, 0.4411764705882353, 'gini = 0.0\nsamples = 2\
nvalue = [0, 2]'),
 Text(0.43195785776997364, 0.4411764705882353, 'gini = 0.0\nsamples =
2\nvalue = [2, 0]'),
 Text(0.4635645302897278, 0.5, 'x[18] <= 0.968\ngini = 0.048\nsamples
= 121\nvalue = [118, 3]'),
```

```
 Text(0.44600526777875327, 0.4411764705882353, 'x[2] <= 0.98\ngini =
0.033\nsamples = 118\nvalue = [116, 2]'),
 Text(0.43195785776997364, 0.38235294117647056, 'x[14] <= 0.938\ngini
= 0.017\nsamples = 114\nvalue = [113, 1]'),
 Text(0.42493415276558383, 0.3235294117647059, 'gini = 0.0\nsamples =
107\nvalue = [107, 0]'),
 Text(0.43898156277436345, 0.3235294117647059, 'x[16] <= 0.25\ngini =
0.245\nsamples = 7\nvalue = [6, 1]'),
 Text(0.43195785776997364, 0.2647058823529412, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.44600526777875327, 0.2647058823529412, 'gini = 0.0\nsamples =
6\nvalue = [6, 0]'),
 Text(0.46005267778753295, 0.38235294117647056, 'x[19] <= 0.833\ngini
= 0.375\nsamples = 4\nvalue = [3, 1]'),
 Text(0.45302897278314314, 0.3235294117647059, 'gini = 0.0\nsamples =
3\nvalue = [3, 0]'),
 Text(0.46707638279192276, 0.3235294117647059, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.4811237928007024, 0.4411764705882353, 'x[6] <= 0.9\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
 Text(0.4741000877963126, 0.38235294117647056, 'gini = 0.0\nsamples =
2\nvalue = [2, 0]'),
 Text(0.4881474978050922, 0.38235294117647056, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.5928446005267779, 0.6764705882352942, 'x[31] <= 0.964\ngini =
0.1\nsamples = 493\nvalue = [467, 26]'),
 Text(0.5649692712906058, 0.6176470588235294, 'x[15] <= 0.167\ngini =
0.097\nsamples = 491\nvalue = [466, 25]'),
 Text(0.5302897278314311, 0.5588235294117647, 'x[14] <= 0.938\ngini =
0.185\nsamples = 97\nvalue = [87, 10]'),
 Text(0.5232660228270413, 0.5, 'x[19] <= 0.944\ngini = 0.17\nsamples =
96\nvalue = [87, 9]'),
 Text(0.5092186128182616, 0.4411764705882353, 'x[0] <= 0.44\ngini =
0.142\nsamples = 91\nvalue = [84, 7]'),
 Text(0.5021949078138718, 0.38235294117647056, 'x[22] <= 0.75\ngini =
0.241\nsamples = 50\nvalue = [43, 7]'),
 Text(0.495171202809482, 0.3235294117647059, 'x[33] <= 0.794\ngini =
0.215\nsamples = 49\nvalue = [43, 6]'),
 Text(0.4881474978050922, 0.2647058823529412, 'x[19] <= 0.389\ngini =
0.187\nsamples = 48\nvalue = [43, 5]'),
 Text(0.46707638279192276, 0.20588235294117646, 'x[17] <= 0.399\ngini
= 0.097\nsamples = 39\nvalue = [37, 2]'),
 Text(0.46005267778753295, 0.14705882352941177, 'gini = 0.0\nsamples =
32\nvalue = [32, 0]'),
 Text(0.4741000877963126, 0.14705882352941177, 'x[12] <= 0.5\ngini =
0.408\nsamples = 7\nvalue = [5, 2]'),
 Text(0.46707638279192276, 0.08823529411764706, 'x[10] <= 0.5\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(0.46005267778753295, 0.029411764705882353, 'gini = 0.0\nsamples
```

