LAB4 : Implement Decision tree algorithm for classification

Import Libraries

In [2]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

import Dataset

In [4]:
```
dataset =  pd.read_csv('manufacturing_quality_test.csv')
```

EDA Steps

In [5]:
```
dataset.head()
```

Out[5]:

	Temperature	Pressure	Density	Conductivity	Status
0	3.62160	8.6661	-2.8073	-0.44699	0
1	4.54590	8.1674	-2.4586	-1.46210	0
2	3.86600	-2.6383	1.9242	0.10645	0
3	3.45660	9.5228	-4.0112	-3.59440	0
4	0.32924	-4.4552	4.5718	-0.98880	0

In [7]:
```
dataset.shape
```

Out[7]:
```
(996, 5)
```

In [8]:
```
dataset.columns
```

Out[8]:
```
Index(['Temperature', 'Pressure', 'Density', 'Conductivity', 'Status'], dtype='object')
```

In [9]:
```
dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 996 entries, 0 to 995
Data columns (total 5 columns):
 #   Column        Non-Null Count  Dtype  
---  ------        --------------  -----  
 0   Temperature   996 non-null    float64
 1   Pressure      996 non-null    float64
 2   Density       996 non-null    float64
 3   Conductivity  996 non-null    float64
 4   Status        996 non-null    int64  
dtypes: float64(4), int64(1)
memory usage: 39.0 KB
```

In [10]:
```
dataset.describe()
```

Out[10]:

	Temperature	Pressure	Density	Conductivity	Status
count	996.000000	996.000000	996.000000	996.000000	996.000000
mean	2.447702	5.484502	0.119042	-1.875386	0.479920
std	1.974464	4.873370	3.440396	1.743205	0.499848
min	-1.654800	-6.810000	-4.679500	-4.862900	0.000000
25%	0.831600	3.297800	-2.631900	-3.501100	0.000000
50%	2.664300	7.617000	-0.479500	-1.772500	0.000000
75%	4.002400	9.260800	2.162400	-0.351270	1.000000
max	6.626900	11.063200	8.502600	1.477100	1.000000

Preprocessing Steps

Step 1 : Seprate input and output variables

In [11]:
```
X = dataset.iloc[:, :-1].values
y = dataset.iloc[:, -1].values
```

Step 4 : splitting Data inti training and testing

In [12]:
```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test = train_test_split(X,y,
                                    test_size = 0.25,
                                    random_state = 0)
```

In [13]:
```
print(X_train.shape)
print(X_test.shape)
```

```
(747, 4)
(249, 4)
```

In [14]:
```
# Step 5 : Feature Scaling
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.fit_transform(X_test)
```

In [15]:
```
print(X_test)
```

```
[[ 9.65186287e-02  8.88951065e-01 -7.41749707e-01 -1.38480801e+00]
 [-1.11991547e-01  5.41976951e-01 -9.54111389e-02 -7.63541798e-01]
 [-4.30718097e-01 -3.98919404e-01  8.80944696e-01  1.39396756e+00]
 [ 1.40994392e+00  7.88289407e-01 -1.07267150e+00 -2.96395205e-01]
 [-1.72840667e+00 -5.44059539e-02  1.01312568e+00  3.38949240e-01]
 [-1.36611147e+00  8.20196015e-01  3.86723772e-01 -1.31823563e+00]
 [ 1.53585925e+00 -2.41929048e-01 -5.13312974e-01  1.10932447e+00]
 [-7.06685226e-01 -2.13303127e+00  1.79341163e+00  2.78133548e-01]
 [ 6.76247050e-01  7.52671297e-01 -1.00013836e+00 -6.85798026e-01]
 [ 1.58586932e+00 -1.55477723e-01 -7.49884797e-01  9.95867012e-01]
 [ 1.14376301e+00  2.63491315e-01 -8.38574342e-01  8.70211646e-01]
 [ 1.70466347e+00  3.25951167e-01 -9.46207837e-01  7.03444416e-01]
 [ 3.51748031e-01 -1.91936560e-01 -1.73453956e-01  1.11393284e+00]
 [-1.18762082e+00 -3.09556294e-01  1.27273744e+00  9.14920015e-01]
 [ 1.47499771e-01  8.94426042e-01 -7.41749707e-01 -1.34149037e+00]
 [-1.09331111e+00 -2.18138332e+00  1.63591516e+00  3.33876516e-01]
 [ 9.37302868e-01  8.88889549e-01 -1.14648464e+00 -1.05895673e+00]
 [-5.12457622e-02  1.50054710e-01 -2.08193065e-01  6.11326027e-01]
 [ 5.95810136e-01  9.27460455e-01 -1.18334855e+00 -1.22031496e+00]
 [ 6.02715518e-01  6.46596178e-01 -9.10908374e-01  7.88871370e-01]
 [-2.01715420e-02 -5.94503149e-02 -7.98119622e-02  9.34601044e-01]
 [-1.43984261e+00  5.77861633e-01  5.55085996e-01 -1.01683602e+00]
 [-1.11281342e+00  7.34872495e-01  3.89340654e-01 -9.00619343e-01]
 [ 1.53585925e+00 -2.41929048e-01 -5.13312974e-01  1.10932447e+00]
 [-1.38096883e+00 -7.18969754e-01  2.32187958e+00  1.35421792e+00]
 [-1.10338325e+00  6.99192868e-01  3.99580627e-01 -7.07741833e-01]
 [-6.74564409e-01  5.99556486e-01  2.11264678e-01 -5.10532559e-01]
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 [-1.95821023e+00  5.78333260e-01  6.17777387e-01 -9.41999092e-01]
 [-1.74733419e-01  6.12064861e-01 -2.19880856e-01 -8.76623648e-01]
 [ 5.63495105e-01  8.96804684e-01 -1.11041718e+00 -1.19973907e+00]
 [ 1.66431015e+00 -1.33229221e-01 -7.74460733e-01  9.74755361e-01]
 [ 6.29312029e-01  8.64262404e-01 -1.32665128e+00 -6.83404157e-01]
 [ 1.12299291e+00  8.40516998e-01 -1.18656276e+00 -6.87393940e-01]
 [ 6.15069679e-01  5.92195000e-01 -8.30695252e-01  1.23842939e-01]
 [ 1.47327922e+00  7.97106786e-01 -1.08319592e+00 -3.20333903e-01]
 [ 3.08373599e-01 -3.63711405e-01 -4.13355477e-02  1.39350589e+00]
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 [ 6.52833488e-01  8.53845594e-01 -1.13721178e+00 -8.66022225e-01]
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 [ 5.69159676e-01  8.98240071e-01 -1.11041718e+00 -1.20087901e+00]
 [ 1.73444293e+00 -7.17536343e-02 -6.13437156e-01  5.87632415e-01]
 [ 1.29750781e-01 -4.00641869e-01 -1.08858499e-02  1.40102378e+00]
 [ 1.40471093e+00 -1.83139489e+00  9.12859279e-01  1.73668422e+00]
 [ 2.23620821e-01  9.44336508e-01 -9.11818594e-01 -1.50883326e+00]
 [ 1.24949382e-01  1.39494361e-01 -2.42112976e-01  6.04822680e-01]
 [ 8.28327304e-01  2.18153583e-01 -6.83552527e-01  8.68393445e-01]
 [ 6.33412100e-01  8.45028215e-01 -1.12668736e+00 -8.44363403e-01]
 [ 7.24045242e-01 -9.75981997e-01  4.02993952e-01  1.55758286e+00]
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 [ 5.37384128e-01  8.90755552e-01 -1.07685283e+00 -1.26112474e+00]
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```

