

# ASSIGNMENT 4 - 21BCE2000

September 28, 2023

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

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

```
[3]: df
```

```
[3]:      Age  Attrition  BusinessTravel  DailyRate      Department \
0      41         Yes      Travel_Rarely      1102              Sales
1      49          No  Travel_Frequently       279  Research & Development
2      37         Yes      Travel_Rarely     1373  Research & Development
3      33          No  Travel_Frequently     1392  Research & Development
4      27          No      Travel_Rarely       591  Research & Development
...  ...  ...  ...  ...  ...
1465   36          No  Travel_Frequently       884  Research & Development
1466   39          No      Travel_Rarely       613  Research & Development
1467   27          No      Travel_Rarely       155  Research & Development
1468   49          No  Travel_Frequently     1023              Sales
1469   34          No      Travel_Rarely       628  Research & Development
```

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

```
      EmployeeNumber  ...  RelationshipSatisfaction  StandardHours \
0                    1  ...              1              80
1                    2  ...              4              80
```

2	4	...	2	80
3	5	...	3	80
4	7	...	4	80
...	...	...	...	...
1465	2061	...	3	80
1466	2062	...	1	80
1467	2064	...	2	80
1468	2065	...	4	80
1469	2068	...	1	80

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

	WorkLifeBalance	YearsAtCompany	YearsInCurrentRole	\
0	1	6	4	
1	3	10	7	
2	3	0	0	
3	3	8	7	
4	3	2	2	
...	...	...	...	
1465	3	5	2	
1466	3	7	7	
1467	3	6	2	
1468	2	9	6	
1469	4	4	3	

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

1469

1

2

[1470 rows x 35 columns]

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

```
[4]:   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]

```
[5]: df.tail()
```

```
[5]:   Age Attrition   BusinessTravel   DailyRate   Department \
1465  36      No  Travel_Frequently    884  Research & Development
```

1466	39	No	Travel_Rarely	613	Research & Development
1467	27	No	Travel_Rarely	155	Research & Development
1468	49	No	Travel_Frequently	1023	Sales
1469	34	No	Travel_Rarely	628	Research & Development

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

	EmployeeNumber	...	RelationshipSatisfaction	StandardHours	\
1465	2061	...	3	80	
1466	2062	...	1	80	
1467	2064	...	2	80	
1468	2065	...	4	80	
1469	2068	...	1	80	

	StockOptionLevel	TotalWorkingYears	TrainingTimesLastYear	\
1465	1	17	3	
1466	1	9	5	
1467	1	6	0	
1468	0	17	3	
1469	0	6	3	

	WorkLifeBalance	YearsAtCompany	YearsInCurrentRole	\
1465	3	5	2	
1466	3	7	7	
1467	3	6	2	
1468	2	9	6	
1469	4	4	3	

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

[5 rows x 35 columns]

```
[6]: df.shape
```

```
[6]: (1470, 35)
```

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

```

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

```

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

```

[8]:           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]

```
[10]: corr=df.corr()
      corr
```

C:\Users\RUSHITHA REPAKULA\AppData\Local\Temp\ipykernel\_12500\3182140910.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()

```
[10]:
```

	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
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	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

```
[26 rows x 26 columns]
```

```
[11]: <Axes: >
```



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

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

```
[13]: df.isnull().any()
```

```
[13]: 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
```

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

```
[14]: 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
```

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

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

      DistanceFromHome  Education  EducationField  EmployeeCount  EmployeeNumber \
```

0	1	2	Life Sciences	1	1
1	8	1	Life Sciences	1	2
2	2	2	Other	1	4
3	3	4	Life Sciences	1	5
4	2	1	Medical	1	7

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

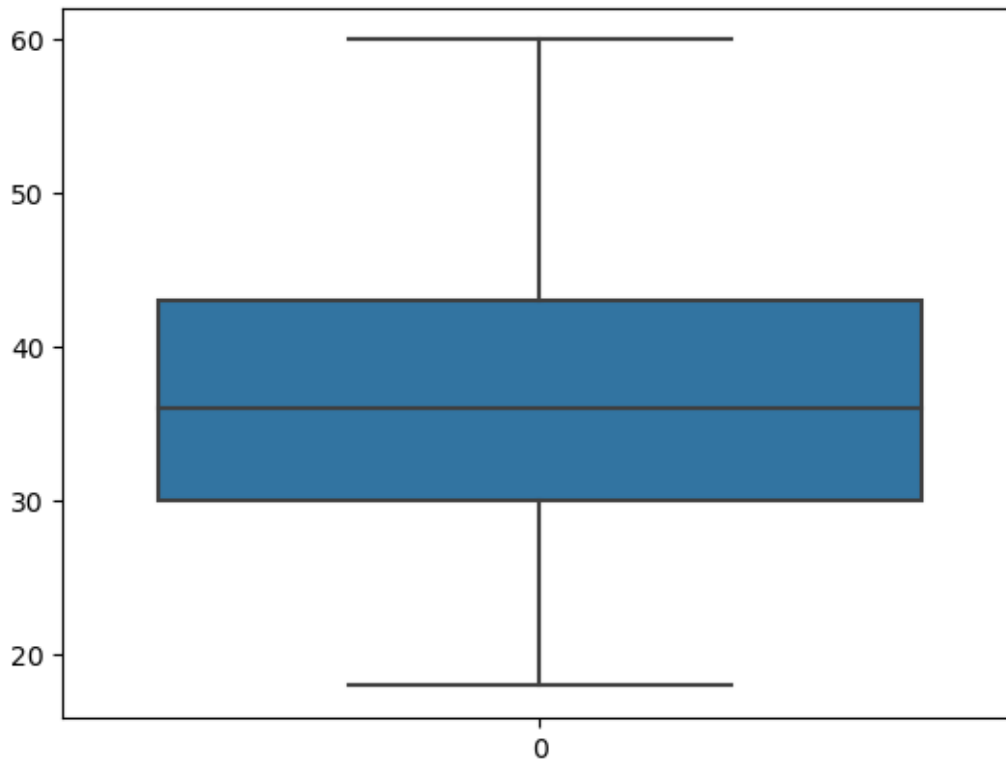
	TotalWorkingYears	TrainingTimesLastYear	WorkLifeBalance	YearsAtCompany	\
0	8	0	1	6	
1	10	3	3	10	
2	7	3	3	0	
3	8	3	3	8	
4	6	3	3	2	

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

[5 rows x 35 columns]

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

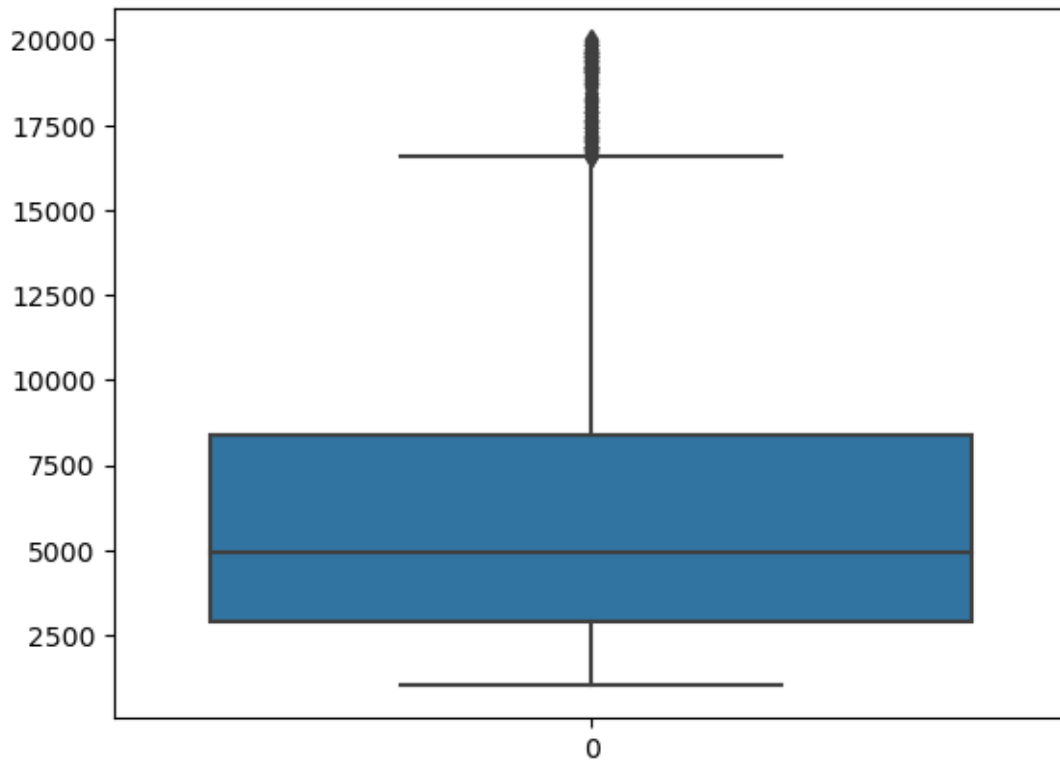
```
[17]: <Axes: >
```



```
[18]: sns.boxplot(df.MonthlyIncome)
```

```
[18]: <Axes: >
```





```
[19]: q1=df.MonthlyIncome.quantile(0.25)
      q3=df.MonthlyIncome.quantile(0.75)
```

```
[20]: IQR=q3-q1
      IQR
```

```
[20]: 5468.0
```

```
[21]: ul=q3 + 1.5*IQR
      ul
```

```
[21]: 16581.0
```

```
[22]: df['MonthlyIncome'].median()
```

```
[22]: 4919.0
```

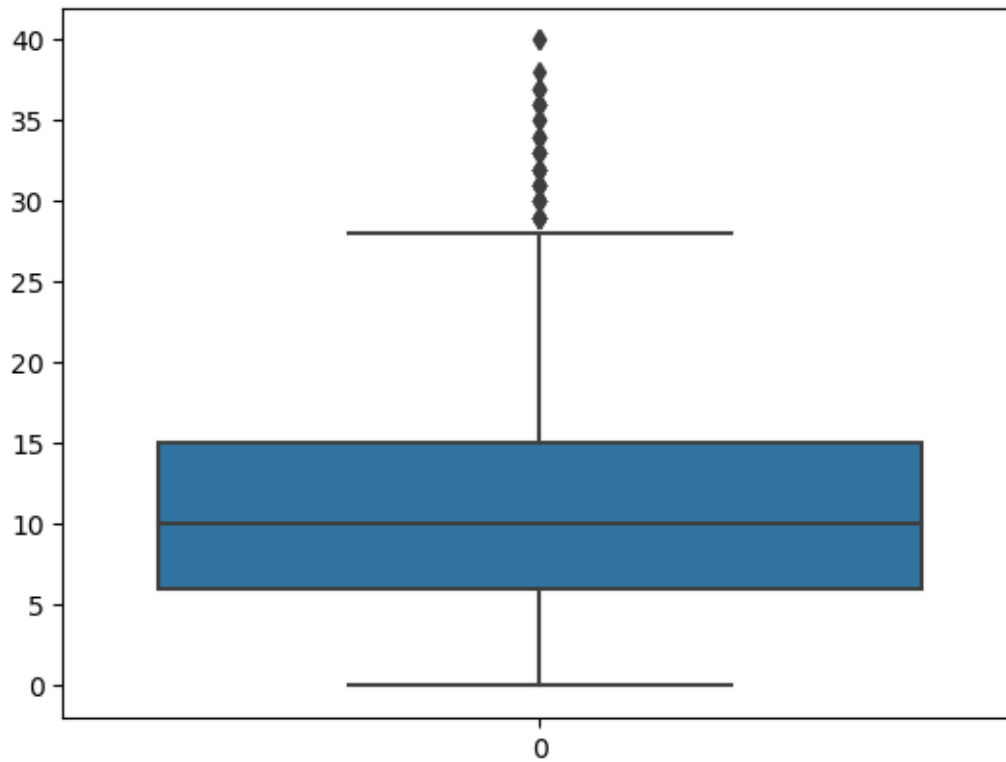
```
[23]: df['MonthlyIncome']=np.where(df['MonthlyIncome']>ul,4919.0,df['MonthlyIncome'])
```