```
= 1\nvalue = [1, 0]'),
 Text(0.4741000877963126, 0.029411764705882353, 'gini = 0.0\nsamples =
2\nvalue = [0, 2]'),
 Text(0.4811237928007024, 0.08823529411764706, 'gini = 0.0\nsamples =
4\nvalue = [4, 0]'),
 Text(0.5092186128182616, 0.20588235294117646, 'x[2] <= 0.262\ngini =
0.444\nsamples = 9\nvalue = [6, 3]'),
 Text(0.5021949078138718, 0.14705882352941177, 'x[17] <= 0.075\ngini =
0.375\nsamples = 4\nvalue = [1, 3]'),
 Text(0.495171202809482, 0.08823529411764706, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.5092186128182616, 0.08823529411764706, 'gini = 0.0\nsamples =
3\nvalue = [0, 3]'),
 Text(0.5162423178226514, 0.14705882352941177, 'gini = 0.0\nsamples =
5\nvalue = [5, 0]'),
 Text(0.5021949078138718, 0.2647058823529412, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.5092186128182616, 0.3235294117647059, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.5162423178226514, 0.38235294117647056, 'gini = 0.0\nsamples =
41\nvalue = [41, 0]'),
 Text(0.5373134328358209, 0.4411764705882353, 'x[17] <= 0.531\ngini =
0.48\nsamples = 5\nvalue = [3, 2]'),
 Text(0.5302897278314311, 0.38235294117647056, 'gini = 0.0\nsamples =
2\nvalue = [0, 2]'),
 Text(0.5443371378402108, 0.38235294117647056, 'gini = 0.0\nsamples =
3\nvalue = [3, 0]'),
 Text(0.5373134328358209, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0,
1]'),
 Text(0.5996488147497805, 0.5588235294117647, 'x[22] <= 0.036\ngini =
0.073\nsamples = 394\nvalue = [379, 15]'),
 Text(0.57243195785777, 0.5, 'x[32] <= 0.7\ngini = 0.198\nsamples =
63\nvalue = [56, 7]'),
 Text(0.5654082528533801, 0.4411764705882353, 'x[28] <= 0.417\ngini =
0.175\nsamples = 62\nvalue = [56, 6]'),
 Text(0.5583845478489904, 0.38235294117647056, 'x[11] <= 0.071\ngini =
0.278\nsamples = 36\nvalue = [30, 6]'),
 Text(0.5513608428446005, 0.3235294117647059, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.5654082528533801, 0.3235294117647059, 'x[15] <= 0.5\ngini =
0.245\nsamples = 35\nvalue = [30, 5]'),
 Text(0.5513608428446005, 0.2647058823529412, 'x[27] <= 0.275\ngini =
0.469\nsamples = 8\nvalue = [5, 3]'),
 Text(0.5443371378402108, 0.20588235294117646, 'x[16] <= 0.25\ngini =
0.375\nsamples = 4\nvalue = [1, 3]'),
 Text(0.5373134328358209, 0.14705882352941177, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.5513608428446005, 0.14705882352941177, 'gini = 0.0\nsamples =
3\nvalue = [0, 3]'),
```