```
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[ 3.21429087e-01 -3.52228307e-01 -5.37762617e-02  1.36924801e+00]
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[ 5.69159676e-01  8.98240071e-01 -1.11041718e+00 -1.20087901e+00]
[ 1.53521187e+00  9.04965886e-01 -1.37901737e+00 -1.16326106e+00]
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[ 1.32335690e+00  7.27859603e-01 -1.16616815e+00 -2.57808304e-01]
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[ 1.60394200e+00  5.56781946e-01 -1.07591416e+00  2.33219991e-01]
[-2.17784161e-01  5.27623078e-01 -1.55144315e-01 -5.82918622e-01]
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[-6.74564409e-01  5.99556486e-01  2.11264678e-01 -5.10532559e-01]
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[ 4.28084874e-01  5.22681245e-01 -5.98219418e-01 -4.10490926e-02]
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[ 5.69159676e-01  8.98240071e-01 -1.11041718e+00 -1.20087901e+00]
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[ 1.54923842e+00  9.10297325e-01 -1.28560606e+00 -1.00783051e+00]
[ 1.33090966e+00  7.32165764e-01 -1.17157258e+00 -2.69207684e-01]
[ 9.65186287e-02  8.88951065e-01 -7.41749707e-01 -1.38480801e+00]
[ 4.94387334e-01  3.81355139e-02 -2.74309158e-01  7.66021313e-01]
[ 3.26554176e-01  2.40955735e-01 -4.32815408e-01  5.68965930e-01]
[ 6.76894429e-01 -3.21779568e-02 -4.22490102e-01  1.06471186e+00]
[ 6.72039082e-01  8.45110237e-01 -1.11536650e+00 -9.24615038e-01]
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[ 3.01845855e-01  7.06287782e-01 -7.59811882e-01 -6.99933258e-01]
[-2.07457672e+00 -1.06754740e+00  2.23811091e+00  1.61648916e+00]
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[ 1.64645326e+00 -1.62859715e-01 -7.60124770e-01  1.01697866e+00]
[ 1.40994392e+00  7.88289407e-01 -1.07267150e+00 -2.96395205e-01]
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[ 1.99559880e-01  9.35519129e-01 -9.01578621e-01 -1.48717444e+00]
[ 1.45418152e+00  8.57495579e-01 -1.25662124e+00 -7.88677431e-01]
[-9.62772406e-01  5.09106583e-01  3.55349632e-01 -5.01185067e-01]
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[ 2.26857719e-01  7.04503801e-01 -7.44992366e-01 -6.95943475e-01]
[ 1.59552606e+00  1.11701360e+00 -1.29817847e+00 -1.22134090e+00]
[ 8.51956659e-01 -1.68373455e+00  4.87331508e-01  1.17580623e+00]
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[ 1.05539569e+00 -3.90737697e-01 -4.46127373e-01  1.16500303e+00]
```