```
[24]: df.shape
```

```
[24]: (1470, 35)
```

```
[25]: sns.boxplot(df.TotalWorkingYears)
```

```
[25]: <Axes: >
```



```
[26]: q1=df.TotalWorkingYears.quantile(0.25)  
      q3=df.TotalWorkingYears.quantile(0.75)
```

```
[27]: IQR=q3-q1  
      IQR
```

```
[27]: 9.0
```

```
[29]: ul=q3+1.5*IQR  
      ul
```

```
[29]: 28.5
```

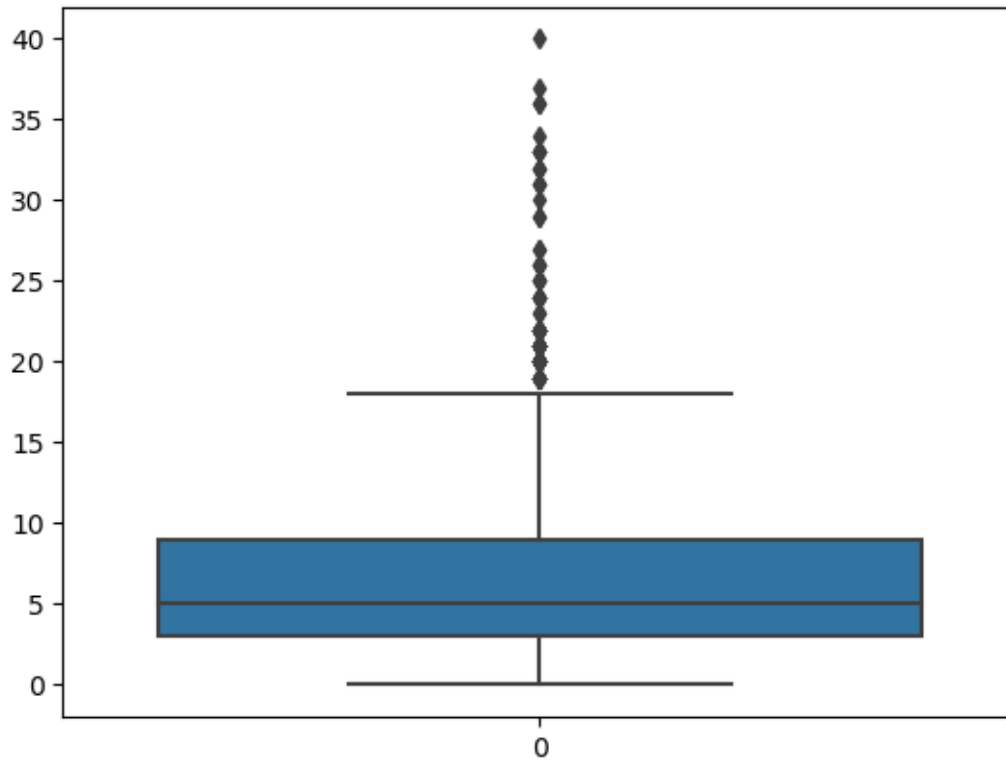
```
[30]: df['TotalWorkingYears'].median()
```

```
[30]: 10.0
```

```
[31]: df['TotalWorkingYears']=np.  
      ↪where(df['TotalWorkingYears']>u1,10,df['TotalWorkingYears'])
```

```
[32]: sns.boxplot(df.YearsAtCompany)
```

```
[32]: <Axes: >
```



```
[33]: q1=df.YearsAtCompany.quantile(0.25)  
      q3=df.YearsAtCompany.quantile(0.75)
```

```
[34]: IQR=q3-q1  
      IQR
```

```
[34]: 6.0
```

```
[35]: u1=q3+1.5*IQR  
      u1
```

```
[35]: 18.0
```

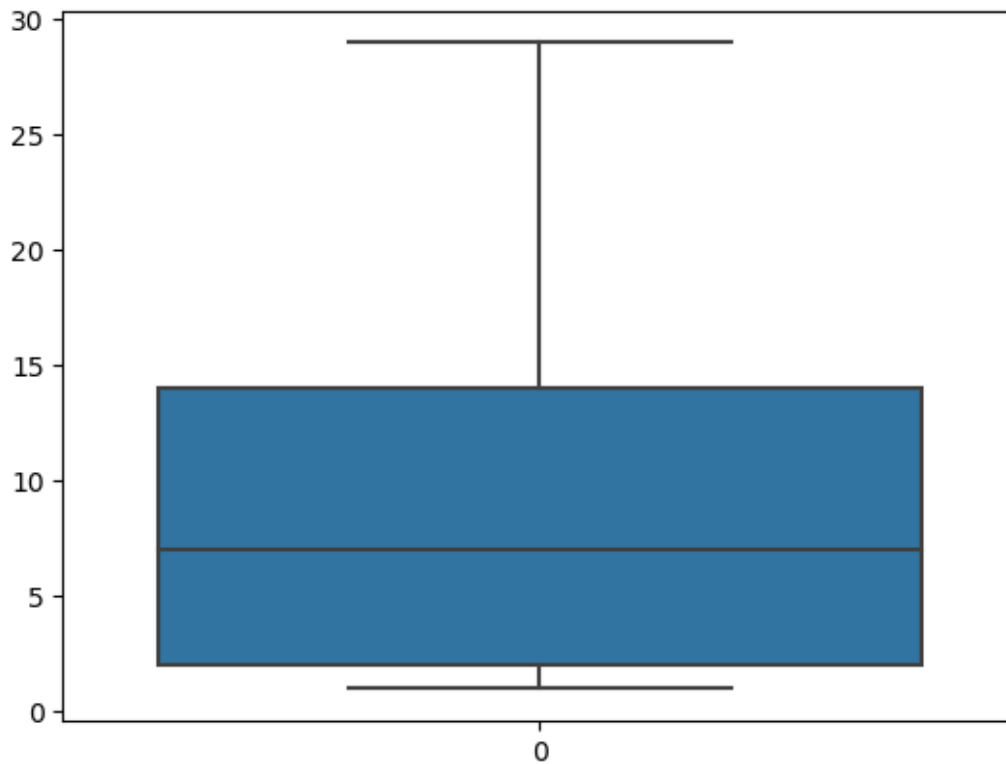
```
[36]: df['YearsAtCompany'].mean()
```

[36]: 7.0081632653061225

```
[37]: df['YearsAtCompany']=np.where(df['YearsAtCompany']>ul,7.  
    ↪0081632653061225,df['YearsAtCompany'])
```

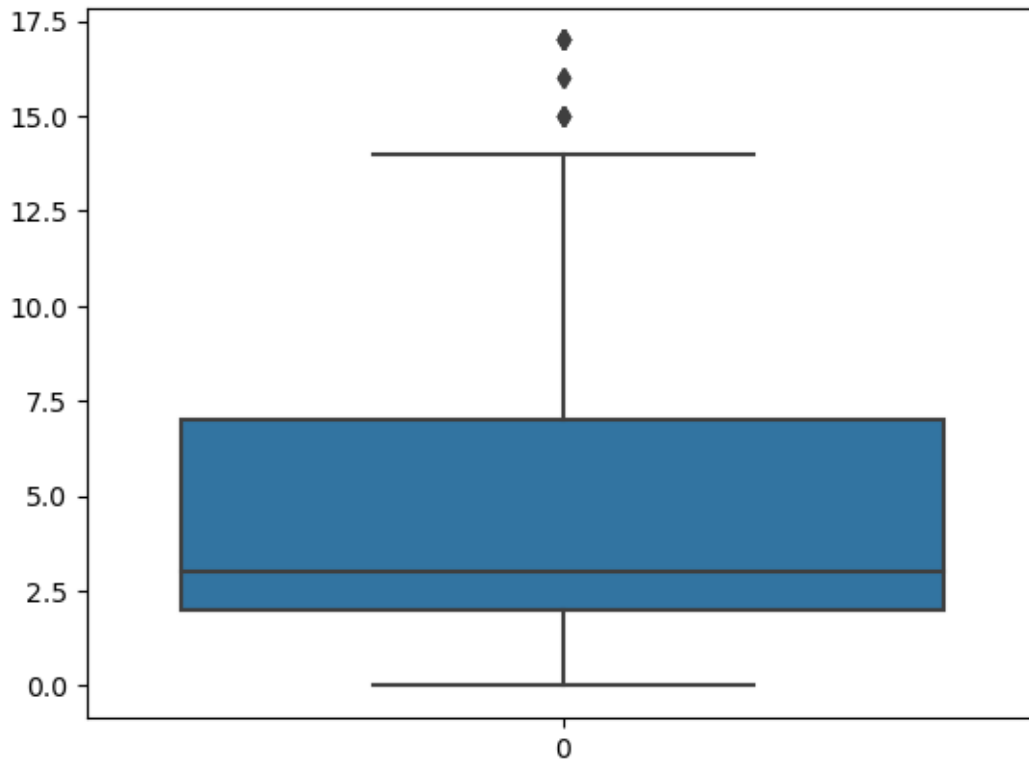
```
[38]: sns.boxplot(df.DistanceFromHome)
```

[38]: <Axes: >



```
[40]: sns.boxplot(df.YearsWithCurrManager)
```

[40]: <Axes: >



```
[41]: q1=df.YearsWithCurrManager.quantile(0.25)
      q3=df.YearsWithCurrManager.quantile(0.75)
```

