Assignment-4 Download the Employee Attrition Dataset https://www.kaggle.com/datasets/patelprashant/employee-attrition 2.Perfrom Data Preprocessing 3.Model Building using Logistic Regression and Decision Tree and Random Forest 4.Calculate Performance metrics

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

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

#Importing the dataset.
df=pd.read_csv("HR_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.shape
```

```
(1470, 35)
```

```
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]
```

```
#Checking for Null Values.
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()
```

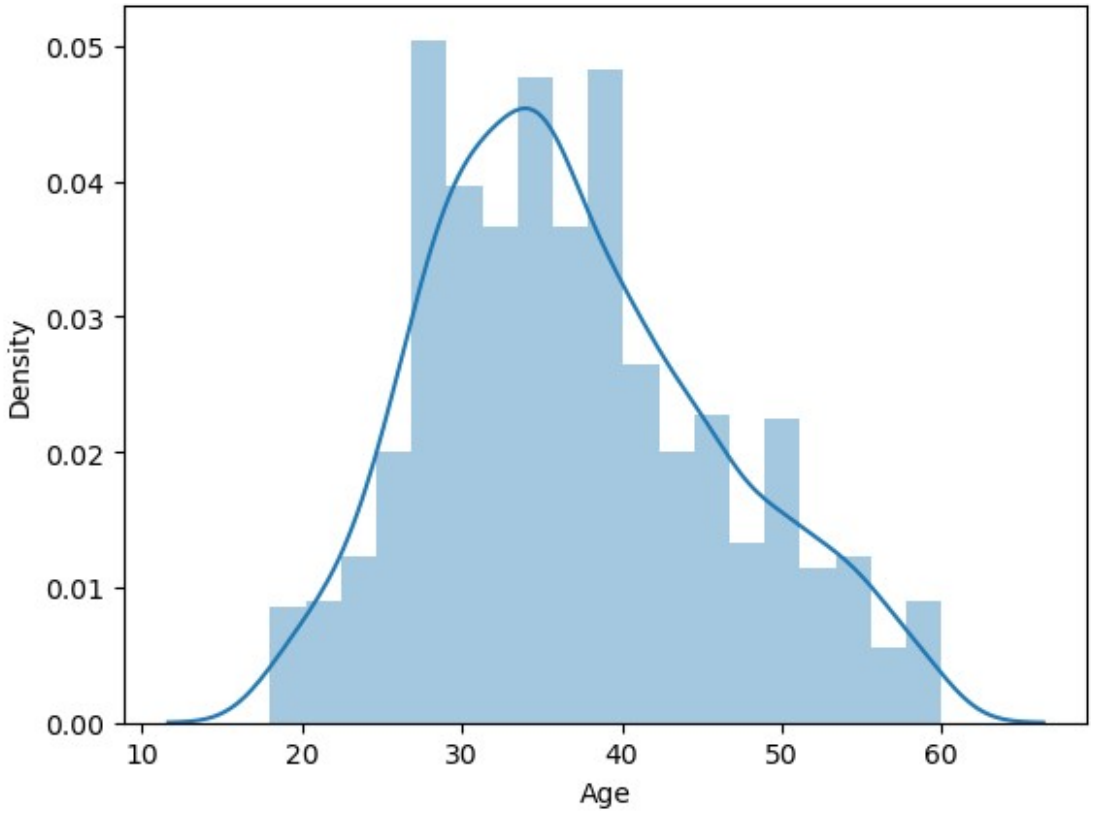
```
Age                         0
Attrition                   0
BusinessTravel              0
DailyRate                   0
Department                  0
DistanceFromHome            0
Education                   0
EducationField              0
EmployeeCount               0
EmployeeNumber              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
```

```
df=df.drop('EmployeeCount', axis=1) # as there are having 0 standard deviation