```
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[-1.97531185e+00  5.44150538e-01  5.91580123e-01 -8.39974641e-01]
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[ 1.88230737e-01 -4.66505639e-01  9.48560945e-02  1.31564812e+00]
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[-8.70094623e-01 -2.11705746e+00  1.78473610e+00  2.36297823e-01]
[ 1.88230737e-01 -4.66505639e-01  9.48560945e-02  1.31564812e+00]
[-2.01715420e-02 -5.94503149e-02 -7.98119622e-02  9.34601044e-01]
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[ 7.29116383e-01 -5.11986910e-01  1.33369771e-01  1.42850198e+00]
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[-7.80788609e-01 -2.01676490e+00  1.71280029e+00  5.67278822e-01]
[ 1.38814095e-01 -7.92379560e-01  6.95462943e-02  1.48767046e+00]
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[ 2.62409648e-01 -4.49075936e-01  1.05090379e-01  1.33618980e+00]
[ 4.28084874e-01  5.22681245e-01 -5.98219418e-01 -4.10490926e-02]
[ 1.15444477e+00 -3.24402299e-01 -6.03652292e-01  1.10212918e+00]
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[ 4.77177826e-01  5.66520097e-02 -2.56010895e-01  7.39882535e-01]
[-1.18762082e+00 -3.09556294e-01  1.27273744e+00  9.14920015e-01]
[-2.16820944e-02  6.57771693e-01 -3.15513672e-01 -7.48437620e-01]
[ 1.53585925e+00 -2.41929048e-01 -5.13312974e-01  1.10932447e+00]
[ 7.74325057e-01  2.26970962e-01 -6.83552527e-01  8.47333091e-01]
[ 3.21429087e-01 -3.52228307e-01 -5.37762617e-02  1.36924801e+00]
[-1.07574554e+00 -2.18281870e+00  1.63648404e+00  3.31596640e-01]
[-6.74564409e-01  5.99556486e-01  2.11264678e-01 -5.10532559e-01]
[ 4.58403818e-01  8.00674748e-01 -6.44299297e-01 -1.18765573e+00]
[-1.95821023e+00  5.78333260e-01  6.17777387e-01 -9.41999092e-01]
[-8.97108994e-02 -1.74510761e+00  1.37931850e+00  1.20058278e+00]
[-1.38096883e+00 -7.18969754e-01  2.32187958e+00  1.35421792e+00]
[-5.72979762e-01  6.57218043e-01 -6.89611178e-01  6.55470126e-01]
[-8.18344477e-02 -2.27609837e+00  1.83755729e+00  7.38748296e-01]
[-1.11991547e-01  5.41976951e-01 -9.54082945e-02 -7.63541798e-01]
[ 1.71464391e+00 -2.61288247e-02 -8.08622421e-01  8.63360619e-01]
[ 6.29312029e-01  8.64262404e-01 -1.32665128e+00 -6.83404157e-01]
[ 1.99559880e-01  9.35519129e-01 -9.01578621e-01 -1.48717444e+00]
[ 6.52833488e-01  8.53845594e-01 -1.13721178e+00 -8.66022225e-01]
[ 9.04772044e-01  8.17366252e-01 -1.09380567e+00 -8.64141327e-01]
[ 1.12299291e+00  8.40516998e-01 -1.18656276e+00 -6.87393940e-01]
[-2.16820944e-02  6.57771693e-01 -3.15513672e-01 -7.48437620e-01]
[-1.11281342e+00  7.34872495e-01  3.89340654e-01 -9.00619343e-01]
[-2.84518207e-01  6.78482280e-01 -8.89798670e-02 -9.62688967e-01]
[ 1.15444477e+00 -3.24402299e-01 -6.03652292e-01  1.10212918e+00]
[-1.38096883e+00 -7.18969754e-01  2.32187958e+00  1.35421792e+00]
[ 4.38982431e-01  7.93292757e-01 -6.34059324e-01 -1.16713685e+00]
[ 8.42947293e-01  9.05868130e-01 -1.17151569e+00 -1.12444617e+00]
[ 1.24949382e-01  1.39494361e-01 -2.42112976e-01  6.04822680e-01]
[ 1.11991786e+00 -3.13144762e-01 -5.46991108e-01  1.05430593e+00]
[-1.10672805e+00 -2.13975708e+00  1.85684258e+00  1.08339783e-01]
[-4.45284138e-01 -2.15169130e+00  2.32330180e+00 -1.07222494e-01]
[-4.05254500e-01  7.39096634e-01 -7.06194245e-01  6.96006321e-01]
[-2.12642103e+00 -9.68009446e-01  2.27210193e+00  1.48629684e+00]
[ 1.24572529e+00 -2.97273480e-01 -6.91602284e-01  9.91347158e-01]
[ 4.38982431e-01  7.91857369e-01 -6.33774880e-01 -1.16599691e+00]
[ 9.18798602e-01 -1.69015278e+00  6.31373796e-01  1.62804813e+00]
[ 1.50456923e+00  9.62483905e-01 -1.27593497e+00 -1.07508685e+00]
[ 1.07055517e+00  9.19155715e-01 -1.22504799e+00 -1.10455425e+00]
[ 7.24045242e-01 -9.75981997e-01  4.02993952e-01  1.55758286e+00]
[-1.85592426e+00  5.00801842e-01  7.13009137e-01 -8.18657801e-01]
[ 1.47327922e+00  7.97106786e-01 -1.08319592e+00 -3.20333903e-01]
[-1.73034880e+00 -4.55885750e-02  1.00288571e+00  3.17290418e-01]
[-1.36611147e+00  8.20196015e-01  3.86723772e-01 -1.31823563e+00]
[ 1.30123809e+00  7.56239259e-01 -1.20089872e+00 -3.59889752e-01]
[ 1.38814095e-01 -7.92379560e-01  6.95462943e-02  1.48767046e+00]
[-1.97531185e+00  5.44150538e-01  5.91580123e-01 -8.39974641e-01]
[ 2.16499646e-01  9.15934370e-02 -1.92662439e-01  7.20326898e-01]
[-9.78638601e-01 -2.31669932e+00  1.64279869e+00  5.15981612e-01]
[ 1.54923842e+00  9.10297325e-01 -1.28560606e+00 -1.00783051e+00]
[ 1.16209758e-01  9.03243421e-01 -7.31509734e-01 -1.36314919e+00]
[-1.64563919e+00  5.81634651e-01  6.68038589e-01 -7.89760372e-01]
[-1.97531185e+00  5.44150538e-01  5.91580123e-01 -8.39974641e-01]
[-5.15039289e-01  8.54624804e-01 -5.68438163e-01 -1.24168879e+00]
[-4.52567158e-01 -2.14328404e+00  2.31306182e+00 -8.67036096e-02]
[-1.33622411e+00  8.26511719e-01  3.35609240e-01 -1.41906315e+00]
[ 1.38998305e+00  8.83660638e-01 -1.28068518e+00 -1.03724091e+00]
[ 4.77177826e-01  5.66520097e-02 -2.56010895e-01  7.39882535e-01]
[ 1.58586932e+00 -1.55477723e-01 -7.49884797e-01  9.95867012e-01]
```

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[ 3.31895057e-01 -1.83367224e-02 -2.42101598e-01  8.13089353e-01]
[ 1.07055517e+00  9.19155715e-01 -1.22504799e+00 -1.10455425e+00]
[-1.37047589e+00 -1.31204307e+00  1.65096223e+00  1.30357618e+00]
[ 9.65186287e-02  8.88951065e-01 -7.41749707e-01 -1.38480801e+00]
[-8.70094623e-01 -2.11705746e+00  1.78473610e+00  2.36297823e-01]
[ 1.00889226e+00 -1.74793935e-01 -6.16651369e-01  8.64397963e-01]
[ 6.29312029e-01  8.64262404e-01 -1.32665128e+00 -6.83404157e-01]
[ 1.16209758e-01  9.03243421e-01 -7.31509734e-01 -1.36314919e+00]
[-2.32512047e-01  3.13299254e-01 -3.44457525e-02 -4.59508260e-02]
[-4.24136405e-01  5.62810572e-01 -8.78053989e-02 -6.39060568e-01]
[-1.11991547e-01  5.41976951e-01 -9.54082945e-02 -7.63541798e-01]
[ 3.83361734e-01  3.25089935e-01 -4.94881023e-01  2.79672464e-01]
[ 9.64438863e-01 -1.79024028e+00  6.52792406e-01  1.74073100e+00]
[ 8.51956659e-01 -1.68373455e+00  4.87331508e-01  1.17580623e+00]
[-9.62772406e-01  5.09106583e-01  3.55349632e-01 -5.01185067e-01]
[ 1.29750781e-01 -4.00641869e-01 -1.08858499e-02  1.40102378e+00]
[-7.74109810e-01 -2.02004579e+00  1.71280029e+00  5.62154801e-01]
[ 1.12703118e-01 -4.00457319e-01 -6.60099006e-04  1.42553814e+00]
[ 1.38814095e-01 -7.92379560e-01  6.95462943e-02  1.48767046e+00]
[-1.43982103e+00  5.77861633e-01  5.55085996e-01 -1.01683602e+00]
[-8.18344477e-02 -2.27609837e+00  1.83755729e+00  7.38748296e-01]
[-1.51427753e-01  6.20267074e-01 -2.03789876e-01 -8.97712501e-01]
[ 2.71634807e-01  7.22138559e-01 -7.78272278e-01 -7.63769786e-01]
[ 5.25731295e-01 -1.33743835e-02 -4.43396714e-01  1.01088000e+00]
[-1.09405559e+00 -2.26301584e+00  1.76311838e+00  2.75397697e-01]]
```