```
[42]: IQR=q3-q1
      IQR
```

```
[42]: 5.0
```

```
[43]: ul=q3+1.5*IQR
      ul
```

```
[43]: 14.5
```

```
[44]: df['YearsWithCurrManager'].median()
```

```
[44]: 3.0
```

```
[45]: df['YearsWithCurrManager']=np.
      ↪where(df['YearsWithCurrManager']>ul,3,df['YearsWithCurrManager'])
```

```
[46]: x=df.iloc[:,df.columns != "Attrition"]
      y=df.iloc[:,1:2]
```

```
[47]: x.head()
```

```
[47]:   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                6.0          4          0
1               10.0          7          1
2                0.0          0          0
3                8.0          7          3
4                2.0          2          2

      YearsWithCurrManager
0                5
1                7
2                0
3                0
4                2

[5 rows x 34 columns]
```

```
[48]: y.head()
```

```
[48]: Attrition
      0      Yes
      1      No
      2      Yes
      3      No
      4      No
```

```
[49]: df.shape
```

```
[49]: (1470, 35)
```

```
[50]: x.shape
```

```
[50]: (1470, 34)
```

```
[51]: y.shape
```

```
[51]: (1470, 1)
```

```
[52]: BusinessTravel=pd.get_dummies(x["BusinessTravel"],drop_first=True)
      BusinessTravel
```

```
[52]:      Travel_Frequently  Travel_Rarely
      0                  0              1
      1                  1              0
      2                  0              1
      3                  1              0
      4                  0              1
      ...
      1465                ...            ...
      1465                1              0
      1466                0              1
      1467                0              1
      1468                1              0
      1469                0              1
```

```
[1470 rows x 2 columns]
```

```
[53]: x=pd.concat([x,BusinessTravel],axis=1)
```

```
[54]: x.drop(["BusinessTravel"],axis=1,inplace=True)
```

```
[57]: Department=pd.get_dummies(x["Department"],drop_first=True)
      Department
```

```
[57]:      Research & Development  Sales
      0                      0      1
      1                      1      0
      2                      1      0
```

```

3          1      0
4          1      0
...
1465      1      0
1466      1      0
1467      1      0
1468      0      1
1469      1      0

```

[1470 rows x 2 columns]

```
[58]: x=pd.concat([x,Department],axis=1)
      x.drop(["Department"],axis=1,inplace=True)
```

```
[59]: x.head()
```

```
[59]:   Age  DailyRate  DistanceFromHome  Education  EducationField  EmployeeCount  \
0    41        1102                 1          2  Life Sciences           1
1    49         279                 8          1  Life Sciences           1
2    37        1373                 2          2          Other           1
3    33        1392                 3          4  Life Sciences           1
4    27         591                 2          1        Medical           1

```

```

      EmployeeNumber  EnvironmentSatisfaction  Gender  HourlyRate  ...  \
0                1                2  Female          94  ...
1                2                3   Male          61  ...
2                4                4   Male          92  ...
3                5                4  Female          56  ...
4                7                1   Male          40  ...

```

```

      TrainingTimesLastYear  WorkLifeBalance  YearsAtCompany  YearsInCurrentRole  \
0                0                1                6.0                4
1                3                3                10.0                7
2                3                3                0.0                0
3                3                3                8.0                7
4                3                3                2.0                2

```

```

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

```

```

      Travel_Rarely  Research & Development  Sales
0                1                0        1
1                0                1        0

```



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

[5 rows x 36 columns]

```
[60]: EducationField=pd.get_dummies(x["EducationField"],drop_first=True)
      EducationField
```

```
[60]:      Life Sciences  Marketing  Medical  Other  Technical Degree
0              1           0         0      0           0
1              1           0         0      0           0
2              0           0         0      1           0
3              1           0         0      0           0
4              0           0         1      0           0
...
1465          ...           ...         ...      ...           ...
1466          0           0         1      0           0
1467          1           0         0      0           0
1468          0           0         1      0           0
1469          0           0         1      0           0
```

[1470 rows x 5 columns]

```
[61]: x=pd.concat([x,EducationField],axis=1)
      x.drop(["EducationField"],axis=1,inplace=True)
```

```
[62]: Gender=pd.get_dummies(x["Gender"],drop_first=True)
      Gender
```

```
[62]:      Male
0         0
1         1
2         1
3         0
4         1
...
1465      1
1466      1
1467      1
1468      1
1469      1
```

[1470 rows x 1 columns]

```
[63]: x=pd.concat([x,Gender],axis=1)
      x.drop(["Gender"],axis=1,inplace=True)
```

```
[64]: JobRole=pd.get_dummies(x["JobRole"],drop_first=True)
      JobRole
```

```
[64]:
```

	Human Resources	Laboratory Technician	Manager	Manufacturing Director	\
0	0	0	0	0	
1	0	0	0	0	
2	0	1	0	0	
3	0	0	0	0	
4	0	1	0	0	
...	...	...	...	...	
1465	0	1	0	0	
1466	0	0	0	0	
1467	0	0	0	1	
1468	0	0	0	0	
1469	0	1	0	0	

	Research Director	Research Scientist	Sales Executive	\
0	0	0	1	
1	0	1	0	
2	0	0	0	
3	0	1	0	
4	0	0	0	
...	...	...	...	
1465	0	0	0	
1466	0	0	0	
1467	0	0	0	
1468	0	0	1	
1469	0	0	0	

	Sales Representative
0	0
1	0
2	0
3	0
4	0
...	...
1465	0
1466	0
1467	0
1468	0
1469	0

[1470 rows x 8 columns]

```
[65]: x=pd.concat([x,JobRole],axis=1)
      x.drop(["JobRole"],axis=1,inplace=True)
```

```
[66]: x.shape
```

```
[66]: (1470, 47)
```

```
[67]: MaritalStatus=pd.get_dummies(x["MaritalStatus"],drop_first=True)
MaritalStatus
```

```
[67]:
```

	Married	Single
0	0	1
1	1	0
2	0	1
3	1	0
4	1	0
...	...	...
1465	1	0
1466	1	0
1467	1	0
1468	1	0
1469	1	0

[1470 rows x 2 columns]

```
[68]: x=pd.concat([x,MaritalStatus],axis=1)
x.drop(["MaritalStatus"],axis=1,inplace=True)
```

```
[70]: x.shape
```

```
[70]: (1470, 48)
```

```
[69]: Over18=pd.get_dummies(x["Over18"],drop_first=True)
Over18
```

```
[69]: Empty DataFrame
Columns: []
Index: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39,
40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59,
60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79,
80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99,
...]

[1470 rows x 0 columns]
```

```
[71]: x=pd.concat([x,MaritalStatus],axis=1)
x.drop(["Over18"],axis=1,inplace=True)
```

```
[72]: OverTime=pd.get_dummies(x["OverTime"],drop_first=True)
OverTime
```

```
[72]:      Yes
      0      1
      1      0
      2      1
      3      1
      4      0
      ...  ...
1465    0
1466    0
1467    1
1468    0
1469    0
```

[1470 rows x 1 columns]

```
[73]: x=pd.concat([x,OverTime],axis=1)
      x.drop(["OverTime"],axis=1,inplace=True)
```

```
[74]: Attrition=pd.get_dummies(y["Attrition"],drop_first=True)
      Attrition
```

```
[74]:      Yes
      0      1
      1      0
      2      1
      3      0
      4      0
      ...  ...
1465    0
1466    0
1467    0
1468    0
1469    0
```

[1470 rows x 1 columns]

```
[75]: y=pd.concat([y,Attrition],axis=1)
      y.drop(["Attrition"],axis=1,inplace=True)
```

```
[76]: y.head()
```

```
[76]:      Yes
      0      1
      1      0
      2      1
      3      0
      4      0
```

```
[77]: from sklearn.preprocessing import LabelEncoder
```

```
[78]: le=LabelEncoder()
```

```
[79]: x["Education"]=le.fit_transform(x["Education"])
      x["Education"]
```

```
[79]: 0      1
      1      0
      2      1
      3      3
      4      0
      ..
     1465     1
     1466     0
     1467     2
     1468     2
     1469     2
      Name: Education, Length: 1470, dtype: int64
```

```
[80]: x["EnvironmentSatisfaction"]=le.fit_transform(x["EnvironmentSatisfaction"])
```

```
[81]: x["JobInvolvement"]=le.fit_transform(x["JobInvolvement"])
```

```
[82]: x["JobSatisfaction"]=le.fit_transform(x["JobSatisfaction"])
```

```
[83]: x["PerformanceRating"]=le.fit_transform(x["PerformanceRating"])
```

```
[84]: x["RelationshipSatisfaction"]=le.fit_transform(x["RelationshipSatisfaction"])
```

```
[85]: x.head()
```

```
[85]:   Age  DailyRate  DistanceFromHome  Education  EmployeeCount  EmployeeNumber  \
0    41        1102                1         1             1           1
1    49         279                8         0             1           2
2    37        1373                2         1             1           4
3    33        1392                3         3             1           5
4    27         591                2         0             1           7
```

```
   EnvironmentSatisfaction  HourlyRate  JobInvolvement  JobLevel  ...  \
0                        1          94                2         2  ...
1                        2          61                1         2  ...
2                        3          92                1         1  ...
3                        3          56                2         1  ...
4                        0          40                2         1  ...
```

```
   Manufacturing Director  Research Director  Research Scientist  \
0                        0                  0                  0
```

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

	Sales Executive	Sales Representative	Married	Single	Married	Single	\
0	1	0	0	1	0	1	
1	0	0	1	0	1	0	
2	0	0	0	1	0	1	
3	0	0	1	0	1	0	
4	0	0	1	0	1	0	

Yes	
0	1
1	0
2	1
3	1
4	0

[5 rows x 49 columns]

[86]: x.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1470 entries, 0 to 1469
Data columns (total 49 columns):
#   Column                                Non-Null Count  Dtype
---  -
0   Age                                   1470 non-null   int64
1   DailyRate                           1470 non-null   int64
2   DistanceFromHome                    1470 non-null   int64
3   Education                           1470 non-null   int64
4   EmployeeCount                       1470 non-null   int64
5   EmployeeNumber                      1470 non-null   int64
6   EnvironmentSatisfaction              1470 non-null   int64
7   HourlyRate                          1470 non-null   int64
8   JobInvolvement                      1470 non-null   int64
9   JobLevel                            1470 non-null   int64
10  JobSatisfaction                     1470 non-null   int64
11  MonthlyIncome                      1470 non-null   float64
12  MonthlyRate                        1470 non-null   int64
13  NumCompaniesWorked                 1470 non-null   int64
14  PercentSalaryHike                  1470 non-null   int64
15  PerformanceRating                   1470 non-null   int64
16  RelationshipSatisfaction             1470 non-null   int64
17  StandardHours                      1470 non-null   int64
18  StockOptionLevel                   1470 non-null   int64
19  TotalWorkingYears                  1470 non-null   int64
```