```
 Text(0.5583845478489904, 0.20588235294117646, 'gini = 0.0\nsamples =
4\nvalue = [4, 0]'),
 Text(0.5794556628621598, 0.2647058823529412, 'x[0] <= 0.595\ngini =
0.137\nsamples = 27\nvalue = [25, 2]'),
 Text(0.57243195785777, 0.20588235294117646, 'gini = 0.0\nsamples =
21\nvalue = [21, 0]'),
 Text(0.5864793678665496, 0.20588235294117646, 'x[9] <= 0.333\ngini =
0.444\nsamples = 6\nvalue = [4, 2]'),
 Text(0.5794556628621598, 0.14705882352941177, 'gini = 0.0\nsamples =
2\nvalue = [0, 2]'),
 Text(0.5935030728709394, 0.14705882352941177, 'gini = 0.0\nsamples =
4\nvalue = [4, 0]'),
 Text(0.57243195785777, 0.38235294117647056, 'gini = 0.0\nsamples =
26\nvalue = [26, 0]'),
 Text(0.5794556628621598, 0.4411764705882353, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.6268656716417911, 0.5, 'x[2] <= 0.03\ngini = 0.047\nsamples =
331\nvalue = [323, 8]'),
 Text(0.5935030728709394, 0.4411764705882353, 'x[17] <= 0.346\ngini =
0.298\nsamples = 11\nvalue = [9, 2]'),
 Text(0.5864793678665496, 0.38235294117647056, 'gini = 0.0\nsamples =
8\nvalue = [8, 0]'),
 Text(0.6005267778753293, 0.38235294117647056, 'x[14] <= 0.625\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(0.5935030728709394, 0.3235294117647059, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.607550482879719, 0.3235294117647059, 'gini = 0.0\nsamples = 2\
nvalue = [0, 2]'),
 Text(0.6602282704126426, 0.4411764705882353, 'x[0] <= 0.655\ngini =
0.037\nsamples = 320\nvalue = [314, 6]'),
 Text(0.6356453028972783, 0.38235294117647056, 'x[17] <= 0.056\ngini =
0.015\nsamples = 265\nvalue = [263, 2]'),
 Text(0.6215978928884986, 0.3235294117647059, 'x[28] <= 0.25\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
 Text(0.6145741878841089, 0.2647058823529412, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.6286215978928885, 0.2647058823529412, 'gini = 0.0\nsamples =
4\nvalue = [4, 0]'),
 Text(0.6496927129060579, 0.3235294117647059, 'x[33] <= 0.088\ngini =
0.008\nsamples = 260\nvalue = [259, 1]'),
 Text(0.6426690079016681, 0.2647058823529412, 'x[14] <= 0.312\ngini =
0.083\nsamples = 23\nvalue = [22, 1]'),
 Text(0.6356453028972783, 0.20588235294117646, 'x[24] <= 0.167\ngini =
0.375\nsamples = 4\nvalue = [3, 1]'),
 Text(0.6286215978928885, 0.14705882352941177, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.6426690079016681, 0.14705882352941177, 'gini = 0.0\nsamples =
3\nvalue = [3, 0]'),
 Text(0.6496927129060579, 0.20588235294117646, 'gini = 0.0\nsamples =
```

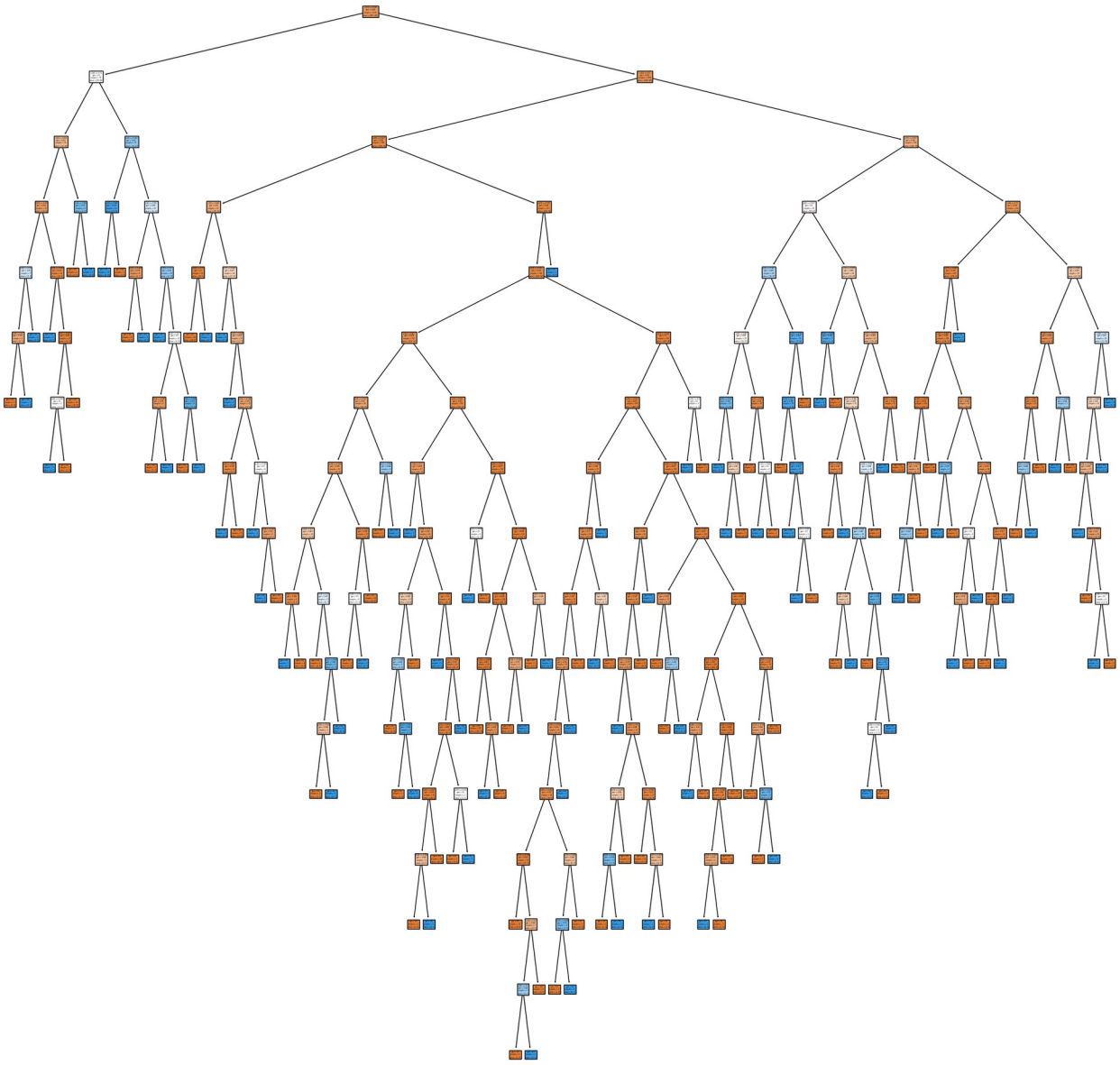
```
19\nvalue = [19, 0]'),
 Text(0.6567164179104478, 0.2647058823529412, 'gini = 0.0\nsamples =
237\nvalue = [237, 0]'),
 Text(0.684811237928007, 0.38235294117647056, 'x[17] <= 0.49\ngini =
0.135\nsamples = 55\nvalue = [51, 4]'),
 Text(0.6777875329236172, 0.3235294117647059, 'x[17] <= 0.32\ngini =
0.346\nsamples = 18\nvalue = [14, 4]'),
 Text(0.6707638279192274, 0.2647058823529412, 'gini = 0.0\nsamples =
13\nvalue = [13, 0]'),
 Text(0.684811237928007, 0.2647058823529412, 'x[16] <= 0.25\ngini =
0.32\nsamples = 5\nvalue = [1, 4]'),
 Text(0.6777875329236172, 0.20588235294117646, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.6918349429323969, 0.20588235294117646, 'gini = 0.0\nsamples =
4\nvalue = [0, 4]'),
 Text(0.6918349429323969, 0.3235294117647059, 'gini = 0.0\nsamples =
37\nvalue = [37, 0]'),
 Text(0.62071992976295, 0.6176470588235294, 'x[32] <= 0.6\ngini = 0.5\
nsamples = 2\nvalue = [1, 1]'),
 Text(0.6136962247585601, 0.5588235294117647, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.6277436347673397, 0.5588235294117647, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.4928665496049166, 0.7352941176470589, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.8147497805092186, 0.8529411764705882, 'x[17] <= 0.157\ngini =
0.385\nsamples = 300\nvalue = [222, 78]'),
 Text(0.723441615452151, 0.7941176470588235, 'x[26] <= 0.167\ngini =
0.5\nsamples = 96\nvalue = [49, 47]'),
 Text(0.6874451273046532, 0.7352941176470589, 'x[4] <= 0.161\ngini =
0.459\nsamples = 42\nvalue = [15, 27]'),
 Text(0.6628621597892889, 0.6764705882352942, 'x[8] <= 0.415\ngini =
0.499\nsamples = 23\nvalue = [12, 11]'),
 Text(0.6488147497805092, 0.6176470588235294, 'x[18] <= 0.561\ngini =
0.355\nsamples = 13\nvalue = [3, 10]'),
 Text(0.6417910447761194, 0.5588235294117647, 'gini = 0.0\nsamples =
8\nvalue = [0, 8]'),
 Text(0.655838454784899, 0.5588235294117647, 'x[9] <= 0.333\ngini =
0.48\nsamples = 5\nvalue = [3, 2]'),
 Text(0.6488147497805092, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0,
2]'),
 Text(0.6628621597892889, 0.5, 'gini = 0.0\nsamples = 3\nvalue = [3,
0]'),
 Text(0.6769095697980685, 0.6176470588235294, 'x[3] <= 0.75\ngini =
0.18\nsamples = 10\nvalue = [9, 1]'),
 Text(0.6698858647936786, 0.5588235294117647, 'gini = 0.0\nsamples =
8\nvalue = [8, 0]'),
 Text(0.6839332748024582, 0.5588235294117647, 'x[5] <= 0.625\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
```