df=df.drop('StandardHours', axis=1)
```

no null values in the given dataset

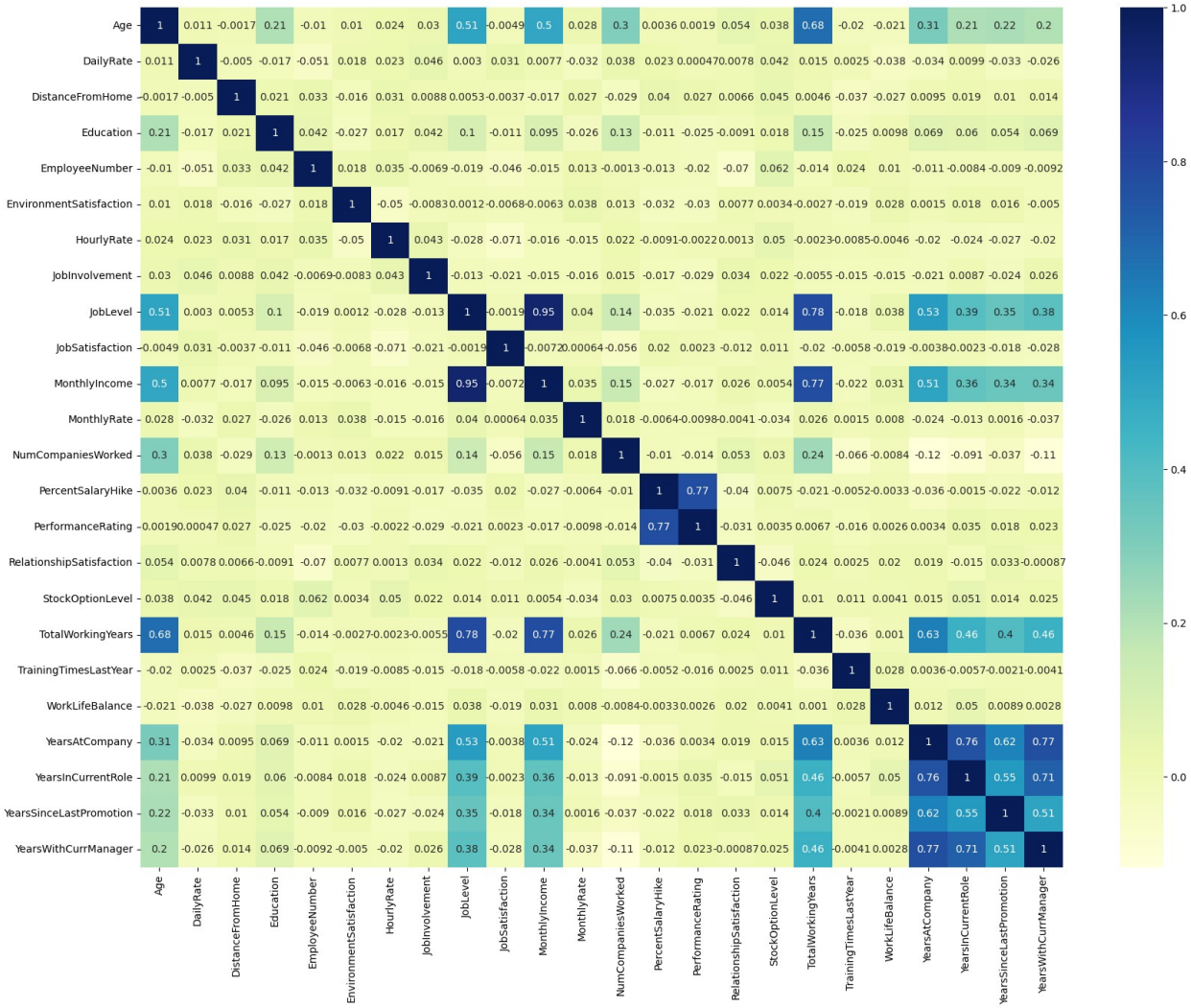
```
#Data Visualization.
sns.distplot(df["Age"])
```

```
C:\Users\Surya\AppData\Local\Temp\ipykernel_24908\2400079689.py:2:
UserWarning:

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

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

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

  sns.distplot(df["Age"])

<Axes: xlabel='Age', ylabel='Density'>
```

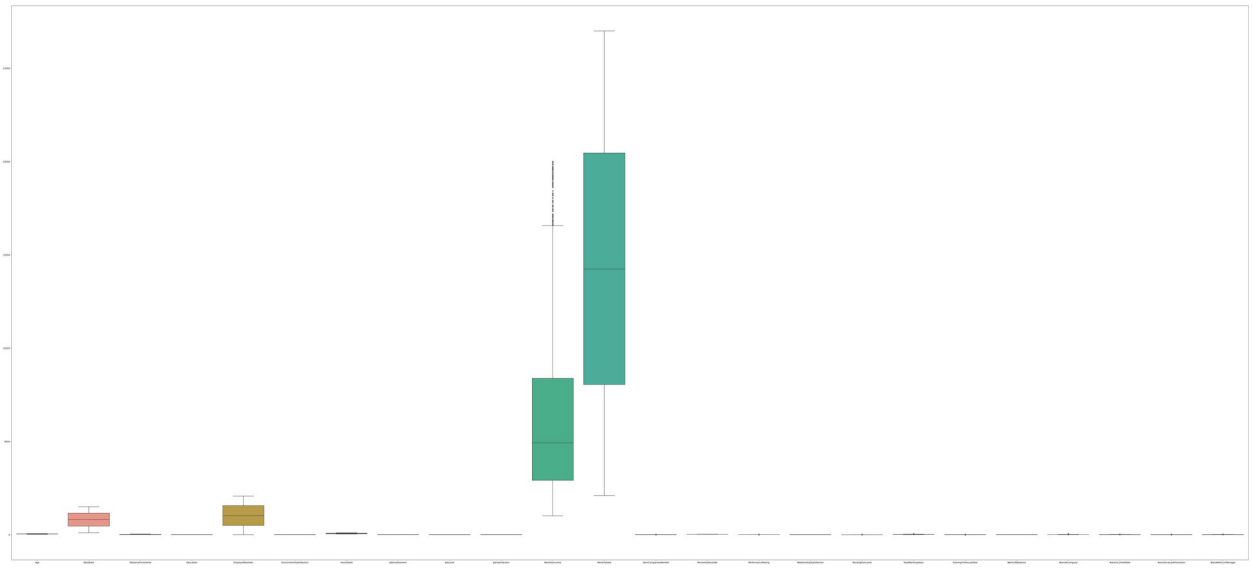