In [18]:
```
dataset['Status'].value_counts()
```

Out[18]:
```
Status
0    518
1    478
Name: count, dtype: int64
```

Train the Decision Tree Classification model on the Training set

In [19]:
```
from sklearn.tree import DecisionTreeClassifier
classifier = DecisionTreeClassifier(criterion = 'entropy',random_state= 0,
                                    splitter='random',ccp_alpha =0.0001)

classifier.fit(X_train,y_train)
```

Out[19]:

DecisionTreeClassifier

```
DecisionTreeClassifier(ccp_alpha=0.0001, criterion='entropy', random_state=0,
                       splitter='random')
```

In [20]:
```
print(classifier.classes_)
```

```
[0 1]
```

In [21]:
```
classifier.max_features_
```

Out[21]:
```
4
```

In [22]:
```
classifier.tree_
```

Out[22]:
```
<sklearn.tree._tree.Tree at 0x17910fc9a00>
```

In [23]:
```
classifier.n_outputs_
```

Out[23]:
```
1
```

Predicting the Test set results

In [24]:
```
ypred = classifier.predict(X_test)
```

In [25]:
```
print(ypred)
```

```
[0 1 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 1 1 0 1 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0
 0 0 1 0 0 0 1 0 0 0 1 1 1 1 1 0 0 0 0 0 1 0 0 0 1 0 1 1 1 0 1 0 0 0 0 1 0
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 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 0 0 1 1 0 1 1 1]
```

Compare the predicted and Actual Output

In [26]:
```
print(np.concatenate((ypred.reshape(len(ypred),1),
                      y_test.reshape(len(y_test),1)),
```

```
                    1))
```

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[[0 0]
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```
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```

Making the Confusion Matrix

In [27]:
```
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_test, ypred)
print(cm)
```

```
[[81 44]
 [83 41]]
```

In [28]:
```
print("Accuracy =",(194+147)/343*100)
```

```
Accuracy = 99.41690962099126
```

In [29]:
```
from sklearn.metrics import accuracy_score
print("Test Accuracy =",accuracy_score(y_test,ypred))
```

```
Test Accuracy = 0.4899598393574297
```

Build the Classification Report

In [30]:
```
from sklearn.metrics import classification_report

print(classification_report(y_test,ypred))
```

```
              precision    recall  f1-score   support

           0       0.49      0.65      0.56       125
           1       0.48      0.33      0.39       124

    accuracy                           0.49       249
   macro avg       0.49      0.49      0.48       249
weighted avg       0.49      0.49      0.48       249
```