```
 Text(0.6769095697980685, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0,
1]'),
 Text(0.6909569798068481, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [1,
0]'),
 Text(0.7120280948200176, 0.6764705882352942, 'x[27] <= 0.35\ngini =
0.266\nsamples = 19\nvalue = [3, 16]'),
 Text(0.7050043898156277, 0.6176470588235294, 'x[11] <= 0.2\ngini =
0.198\nsamples = 18\nvalue = [2, 16]'),
 Text(0.6979806848112379, 0.5588235294117647, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.7120280948200176, 0.5588235294117647, 'x[31] <= 0.393\ngini =
0.111\nsamples = 17\nvalue = [1, 16]'),
 Text(0.7050043898156277, 0.5, 'gini = 0.0\nsamples = 15\nvalue = [0,
15]'),
 Text(0.7190517998244074, 0.5, 'x[0] <= 0.44\ngini = 0.5\nsamples = 2\
nvalue = [1, 1]'),
 Text(0.7120280948200176, 0.4411764705882353, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.7260755048287972, 0.4411764705882353, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.7190517998244074, 0.6176470588235294, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.7594381035996488, 0.7352941176470589, 'x[0] <= 0.202\ngini =
0.466\nsamples = 54\nvalue = [34, 20]'),
 Text(0.7401229148375769, 0.6764705882352942, 'x[12] <= 0.833\ngini =
0.245\nsamples = 7\nvalue = [1, 6]'),
 Text(0.733099209833187, 0.6176470588235294, 'gini = 0.0\nsamples = 6\
nvalue = [0, 6]'),
 Text(0.7471466198419666, 0.6176470588235294, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.7787532923617209, 0.6764705882352942, 'x[2] <= 0.622\ngini =
0.418\nsamples = 47\nvalue = [33, 14]'),
 Text(0.7611940298507462, 0.6176470588235294, 'x[2] <= 0.145\ngini =
0.482\nsamples = 32\nvalue = [19, 13]'),
 Text(0.7471466198419666, 0.5588235294117647, 'x[30] <= 0.679\ngini =
0.18\nsamples = 10\nvalue = [9, 1]'),
 Text(0.7401229148375769, 0.5, 'gini = 0.0\nsamples = 9\nvalue = [9,
0]'),
 Text(0.7541703248463565, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0,
1]'),
 Text(0.7752414398595259, 0.5588235294117647, 'x[18] <= 0.87\ngini =
0.496\nsamples = 22\nvalue = [10, 12]'),
 Text(0.7682177348551361, 0.5, 'x[8] <= 0.41\ngini = 0.465\nsamples =
19\nvalue = [7, 12]'),
 Text(0.7541703248463565, 0.4411764705882353, 'x[18] <= 0.715\ngini =
0.469\nsamples = 8\nvalue = [5, 3]'),
 Text(0.7471466198419666, 0.38235294117647056, 'gini = 0.0\nsamples =
5\nvalue = [5, 0]'),
 Text(0.7611940298507462, 0.38235294117647056, 'gini = 0.0\nsamples =
```