```
corr=df.corr()

C:\Users\Surya\AppData\Local\Temp\ipykernel_24908\1515641297.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()

plt.subplots(figsize=(20,15))
sns.heatmap(corr,annot=True,cmap="YlGnBu")

<Axes: >
```




```
plt.subplots(figsize=(100,45))
sns.boxplot(df)

<Axes: >
```



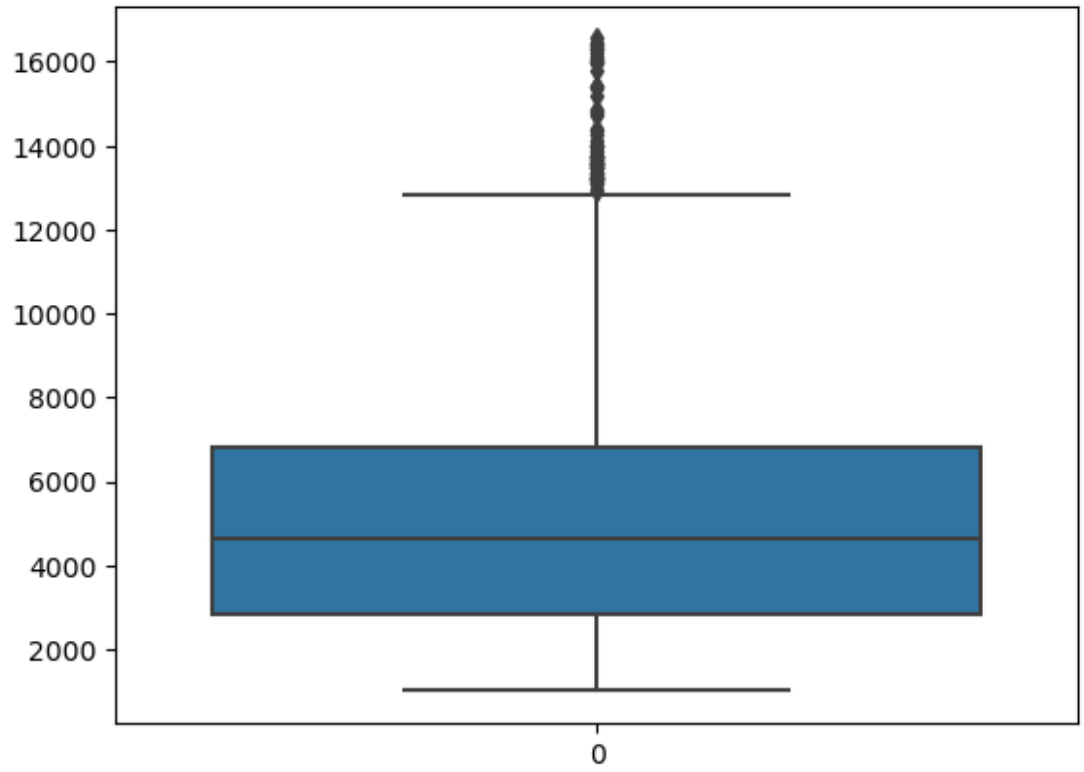
outliers are present in monthlyincome feature removing them using iqr method

```
q1= df.MonthlyIncome.quantile(0.25)# finding q1 formula
q3= df.MonthlyIncome.quantile(0.75)# finding q3 formula