Visualising the Training set results

VISUALIZE TEXT REPRESENTATION

In [31]:
```
!pip install -U scikit-learn
```

```
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: scikit-learn in c:\users\mohammed meraj\appdata\roaming\python\python312\site-pac
kages (1.6.1)
Requirement already satisfied: numpy>=1.19.5 in c:\python312\lib\site-packages (from scikit-learn) (2.1.3)
Requirement already satisfied: scipy>=1.6.0 in c:\python312\lib\site-packages (from scikit-learn) (1.14.1)
Requirement already satisfied: joblib>=1.2.0 in c:\users\mohammed meraj\appdata\roaming\python\python312\site-pa
ckages (from scikit-learn) (1.4.2)
Requirement already satisfied: threadpoolctl>=3.1.0 in c:\users\mohammed meraj\appdata\roaming\python\python312\
site-packages (from scikit-learn) (3.6.0)
[notice] A new release of pip is available: 25.0.1 -> 25.1.1
[notice] To update, run: python.exe -m pip install --upgrade pip
```

In [32]:
```
## if not working update scikit learn package
## !pip install -U scikit-learn
from sklearn.tree import export_text
text_representation = export_text(classifier)
print(text_representation)
```

```
|--- feature_0 <= -0.84
|   |--- feature_3 <= -1.25
|   |   |--- feature_2 <= 0.37
|   |   |   |--- feature_2 <= 0.37
|   |   |   |   |--- class: 0
|   |   |   |--- feature_2 >  0.37
|   |   |   |   |--- class: 1
|   |   |--- feature_2 >  0.37
|   |   |   |--- feature_1 <= 0.81
|   |   |   |   |--- class: 0
|   |   |   |--- feature_1 >  0.81
|   |   |   |   |--- feature_2 <= 0.47
|   |   |   |   |   |--- feature_0 <= -1.38
|   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  -1.38
|   |   |   |   |   |   |--- feature_2 <= 0.43
|   |   |   |   |   |   |   |--- feature_1 <= 0.84
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_1 >  0.84
|   |   |   |   |   |   |   |   |--- feature_2 <= 0.38
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_2 >  0.38
|   |   |   |   |   |   |   |   |   |--- class: 0
```

```
|   |   |   |   |   |   |   |--- feature_2 >  0.43
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_2 >  0.47
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |--- feature_3 >  -1.25
|   |   |   |--- feature_0 <= -1.16
|   |   |   |   |--- feature_0 <= -1.44
|   |   |   |   |   |--- feature_3 <= -1.14
|   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- feature_3 >  -1.14
|   |   |   |   |   |   |--- feature_3 <= 1.27
|   |   |   |   |   |   |   |--- feature_3 <= -0.89
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.55
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_1 >  0.55
|   |   |   |   |   |   |   |   |   |--- feature_0 <= -1.75
|   |   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.61
|   |   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.66
|   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 6
|   |   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.66
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_1 >  0.61
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_0 >  -1.75
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_3 >  -0.89
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.11
|   |   |   |   |   |   |   |   |   |--- feature_1 <= -0.02
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_1 >  -0.02
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_1 >  0.11
|   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.61
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.69
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.69
|   |   |   |   |   |   |   |   |   |   |   |--- feature_3 <= -0.87
|   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |   |--- feature_3 >  -0.87
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_1 >  0.61
|   |   |   |   |   |   |   |   |   |   |--- feature_1 <= 1.11
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_1 >  1.11
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_3 >  1.27
|   |   |   |   |   |   |   |   |--- feature_3 <= 1.46
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_3 >  1.46
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_0 >  -1.44
|   |   |   |   |   |--- feature_2 <= 1.08
|   |   |   |   |   |   |--- feature_2 <= 0.52
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_2 >  0.52
|   |   |   |   |   |   |   |--- feature_2 <= 0.61
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- feature_2 >  0.61
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.61
|   |   |   |   |   |   |   |   |   |--- feature_0 <= -1.44
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_0 >  -1.44
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  0.61
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_2 >  1.08
|   |   |   |   |   |   |--- feature_0 <= -1.20
|   |   |   |   |   |   |   |--- feature_3 <= 1.04
|   |   |   |   |   |   |   |   |--- feature_2 <= 1.90
|   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.73
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_3 >  0.73
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_2 >  1.90
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_3 >  1.04
|   |   |   |   |   |   |   |   |--- feature_2 <= 2.41
|   |   |   |   |   |   |   |   |   |--- feature_2 <= 1.53
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_2 >  1.53
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 1.73
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_2 >  1.73
```