20	TrainingTimesLastYear	1470	non-null	int64
21	WorkLifeBalance	1470	non-null	int64
22	YearsAtCompany	1470	non-null	float64
23	YearsInCurrentRole	1470	non-null	int64
24	YearsSinceLastPromotion	1470	non-null	int64
25	YearsWithCurrManager	1470	non-null	int64
26	Travel_Frequently	1470	non-null	uint8
27	Travel_Rarely	1470	non-null	uint8
28	Research & Development	1470	non-null	uint8
29	Sales	1470	non-null	uint8
30	Life Sciences	1470	non-null	uint8
31	Marketing	1470	non-null	uint8
32	Medical	1470	non-null	uint8
33	Other	1470	non-null	uint8
34	Technical Degree	1470	non-null	uint8
35	Male	1470	non-null	uint8
36	Human Resources	1470	non-null	uint8
37	Laboratory Technician	1470	non-null	uint8
38	Manager	1470	non-null	uint8
39	Manufacturing Director	1470	non-null	uint8
40	Research Director	1470	non-null	uint8
41	Research Scientist	1470	non-null	uint8
42	Sales Executive	1470	non-null	uint8
43	Sales Representative	1470	non-null	uint8
44	Married	1470	non-null	uint8
45	Single	1470	non-null	uint8
46	Married	1470	non-null	uint8
47	Single	1470	non-null	uint8
48	Yes	1470	non-null	uint8

dtypes: float64(2), int64(24), uint8(23)

memory usage: 331.7 KB

```
[87]: from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.3,random_state=0)
```

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

```
[88]: ((1029, 49), (441, 49), (1029, 1), (441, 1))
```

```
[89]: from sklearn.preprocessing import StandardScaler
sc=StandardScaler()
```

```
[90]: x_train=sc.fit_transform(x_train)
x_test=sc.fit_transform(x_test)
```

```
[91]: x_train
```

```
[91]: array([[ -0.75016842, -0.58244694, -0.51036458, ..., -0.90267093,
          -0.69784971, -0.61441846],
          [ -0.41863372, -1.12354988, -0.51036458, ..., -0.90267093,
           1.43297329,  1.62755527],
          [ 0.90750511, -0.04626313,  1.84630474, ..., -0.90267093,
           1.43297329, -0.61441846],
          ...,
          [ 0.68648197,  0.91542436, -0.88247026, ...,  1.10782342,
          -0.69784971,  1.62755527],
          [ 0.13392413, -1.3252337 , -0.88247026, ...,  1.10782342,
          -0.69784971,  1.62755527],
          [ 0.35494726, -0.36600577,  0.10981156, ..., -0.90267093,
          -0.69784971, -0.61441846]])
```

```
[92]: x_test
```

```
[92]: array([[ -0.13313793, -0.3978601 ,  0.07634069, ..., -0.95780546,
           1.52177182, -0.66066791],
          [ -0.45515161, -0.54952521,  1.90602783, ..., -0.95780546,
           1.52177182, -0.66066791],
          [ -0.24047582, -0.32961081,  1.05217383, ...,  1.04405335,
          -0.65712874,  1.51361976],
          ...,
          [ 0.29621364,  0.76237796,  2.27196526, ..., -0.95780546,
          -0.65712874, -0.66066791],
          [ 1.58426835, -1.19662966, -0.77751331, ...,  1.04405335,
          -0.65712874,  1.51361976],
          [ -0.45515161, -1.46457135, -0.28959674, ...,  1.04405335,
          -0.65712874, -0.66066791]])
```

## 1 Logistic Regression

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

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

```
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-
packages\sklearn\utils\validation.py:1184: DataConversionWarning: A column-
vector y was passed when a 1d array was expected. Please change the shape of y
to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
```

```
[94]: LogisticRegression()
```

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



```
[96]: pred
```

```
[96]: array([0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 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, 1, 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, 0, 0, 0, 0, 0,
         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, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0,
         1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 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, 0, 0, 0,
         0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 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, 0, 0,
         0, 0, 1, 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, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0,
         0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
         0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
         0, 0, 0, 0, 0, 0, 0, 0, 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, 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, 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], dtype=uint8)
```

```
[97]: y_test
```

```
[97]:      Yes
442    0
1091   0
981    1
785    0
1332   1
...    ...
817    0
399    0
458    0
406    0
590    0
```

```
[441 rows x 1 columns]
```

## 2 Model Classification

```
[98]: from sklearn.metrics import \
      accuracy_score, confusion_matrix, classification_report, roc_auc_score, roc_curve
```

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

```
[99]: 0.8866213151927438
```

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

```
[100]: array([[362,  9],  
           [ 41, 29]], dtype=int64)
```

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

	precision	recall	f1-score	support
0	0.90	0.98	0.94	371
1	0.76	0.41	0.54	70
accuracy			0.89	441
macro avg	0.83	0.70	0.74	441
weighted avg	0.88	0.89	0.87	441

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

```
[102]: array([9.78796690e-02, 6.49693921e-02, 6.07481146e-01, 1.83162250e-01,  
             8.31084648e-01, 5.36392103e-02, 4.32850819e-01, 3.14266433e-02,  
             4.44634741e-04, 6.01649262e-01, 2.00126658e-02, 1.72875273e-01,  
             1.35432484e-02, 6.13546704e-01, 5.48696953e-02, 1.25074596e-02,  
             1.17401377e-01, 4.61662962e-02, 3.34247564e-02, 2.93915157e-01,  
             1.68598420e-01, 8.37652504e-03, 1.21719673e-02, 6.32241866e-02,  
             7.75894857e-01, 4.74787345e-01, 5.33696627e-02, 3.79406056e-02,  
             6.67224841e-01, 4.77326470e-02, 5.10200006e-03, 2.57723249e-01,  
             3.44646694e-02, 2.16176812e-01, 2.21640011e-02, 3.05570340e-03,  
             1.49171594e-01, 4.32273605e-02, 2.40340735e-02, 1.25059338e-01,  
             1.00460399e-01, 9.20489402e-03, 6.70928324e-04, 1.03062961e-02,  
             6.68856203e-03, 5.77491219e-01, 4.31402098e-01, 1.21367756e-03,  
             4.05592771e-01, 3.79607455e-01, 3.81580646e-02, 8.49277879e-01,  
             2.95953756e-02, 4.85176455e-01, 4.23160010e-01, 2.66465926e-01,  
             8.72672403e-03, 4.32518565e-01, 1.67403507e-02, 3.57052308e-01,  
             1.31315939e-02, 1.96567213e-01, 8.61257435e-02, 5.48437472e-02,  
             9.60323031e-02, 2.20585134e-02, 2.87914859e-01, 1.80117569e-01,  
             9.74594292e-02, 1.85851697e-01, 4.06587491e-02, 1.51033053e-01,  
             6.43832781e-02, 3.53040608e-02, 1.08767146e-01, 4.32579625e-02,  
             3.77016174e-02, 1.83059419e-01, 4.61556301e-01, 2.14908949e-02,  
             1.25883864e-03, 2.60234237e-02, 2.69275940e-01, 1.46485917e-02,  
             1.61445485e-02, 8.53742071e-02, 4.95616689e-03, 1.55530770e-02,  
             1.40747973e-02, 7.08803509e-02, 1.01528686e-01, 9.44966673e-02,  
             3.35931374e-01, 1.39668465e-01, 5.48641117e-04, 9.41450016e-02,  
             4.77921886e-01, 6.06499153e-01, 6.58457434e-02, 9.30497362e-02,  
             1.68660449e-01, 5.05528660e-01, 4.46602572e-01, 6.26135722e-03,
```

1.72756707e-01, 6.06200602e-03, 9.94495564e-02, 2.35511586e-01,  
2.50353979e-02, 2.24177879e-01, 2.65882117e-02, 1.47976461e-02,  
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5.53619885e-01, 3.34527076e-02, 1.96485980e-01, 6.48546577e-03,  
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6.49887183e-02, 5.08421286e-02, 5.21376626e-02, 2.67089375e-02,  
4.01450235e-02, 3.11310492e-01, 4.22448598e-03, 9.33124086e-03,  
7.81418490e-01, 2.59763563e-03, 4.99285495e-02, 9.46891747e-01,  
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2.10250011e-02, 2.22732621e-01, 9.62804687e-03, 8.95772250e-01,  
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5.61108036e-01, 2.23627428e-01, 2.77306814e-01, 2.85548561e-01,  
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7.56914230e-01, 7.06421081e-02, 5.57090442e-02, 2.49241355e-01,  
3.14683680e-02, 3.10204624e-02, 1.53733673e-01, 1.27604748e-01,  
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1.82859002e-03, 6.94124038e-01, 6.88418695e-01, 3.77702931e-01,  
1.60408349e-01, 3.73438153e-02, 2.55822094e-01, 7.35121303e-02,  
5.77759036e-02, 8.82445083e-02, 1.12495644e-03, 3.97007877e-01,  
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3.30098041e-02, 8.86162342e-02, 3.36876695e-04, 1.25967516e-01,  
1.84537176e-03, 9.98455150e-03, 9.78501437e-02, 7.56009417e-01,