IQR = q3-q1

uuper_limit = q3+1.5*(IQR)
uuper_limit
```

```
16581.0
```

```
df=df[df.MonthlyIncome<uuper_limit]

sns.boxplot(df['MonthlyIncome'])
```

```
<Axes: >
```




```
df.shape
```

```
(1356, 33)
```

```
#label encoding
from sklearn.preprocessing import LabelEncoder
le=LabelEncoder()
df.Gender=le.fit_transform(df.Gender)
```

```
df
```

```
      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  EmployeeNumber  \
0                    1          2  Life Sciences               1
1                    8          1  Life Sciences               2
2                    2          2          Other               4
3                    3          4  Life Sciences               5
4                    2          1        Medical               7
...                ...        ...            ...             ...
1465                23          2        Medical            2061
1466                 6          1        Medical            2062
1467                 4          3  Life Sciences            2064
1468                 2          3        Medical            2065
1469                 8          3        Medical            2068

      EnvironmentSatisfaction  ...  PerformanceRating  \
0                           2  ...                  3
1                           3  ...                  4
2                           4  ...                  3
3                           4  ...                  3
4                           1  ...                  3
...                       ...  ...                ...
1465                        3  ...                  3
1466                        4  ...                  3
1467                        2  ...                  4
1468                        4  ...                  3
1469                        2  ...                  3

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

     TrainingTimesLastYear  WorkLifeBalance YearsAtCompany  \
```

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

      YearsInCurrentRole  YearsSinceLastPromotion
YearsWithCurrManager
0                      4                        0
5
1                      7                        1
7
2                      0                        0
0
3                      7                        3
0
4                      2                        2
2
...                  ...                      ...                    ..
.
1465                   2                        0
3
1466                   7                        1
7
1467                   2                        0
3
1468                   6                        0
8
1469                   3                        1
2

[1356 rows x 33 columns]
```

```
 #Convert categorical variables to dummy/indicator variables (one-hot
encoding)
df = pd.get_dummies(df, columns=['Department', 'EducationField',
'MaritalStatus',
'Gender','JobRole','Over18','OverTime','BusinessTravel'],
drop_first=True)

df
```

```
      Age Attrition  DailyRate  DistanceFromHome  Education
EmployeeNumber  \
```

```
0      41        Yes       1102                   1           2
1
1      49         No        279                   8           1
2
2      37        Yes       1373                   2           2
4
3      33         No       1392                   3           4
5
4      27         No        591                   2           1
7
...   ...        ...        ...                 ...         ...
...
1465   36         No        884                  23           2
2061
1466   39         No        613                   6           1
2062
1467   27         No        155                   4           3
2064
1468   49         No       1023                   2           3
2065
1469   34         No        628                   8           3
2068

      EnvironmentSatisfaction  HourlyRate  JobInvolvement
JobLevel  ...  \
0                           2          94               3
2  ...
1                           3          61               2
2  ...
2                           4          92               2
1  ...
3                           4          56               3
1  ...
4                           1          40               3
1  ...
...                       ...         ...             ...       ...  .
..
1465                        3          41               4
2  ...
1466                        4          42               2
3  ...
1467                        2          87               4
2  ...
1468                        4          63               2
2  ...
1469                        2          82               4
2  ...

      JobRole_Laboratory Technician  JobRole_Manager  \
```

```
0                                    0                  0
1                                    0                  0
2                                    1                  0
3                                    0                  0
4                                    1                  0
...                                ...                ...
1465                                 1                  0
1466                                 0                  0
1467                                 0                  0
1468                                 0                  0
1469                                 1                  0

      JobRole_Manufacturing Director  JobRole_Research Director  \
0                                    0                          0
1                                    0                          0
2                                    0                          0
3                                    0                          0
4                                    0                          0
...                                ...                        ...
1465                                 0                          0
1466                                 0                          0
1467                                 1                          0
1468                                 0                          0
1469                                 0                          0

      JobRole_Research Scientist  JobRole_Sales Executive  \
0                              0                         1
1                              1                         0
2                              0                         0
3                              1                         0
4                              0                         0
...                          ...                       ...
1465                           0                         0
1466                           0                         0
1467                           0                         0
1468                           0                         1
1469                           0                         0

      JobRole_Sales Representative  OverTime_Yes  \
0                                0             1
1                                0             0
2                                0             1
3                                0             1
4                                0             0
...                            ...           ...
1465                             0             0
1466                             0             0
1467                             0             1
1468                             0             0
1469                             0             0
```

```
      BusinessTravel_Travel_Frequently  BusinessTravel_Travel_Rarely
0                                    0                             1
1                                    1                             0
2                                    0                             1
3                                    1                             0
4                                    0                             1
...                                ...                           ...
1465                                 1                             0
1466                                 0                             1
1467                                 0                             1
1468                                 1                             0
1469                                 0                             1

[1356 rows x 46 columns]
```

df.head()

```
   Age Attrition  DailyRate  DistanceFromHome  Education
EmployeeNumber  \
0   41       Yes       1102                 1          2
1
1   49        No        279                 8          1
2
2   37       Yes       1373                 2          2
4
3   33        No       1392                 3          4
5
4   27        No        591                 2          1
7

   EnvironmentSatisfaction  HourlyRate  JobInvolvement  JobLevel  ...
\
0                        2          94               3         2  ...

1                        3          61               2         2  ...

2                        4          92               2         1  ...

3                        4          56               3         1  ...

4                        1          40               3         1  ...


   JobRole_Laboratory Technician  JobRole_Manager  \
0                              0                0
1                              0                0
2                              1                0
3                              0                0
4                              1                0
```

```
   JobRole_Manufacturing Director  JobRole_Research Director  \
0                               0                          0
1                               0                          0
2                               0                          0
3                               0                          0
4                               0                          0

   JobRole_Research Scientist  JobRole_Sales Executive  \
0                           0                        1
1                           1                        0
2                           0                        0
3                           1                        0
4                           0                        0

   JobRole_Sales Representative  OverTime_Yes  \
0                             0             1
1                             0             0
2                             0             1
3                             0             1
4                             0             0

   BusinessTravel_Travel_Frequently  BusinessTravel_Travel_Rarely
0                                 0                            1
1                                 1                            0
2                                 0                            1
3                                 1                            0
4                                 0                            1

[5 rows x 46 columns]
```

```
#Splitting Dependent and Independent variables
# here the dependent variable (y) is attrition and remamining are
indepdendent variables(x)
x=df.drop('Attrition', axis=1)

y=df.Attrition
y.head()
```

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

```
x
```

```
      Age  DailyRate  DistanceFromHome  Education  EmployeeNumber  \
0      41       1102                 1          2               1
1      49        279                 8          1               2
2      37       1373                 2          2               4
```

```
3      33       1392                3          4               5
4      27        591                2          1               7
...   ...        ...              ...        ...             ...
1465   36        884               23          2            2061
1466   39        613                6          1            2062
1467   27        155                4          3            2064
1468   49       1023                2          3            2065
1469   34        628                8          3            2068

      EnvironmentSatisfaction  HourlyRate  JobInvolvement  JobLevel  \
0                           2          94               3         2
1                           3          61               2         2
2                           4          92               2         1
3                           4          56               3         1
4                           1          40               3         1
...                       ...         ...             ...       ...
1465                        3          41               4         2
1466                        4          42               2         3
1467                        2          87               4         2
1468                        4          63               2         2
1469                        2          82               4         2

      JobSatisfaction  ...  JobRole_Laboratory Technician
JobRole_Manager  \
0                   4  ...                              0
0
1                   2  ...                              0
0
2                   3  ...                              1
0
3                   3  ...                              0
0
4                   2  ...                              1
0
...               ...  ...                            ...
...
1465                4  ...                              1
0
1466                1  ...                              0
0
1467                2  ...                              0
0
1468                2  ...                              0
0
1469                3  ...                              1
0

      JobRole_Manufacturing Director  JobRole_Research Director  \
0                                  0                          0
1                                  0                          0
```

```
2                                    0                                    0
3                                    0                                    0
4                                    0                                    0
...                                ...                                  ...
1465                                 0                                    0
1466                                 0                                    0
1467                                 1                                    0
1468                                 0                                    0
1469                                 0                                    0

      JobRole_Research Scientist  JobRole_Sales Executive  \
0                              0                         1
1                              1                         0
2                              0                         0
3                              1                         0
4                              0                         0
...                          ...                       ...
1465                           0                         0
1466                           0                         0
1467                           0                         0
1468                           0                         1
1469                           0                         0

      JobRole_Sales Representative  OverTime_Yes  \
0                                0             1
1                                0             0
2                                0             1
3                                0             1
4                                0             0
...                            ...           ...
1465                             0             0
1466                             0             0
1467                             0             1
1468                             0             0
1469                             0             0

      BusinessTravel_Travel_Frequently  BusinessTravel_Travel_Rarely
0                                    0                             1
1                                    1                             0
2                                    0                             1
3                                    1                             0
4                                    0                             1
...                                ...                           ...
1465                                 1                             0
1466                                 0                             1
1467                                 0                             1
1468                                 1                             0
1469                                 0                             1

[1356 rows x 45 columns]
```

```
#feature scaling
#Feature scaling is a method used to standardize the range of
independent variables or features of data.
#Since the range of values of raw data varies widely, in some machine
learning algorithms, objective functions will not work properly
without normalization.
from sklearn.preprocessing import StandardScaler
scale = StandardScaler()
x_scaled = scale.fit_transform(x)

x_scaled
```

```
array([[ 0.56346638,  0.743224  , -1.02743082, ...,  1.58522975,
        -0.48937523,  0.64799328],
       [ 1.47198055, -1.29718689, -0.16621806, ..., -0.63082339,
         2.04342177, -1.54322589],
       [ 0.1092093 ,  1.41509685, -0.90440042, ...,  1.58522975,
        -0.48937523,  0.64799328],
       ...,
       [-1.02643341, -1.6046121 , -0.65833963, ...,  1.58522975,
        -0.48937523,  0.64799328],
       [ 1.47198055,  0.54736439, -0.90440042, ..., -0.63082339,
         2.04342177, -1.54322589],
       [-0.23148351, -0.43193367, -0.16621806, ..., -0.63082339,
        -0.48937523,  0.64799328]])
```

```
#Splitting Data into Train and Test.
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(x_scaled,y,test_size=0.
2,random_state=42)

x_train.shape,x_test.shape,y_train.shape,y_test.shape
```

```
((1084, 45), (272, 45), (1084,), (272,))
```

```
x_train
```

```
array([[-0.11791924,  0.84239343,  1.67923787, ...,  1.58522975,
        -0.48937523,  0.64799328],
       [ 1.244852  ,  0.89197814, -1.02743082, ..., -0.63082339,
        -0.48937523, -1.54322589],
       [ 0.56346638, -1.57486127,  0.32590352, ...,  1.58522975,
        -0.48937523,  0.64799328],
       ...,
       [ 2.0398019 , -1.59965363,  0.07984273, ...,  1.58522975,
        -0.48937523,  0.64799328],
       [-0.00435497, -1.18314205,  0.07984273, ..., -0.63082339,
        -0.48937523,  0.64799328],
       [ 0.56346638, -0.62035557, -0.65833963, ..., -0.63082339,
        -0.48937523, -1.54322589]])
```

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

Model Building using logistic Regression

```
from sklearn.linear_model import LogisticRegression
model=LogisticRegression()

model.fit(x_train,y_train)

LogisticRegression()

pred=model.predict(x_test)
pred

array(['No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'Yes', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'Yes', 'No', 'Yes',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'Yes', 'No', 'No', 'Yes', 'No', 'No', 'No', 'Yes', 'No',
       'No', 'Yes', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No',
'No',
       'Yes', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'Yes',
'No',
       'No', 'Yes', 'No', 'No', 'No', 'No', 'Yes', 'No', 'No', 'No',
'No',
```

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

```
y_test
```

```
52       No
984      No
1428     No
393      No
1014     No
       ...
818      No
800     Yes
1397     No
423      No
792     Yes
Name: Attrition, Length: 272, dtype: object
```

Evaluation of classification model

```
#Accuracy score
from sklearn.metrics import
accuracy_score,confusion_matrix,classification_report,roc_auc_score,ro
c_curve
```

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

```
0.9007352941176471
```

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

```
array([[218,   6],
       [ 21,  27]], dtype=int64)
```

```
pd.crosstab(y_test,pred)
```

```
col_0       No  Yes
Attrition
```

```
No         218    6
Yes         21   27
```

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

```
              precision    recall  f1-score   support

          No       0.91      0.97      0.94       224
         Yes       0.82      0.56      0.67        48

    accuracy                           0.90       272
   macro avg       0.87      0.77      0.80       272
weighted avg       0.90      0.90      0.89       272
```

```
#tunning hyperparameters using gridcv
from sklearn.model_selection import GridSearchCV
lg = LogisticRegression(random_state=123)
# Create grid parameters for hyperparameter tuning
param_grid = {
    'C': [0.001, 0.01, 0.1, 1, 10, 100],
    'penalty': ['l1', 'l2'],
    'solver': ['liblinear', 'lbfgs']
}
# Create gridsearch instance

lr = LogisticRegression()
clf = GridSearchCV(estimator=lr, param_grid=param_grid, cv=5,
scoring='accuracy', verbose=1)

clf.fit(x_train,y_train)
```

```
Fitting 5 folds for each of 24 candidates, totalling 120 fits

C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\linear_model\
_logistic.py:460: ConvergenceWarning: lbfgs failed to converge
(status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as
shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\linear_model\
_logistic.py:460: ConvergenceWarning: lbfgs failed to converge
(status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.
```

```
Increase the number of iterations (max_iter) or scale the data as
shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\linear_model\
_logistic.py:460: ConvergenceWarning: lbfgs failed to converge
(status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as
shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\linear_model\
_logistic.py:460: ConvergenceWarning: lbfgs failed to converge
(status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as
shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\linear_model\
_logistic.py:460: ConvergenceWarning: lbfgs failed to converge
(status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as
shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\linear_model\
_logistic.py:460: ConvergenceWarning: lbfgs failed to converge
```

```
(status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as
shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\model_selection\
_validation.py:425: FitFailedWarning:
30 fits failed out of a total of 120.
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:
--------------------------------------------------------------------
----------
30 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\Surya\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\Surya\anaconda3\Lib\site-packages\sklearn\base.py",
line 1151, in wrapper
    return fit_method(estimator, *args, **kwargs)
           ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\
linear_model\_logistic.py", line 1168, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
             ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\
linear_model\_logistic.py", line 56, in _check_solver
    raise ValueError(
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got
l1 penalty.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\model_selection\
_search.py:976: UserWarning: One or more of the test scores are non-
finite: [0.83026114        nan 0.85609746 0.83026114 0.83026114
nan
 0.8708568  0.84870285 0.8671659         nan 0.87546083 0.87730415
 0.8754651         nan 0.87177419 0.87177419 0.87268732        nan
 0.87268732 0.87176566 0.87360898        nan 0.87360898 0.87360898]
  warnings.warn(
```

```
GridSearchCV(cv=5, estimator=LogisticRegression(),
             param_grid={'C': [0.001, 0.01, 0.1, 1, 10, 100],
                         'penalty': ['l1', 'l2'],
                         'solver': ['liblinear', 'lbfgs']},
             scoring='accuracy', verbose=1)

best_params = clf.best_params_
best_model = clf.best_estimator_

accuracy = best_model.score(x_test, y_test)
accuracy
```

```
0.8970588235294118
```

```
grid_predictions = grid.predict(x_test)

print(classification_report(y_test, grid_predictions))
```

```
              precision    recall  f1-score   support

          No       0.84      0.98      0.91       224
         Yes       0.64      0.15      0.24        48

    accuracy                           0.83       272
   macro avg       0.74      0.56      0.57       272
weighted avg       0.81      0.83      0.79       272


confusion_matrix(y_test,pred)

array([[218,   6],
       [ 21,  27]], dtype=int64)

#final best accuracy
accuracy_score(y_test,pred)

0.9007352941176471

#final confusion matrix
confusion_matrix(y_test,pred)

array([[218,   6],
       [ 21,  27]], dtype=int64)
```

Model building using decision tree

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
dtc=DecisionTreeClassifier()
```

```
dtc.fit(x_train, y_train)
# print prediction results
predictions = dtc.predict(x_test)
print(classification_report(y_test, predictions))
```

```
              precision    recall  f1-score   support

          No       0.88      0.83      0.86       224
         Yes       0.37      0.46      0.41        48

    accuracy                           0.77       272
   macro avg       0.63      0.65      0.63       272
weighted avg       0.79      0.77      0.78       272
```

```
 #accuracy score
accuracy_score(y_test,predictions)
```

```
0.7683823529411765
```

```
clf = DecisionTreeClassifier(random_state=123)
# Create grid parameters for hyperparameter tuning
params =  {
    'min_samples_leaf': [1, 2, 3],
    'max_depth': [1, 2, 3]
}

# Create gridsearch instance
grid = GridSearchCV(estimator=clf,
                    param_grid=params,
                    cv=10,
                    n_jobs=1,
                    verbose=2)

# fitting the model for grid search
grid.fit(x_train, y_train)
# print best parameter after tuning
print(grid.best_params_)
grid_predictions = grid.predict(x_test)
```

```
Fitting 10 folds for each of 9 candidates, totalling 90 fits
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
```

```
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=1, min_samples_leaf=3; total
```

```
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
```

```
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=2, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=1; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
```

```
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=2; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
[CV] END ....................max_depth=3, min_samples_leaf=3; total
time=   0.0s
{'max_depth': 2, 'min_samples_leaf': 1}
```

```
# print classification report
print(classification_report(y_test, grid_predictions))
```

```
              precision    recall  f1-score   support

          No       0.84      0.98      0.91       224
         Yes       0.64      0.15      0.24        48

    accuracy                           0.83       272
   macro avg       0.74      0.56      0.57       272
weighted avg       0.81      0.83      0.79       272
```

```
confusion_matrix(y_test,grid_predictions)
```

```
array([[220,   4],
       [ 41,   7]], dtype=int64)
```

As we can see that before tunning hyper parameters we got lesss accuracy and also the confusion matrix tp is more and fp is more (42) by using grid cv we improved the accuracy and the fp is decresed to (0).Good confusion matrix is Good model

```
#final accuracy
accuracy_score(y_test,grid_predictions)
```

```
0.8345588235294118
```

```
#final confusion matrix
confusion_matrix(y_test,grid_predictions)
```

```
array([[220,   4],
       [ 41,   7]], dtype=int64)
```

Model building using random forest

```
# random forest classifier
from sklearn.ensemble import RandomForestClassifier
rfc= RandomForestClassifier(n_estimators=100, random_state=42)
rfc.fit(x_train, y_train)
```

```
RandomForestClassifier(random_state=42)
```

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

```
array(['No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
'No',
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'No',
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'No',
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'No',
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'No',
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'No',
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'No',
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'No',
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'No',
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'No',
       'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No', 'No',
```

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

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

```
0.8382352941176471
```

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

```
array([[223,   1],
       [ 43,   5]], dtype=int64)
```

```
pd.crosstab(y_test,pred)
```

```
col_0       No  Yes
Attrition
No         223    1
Yes         43    5
```

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

```
              precision    recall  f1-score   support

          No       0.84      1.00      0.91       224
         Yes       0.83      0.10      0.19        48

    accuracy                           0.84       272
   macro avg       0.84      0.55      0.55       272
weighted avg       0.84      0.84      0.78       272
```

```
from sklearn.model_selection import GridSearchCV
rfc = RandomForestClassifier(random_state=123)
# Create grid parameters for hyperparameter tuning
```

```python
params =  {
    'max_depth':[3,5,10,None],
    'n_estimators':[10,100,200],
    'max_features':[1,3,5,7],
    'min_samples_leaf': [1, 2, 3],
    'max_depth': [1, 2, 3]
}

# Create gridsearch instance
grid = GridSearchCV(estimator=rfc,
                    param_grid=params,
                    cv=10,
                    n_jobs=1,
                    verbose=2)
# fitting the model for grid search
grid.fit(x_train, y_train)
# print best parameter after tuning
print(grid.best_params_)
grid_predictions = grid.predict(x_test)
```

```
Fitting 10 folds for each of 108 candidates, totalling 1080 fits
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n_estimators=10; total time=   0.0s
[CV] END max_depth=1, max_features=1, min_samples_leaf=1,
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[CV] END max_depth=1, max_features=1, min_samples_leaf=1,
```

```
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```

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```

```
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```

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```

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n_estimators=100; total time=   0.3s
```

```
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```

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```

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n_estimators=10; total time=   0.0s
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n_estimators=10; total time=   0.0s
[CV] END max_depth=1, max_features=7, min_samples_leaf=3,
```

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n_estimators=10; total time=   0.0s
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n_estimators=10; total time=   0.0s
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n_estimators=10; total time=   0.0s
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n_estimators=200; total time=   0.6s
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n_estimators=200; total time=   0.6s
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```

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n_estimators=200; total time=   0.7s
[CV] END max_depth=2, max_features=1, min_samples_leaf=1,
```

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```

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```

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```

```
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```

```
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```

```
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```

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```

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```

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```

```
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[CV] END max_depth=2, max_features=7, min_samples_leaf=3,
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n_estimators=10; total time=   0.0s
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n_estimators=10; total time=   0.0s
```

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```

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```

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```

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[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=100; total time=   0.4s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=100; total time=   0.4s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=100; total time=   0.4s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=100; total time=   0.4s
```

```
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   0.9s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   1.0s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   1.0s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   1.0s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   0.9s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   0.9s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   0.9s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   0.9s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   0.9s
[CV] END max_depth=3, max_features=7, min_samples_leaf=3,
n_estimators=200; total time=   0.9s
{'max_depth': 3, 'max_features': 7, 'min_samples_leaf': 1,
'n_estimators': 100}
```

```
print('Best score is: '+str(grid.best_score_))
```

```
Best score is: 0.8404349303431872
```

```
# print classification report
print(classification_report(y_test, grid_predictions))
```

```
              precision    recall  f1-score   support

          No       0.82      1.00      0.90       224
         Yes       0.00      0.00      0.00        48

    accuracy                           0.82       272
   macro avg       0.41      0.50      0.45       272
weighted avg       0.68      0.82      0.74       272


C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\metrics\
_classification.py:1469: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\metrics\
_classification.py:1469: UndefinedMetricWarning: Precision and F-score
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samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Surya\anaconda3\Lib\site-packages\sklearn\metrics\
```

```
_classification.py:1469: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))

confusion_matrix(y_test,grid_predictions)

array([[224,   0],
       [ 48,   0]], dtype=int64)

#final confusion matrix
confusion_matrix(y_test,pred)

array([[223,   1],
       [ 43,   5]], dtype=int64)

#final better accuracy
accuracy_score(y_test,pred)

0.8382352941176471
```