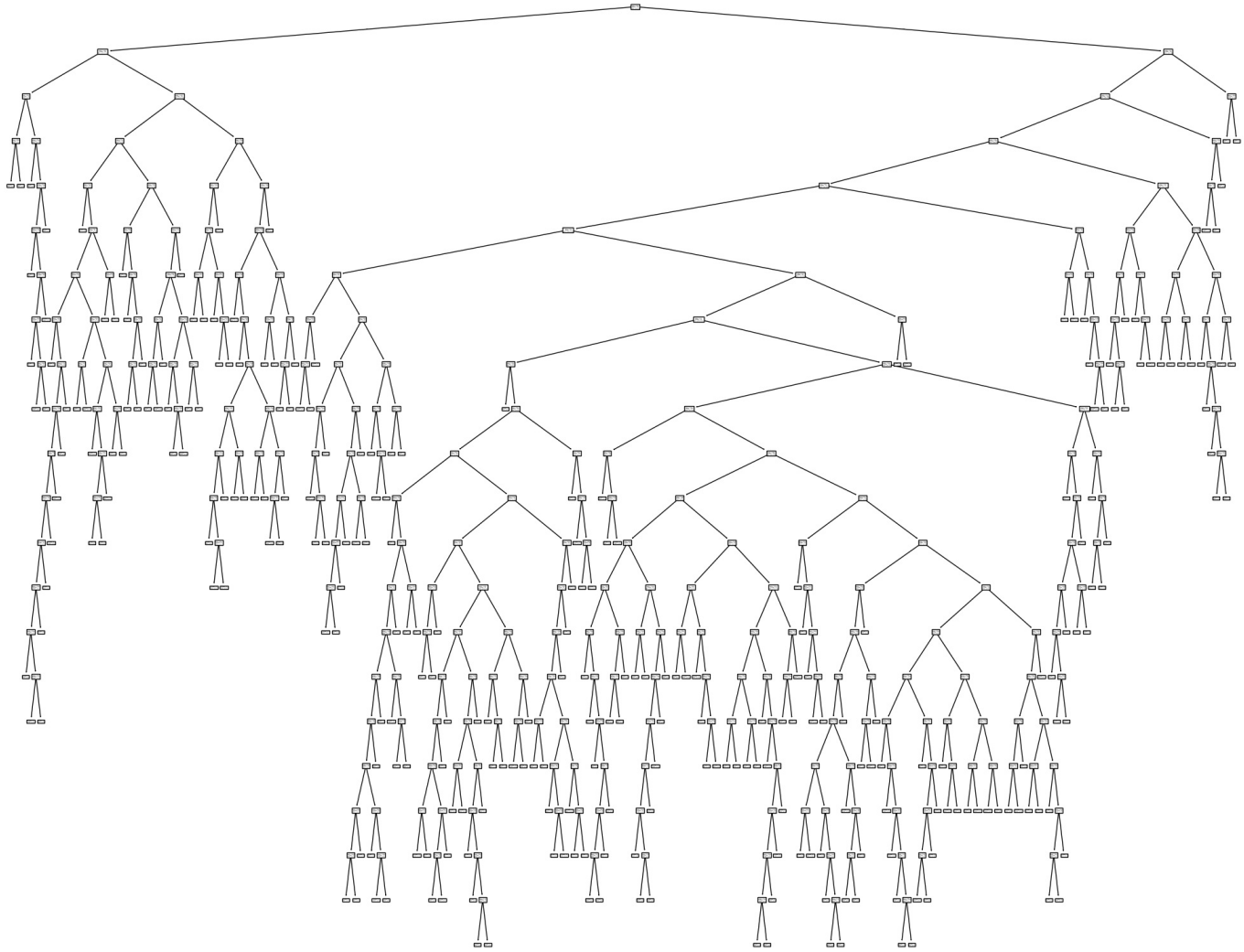
```
|   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_2 >  2.41
|   |   |   |   |   |   |   |   |   |--- feature_0 <= -1.40
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  -1.40
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_0 >  -1.20
|   |   |   |   |   |   |--- class: 1
|   |   |--- feature_0 >  -1.16
|   |   |   |--- feature_2 <= 0.56
|   |   |   |   |--- feature_0 <= -0.94
|   |   |   |   |   |--- feature_1 <= 0.54
|   |   |   |   |   |   |--- feature_0 <= -0.96
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_0 >  -0.96
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- feature_1 >  0.54
|   |   |   |   |   |   |--- feature_2 <= 0.37
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- feature_2 >  0.37
|   |   |   |   |   |   |   |--- feature_3 <= -0.96
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_3 >  -0.96
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_0 >  -0.94
|   |   |   |   |   |--- class: 1
|   |   |   |--- feature_2 >  0.56
|   |   |   |   |--- feature_1 <= -1.94
|   |   |   |   |   |--- feature_2 <= 1.91
|   |   |   |   |   |   |--- feature_1 <= -2.25
|   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- feature_1 >  -2.25
|   |   |   |   |   |   |   |--- feature_2 <= 1.32
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_2 >  1.32
|   |   |   |   |   |   |   |   |--- feature_1 <= -2.18
|   |   |   |   |   |   |   |   |   |--- feature_1 <= -2.24
|   |   |   |   |   |   |   |   |   |   |--- feature_1 <= -2.24
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |   |--- feature_1 >  -2.24
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |--- feature_1 >  -2.24
|   |   |   |   |   |   |   |   |   |   |--- feature_1 <= -2.23
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_1 >  -2.23
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_1 >  -2.18
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.20
|   |   |   |   |   |   |   |   |   |   |   |--- feature_1 <= -2.10
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |   |--- feature_1 >  -2.10
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  0.20
|   |   |   |   |   |   |   |   |   |   |   |--- feature_0 <= -1.03
|   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |   |--- feature_0 >  -1.03
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |--- feature_2 >  1.91
|   |   |   |   |   |   |--- feature_3 <= -0.13
|   |   |   |   |   |   |   |--- feature_2 <= 2.42
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_2 >  2.42
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- feature_3 >  -0.13
|   |   |   |   |   |   |   |--- feature_2 <= 1.96
|   |   |   |   |   |   |   |   |--- feature_1 <= -1.98
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_1 >  -1.98
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_2 >  1.96
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- feature_1 >  -1.94
|   |   |   |   |   |--- class: 0
|--- feature_0 >  -0.84
|   |--- feature_2 <= 2.14
|   |   |--- feature_0 <= 1.67
|   |   |   |--- feature_0 <= 1.32
|   |   |   |   |--- feature_1 <= 0.95
|   |   |   |   |   |--- feature_1 <= -1.61
|   |   |   |   |   |   |--- feature_1 <= -2.02
|   |   |   |   |   |   |   |--- feature_3 <= 0.33
|   |   |   |   |   |   |   |   |--- feature_2 <= 1.89
|   |   |   |   |   |   |   |   |   |--- class: 0
```

```
|   |   |   |   |   |   |   |   |--- feature_2 >  1.89
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_3 >  0.33
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- feature_1 >  -2.02
|   |   |   |   |   |   |   |   |--- feature_3 <= 1.59
|   |   |   |   |   |   |   |   |   |--- feature_2 <= 1.41
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 1.58
|   |   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 1.48
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |   |--- feature_3 >  1.48
|   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  1.58
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_2 >  1.41
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 0.85
|   |   |   |   |   |   |   |   |   |   |   |--- feature_1 <= -1.93
|   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 4
|   |   |   |   |   |   |   |   |   |   |   |--- feature_1 >  -1.93
|   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  0.85
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_3 >  1.59
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 1.13
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 1.75
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  1.75
|   |   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.77
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.77
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  1.13
|   |   |   |   |   |   |   |   |   |   |--- feature_3 <= 1.70
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_3 >  1.70
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_1 >  -1.61
|   |   |   |   |   |   |   |   |--- feature_2 <= 0.70
|   |   |   |   |   |   |   |   |   |--- feature_3 <= -0.76
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= -0.62
|   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  -0.62
|   |   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 1.16
|   |   |   |   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.80