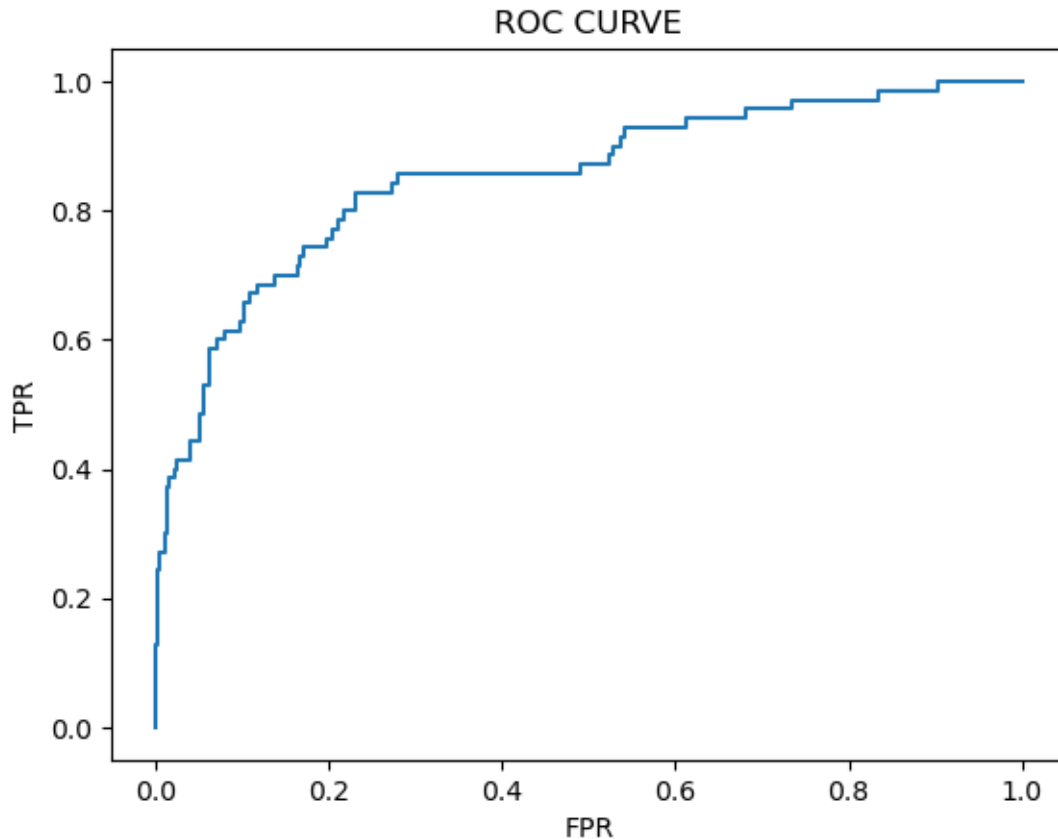
```

2.45925124e-02, 6.59141937e-02, 4.33927247e-02, 3.12662254e-02,
4.78772831e-01, 6.33881559e-02, 9.33838870e-01, 6.11375300e-03,
2.07747746e-01, 3.93356726e-02, 6.01603324e-02, 5.07841575e-03,
3.26352050e-02, 9.31981726e-02, 4.72478251e-01, 9.31123821e-01,
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1.17292351e-01, 6.69597602e-02, 1.05365545e-01, 1.66076320e-01,
7.47401091e-02, 6.15752530e-02, 5.60925232e-02, 5.18658274e-03,
4.31644060e-01, 1.54872889e-02, 2.95692896e-01, 2.71973828e-01,
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2.43234850e-03, 1.46446371e-02, 1.53939632e-02, 2.35216731e-01,
6.81982634e-02, 3.94132256e-01, 1.80752417e-01, 8.72236474e-02,
7.31484062e-02, 7.29981364e-04, 8.38406603e-02, 4.97134554e-02,
1.40067425e-01, 5.71254372e-01, 2.46895181e-02, 2.57965968e-01,
3.15199536e-02, 5.59383981e-03, 9.44886352e-02, 2.13266413e-01,
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4.96742383e-03, 4.29077834e-03, 1.08815311e-02, 2.21587385e-03,
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1.51268070e-02, 8.23374179e-02, 4.78748775e-03, 5.55329137e-01,
1.17147513e-02, 4.36125499e-02, 4.55052186e-01, 3.26172268e-01,
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2.80919776e-02, 3.56562691e-01, 8.66195889e-02, 3.08977895e-02,
2.19886880e-01, 9.84291161e-02, 4.95304390e-02, 2.03314116e-03,
1.86101979e-03, 2.03859038e-02, 1.03879381e-01, 8.55390066e-02,
2.59636309e-01, 6.97127835e-03, 1.21093498e-01, 2.16623712e-01,
6.77560665e-03, 1.35869166e-01, 1.54017661e-01, 1.19158489e-01,
1.23249508e-02, 1.54454121e-01, 6.15739824e-02, 4.12836693e-03,
4.58878117e-04])

```

```
[103]: fpr,tpr,threshholds = roc_curve(y_test,prob)
```

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



### 3 Decision Tree

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

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

```
[106]: DecisionTreeClassifier()
```

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

```
[107]: array([0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 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, 1, 0, 0, 0, 0, 0, 0, 0, 0,
0, 1, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0,
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0, 1, 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, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,
```

```

0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0,
0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 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], dtype=uint8)

```

```
[108]: y_test
```

```

[108]:      Yes
442      0
1091     0
981      1
785      0
1332     1
...      ...
817      0
399      0
458      0
406      0
590      0

```

```
[441 rows x 1 columns]
```

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

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

```
[110]: 0.7777777777777778
```

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

```
[111]: array([[319,  52],
      [ 46,  24]], dtype=int64)
```

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

```

precision    recall  f1-score   support


```

0	0.87	0.86	0.87	371
1	0.32	0.34	0.33	70
accuracy				0.78 441
macro avg	0.59	0.60	0.60	441
weighted avg	0.79	0.78	0.78	441

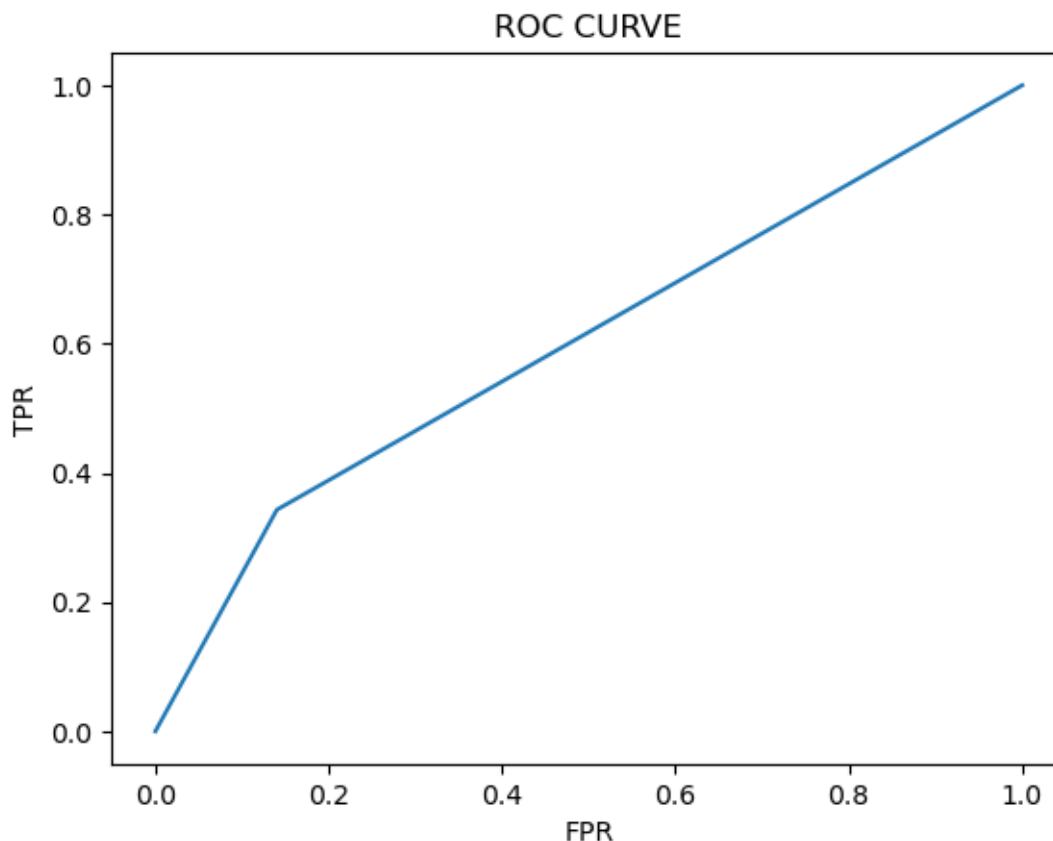
## 4 ROC-AUC CURVE

```
[113]: prob=dtc.predict_proba(x_test)[: ,1]
       prob
```

```
[113]: array([0., 0., 0., 0., 1., 1., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,
        1., 0., 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., 1., 0., 1., 0., 0.,
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        0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0.,
        0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1.,
        1., 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., 1., 0., 0., 0., 0., 0.,
        0., 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., 1., 0., 1., 1., 0., 0., 0., 0., 0.,
        0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 1., 1., 0., 0.,
        1., 0., 0., 1., 1., 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., 0., 0., 1., 0.,
        1., 1., 0., 1., 0., 0., 1., 1., 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., 1., 0., 1., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0.,
        0., 0., 0., 0., 1., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0.,
        0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0., 0.,
        1., 1., 0., 1., 0., 0., 1., 0., 0., 0., 0., 0., 1., 0., 0., 0., 0.,
        0., 0., 0., 0., 1., 1., 1., 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.]
```

```
[114]: fpr,tpr,threshholds = roc_curve(y_test,prob)
```

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



## 5 Hyperparameter Tuning

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

```
[116]: [Text(0.5248130471789884, 0.9642857142857143, 'x[48] <= 0.507\ngini =
0.272\nsamples = 1029\nvalue = [862, 167]'),
Text(0.2221698686770428, 0.8928571428571429, 'x[22] <= -1.115\ngini =
0.191\nsamples = 747\nvalue = [667, 80]'),
Text(0.08560311284046693, 0.8214285714285714, 'x[0] <= -0.584\ngini =
0.397\nsamples = 110\nvalue = [80, 30]'),
Text(0.042801556420233464, 0.75, 'x[26] <= 0.804\ngini = 0.499\nsamples =
46\nvalue = [24, 22]'),
Text(0.03501945525291829, 0.6785714285714286, 'x[1] <= -1.14\ngini =
0.473\nsamples = 39\nvalue = [24, 15]'),
Text(0.01556420233463035, 0.6071428571428571, 'x[27] <= -0.464\ngini =
0.245\nsamples = 7\nvalue = [1, 6]'),
Text(0.007782101167315175, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue
```



```

= [1, 0]'),
  Text(0.023346303501945526, 0.5357142857142857, 'gini = 0.0\nsamples = 6\nvalue
= [0, 6]'),
  Text(0.054474708171206226, 0.6071428571428571, 'x[21] <= -0.355\ngini =
0.404\nsamples = 32\nvalue = [23, 9]'),
  Text(0.038910505836575876, 0.5357142857142857, 'x[18] <= 0.823\ngini =
0.42\nsamples = 10\nvalue = [3, 7]'),
  Text(0.0311284046692607, 0.4642857142857143, 'gini = 0.0\nsamples = 7\nvalue =
[0, 7]'),
  Text(0.04669260700389105, 0.4642857142857143, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
  Text(0.07003891050583658, 0.5357142857142857, 'x[0] <= -0.695\ngini =
0.165\nsamples = 22\nvalue = [20, 2]'),
  Text(0.0622568093385214, 0.4642857142857143, 'gini = 0.0\nsamples = 19\nvalue =
[19, 0]'),
  Text(0.07782101167315175, 0.4642857142857143, 'x[41] <= 0.691\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
  Text(0.07003891050583658, 0.39285714285714285, 'gini = 0.0\nsamples = 2\nvalue
= [0, 2]'),
  Text(0.08560311284046693, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
  Text(0.05058365758754864, 0.6785714285714286, 'gini = 0.0\nsamples = 7\nvalue =
[0, 7]'),
  Text(0.12840466926070038, 0.75, 'x[6] <= -1.134\ngini = 0.219\nsamples =
64\nvalue = [56, 8]'),
  Text(0.10894941634241245, 0.6785714285714286, 'x[13] <= 0.697\ngini =
0.457\nsamples = 17\nvalue = [11, 6]'),
  Text(0.0933852140077821, 0.6071428571428571, 'x[18] <= 0.823\ngini =
0.18\nsamples = 10\nvalue = [9, 1]'),
  Text(0.08560311284046693, 0.5357142857142857, 'gini = 0.0\nsamples = 9\nvalue =
[9, 0]'),
  Text(0.10116731517509728, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
  Text(0.1245136186770428, 0.6071428571428571, 'x[14] <= 0.761\ngini =
0.408\nsamples = 7\nvalue = [2, 5]'),
  Text(0.11673151750972763, 0.5357142857142857, 'gini = 0.0\nsamples = 5\nvalue =
[0, 5]'),
  Text(0.13229571984435798, 0.5357142857142857, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
  Text(0.14785992217898833, 0.6785714285714286, 'x[12] <= -1.512\ngini =
0.081\nsamples = 47\nvalue = [45, 2]'),
  Text(0.14007782101167315, 0.6071428571428571, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
  Text(0.1556420233463035, 0.6071428571428571, 'x[12] <= 1.684\ngini =
0.043\nsamples = 46\nvalue = [45, 1]'),
  Text(0.14785992217898833, 0.5357142857142857, 'gini = 0.0\nsamples = 45\nvalue
= [45, 0]'),