```
3\nvalue = [0, 3]'),
 Text(0.7822651448639157, 0.4411764705882353, 'x[0] <= 0.25\ngini =
0.298\nsamples = 11\nvalue = [2, 9]'),
 Text(0.7752414398595259, 0.38235294117647056, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.7892888498683055, 0.38235294117647056, 'x[3] <= 0.25\ngini =
0.18\nsamples = 10\nvalue = [1, 9]'),
 Text(0.7822651448639157, 0.3235294117647059, 'x[18] <= 0.063\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
 Text(0.7752414398595259, 0.2647058823529412, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.7892888498683055, 0.2647058823529412, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.7963125548726954, 0.3235294117647059, 'gini = 0.0\nsamples =
8\nvalue = [0, 8]'),
 Text(0.7822651448639157, 0.5, 'gini = 0.0\nsamples = 3\nvalue = [3,
0]'),
 Text(0.7963125548726954, 0.6176470588235294, 'x[11] <= 0.064\ngini =
0.124\nsamples = 15\nvalue = [14, 1]'),
 Text(0.7892888498683055, 0.5588235294117647, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.8033362598770851, 0.5588235294117647, 'gini = 0.0\nsamples =
14\nvalue = [14, 0]'),
 Text(0.9060579455662863, 0.7941176470588235, 'x[16] <= 0.75\ngini =
0.258\nsamples = 204\nvalue = [173, 31]'),
 Text(0.8507462686567164, 0.7352941176470589, 'x[17] <= 0.992\ngini =
0.138\nsamples = 147\nvalue = [136, 11]'),
 Text(0.8437225636523266, 0.6764705882352942, 'x[4] <= 0.482\ngini =
0.128\nsamples = 146\nvalue = [136, 10]'),
 Text(0.8244073748902546, 0.6176470588235294, 'x[30] <= 0.179\ngini =
0.038\nsamples = 104\nvalue = [102, 2]'),
 Text(0.8173836698858647, 0.5588235294117647, 'x[11] <= 0.193\ngini =
0.32\nsamples = 10\nvalue = [8, 2]'),
 Text(0.810359964881475, 0.5, 'x[17] <= 0.599\ngini = 0.444\nsamples =
3\nvalue = [1, 2]'),
 Text(0.8033362598770851, 0.4411764705882353, 'gini = 0.0\nsamples =
2\nvalue = [0, 2]'),
 Text(0.8173836698858647, 0.4411764705882353, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.8244073748902546, 0.5, 'gini = 0.0\nsamples = 7\nvalue = [7,
0]'),
 Text(0.8314310798946444, 0.5588235294117647, 'gini = 0.0\nsamples =
94\nvalue = [94, 0]'),
 Text(0.8630377524143986, 0.6176470588235294, 'x[9] <= 0.167\ngini =
0.308\nsamples = 42\nvalue = [34, 8]'),
 Text(0.845478489903424, 0.5588235294117647, 'x[2] <= 0.736\ngini =
0.375\nsamples = 4\nvalue = [1, 3]'),
 Text(0.8384547848990342, 0.5, 'gini = 0.0\nsamples = 3\nvalue = [0,
3]'),
 Text(0.8525021949078139, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [1,
```

```
0]'),
 Text(0.8805970149253731, 0.5588235294117647, 'x[0] <= 0.393\ngini =
0.229\nsamples = 38\nvalue = [33, 5]'),
 Text(0.8665496049165935, 0.5, 'x[2] <= 0.51\ngini = 0.5\nsamples = 6\
nvalue = [3, 3]'),
 Text(0.8595258999122037, 0.4411764705882353, 'x[12] <= 0.333\ngini =
0.375\nsamples = 4\nvalue = [3, 1]'),
 Text(0.8525021949078139, 0.38235294117647056, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.8665496049165935, 0.38235294117647056, 'gini = 0.0\nsamples =
3\nvalue = [3, 0]'),
 Text(0.8735733099209834, 0.4411764705882353, 'gini = 0.0\nsamples =
2\nvalue = [0, 2]'),
 Text(0.8946444249341527, 0.5, 'x[28] <= 0.917\ngini = 0.117\nsamples
= 32\nvalue = [30, 2]'),
 Text(0.887620719929763, 0.4411764705882353, 'x[8] <= 0.992\ngini =
0.062\nsamples = 31\nvalue = [30, 1]'),
 Text(0.8805970149253731, 0.38235294117647056, 'gini = 0.0\nsamples =
30\nvalue = [30, 0]'),
 Text(0.8946444249341527, 0.38235294117647056, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.9016681299385426, 0.4411764705882353, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.8577699736611062, 0.6764705882352942, 'gini = 0.0\nsamples =
1\nvalue = [0, 1]'),
 Text(0.961369622475856, 0.7352941176470589, 'x[14] <= 0.812\ngini =
0.456\nsamples = 57\nvalue = [37, 20]'),
 Text(0.9367866549604916, 0.6764705882352942, 'x[32] <= 0.4\ngini =
0.238\nsamples = 29\nvalue = [25, 4]'),
 Text(0.922739244951712, 0.6176470588235294, 'x[8] <= 0.071\ngini =
0.142\nsamples = 26\nvalue = [24, 2]'),
 Text(0.9157155399473222, 0.5588235294117647, 'x[0] <= 0.321\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(0.9086918349429324, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [1,
0]'),
 Text(0.922739244951712, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0,
2]'),
 Text(0.9297629499561019, 0.5588235294117647, 'gini = 0.0\nsamples =
23\nvalue = [23, 0]'),
 Text(0.9508340649692713, 0.6176470588235294, 'x[29] <= 0.833\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
 Text(0.9438103599648815, 0.5588235294117647, 'gini = 0.0\nsamples =
2\nvalue = [0, 2]'),
 Text(0.9578577699736611, 0.5588235294117647, 'gini = 0.0\nsamples =
1\nvalue = [1, 0]'),
 Text(0.9859525899912204, 0.6764705882352942, 'x[32] <= 0.1\ngini =
0.49\nsamples = 28\nvalue = [12, 16]'),
 Text(0.9789288849868305, 0.6176470588235294, 'x[12] <= 0.833\ngini =
0.48\nsamples = 20\nvalue = [12, 8]'),
```

```
 Text(0.9719051799824407, 0.5588235294117647, 'x[30] <= 0.036\ngini =
0.415\nsamples = 17\nvalue = [12, 5]'),
 Text(0.9648814749780509, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0,
2]'),
 Text(0.9789288849868305, 0.5, 'x[18] <= 0.505\ngini = 0.32\nsamples =
15\nvalue = [12, 3]'),
 Text(0.9719051799824407, 0.4411764705882353, 'gini = 0.0\nsamples =
9\nvalue = [9, 0]'),
 Text(0.9859525899912204, 0.4411764705882353, 'x[18] <= 0.706\ngini =
0.5\nsamples = 6\nvalue = [3, 3]'),
 Text(0.9789288849868305, 0.38235294117647056, 'gini = 0.0\nsamples =
3\nvalue = [0, 3]'),
 Text(0.9929762949956101, 0.38235294117647056, 'gini = 0.0\nsamples =
3\nvalue = [3, 0]'),
 Text(0.9859525899912204, 0.5588235294117647, 'gini = 0.0\nsamples =
3\nvalue = [0, 3]'),
 Text(0.9929762949956101, 0.6176470588235294, 'gini = 0.0\nsamples =
8\nvalue = [0, 8]')]
```



```
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']
}

grid_search =
GridSearchCV(estimator=dt,param_grid=parameter,cv=5,scoring='accuracy'
)
grid_search.fit(x_train,y_train)
```

```
C:\Users\tejos\anaconda\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\tejos\anaconda\Lib\site-packages\sklearn\
model_selection\_validation.py", line 732, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\tejos\anaconda\Lib\site-packages\sklearn\base.py",
line 1144, in wrapper
    estimator._validate_params()
  File "C:\Users\tejos\anaconda\Lib\site-packages\sklearn\base.py",
line 637, in _validate_params
    validate_parameter_constraints(
  File "C:\Users\tejos\anaconda\Lib\site-packages\sklearn\utils\
_param_validation.py", line 95, in validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The
'max_features' parameter of DecisionTreeClassifier must 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\tejos\anaconda\Lib\site-packages\sklearn\model_selection\
_search.py:976: UserWarning: One or more of the test scores are non-
finite: [       nan        nan 0.84013704 0.84013704 0.84013704
0.84013704
        nan        nan 0.83928597 0.84013704 0.82993148 0.83758384
        nan        nan 0.83420483 0.84013704 0.83417598 0.84183916
        nan        nan 0.83671114 0.84014064 0.83332853 0.84099171
        nan        nan 0.83078255 0.83248467 0.82737108 0.83163722
        nan        nan 0.84013704 0.84013704 0.84013704 0.84013704
        nan        nan 0.84013704 0.84013704 0.83928597 0.83758384
        nan        nan 0.84012982 0.84013704 0.83673999 0.84183556
        nan        nan 0.84183195 0.84098449 0.83077533 0.8409881
        nan        nan 0.83164082 0.83929318 0.82993509 0.84862964]
  warnings.warn(

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')

grid_search.best_params_

{'criterion': 'entropy',
 'max_depth': 5,
 'max_features': 'log2',
 'splitter': 'random'}

dt_cv =
DecisionTreeClassifier(criterion='entropy',max_depth=3,max_features='s
qrt')
dt_cv.fit(x_train,y_train)

DecisionTreeClassifier(criterion='entropy', max_depth=3,
max_features='sqrt')

pred = dt_cv.predict(x_test)

print(classification_report(y_test,pred))

              precision    recall  f1-score   support

           0       0.84      1.00      0.91       245
           1       1.00      0.04      0.08        49

    accuracy                           0.84       294
   macro avg       0.92      0.52      0.50       294
weighted avg       0.87      0.84      0.77       294
```

Random Forest

```
from sklearn.ensemble import RandomForestClassifier
rf = RandomForestClassifier()

forest_params = [{'max_depth':list(range(10,15)),'max_features':
['auto', 'sqrt', 'log2']}]

rf_cv = GridSearchCV(rf,param_grid = forest_params,cv =
10,scoring='accuracy')
rf_cv.fit(x_train,y_train)

C:\Users\tejos\anaconda\Lib\site-packages\sklearn\model_selection\
_validation.py:425: FitFailedWarning:
50 fits failed out of a total of 150.
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\tejos\anaconda\Lib\site-packages\sklearn\
model_selection\_validation.py", line 732, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\tejos\anaconda\Lib\site-packages\sklearn\base.py",
line 1144, in wrapper
    estimator._validate_params()
  File "C:\Users\tejos\anaconda\Lib\site-packages\sklearn\base.py",
line 637, in _validate_params
    validate_parameter_constraints(
  File "C:\Users\tejos\anaconda\Lib\site-packages\sklearn\utils\
_param_validation.py", line 95, in validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The
'max_features' parameter of RandomForestClassifier must 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\tejos\anaconda\Lib\site-packages\sklearn\model_selection\
_search.py:976: UserWarning: One or more of the test scores are non-
finite: [       nan 0.8605389  0.85797479        nan 0.85967695
0.8605389
        nan 0.86224105 0.85543966        nan 0.85543966 0.85714907
        nan 0.85799652 0.85799652]
  warnings.warn(
```

```
GridSearchCV(cv=10, estimator=RandomForestClassifier(),
             param_grid=[{'max_depth': [10, 11, 12, 13, 14],
                          'max_features': ['auto', 'sqrt', 'log2']}],
             scoring='accuracy')
```

```
pred = rf_cv.predict(x_test)
```

```
accuracy_score(y_test,pred)
```

```
0.8503401360544217
```

```
print(classification_report(y_test,pred))
```

```
              precision    recall  f1-score   support

           0       0.86      0.99      0.92       245
           1       0.73      0.16      0.27        49

    accuracy                           0.85       294
   macro avg       0.79      0.58      0.59       294
```

```
weighted avg       0.83      0.85      0.81       294


rf_cv.best_params_

{'max_depth': 12, 'max_features': 'sqrt'}

rf.fit(x_train,y_train)

RandomForestClassifier()

probabo = rf.predict_proba(x_test)[:,1]
probabo

array([0.07, 0.03, 0.14, 0.17, 0.69, 0.18, 0.29, 0.08, 0.07, 0.17,
0.06,
       0.16, 0.08, 0.37, 0.05, 0.02, 0.16, 0.15, 0.12, 0.24, 0.56,
0.05,
       0.01, 0.06, 0.29, 0.27, 0.03, 0.06, 0.64, 0.02, 0.07, 0.12,
0.26,
       0.1 , 0.09, 0.04, 0.18, 0.11, 0.11, 0.08, 0.14, 0.08, 0.11, 0.1
,
       0.04, 0.46, 0.33, 0.02, 0.68, 0.44, 0.16, 0.45, 0.25, 0.15, 0.4
,
       0.16, 0.06, 0.06, 0.08, 0.34, 0.08, 0.16, 0.08, 0.14, 0.25,
0.12,
       0.22, 0.16, 0.05, 0.17, 0.15, 0.35, 0.17, 0.14, 0.1 , 0.12, 0.1
,
       0.03, 0.32, 0.06, 0.07, 0.07, 0.15, 0.12, 0.14, 0.03, 0.04, 0.2
,
       0.06, 0.1 , 0.59, 0.1 , 0.16, 0.22, 0.08, 0.07, 0.1 , 0.34,
0.11,
       0.11, 0.22, 0.2 , 0.28, 0.08, 0.07, 0.05, 0.13, 0.43, 0.24,
0.18,
       0.2 , 0.07, 0.04, 0.05, 0.11, 0.14, 0.06, 0.14, 0.07, 0.01,
0.15,
       0.02, 0.01, 0.63, 0.26, 0.13, 0.03, 0.08, 0.1 , 0.09, 0.02,
0.31,
       0.37, 0.21, 0.23, 0.16, 0.36, 0.18, 0.1 , 0.1 , 0.11, 0.12, 0.1
,
       0.1 , 0.17, 0.11, 0.08, 0.06, 0.14, 0.09, 0.07, 0.23, 0.08,
0.29,
       0.16, 0.17, 0.07, 0.17, 0.17, 0.04, 0.33, 0.03, 0.3 , 0.62,
0.05,
       0.22, 0.15, 0.06, 0.1 , 0.09, 0.07, 0.15, 0.11, 0.2 , 0.11,
0.48,
       0.07, 0.24, 0.21, 0.13, 0.02, 0.  , 0.02, 0.52, 0.03, 0.08,
0.22,
       0.08, 0.2 , 0.23, 0.29, 0.63, 0.19, 0.06, 0.14, 0.06, 0.1 ,
0.04,
       0.39, 0.14, 0.27, 0.16, 0.28, 0.08, 0.2 , 0.16, 0.46, 0.06,
```

```
0.07,
       0.01, 0.1 , 0.14, 0.15, 0.2 , 0.05, 0.05, 0.06, 0.15, 0.14,
0.46,
       0.13, 0.41, 0.35, 0.16, 0.16, 0.06, 0.06, 0.31, 0.53, 0.13,
0.06,
       0.26, 0.04, 0.1 , 0.03, 0.25, 0.28, 0.04, 0.16, 0.11, 0.21,
0.12,
       0.1 , 0.08, 0.19, 0.1 , 0.08, 0.25, 0.09, 0.13, 0.16, 0.18,
0.39,
       0.05, 0.23, 0.15, 0.03, 0.57, 0.24, 0.29, 0.07, 0.08, 0.16,
0.09,
       0.16, 0.23, 0.04, 0.19, 0.16, 0.04, 0.1 , 0.01, 0.06, 0.09,
0.03,
       0.09, 0.1 , 0.46, 0.13, 0.34, 0.26, 0.12, 0.18, 0.15, 0.15,
0.24,
       0.03, 0.13, 0.03, 0.08, 0.16, 0.27, 0.07, 0.12])

fpr,tpr,threshsholds = roc_curve(y_test,probabo)

plt.plot(fpr,tpr)

[<matplotlib.lines.Line2D at 0x1a1c5d78d50>]
```