|   |   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 10
|   |   |   |   |   |   |   |   |   |   |   |   |--- feature_1 >  0.80
|   |   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 11
|   |   |   |   |   |   |   |   |   |   |   |--- feature_0 >  1.16
|   |   |   |   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.92
|   |   |   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |   |   |--- feature_1 >  0.92
|   |   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |--- feature_3 >  -0.76
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.22
|   |   |   |   |   |   |   |   |   |   |   |--- feature_1 <= -0.67
|   |   |   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.03
|   |   |   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.03
|   |   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |   |--- feature_1 >  -0.67
|   |   |   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 0.37
|   |   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 11
|   |   |   |   |   |   |   |   |   |   |   |   |--- feature_0 >  0.37
|   |   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 11
|   |   |   |   |   |   |   |   |   |--- feature_2 >  0.22
|   |   |   |   |   |   |   |   |   |   |--- feature_2 <= 0.37
|   |   |   |   |   |   |   |   |   |   |   |--- feature_3 <= -0.44
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |   |--- feature_3 >  -0.44
|   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 6
|   |   |   |   |   |   |   |   |   |   |--- feature_2 >  0.37
|   |   |   |   |   |   |   |   |   |   |   |--- feature_0 <= -0.41
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |   |   |   |--- feature_0 >  -0.41
|   |   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |--- feature_2 >  0.70
|   |   |   |   |   |   |   |   |--- feature_0 <= 0.31
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_0 >  0.31
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |--- feature_1 >  0.95
|   |   |   |   |   |   |   |--- feature_3 <= -1.29
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.97
```

```
|   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_1 >  0.97
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_3 >  -1.29
|   |   |   |   |   |   |   |--- feature_1 <= 0.96
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- feature_1 >  0.96
|   |   |   |   |   |   |   |   |--- feature_3 <= -1.19
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_3 >  -1.19
|   |   |   |   |   |   |   |   |   |--- feature_3 <= -1.14
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_3 >  -1.14
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |--- feature_0 >  1.32
|   |   |   |   |   |--- feature_3 <= -0.53
|   |   |   |   |   |   |--- feature_1 <= 1.02
|   |   |   |   |   |   |   |--- feature_0 <= 1.45
|   |   |   |   |   |   |   |   |--- feature_2 <= -1.32
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_2 >  -1.32
|   |   |   |   |   |   |   |   |   |--- feature_0 <= 1.36
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_0 >  1.36
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_0 >  1.45
|   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_1 >  1.02
|   |   |   |   |   |   |   |--- feature_3 <= -1.30
|   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |--- feature_3 >  -1.30
|   |   |   |   |   |   |   |   |--- feature_0 <= 1.59
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_0 >  1.59
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |--- feature_3 >  -0.53
|   |   |   |   |   |   |--- feature_1 <= -0.03
|   |   |   |   |   |   |   |--- feature_3 <= 0.87
|   |   |   |   |   |   |   |   |--- feature_1 <= -0.05
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  -0.05
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_3 >  0.87
|   |   |   |   |   |   |   |   |--- feature_1 <= -0.14
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  -0.14
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |--- feature_1 >  -0.03
|   |   |   |   |   |   |   |--- feature_2 <= -0.82
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.25
|   |   |   |   |   |   |   |   |   |--- class: 1
|   |   |   |   |   |   |   |   |--- feature_1 >  0.25
|   |   |   |   |   |   |   |   |   |--- feature_1 <= 0.31
|   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |--- feature_1 >  0.31
|   |   |   |   |   |   |   |   |   |   |--- feature_0 <= 1.43
|   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |--- feature_0 >  1.43
|   |   |   |   |   |   |   |   |   |   |   |--- feature_2 <= -0.94
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |   |   |   |--- feature_2 >  -0.94
|   |   |   |   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |--- feature_2 >  -0.82
|   |   |   |   |   |   |   |   |--- feature_1 <= 0.24
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |   |   |   |   |   |--- feature_1 >  0.24
|   |   |   |   |   |   |   |   |   |--- class: 0
|   |   |   |--- feature_0 >  1.67
|   |   |   |   |--- feature_1 <= 1.02
|   |   |   |   |   |--- feature_1 <= 0.90
|   |   |   |   |   |   |--- class: 1
|   |   |   |   |--- feature_1 >  0.90
|   |   |   |   |   |--- class: 0
|   |   |   |--- feature_1 >  1.02
|   |   |   |   |--- class: 1
|   |--- feature_2 >  2.14
|   |   |--- feature_1 <= -2.49
|   |   |   |--- class: 0
|   |   |--- feature_1 >  -2.49
|   |   |   |--- class: 1
```