```

```

Text(0.16342412451361868, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.35873662451361865, 0.8214285714285714, 'x[10] <= -1.119\ngini =
0.145\nsamples = 637\nvalue = [587, 50]'),
Text(0.2509727626459144, 0.75, 'x[18] <= -0.354\ngini = 0.265\nsamples =
121\nvalue = [102, 19]'),
Text(0.20622568093385213, 0.6785714285714286, 'x[16] <= 0.754\ngini =
0.393\nsamples = 52\nvalue = [38, 14]'),
Text(0.19844357976653695, 0.6071428571428571, 'x[13] <= -0.487\ngini =
0.475\nsamples = 36\nvalue = [22, 14]'),
Text(0.17898832684824903, 0.5357142857142857, 'x[34] <= 1.429\ngini =
0.332\nsamples = 19\nvalue = [15, 4]'),
Text(0.17120622568093385, 0.4642857142857143, 'x[24] <= 3.369\ngini =
0.208\nsamples = 17\nvalue = [15, 2]'),
Text(0.16342412451361868, 0.39285714285714285, 'x[21] <= -1.741\ngini =
0.117\nsamples = 16\nvalue = [15, 1]'),
Text(0.1556420233463035, 0.32142857142857145, 'x[7] <= -0.403\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.14785992217898833, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.16342412451361868, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.17120622568093385, 0.32142857142857145, 'gini = 0.0\nsamples = 14\nvalue
= [14, 0]'),
Text(0.17898832684824903, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.1867704280155642, 0.4642857142857143, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.2178988326848249, 0.5357142857142857, 'x[2] <= -0.82\ngini =
0.484\nsamples = 17\nvalue = [7, 10]'),
Text(0.20233463035019456, 0.4642857142857143, 'x[11] <= -0.731\ngini =
0.375\nsamples = 8\nvalue = [6, 2]'),
Text(0.19455252918287938, 0.39285714285714285, 'x[23] <= 0.086\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.1867704280155642, 0.32142857142857145, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.20233463035019456, 0.32142857142857145, 'gini = 0.0\nsamples = 2\nvalue
= [0, 2]'),
Text(0.21011673151750973, 0.39285714285714285, 'gini = 0.0\nsamples = 5\nvalue
= [5, 0]'),
Text(0.23346303501945526, 0.4642857142857143, 'x[21] <= -1.741\ngini =
0.198\nsamples = 9\nvalue = [1, 8]'),
Text(0.22568093385214008, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.24124513618677043, 0.39285714285714285, 'gini = 0.0\nsamples = 8\nvalue
= [0, 8]'),
Text(0.2140077821011673, 0.6071428571428571, 'gini = 0.0\nsamples = 16\nvalue =
[16, 0]'),
Text(0.29571984435797666, 0.6785714285714286, 'x[1] <= 1.506\ngini =

```

```

0.134\nsamples = 69\nvalue = [64, 5]'),
Text(0.28793774319066145, 0.6071428571428571, 'x[0] <= -0.253\ngini =
0.111\nsamples = 68\nvalue = [64, 4]'),
Text(0.2801556420233463, 0.5357142857142857, 'x[11] <= -0.076\ngini =
0.238\nsamples = 29\nvalue = [25, 4]'),
Text(0.26459143968871596, 0.4642857142857143, 'x[6] <= -1.134\ngini =
0.095\nsamples = 20\nvalue = [19, 1]'),
Text(0.25680933852140075, 0.39285714285714285, 'x[20] <= 0.583\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.2490272373540856, 0.32142857142857145, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.26459143968871596, 0.32142857142857145, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.2723735408560311, 0.39285714285714285, 'gini = 0.0\nsamples = 18\nvalue
= [18, 0]'),
Text(0.29571984435797666, 0.4642857142857143, 'x[19] <= -0.114\ngini =
0.444\nsamples = 9\nvalue = [6, 3]'),
Text(0.28793774319066145, 0.39285714285714285, 'gini = 0.0\nsamples = 4\nvalue
= [4, 0]'),
Text(0.3035019455252918, 0.39285714285714285, 'x[20] <= -0.223\ngini =
0.48\nsamples = 5\nvalue = [2, 3]'),
Text(0.29571984435797666, 0.32142857142857145, 'gini = 0.0\nsamples = 2\nvalue
= [2, 0]'),
Text(0.311284046692607, 0.32142857142857145, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.29571984435797666, 0.5357142857142857, 'gini = 0.0\nsamples = 39\nvalue
= [39, 0]'),
Text(0.3035019455252918, 0.6071428571428571, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.46650048638132297, 0.75, 'x[1] <= -1.7\ngini = 0.113\nsamples =
516\nvalue = [485, 31]'),
Text(0.42485408560311283, 0.6785714285714286, 'x[16] <= -1.082\ngini =
0.5\nsamples = 4\nvalue = [2, 2]'),
Text(0.4170719844357977, 0.6071428571428571, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.43263618677042803, 0.6071428571428571, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.508146887159533, 0.6785714285714286, 'x[11] <= 0.612\ngini =
0.107\nsamples = 512\nvalue = [483, 29]'),
Text(0.4482003891050584, 0.6071428571428571, 'x[19] <= -0.432\ngini =
0.077\nsamples = 400\nvalue = [384, 16]'),
Text(0.4022373540856031, 0.5357142857142857, 'x[13] <= 0.697\ngini =
0.155\nsamples = 154\nvalue = [141, 13]'),
Text(0.35700389105058367, 0.4642857142857143, 'x[25] <= -1.036\ngini =
0.085\nsamples = 135\nvalue = [129, 6]'),
Text(0.3346303501945525, 0.39285714285714285, 'x[11] <= -0.822\ngini =
0.408\nsamples = 7\nvalue = [5, 2]'),

```

```

Text(0.32684824902723736, 0.32142857142857145, 'gini = 0.0\nsamples = 2\nvalue
= [0, 2]'),
Text(0.3424124513618677, 0.32142857142857145, 'gini = 0.0\nsamples = 5\nvalue
= [5, 0]'),
Text(0.37937743190661477, 0.39285714285714285, 'x[24] <= 1.188\ngini =
0.061\nsamples = 128\nvalue = [124, 4]'),
Text(0.35797665369649806, 0.32142857142857145, 'x[11] <= -1.048\ngini =
0.046\nsamples = 126\nvalue = [123, 3]'),
Text(0.33852140077821014, 0.25, 'x[46] <= 0.103\ngini = 0.5\nsamples = 2\nvalue
= [1, 1]'),
Text(0.33073929961089493, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.3463035019455253, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue
= [1, 0]'),
Text(0.377431906614786, 0.25, 'x[13] <= 0.302\ngini = 0.032\nsamples =
124\nvalue = [122, 2]'),
Text(0.36186770428015563, 0.17857142857142858, 'x[0] <= -1.69\ngini =
0.017\nsamples = 118\nvalue = [117, 1]'),
Text(0.3540856031128405, 0.10714285714285714, 'x[15] <= 0.956\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.3463035019455253, 0.03571428571428571, 'gini = 0.0\nsamples = 5\nvalue
= [5, 0]'),
Text(0.36186770428015563, 0.03571428571428571, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.36964980544747084, 0.10714285714285714, 'gini = 0.0\nsamples =
112\nvalue = [112, 0]'),
Text(0.39299610894941633, 0.17857142857142858, 'x[16] <= -1.082\ngini =
0.278\nsamples = 6\nvalue = [5, 1]'),
Text(0.3852140077821012, 0.10714285714285714, 'gini = 0.0\nsamples = 1\nvalue
= [0, 1]'),
Text(0.40077821011673154, 0.10714285714285714, 'gini = 0.0\nsamples = 5\nvalue
= [5, 0]'),
Text(0.40077821011673154, 0.32142857142857145, 'x[35] <= -0.228\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.39299610894941633, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.4085603112840467, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.4474708171206226, 0.4642857142857143, 'x[1] <= 1.373\ngini =
0.465\nsamples = 19\nvalue = [12, 7]'),
Text(0.4396887159533074, 0.39285714285714285, 'x[0] <= -0.584\ngini =
0.375\nsamples = 16\nvalue = [12, 4]'),
Text(0.43190661478599224, 0.32142857142857145, 'x[1] <= 0.334\ngini =
0.5\nsamples = 8\nvalue = [4, 4]'),
Text(0.42412451361867703, 0.25, 'gini = 0.0\nsamples = 4\nvalue = [0, 4]'),
Text(0.4396887159533074, 0.25, 'gini = 0.0\nsamples = 4\nvalue = [4, 0]'),
Text(0.4474708171206226, 0.32142857142857145, 'gini = 0.0\nsamples = 8\nvalue
= [8, 0]'),
Text(0.45525291828793774, 0.39285714285714285, 'gini = 0.0\nsamples = 3\nvalue

```

```

= [0, 3]'),
Text(0.49416342412451364, 0.5357142857142857, 'x[0] <= 1.626\ngini =
0.024\nsamples = 246\nvalue = [243, 3]'),
Text(0.4785992217898833, 0.4642857142857143, 'x[25] <= -0.737\ngini =
0.009\nsamples = 221\nvalue = [220, 1]'),
Text(0.4708171206225681, 0.39285714285714285, 'x[37] <= 0.878\ngini =
0.091\nsamples = 21\nvalue = [20, 1]'),
Text(0.46303501945525294, 0.32142857142857145, 'gini = 0.0\nsamples = 18\nvalue
= [18, 0]'),
Text(0.4785992217898833, 0.32142857142857145, 'x[12] <= 0.37\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.4708171206225681, 0.25, 'gini = 0.0\nsamples = 2\nvalue = [2, 0]'),
Text(0.48638132295719844, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.48638132295719844, 0.39285714285714285, 'gini = 0.0\nsamples =
200\nvalue = [200, 0]'),
Text(0.5097276264591439, 0.4642857142857143, 'x[11] <= -0.943\ngini =
0.147\nsamples = 25\nvalue = [23, 2]'),
Text(0.5019455252918288, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.5175097276264592, 0.39285714285714285, 'x[31] <= 1.272\ngini =
0.08\nsamples = 24\nvalue = [23, 1]'),
Text(0.5097276264591439, 0.32142857142857145, 'gini = 0.0\nsamples = 22\nvalue
= [22, 0]'),
Text(0.5252918287937743, 0.32142857142857145, 'x[16] <= 0.754\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.5175097276264592, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [1, 0]'),
Text(0.5330739299610895, 0.25, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
Text(0.5680933852140078, 0.6071428571428571, 'x[1] <= -1.619\ngini =
0.205\nsamples = 112\nvalue = [99, 13]'),
Text(0.5486381322957199, 0.5357142857142857, 'x[5] <= -0.421\ngini =
0.375\nsamples = 4\nvalue = [1, 3]'),
Text(0.5408560311284046, 0.4642857142857143, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.556420233463035, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.5875486381322957, 0.5357142857142857, 'x[14] <= -1.017\ngini =
0.168\nsamples = 108\nvalue = [98, 10]'),
Text(0.5719844357976653, 0.4642857142857143, 'x[19] <= 1.001\ngini =
0.397\nsamples = 22\nvalue = [16, 6]'),
Text(0.5642023346303502, 0.39285714285714285, 'x[13] <= -0.487\ngini =
0.266\nsamples = 19\nvalue = [16, 3]'),
Text(0.556420233463035, 0.32142857142857145, 'x[13] <= -0.882\ngini =
0.5\nsamples = 6\nvalue = [3, 3]'),
Text(0.5486381322957199, 0.25, 'gini = 0.0\nsamples = 3\nvalue = [3, 0]'),
Text(0.5642023346303502, 0.25, 'gini = 0.0\nsamples = 3\nvalue = [0, 3]'),
Text(0.5719844357976653, 0.32142857142857145, 'gini = 0.0\nsamples = 13\nvalue
= [13, 0]'),

```

```

Text(0.5797665369649806, 0.39285714285714285, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.603112840466926, 0.4642857142857143, 'x[11] <= 0.633\ngini =
0.089\nsamples = 86\nvalue = [82, 4]'),
Text(0.5953307392996109, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6108949416342413, 0.39285714285714285, 'x[0] <= 1.294\ngini =
0.068\nsamples = 85\nvalue = [82, 3]'),
Text(0.603112840466926, 0.32142857142857145, 'gini = 0.0\nsamples = 62\nvalue =
[62, 0]'),
Text(0.6186770428015564, 0.32142857142857145, 'x[11] <= 1.562\ngini =
0.227\nsamples = 23\nvalue = [20, 3]'),
Text(0.6108949416342413, 0.25, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.6264591439688716, 0.25, 'x[12] <= 1.488\ngini = 0.091\nsamples =
21\nvalue = [20, 1]'),
Text(0.6186770428015564, 0.17857142857142858, 'gini = 0.0\nsamples = 20\nvalue
= [20, 0]'),
Text(0.6342412451361867, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.8274562256809338, 0.8928571428571429, 'x[11] <= -0.434\ngini =
0.427\nsamples = 282\nvalue = [195, 87]'),
Text(0.7453793774319066, 0.8214285714285714, 'x[8] <= 1.094\ngini =
0.493\nsamples = 109\nvalue = [48, 61]'),
Text(0.7008754863813229, 0.75, 'x[0] <= -1.137\ngini = 0.474\nsamples =
96\nvalue = [37, 59]'),
Text(0.6536964980544747, 0.6785714285714286, 'x[24] <= -0.214\ngini =
0.204\nsamples = 26\nvalue = [3, 23]'),
Text(0.6381322957198443, 0.6071428571428571, 'x[7] <= -1.528\ngini =
0.083\nsamples = 23\nvalue = [1, 22]'),
Text(0.6303501945525292, 0.5357142857142857, 'x[5] <= 0.251\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.622568093385214, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6381322957198443, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.6459143968871596, 0.5357142857142857, 'gini = 0.0\nsamples = 21\nvalue =
[0, 21]'),
Text(0.669260700389105, 0.6071428571428571, 'x[37] <= 0.878\ngini =
0.444\nsamples = 3\nvalue = [2, 1]'),
Text(0.6614785992217899, 0.5357142857142857, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.6770428015564203, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7480544747081712, 0.6785714285714286, 'x[1] <= 0.807\ngini =
0.5\nsamples = 70\nvalue = [34, 36]'),
Text(0.7217898832684825, 0.6071428571428571, 'x[14] <= 0.898\ngini =
0.468\nsamples = 51\nvalue = [19, 32]'),

```

```

Text(0.6926070038910506, 0.5357142857142857, 'x[0] <= -0.142\ngini =
0.497\nsamples = 39\nvalue = [18, 21]'),
Text(0.6575875486381323, 0.4642857142857143, 'x[0] <= -0.916\ngini =
0.434\nsamples = 22\nvalue = [7, 15]'),
Text(0.642023346303502, 0.39285714285714285, 'x[18] <= 2.001\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.6342412451361867, 0.32142857142857145, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
Text(0.6498054474708171, 0.32142857142857145, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6731517509727627, 0.39285714285714285, 'x[14] <= 0.077\ngini =
0.291\nsamples = 17\nvalue = [3, 14]'),
Text(0.6653696498054474, 0.32142857142857145, 'x[12] <= 1.15\ngini =
0.124\nsamples = 15\nvalue = [1, 14]'),
Text(0.6575875486381323, 0.25, 'gini = 0.0\nsamples = 13\nvalue = [0, 13]'),
Text(0.6731517509727627, 0.25, 'x[37] <= 0.878\ngini = 0.5\nsamples = 2\nvalue
= [1, 1]'),
Text(0.6653696498054474, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.6809338521400778, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.6809338521400778, 0.32142857142857145, 'gini = 0.0\nsamples = 2\nvalue =
[2, 0]'),
Text(0.7276264591439688, 0.4642857142857143, 'x[0] <= 1.073\ngini =
0.457\nsamples = 17\nvalue = [11, 6]'),
Text(0.7198443579766537, 0.39285714285714285, 'x[24] <= -0.525\ngini =
0.337\nsamples = 14\nvalue = [11, 3]'),
Text(0.7120622568093385, 0.32142857142857145, 'x[5] <= 0.13\ngini =
0.5\nsamples = 6\nvalue = [3, 3]'),
Text(0.7042801556420234, 0.25, 'x[16] <= -1.082\ngini = 0.375\nsamples =
4\nvalue = [3, 1]'),
Text(0.6964980544747081, 0.17857142857142858, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7120622568093385, 0.17857142857142858, 'gini = 0.0\nsamples = 3\nvalue =
[3, 0]'),
Text(0.7198443579766537, 0.25, 'gini = 0.0\nsamples = 2\nvalue = [0, 2]'),
Text(0.7276264591439688, 0.32142857142857145, 'gini = 0.0\nsamples = 8\nvalue =
[8, 0]'),
Text(0.7354085603112841, 0.39285714285714285, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.7509727626459144, 0.5357142857142857, 'x[11] <= -0.459\ngini =
0.153\nsamples = 12\nvalue = [1, 11]'),
Text(0.7431906614785992, 0.4642857142857143, 'gini = 0.0\nsamples = 11\nvalue =
[0, 11]'),
Text(0.7587548638132295, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.77431906614786, 0.6071428571428571, 'x[6] <= -1.134\ngini =

```

```

0.332\nsamples = 19\nvalue = [15, 4]'),
Text(0.7665369649805448, 0.5357142857142857, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.7821011673151751, 0.5357142857142857, 'x[5] <= -1.467\ngini =
0.117\nsamples = 16\nvalue = [15, 1]'),
Text(0.77431906614786, 0.4642857142857143, 'x[19] <= -0.83\ngini = 0.5\nsamples
= 2\nvalue = [1, 1]'),
Text(0.7665369649805448, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7821011673151751, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.7898832684824902, 0.4642857142857143, 'gini = 0.0\nsamples = 14\nvalue =
[14, 0]'),
Text(0.7898832684824902, 0.75, 'x[22] <= -1.374\ngini = 0.26\nsamples =
13\nvalue = [11, 2]'),
Text(0.7821011673151751, 0.6785714285714286, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.7976653696498055, 0.6785714285714286, 'x[26] <= 0.804\ngini =
0.153\nsamples = 12\nvalue = [11, 1]'),
Text(0.7898832684824902, 0.6071428571428571, 'gini = 0.0\nsamples = 11\nvalue =
[11, 0]'),
Text(0.8054474708171206, 0.6071428571428571, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.9095330739299611, 0.8214285714285714, 'x[45] <= 0.368\ngini =
0.255\nsamples = 173\nvalue = [147, 26]'),
Text(0.8618677042801557, 0.75, 'x[12] <= 1.46\ngini = 0.123\nsamples =
121\nvalue = [113, 8]'),
Text(0.8404669260700389, 0.6785714285714286, 'x[25] <= -1.036\ngini =
0.085\nsamples = 113\nvalue = [108, 5]'),
Text(0.8210116731517509, 0.6071428571428571, 'x[10] <= 0.709\ngini =
0.42\nsamples = 10\nvalue = [7, 3]'),
Text(0.8132295719844358, 0.5357142857142857, 'x[0] <= 0.079\ngini =
0.375\nsamples = 4\nvalue = [1, 3]'),
Text(0.8054474708171206, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.8210116731517509, 0.4642857142857143, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.8287937743190662, 0.5357142857142857, 'gini = 0.0\nsamples = 6\nvalue =
[6, 0]'),
Text(0.8599221789883269, 0.6071428571428571, 'x[2] <= 2.404\ngini =
0.038\nsamples = 103\nvalue = [101, 2]'),
Text(0.8443579766536965, 0.5357142857142857, 'x[8] <= -1.733\ngini =
0.02\nsamples = 101\nvalue = [100, 1]'),
Text(0.8365758754863813, 0.4642857142857143, 'x[23] <= -0.465\ngini =
0.32\nsamples = 5\nvalue = [4, 1]'),
Text(0.8287937743190662, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),

```



```

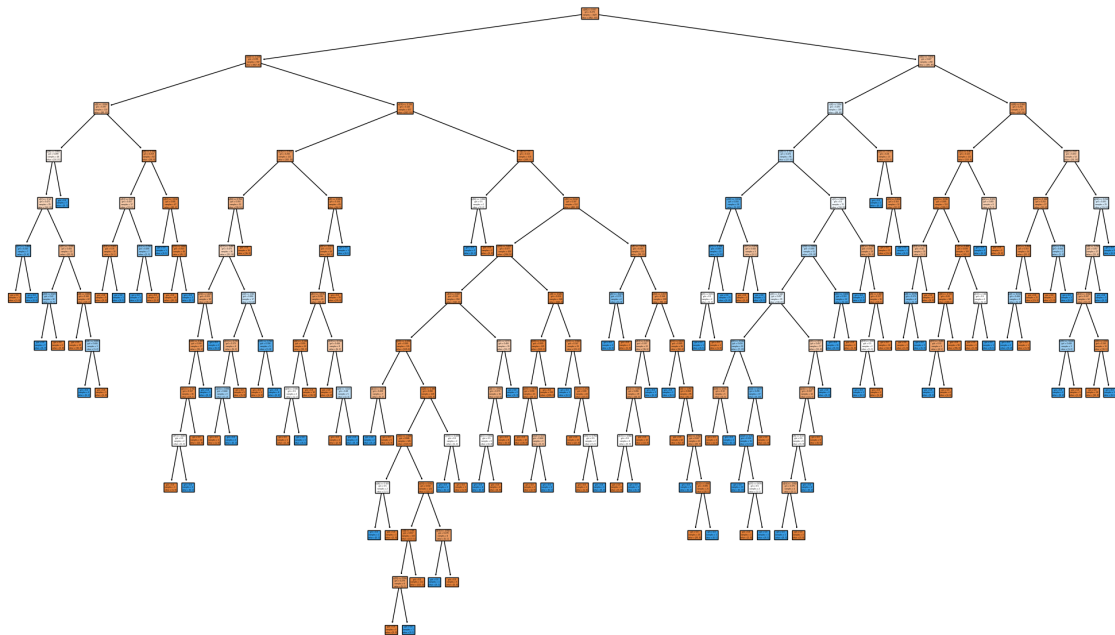
Text(0.8443579766536965, 0.39285714285714285, 'gini = 0.0\nsamples = 4\nvalue =
[4, 0]'),
Text(0.8521400778210116, 0.4642857142857143, 'gini = 0.0\nsamples = 96\nvalue =
[96, 0]'),
Text(0.8754863813229572, 0.5357142857142857, 'x[11] <= 1.66\ngini =
0.5\nsamples = 2\nvalue = [1, 1]'),
Text(0.867704280155642, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.8832684824902723, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.8832684824902723, 0.6785714285714286, 'x[6] <= -0.221\ngini =
0.469\nsamples = 8\nvalue = [5, 3]'),
Text(0.8754863813229572, 0.6071428571428571, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.8910505836575876, 0.6071428571428571, 'gini = 0.0\nsamples = 5\nvalue =
[5, 0]'),
Text(0.9571984435797666, 0.75, 'x[42] <= 0.67\ngini = 0.453\nsamples =
52\nvalue = [34, 18]'),
Text(0.9299610894941635, 0.6785714285714286, 'x[24] <= 1.188\ngini =
0.252\nsamples = 27\nvalue = [23, 4]'),
Text(0.914396887159533, 0.6071428571428571, 'x[5] <= -1.454\ngini =
0.153\nsamples = 24\nvalue = [22, 2]'),
Text(0.9066147859922179, 0.5357142857142857, 'x[2] <= 0.234\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.8988326848249028, 0.4642857142857143, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.914396887159533, 0.4642857142857143, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.9221789883268483, 0.5357142857142857, 'gini = 0.0\nsamples = 21\nvalue =
[21, 0]'),
Text(0.9455252918287937, 0.6071428571428571, 'x[5] <= -0.74\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.9377431906614786, 0.5357142857142857, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0]'),
Text(0.953307392996109, 0.5357142857142857, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.9844357976653697, 0.6785714285714286, 'x[24] <= -0.214\ngini =
0.493\nsamples = 25\nvalue = [11, 14]'),
Text(0.9766536964980544, 0.6071428571428571, 'x[8] <= 1.094\ngini =
0.457\nsamples = 17\nvalue = [11, 6]'),
Text(0.9688715953307393, 0.5357142857142857, 'x[16] <= -1.082\ngini =
0.337\nsamples = 14\nvalue = [11, 3]'),
Text(0.953307392996109, 0.4642857142857143, 'x[35] <= -0.228\ngini =
0.444\nsamples = 3\nvalue = [1, 2]'),
Text(0.9455252918287937, 0.39285714285714285, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2]'),
Text(0.9610894941634242, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =

```

```

[1, 0]'),
Text(0.9844357976653697, 0.4642857142857143, 'x[5] <= 1.155\ngini =
0.165\nsamples = 11\nvalue = [10, 1]'),
Text(0.9766536964980544, 0.39285714285714285, 'gini = 0.0\nsamples = 10\nvalue
= [10, 0]'),
Text(0.9922178988326849, 0.39285714285714285, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1]'),
Text(0.9844357976653697, 0.5357142857142857, 'gini = 0.0\nsamples = 3\nvalue =
[0, 3]'),
Text(0.9922178988326849, 0.6071428571428571, 'gini = 0.0\nsamples = 8\nvalue =
[0, 8]')])

```



```

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

```

```

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

```

```

[123]: grid_search.fit(x_train,y_train)

```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\model\_selection\\_validation.py:425: FitFailedWarning:

100 fits failed out of a total of 300.  
The score on these train-test partitions for these parameters will be set to nan.  
If these failures are not expected, you can try to debug them by setting `error_score='raise'`.

Below are more details about the failures:

```
-----
100 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\RUSHITHA REPAKULA\anaconda3\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\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py",
line 1144, in wrapper
    estimator._validate_params()
  File "C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py",
line 637, in _validate_params
    validate_parameter_constraints(
  File "C:\Users\RUSHITHA REPAKULA\anaconda3\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 {'log2', 'sqrt'} or None. Got 'auto'
instead.
```

```
warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-
packages\sklearn\model_selection\_search.py:976: UserWarning: One or more of the
test scores are non-finite: [          nan          nan 0.83770779 0.83770779
0.83867866 0.83770779
```

```
      nan      nan 0.83770305 0.84062041 0.83576604 0.83770779
      nan      nan 0.83575657 0.84450864 0.82895098 0.83770779
      nan      nan 0.8415534  0.84451338 0.82990291 0.83089273
      nan      nan 0.82507222 0.82701397 0.82605257 0.84743074
      nan      nan 0.83770779 0.83770779 0.83770779 0.83770779
      nan      nan 0.83965901 0.83770779 0.8338243  0.83770779
      nan      nan 0.84062515 0.83673692 0.83674639 0.83867866
      nan      nan 0.8513095  0.83965901 0.84157234 0.83867393
      nan      nan 0.82308785 0.84450391 0.83086905 0.83575657]
```

```
warnings.warn(
```

```
[123]: 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')

```

```
[124]: grid_search.best_params_
```

```
[124]: {'criterion': 'entropy',
       'max_depth': 4,
       'max_features': 'sqrt',
       'splitter': 'best'}
```

```
[125]: dtc_cv=DecisionTreeClassifier(criterion= 'entropy',
max_depth=4,
max_features='sqrt',
splitter='best')
dtc_cv.fit(x_train,y_train)
```

```
[125]: DecisionTreeClassifier(criterion='entropy', max_depth=4, max_features='sqrt')
```

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

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

	precision	recall	f1-score	support
0	0.84	0.98	0.91	371
1	0.33	0.04	0.08	70
accuracy			0.83	441
macro avg	0.59	0.51	0.49	441
weighted avg	0.76	0.83	0.78	441

After performing Hyperparameter tuning the accuracy has been improved.

## 6 Random Forest

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

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

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

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

```
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
```

expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n\_samples,), for example using ravel().

```
return fit_method(estimator, *args, **kwargs)
```

```
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
    return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
    return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
    return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
    return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
    return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py:1151:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
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ravel().
    return fit_method(estimator, *args, **kwargs)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\model_selection\_validation.py:425: FitFailedWarning:
50 fits failed out of a total of 700.
The score on these train-test partitions for these parameters will be set to
nan.
If these failures are not expected, you can try to debug them by setting
error_score='raise'.

Below are more details about the failures:
-----
50 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\RUSHITHA REPAKULA\anaconda3\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\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py",

```



```

line 1144, in wrapper
    estimator._validate_params()
  File "C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-packages\sklearn\base.py",
line 637, in _validate_params
    validate_parameter_constraints(
  File "C:\Users\RUSHITHA REPAKULA\anaconda3\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 {'log2', 'sqrt'} or None. Got 0
instead.

```

```

    warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\RUSHITHA REPAKULA\anaconda3\Lib\site-
packages\sklearn\model_selection\_search.py:976: UserWarning: One or more of the
test scores are non-finite: [      nan 0.84159528 0.84547877 0.84936227
0.85519703 0.85227489
0.85518751 0.85325528 0.85421664 0.85615839 0.8483914  0.85421664
0.85421664 0.847411      nan 0.84353703 0.85132305 0.85032362
0.85228441 0.85422616 0.85518751 0.85033314 0.85323625 0.85032362
0.84547877 0.85226537 0.84448886 0.85324576      nan 0.84355606
0.85132305 0.85229393 0.84936227 0.85712926 0.85520655 0.85324576
0.85324576 0.85130402 0.85712926 0.85518751 0.85033314 0.85032362
      nan 0.8445079  0.84449838 0.85228441 0.85032362 0.8512945
0.85226537 0.85226537 0.85713878 0.85421664 0.85032362 0.85420712
0.85907101 0.84545974      nan 0.8445079  0.84936227 0.85131354
0.85032362 0.85324576 0.85130402 0.84937179 0.85131354 0.84937179
0.85323625 0.85324576 0.85032362 0.85228441]
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```

```

    return fit_method(estimator, *args, **kwargs)

```

```

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

```

```

[132]: pred=rfc_cv.predict(x_test)

```

```

[133]: print(classification_report(y_test, pred))

```

```

precision    recall  f1-score   support

```

0	0.87	0.99	0.93	371
1	0.79	0.21	0.34	70
accuracy			0.87	441
macro avg	0.83	0.60	0.63	441
weighted avg	0.86	0.87	0.83	441

```
[134]: rfc_cv.best_params_
```

```
[134]: {'max_depth': 13, 'max_features': 12}
```

```
[ ]:
```