Visualize the tree

In [33]:
```
from sklearn import tree
fig = plt.figure(figsize=(25,20))
tree.plot_tree(classifier)
plt.show()
```



In [42]:
```
#
from sklearn.tree import DecisionTreeClassifier
classifier = DecisionTreeClassifier(criterion = 'log_loss',random_state= 0,
                                    splitter='random',ccp_alpha =0.0009)

classifier.fit(X_train,y_train)
```

Out[42]:

DecisionTreeClassifier

```
DecisionTreeClassifier(ccp_alpha=0.0009, criterion='log_loss', random_state=0,
                       splitter='random')
```

In [43]:
```
print(classifier.classes_)
```

```
[0 1]
```

In [44]:
```
classifier.max_features_
```

Out[44]:
```
4
```

In [45]:
```
classifier.tree_
```

Out[45]:
```
<sklearn.tree._tree.Tree at 0x17911333de0>
```

In [46]:
```
print(ypred)
```

```
[0 1 1 0 0 0 0 0 1 0 0 1 0 1 0 0 0 1 1 0 1 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0
 0 0 1 0 0 0 1 0 0 0 1 1 1 1 1 0 0 0 0 0 1 0 0 0 1 0 1 1 1 0 1 0 0 0 0 1 0
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```

In [47]:
```
print(np.concatenate((ypred.reshape(len(ypred),1),
                      y_test.reshape(len(y_test),1)),
                     1))
```

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In [48]:
```
from sklearn.metrics import classification_report

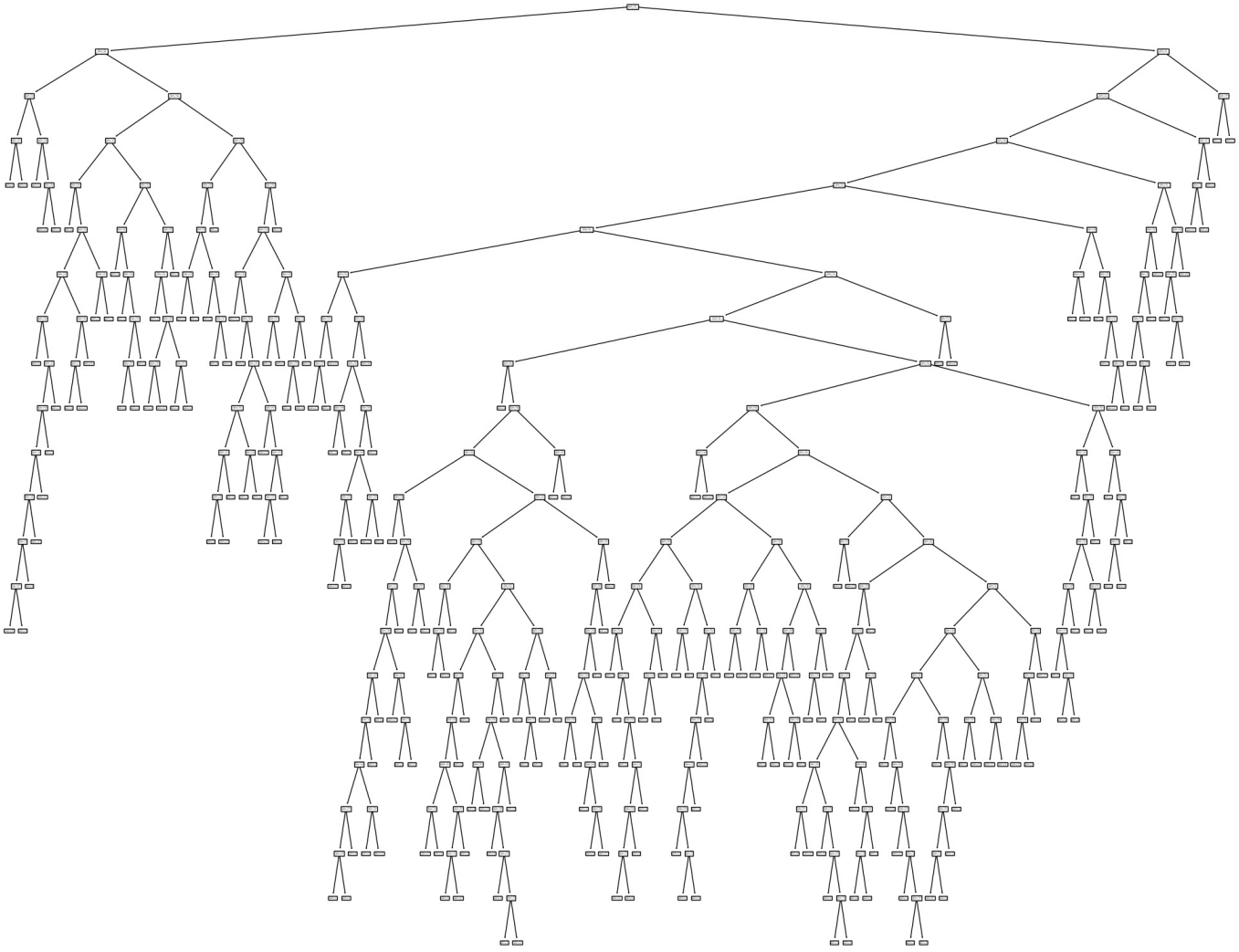
print(classification_report(y_test,ypred))
```

```
              precision    recall  f1-score   support

           0       0.49      0.65      0.56       125
           1       0.48      0.33      0.39       124

    accuracy                           0.49       249
   macro avg       0.49      0.49      0.48       249
weighted avg       0.49      0.49      0.48       249
```

In [49]:
```
from sklearn import tree
fig = plt.figure(figsize=(25,20))
tree.plot_tree(classifier)
plt.show()
```



In [ ]: