Data Source

https://www.kaggle.com/uciml/red-wine-quality-cortez-et-al-2009

GOAL- Use machine learning to determine which physiochemical properties make a wine 'good'!

Assumption: 1) I used for random_state = 42

In [1]:
```
import matplotlib
import pylab as plt
import numpy as np
import pandas as pd
```

In [2]:
```
from numpy import random

df= pd.read_csv("winequality-red.csv",na_values=['NA', '?','']) # Read data file # na values can be represen
np.random.seed(42)# undo the random error function to not chnage ur data after shuffling
#if u comment on the above function it will keep on manupulating
#pick a random number everytime
wine = df.reindex(np.random.permutation(df.index))  #shuffle data
#permutation of index
#index of pandas, randomly select indices, redindex our inces
wine.reset_index(inplace=True, drop=True) # Reset index

wine[0:5] # Display top five rows
```

Out[2]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	7.7	0.56	0.08	2.50	0.114	14.0	46.0	0.9971	3.24	0.66	9.6	6
1	7.8	0.50	0.17	1.60	0.082	21.0	102.0	0.9960	3.39	0.48	9.5	5
2	10.7	0.67	0.22	2.70	0.107	17.0	34.0	1.0004	3.28	0.98	9.9	6
3	8.5	0.46	0.31	2.25	0.078	32.0	58.0	0.9980	3.33	0.54	9.8	5
4	6.7	0.46	0.24	1.70	0.077	18.0	34.0	0.9948	3.39	0.60	10.6	6

In [3]:
```
wine.shape
```

Out[3]: (1599, 12)

There are 1599 rows and 12 columns

COMMENT - All the data is regression so no one-hot coding is required.

In [4]:
```
wine.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1599 entries, 0 to 1598
Data columns (total 12 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   fixed acidity         1599 non-null   float64
 1   volatile acidity      1599 non-null   float64
 2   citric acid           1599 non-null   float64
 3   residual sugar        1599 non-null   float64
 4   chlorides             1599 non-null   float64
 5   free sulfur dioxide   1599 non-null   float64
 6   total sulfur dioxide  1599 non-null   float64
 7   density               1599 non-null   float64
 8   pH                    1599 non-null   float64
 9   sulphates             1599 non-null   float64
 10  alcohol               1599 non-null   float64
 11  quality               1599 non-null   int64
dtypes: float64(11), int64(1)
memory usage: 150.0 KB
```

CONCLUSION - The data has no missing values and no imputation is needed.

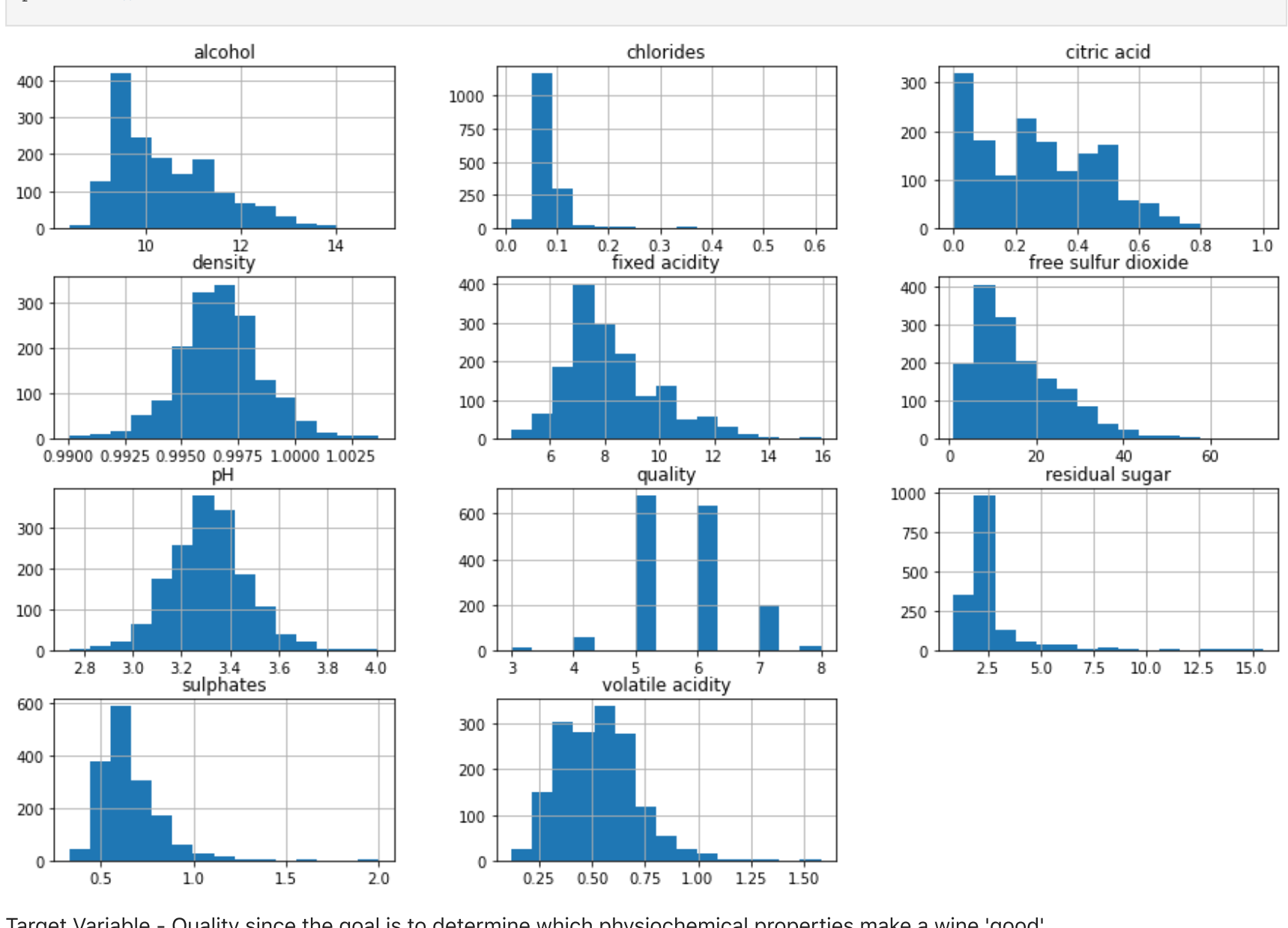
In [5]:
```
wine.describe()
```

Out[5]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH
count	1599.000000	1599.000000	1599.000000	1599.000000	1599.000000	1599.000000	1599.000000	1599.000000	1599.000000
mean	8.319637	0.527821	0.270976	2.538806	0.087467	15.874922	46.467792	0.996747	3.311113
std	1.741096	0.179060	0.194801	1.409928	0.047065	10.460157	32.895324	0.001887	0.154386
min	4.600000	0.120000	0.000000	0.900000	0.012000	1.000000	6.000000	0.990070	2.740000
25%	7.100000	0.390000	0.090000	1.900000	0.070000	7.000000	22.000000	0.995600	3.210000
50%	7.900000	0.520000	0.260000	2.200000	0.079000	14.000000	38.000000	0.996750	3.310000
75%	9.200000	0.640000	0.420000	2.600000	0.090000	21.000000	62.000000	0.997835	3.400000
max	15.900000	1.580000	1.000000	15.500000	0.611000	72.000000	289.000000	1.003690	4.010000

Look at distribution make a histogram

In [6]:
```
columns=['fixed acidity','volatile acidity','citric acid','residual sugar','chlorides','free sulfur dioxide'
wine[columns].hist(bins=15, layout=(4, 3), figsize=(15,10)) # 3 rows and 3 columns # figure size is the spre
plt.show()
```



Target Variable - Quality since the goal is to determine which physiochemical properties make a wine 'good'.

Assign good quality wine where wine_quality is greater than 6.

The remaining wine is classified as poor quality wine

METHOD 1

In [7]:
```
wine["wine_quality"]=(wine["quality"]>6)*1

wine[10:20]
```

Out[7]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality	wine_quality
10	10.5	0.510	0.64	2.4	0.107	6.0	15.0	0.99730	3.09	0.66	11.80	7	1
11	6.7	0.760	0.02	1.8	0.078	6.0	12.0	0.99600	3.55	0.63	9.95	3	0
12	6.7	0.480	0.08	2.1	0.064	18.0	34.0	0.99552	3.33	0.64	9.70	5	0
13	7.0	0.560	0.13	1.6	0.077	25.0	42.0	0.99629	3.34	0.59	9.20	5	0
14	7.8	0.340	0.37	2.0	0.082	24.0	58.0	0.99640	3.34	0.59	9.40	6	0
15	8.9	0.280	0.45	1.7	0.067	7.0	12.0	0.99354	3.25	0.55	12.30	7	1
16	6.7	0.675	0.07	2.4	0.089	17.0	82.0	0.99580	3.35	0.54	10.10	5	0
17	10.1	0.430	0.40	2.6	0.092	13.0	52.0	0.99834	3.22	0.64	10.00	7	1
18	9.4	0.300	0.56	2.8	0.080	6.0	17.0	0.99640	3.15	0.92	11.70	8	1
19	8.4	0.745	0.11	1.9	0.090	16.0	63.0	0.99650	3.19	0.82	9.60	5	0

METHOD 2

In [8]:
```
wine["wine_quality_cat"]=np.ceil(wine["quality"]>=7) # 10 leads to most data in categories in 4 arbitary # t
#22 will work as well, just looking for an even distribution
#wine["wine_quality_cat"].where(wine["quality"] < 1, 1, inplace=True) #anything more than 4 assign to 4
#any number will work, 4 is generally chosen, bigger the # more the computation time
wine[10:20]
```

Out[8]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality	wine_quality	wine_qual
10	10.5	0.510	0.64	2.4	0.107	6.0	15.0	0.99730	3.09	0.66	11.80	7	1	
11	6.7	0.760	0.02	1.8	0.078	6.0	12.0	0.99600	3.55	0.63	9.95	3	0	
12	6.7	0.480	0.08	2.1	0.064	18.0	34.0	0.99552	3.33	0.64	9.70	5	0	
13	7.0	0.560	0.13	1.6	0.077	25.0	42.0	0.99629	3.34	0.59	9.20	5	0	
14	7.8	0.340	0.37	2.0	0.082	24.0	58.0	0.99640	3.34	0.59	9.40	6	0	
15	8.9	0.280	0.45	1.7	0.067	7.0	12.0	0.99354	3.25	0.55	12.30	7	1	
16	6.7	0.675	0.07	2.4	0.089	17.0	82.0	0.99580	3.35	0.54	10.10	5	0	
17	10.1	0.430	0.40	2.6	0.092	13.0	52.0	0.99834	3.22	0.64	10.00	7	1	
18	9.4	0.300	0.56	2.8	0.080	6.0	17.0	0.99640	3.15	0.92	11.70	8	1	
19	8.4	0.745	0.11	1.9	0.090	16.0	63.0	0.99650	3.19	0.82	9.60	5	0	

We see that by both of the methods any wine with quality greater than 7 has been assigned as good ie. binary as 1 in wine_quality and wine_quality_cat and vice versa

In [9]:
```
df=wine.copy()
```

In [ ]:

Remove Outliers

Outliers are usually extreme high or low values that are different from pattern of majority data. A straightforward approach to detect outliers are several (n) standard deviations from the mean $m \pm n\sigma$ (m=mean, σ=standard deviation). For example, an outlier can be bigger than $m + 3\sigma$ or less than $m - 3\sigma$. The following function can be used to apply this approach.

In [10]:
```
def outlier_remove(df, n,name):
    """Delete rows for a specified column where values are out of +/- n*sd standard deviations
    df  : Pandas dataframe
    n   : n in the equation m±nσ
    name: Column name
    """
    mean=df[name].mean() # Calclute mean of column
    sd=df[name].std()     # Calclute standard deviation of column
    drop_r = df.index[(mean -n * sd> df[name]) | (mean+n * sd< df[name])]# vertical line is or
    df.drop(drop_r, axis=0, inplace=True)# dropping rows that dont satisfy the code
    df.reset_index(inplace=True, drop=True) # Reset index

# Drop outliers in last column 'OIL Prod. (e3m3/month)'
outlier_remove(df, n=3,name='quality') #based on oil production
df.describe()
```

Out[10]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH
count	1589.000000	1589.000000	1589.000000	1589.000000	1589.000000	1589.000000	1589.000000	1589.000000	1589.000000
mean	8.319383	0.525576	0.271605	2.538200	0.087246	15.905601	46.603524	0.996742	3.310566
std	1.741471	0.175602	0.194337	1.410398	0.046866	10.460067	32.929680	0.001886	0.154337
min	4.600000	0.120000	0.000000	0.900000	0.012000	1.000000	6.000000	0.990070	2.740000
25%	7.100000	0.390000	0.100000	1.900000	0.070000	7.000000	22.000000	0.995600	3.210000
50%	7.900000	0.520000	0.260000	2.200000	0.079000	14.000000	38.000000	0.996750	3.310000
75%	9.200000	0.635000	0.420000	2.600000	0.090000	21.000000	63.000000	0.997820	3.400000
max	15.900000	1.330000	1.000000	15.500000	0.611000	72.000000	289.000000	1.003690	4.010000

The number of rows have been removed so the number of rows have been reduced from 1599 to 1571.

In [ ]:

BINARY CLASSIFICATION

Now removing quality and wine_quality

In [11]:
```
df_binary=df.copy()
df_binary.drop(['wine_quality_cat'], axis=1, inplace=True)
df_binary.drop(['quality'], axis=1, inplace=True)
df_binary.reset_index(inplace=True, drop=True) # Reset index
df_binary[0:5]
```

Out[11]:

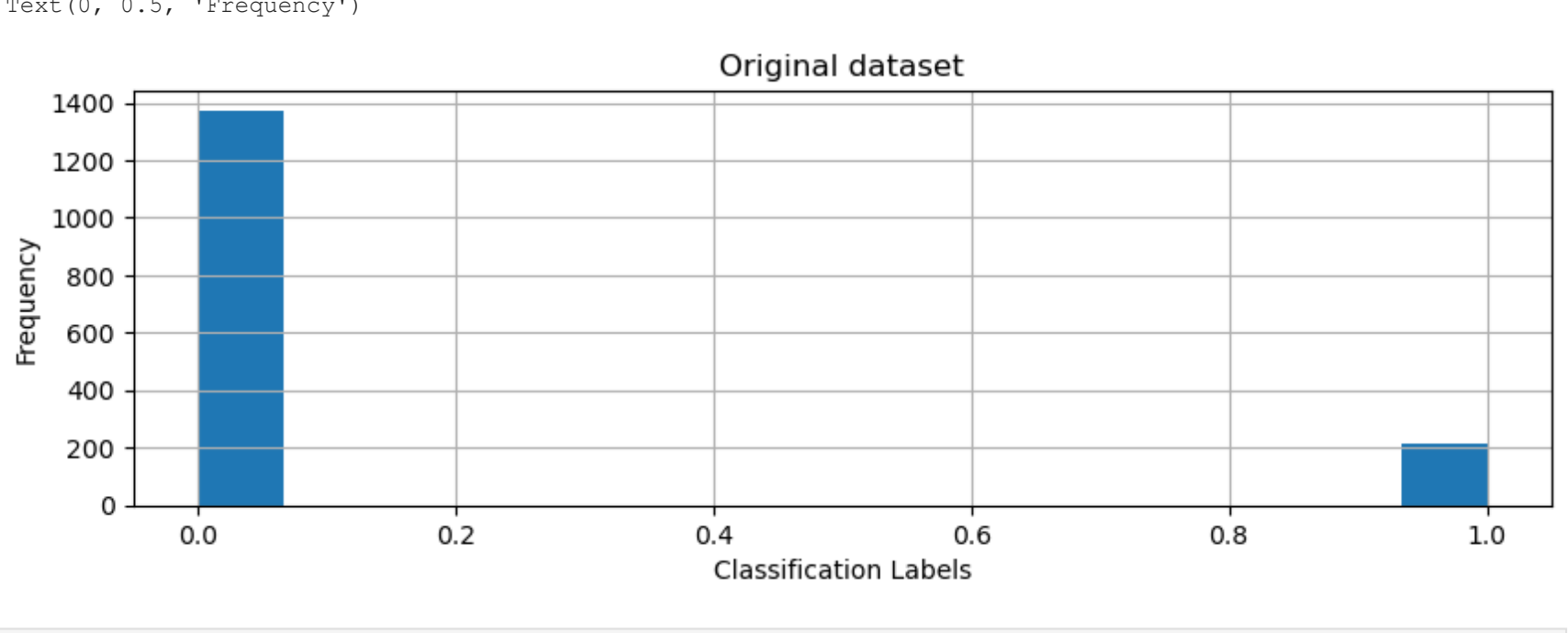
	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	wine_quality
0	7.7	0.56	0.08	2.50	0.114	14.0	46.0	0.9971	3.24	0.66	9.6	0
1	7.8	0.50	0.17	1.60	0.082	21.0	102.0	0.9960	3.39	0.48	9.5	0
2	10.7	0.67	0.22	2.70	0.107	17.0	34.0	1.0004	3.28	0.98	9.9	0
3	8.5	0.46	0.31	2.25	0.078	32.0	58.0	0.9980	3.33	0.54	9.8	0
4	6.7	0.46	0.24	1.70	0.077	18.0	34.0	0.9948	3.39	0.60	10.6	0

In [12]:
```
font = {'size'   : 10}
matplotlib.rc('font', **font)

fig = plt.subplots(figsize=(10, 3), dpi= 100, facecolor='w', edgecolor='k')


df_binary['wine_quality'].hist(bins=15)
plt.title("Original dataset")
plt.xlabel("Classification Labels")
plt.ylabel("Frequency")
```

Out[12]: Text(0, 0.5, 'Frequency')



In [13]:
```
df_binary['wine_quality'].value_counts()
```

Out[13]:
```
0    1372
1     217
Name: wine_quality, dtype: int64
```

The original dataset has apprximately 199 is classified as good quality wine i.e. 12.7% of the total cases. The original dataset has apprximately 1372 is classified as poor quality wine ie 87.3% of the total cases.

In [14]:
```
df_binary
```

Out[14]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	wine_quality
0	7.7	0.560	0.08	2.50	0.114	14.0	46.0	0.99710	3.24	0.66	9.6	0
1	7.8	0.500	0.17	1.60	0.082	21.0	102.0	0.99600	3.39	0.48	9.5	0
2	10.7	0.670	0.22	2.70	0.107	17.0	34.0	1.00040	3.28	0.98	9.9	0
3	8.5	0.460	0.31	2.25	0.078	32.0	58.0	0.99800	3.33	0.54	9.8	0
4	6.7	0.460	0.24	1.70	0.077	18.0	34.0	0.99480	3.39	0.60	10.6	0
...	...	...	...	...	...	...	...	...	...	...	...	...
1584	9.1	0.600	0.00	1.90	0.058	5.0	10.0	0.99770	3.18	0.63	10.4	0
1585	8.2	0.635	0.10	2.10	0.073	25.0	60.0	0.99638	3.29	0.75	10.9	0
1586	7.2	0.620	0.06	2.70	0.077	15.0	85.0	0.99746	3.51	0.54	9.5	0
1587	7.9	0.200	0.35	1.70	0.054	7.0	15.0	0.99458	3.32	0.80	11.9	1
1588	5.8	0.290	0.26	1.70	0.063	3.0	11.0	0.99150	3.39	0.54	13.5	0

1589 rows × 12 columns

SPLIT DATA INTO TEST AND TRAINING DATA BY STARTIFIED SAMPLING

In [15]:
```
from sklearn.model_selection import StratifiedShuffleSplit

# Training and Test
spt = StratifiedShuffleSplit(n_splits=1, test_size=0.2, random_state=42)#always use shuffle
for train_idx, test_idx in spt.split(df_binary, df_binary['wine_quality']):#split training and testing data
    train_set_strat = df_binary.loc[train_idx]
    test_set_strat  = df_binary.loc[test_idx]

for dataset in (train_set_strat, test_set_strat): dataset.reset_index(inplace=True, drop=True) # Reset index
train_set_strat[0:4]
```

Out[15]:

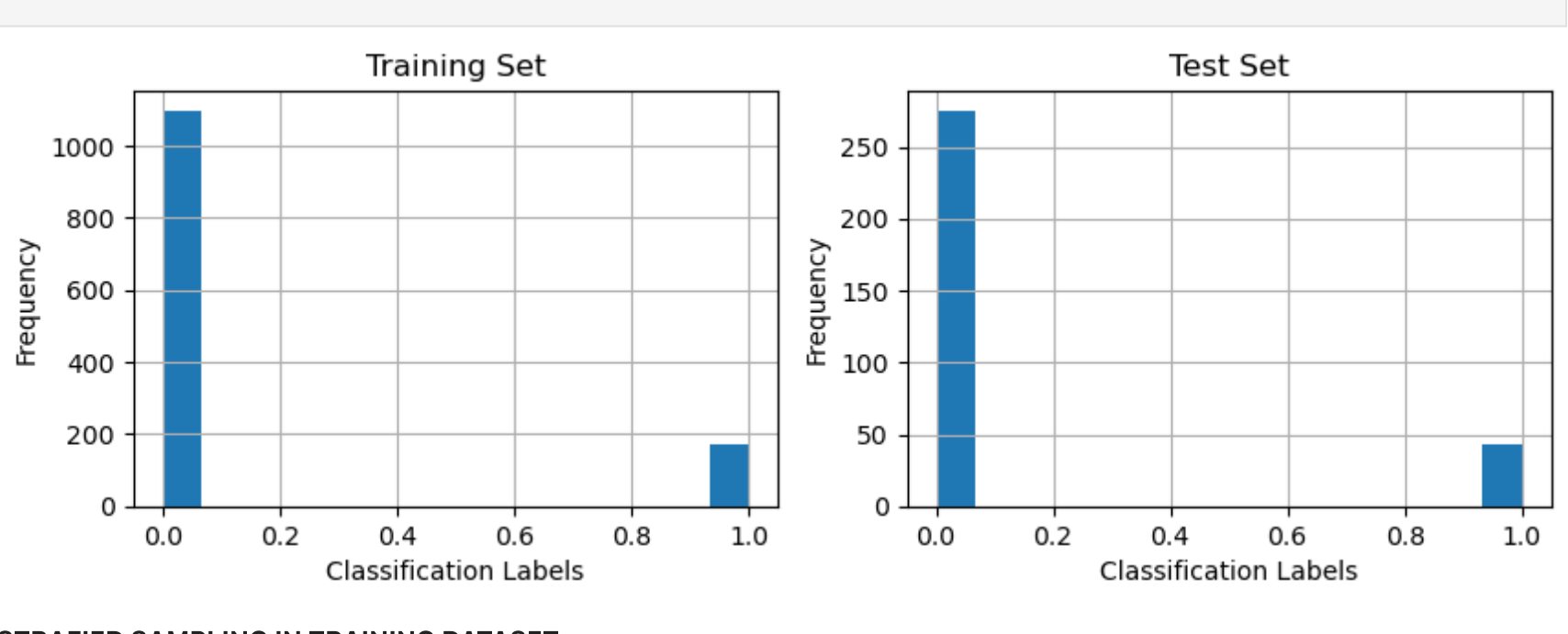
	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	wine_quality
0	7.6	0.685	0.23	2.3	0.111	20.0	84.0	0.99640	3.21	0.61	9.3	0
1	5.9	0.440	0.00	1.6	0.042	3.0	11.0	0.99440	3.48	0.85	11.7	0
2	7.9	0.690	0.21	2.1	0.080	33.0	141.0	0.99620	3.25	0.51	9.9	0
3	9.1	0.660	0.15	3.2	0.097	9.0	59.0	0.99976	3.28	0.54	9.6	0

In [16]:
```
font = {'size'   : 10}
matplotlib.rc('font', **font)

fig = plt.subplots(figsize=(10, 3), dpi= 100, facecolor='w', edgecolor='k')

ax1=plt.subplot(1,2,1)
train_set_strat['wine_quality'].hist(bins=15)
plt.title("Training Set")
plt.xlabel("Classification Labels")
plt.ylabel("Frequency")

ax2=plt.subplot(1,2,2)
test_set_strat['wine_quality'].hist(bins=15)
plt.title("Test Set")
plt.xlabel("Classification Labels")
plt.ylabel("Frequency")
plt.show()
```



STRAFIED SAMPLING IN TRAINING DATASET

In [17]:
```
train_set_strat['wine_quality'].value_counts()
```

Out[17]:
```
0    1097
1     174
Name: wine_quality, dtype: int64
```

The training dataset has approximately 159 good quality wine i.e. 12.6% of the total cases. The training dataset has approximately 1097 aas poor quality wine i.e. 87.4% of the total cases.

In [ ]:

STRATIFIED SAMPLING IN TEST DATASET

In [18]:
```
test_set_strat['wine_quality'].value_counts()
```

Out[18]:
```
0    275
1     43
Name: wine_quality, dtype: int64
```

The test dataset has approximately 40 as good quality wine i.e. 12.6% of the total cases. The test dataset has approximately 275 as poor quality wine i.e. 87.4% of the total cases.

conclusion

Both the training and test dataset as well as the original dataset have almost the same ratio for good and poor quality wine. There is similar split in all the datasets.

In [ ]:

Now setting Classification column as target

In [19]:
```
# Note that drop() creates a copy and does not affect train_set_strat
X_train = train_set_strat.drop("wine_quality", axis=1)# remove target
y_train = train_set_strat["wine_quality"].values# only taget values
```

In [20]:
```
X_train
```

Out[20]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
0	7.6	0.685	0.23	2.3	0.111	20.0	84.0	0.99640	3.21	0.61	9.3
1	5.9	0.440	0.00	1.6	0.042	3.0	11.0	0.99440	3.48	0.85	11.7
2	7.9	0.690	0.21	2.1	0.080	33.0	141.0	0.99620	3.25	0.51	9.9
3	9.1	0.660	0.15	3.2	0.097	9.0	59.0	0.99976	3.28	0.54	9.6
4	7.9	0.720	0.17	2.6	0.096	20.0	38.0	0.99780	3.40	0.53	9.5
...	...	...	...	...	...	...	...	...	...	...	...
1266	10.0	0.260	0.54	1.9	0.083	42.0	74.0	0.99451	2.98	0.63	11.8
1267	5.0	1.020	0.04	1.4	0.045	41.0	85.0	0.99380	3.75	0.48	10.5
1268	6.6	0.725	0.20	7.8	0.073	29.0	79.0	0.99770	3.29	0.54	9.2
1269	7.0	0.620	0.08	1.8	0.076	8.0	24.0	0.99780	3.48	0.53	9.0
1270	7.0	0.380	0.49	2.5	0.097	33.0	85.0	0.99620	3.39	0.77	11.4

1271 rows × 11 columns

In [21]:
```
X_train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1271 entries, 0 to 1270
Data columns (total 11 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   fixed acidity         1271 non-null   float64
 1   volatile acidity      1271 non-null   float64
 2   citric acid           1271 non-null   float64
 3   residual sugar        1271 non-null   float64
 4   chlorides             1271 non-null   float64
 5   free sulfur dioxide   1271 non-null   float64
 6   total sulfur dioxide  1271 non-null   float64
 7   density               1271 non-null   float64
 8   pH                    1271 non-null   float64
 9   sulphates             1271 non-null   float64
 10  alcohol               1271 non-null   float64
dtypes: float64(11)
memory usage: 109.4 KB
```

In [22]:
```
y_train
```

Out[22]: array([0, 0, 0, ..., 0, 0, 0])

In [23]:
```
y_train.shape
```

Out[23]: (1271,)

The target column -Wine Quality has been removed from the X_train datatset. The target column - Wine Quality has been set as the the y_train datatset.

In [ ]:

DATA VISUALIZATION

CORRELATION MATRIX

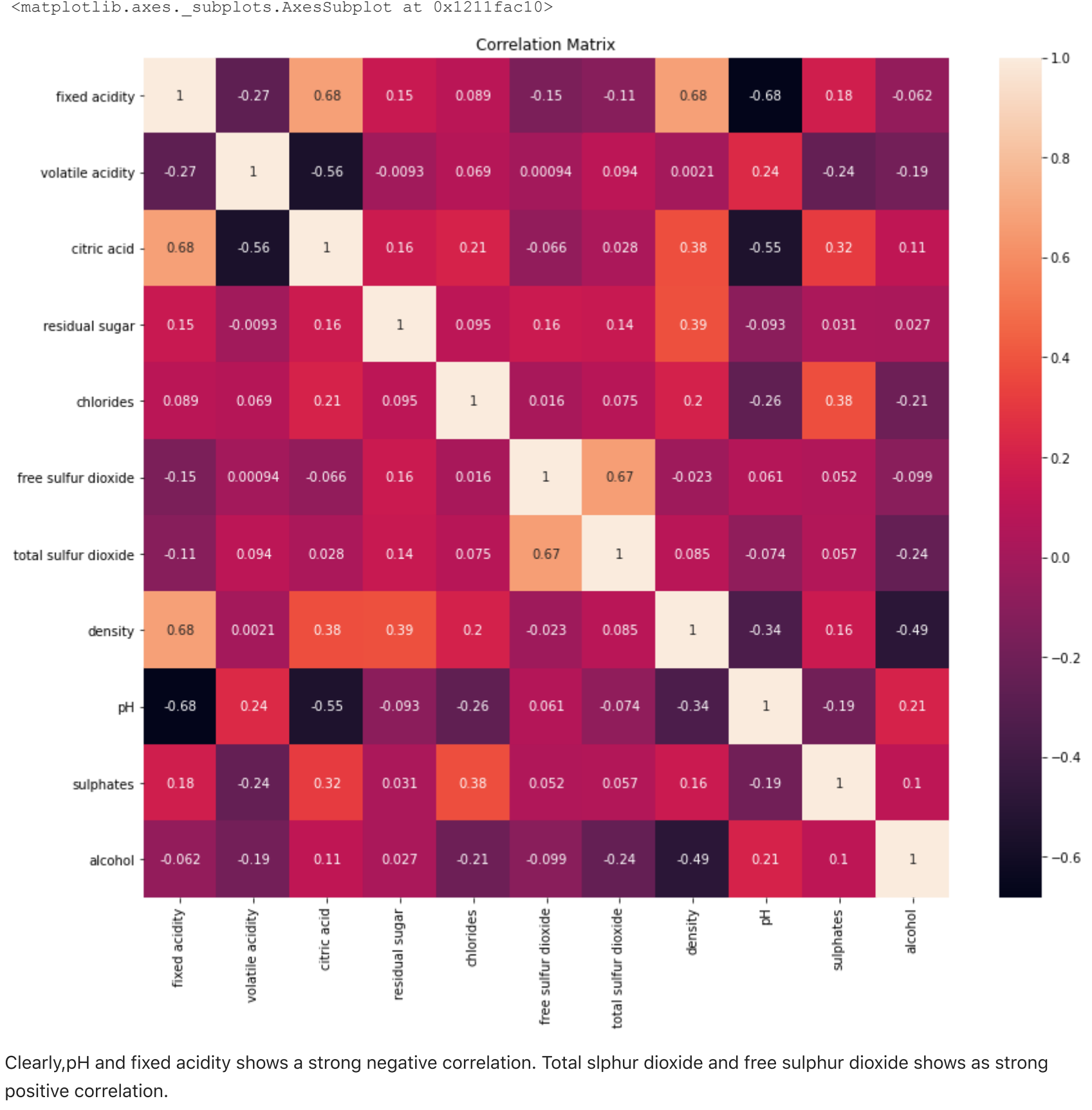
In [24]:
```
corr_matrix=X_train.corr() #data is Oil_Prod
corr_matrix
```

Out[24]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alco
fixed acidity	1.000000	-0.268326	0.675981	0.146544	0.089182	-0.153752	-0.106373	0.676453	-0.681435	0.184887	-0.061
volatile acidity	-0.268326	1.000000	-0.559032	-0.009348	0.068949	0.000937	0.093661	0.002105	0.240034	-0.243413	-0.185
citric acid	0.675981	-0.559032	1.000000	0.161770	0.206215	-0.065928	0.028217	0.381078	-0.545670	0.315849	0.107
residual sugar	0.146544	-0.009348	0.161770	1.000000	0.095245	0.156969	0.142678	0.388331	-0.093356	0.030549	0.026
chlorides	0.089182	0.068949	0.206215	0.095245	1.000000	0.016203	0.074707	0.200537	-0.262957	0.380501	-0.208
free sulfur dioxide	-0.153752	0.000937	-0.065928	0.156969	0.016203	1.000000	0.671588	-0.022514	0.061167	0.052369	-0.099
total sulfur dioxide	-0.106373	0.093661	0.028217	0.142678	0.074707	0.671588	1.000000	0.085423	-0.074138	0.057431	-0.241
density	0.676453	0.002105	0.381078	0.388331	0.200537	-0.022514	0.085423	1.000000	-0.344659	0.157188	-0.487
pH	-0.681435	0.240034	-0.545670	-0.093356	-0.262957	0.061167	-0.074138	-0.344659	1.000000	-0.194210	0.209
sulphates	0.184887	-0.243413	0.315849	0.030549	0.380501	0.052369	0.057431	0.157188	-0.194210	1.000000	0.100
alcohol	-0.061642	-0.185500	0.107516	0.026837	-0.208865	-0.099497	-0.241980	-0.487399	0.209054	0.100516	1.000

In [25]:
```
import seaborn as sns
plt.figure(figsize=(14,12))
plt.title("Correlation Matrix")
sns.heatmap(data = corr_matrix, annot=True)
```

Out[25]: <matplotlib.axes._subplots.AxesSubplot at 0x1211fac10>



Clearly,pH and fixed acidity shows a strong negative correlation. Total slphur dioxide and free sulphur dioxide shows as strong positive correlation.

In [ ]:

Kernel density estimation

In [26]:
```
train_set_strat
```

Out[26]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	wine_quality
0	7.6	0.685	0.23	2.3	0.111	20.0	84.0	0.99640	3.21	0.61	9.3	0
1	5.9	0.440	0.00	1.6	0.042	3.0	11.0	0.99440	3.48	0.85	11.7	0
2	7.9	0.690	0.21	2.1	0.080	33.0	141.0	0.99620	3.25	0.51	9.9	0
3	9.1	0.660	0.15	3.2	0.097	9.0	59.0	0.99976	3.28	0.54	9.6	0
4	7.9	0.720	0.17	2.6	0.096	20.0	38.0	0.99780	3.40	0.53	9.5	0
...	...	...	...	...	...	...	...	...	...	...	...	...
1266	10.0	0.260	0.54	1.9	0.083	42.0	74.0	0.99451	2.98	0.63	11.8	1
1267	5.0	1.020	0.04	1.4	0.045	41.0	85.0	0.99380	3.75	0.48	10.5	0
1268	6.6	0.725	0.20	7.8	0.073	29.0	79.0	0.99770	3.29	0.54	9.2	0
1269	7.0	0.620	0.08	1.8	0.076	8.0	24.0	0.99780	3.48	0.53	9.0	0
1270	7.0	0.380	0.49	2.5	0.097	33.0	85.0	0.99620	3.39	0.77	11.4	0

1271 rows × 12 columns

In [27]:
```
k_poor = train_set_strat.loc[train_set_strat.wine_quality == 0]
k_poor
```

Out[27]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	wine_quality
0	7.6	0.685	0.23	2.3	0.111	20.0	84.0	0.99640	3.21	0.61	9.3	0
1	5.9	0.440	0.00	1.6	0.042	3.0	11.0	0.99440	3.48	0.85	11.7	0
2	7.9	0.690	0.21	2.1	0.080	33.0	141.0	0.99620	3.25	0.51	9.9	0
3	9.1	0.660	0.15	3.2	0.097	9.0	59.0	0.99976	3.28	0.54	9.6	0
4	7.9	0.720	0.17	2.6	0.096	20.0	38.0	0.99780	3.40	0.53	9.5	0
...	...	...	...	...	...	...	...	...	...	...	...	...
1264	5.9	0.395	0.13	2.4	0.056	14.0	28.0	0.99362	3.62	0.67	12.4	0
1267	5.0	1.020	0.04	1.4	0.045	41.0	85.0	0.99380	3.75	0.48	10.5	0
1268	6.6	0.725	0.20	7.8	0.073	29.0	79.0	0.99770	3.29	0.54	9.2	0
1269	7.0	0.620	0.08	1.8	0.076	8.0	24.0	0.99780	3.48	0.53	9.0	0
1270	7.0	0.380	0.49	2.5	0.097	33.0	85.0	0.99620	3.39	0.77	11.4	0

1097 rows × 12 columns

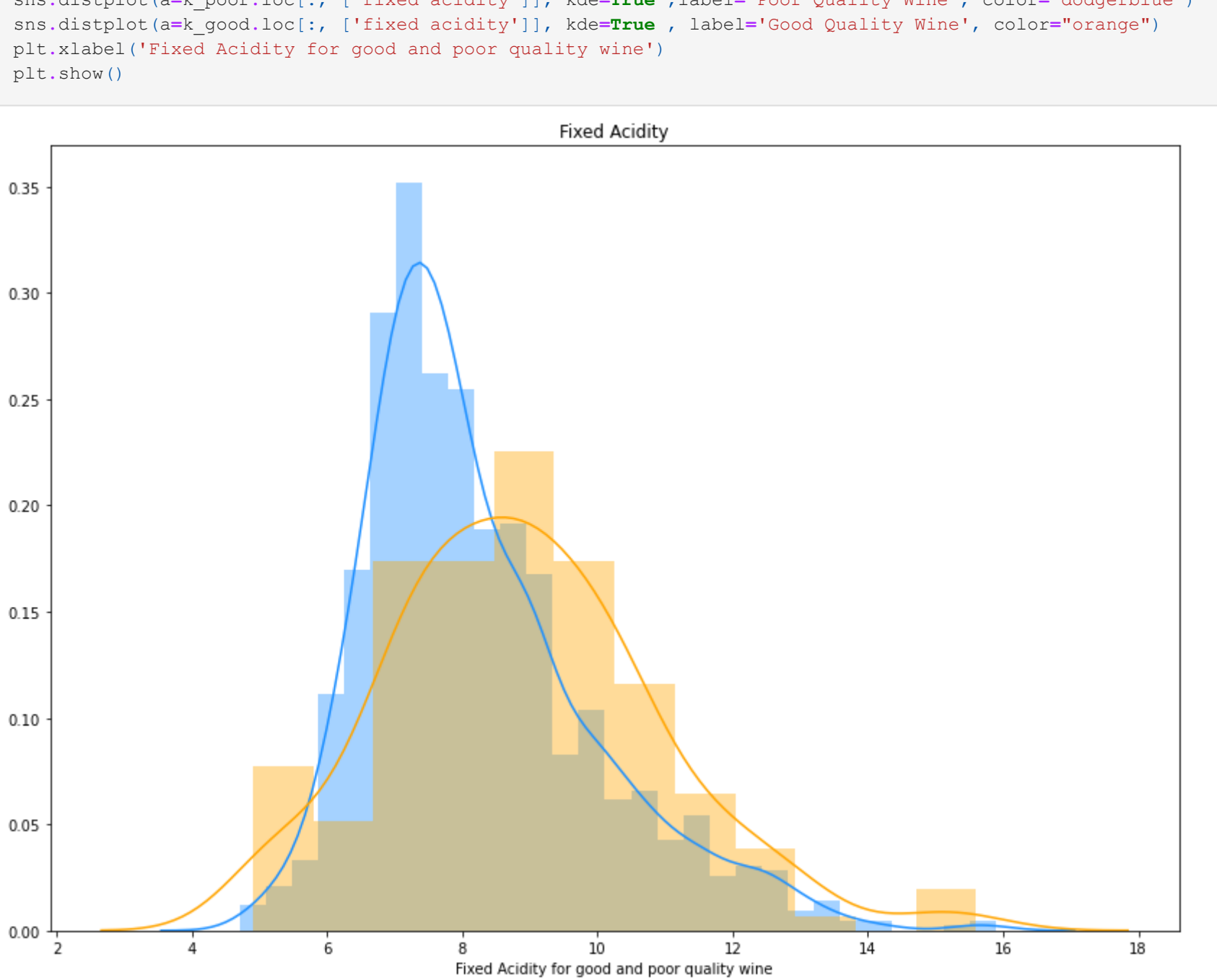
In [28]:
```
k_good = train_set_strat.loc[train_set_strat.wine_quality == 1]
k_good
```

Out[28]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	wine_quality
11	8.9	0.480	0.53	4.00	0.101	3.0	10.0	0.99586	3.21	0.59	12.1	1
16	8.7	0.410	0.41	6.20	0.078	25.0	42.0	0.99530	3.24	0.77	12.6	1
18	7.6	0.735	0.02	2.50	0.071	10.0	14.0	0.99538	3.51	0.71	11.7	1
26	11.9	0.430	0.66	3.10	0.109	10.0	23.0	1.00000	3.15	0.85	10.4	1
30	9.1	0.290	0.33	2.05	0.063	13.0	27.0	0.99516	3.26	0.84	11.7	1
...	...	...	...	...	...	...	...	...	...	...	...	...
1244	8.8	0.330	0.41	5.90	0.073	7.0	13.0	0.99658	3.30	0.62	12.1	1
1257	8.5	0.320	0.42	2.30	0.075	12.0	19.0	0.99434	3.14	0.71	11.8	1
1261	7.3	0.480	0.32	2.10	0.062	31.0	54.0	0.99728	3.30	0.65	10.0	1
1265	8.7	0.520	0.09	2.50	0.091	20.0	49.0	0.99760	3.34	0.86	10.6	1
1266	10.0	0.260	0.54	1.90	0.083	42.0	74.0	0.99451	2.98	0.63	11.8	1

174 rows × 12 columns

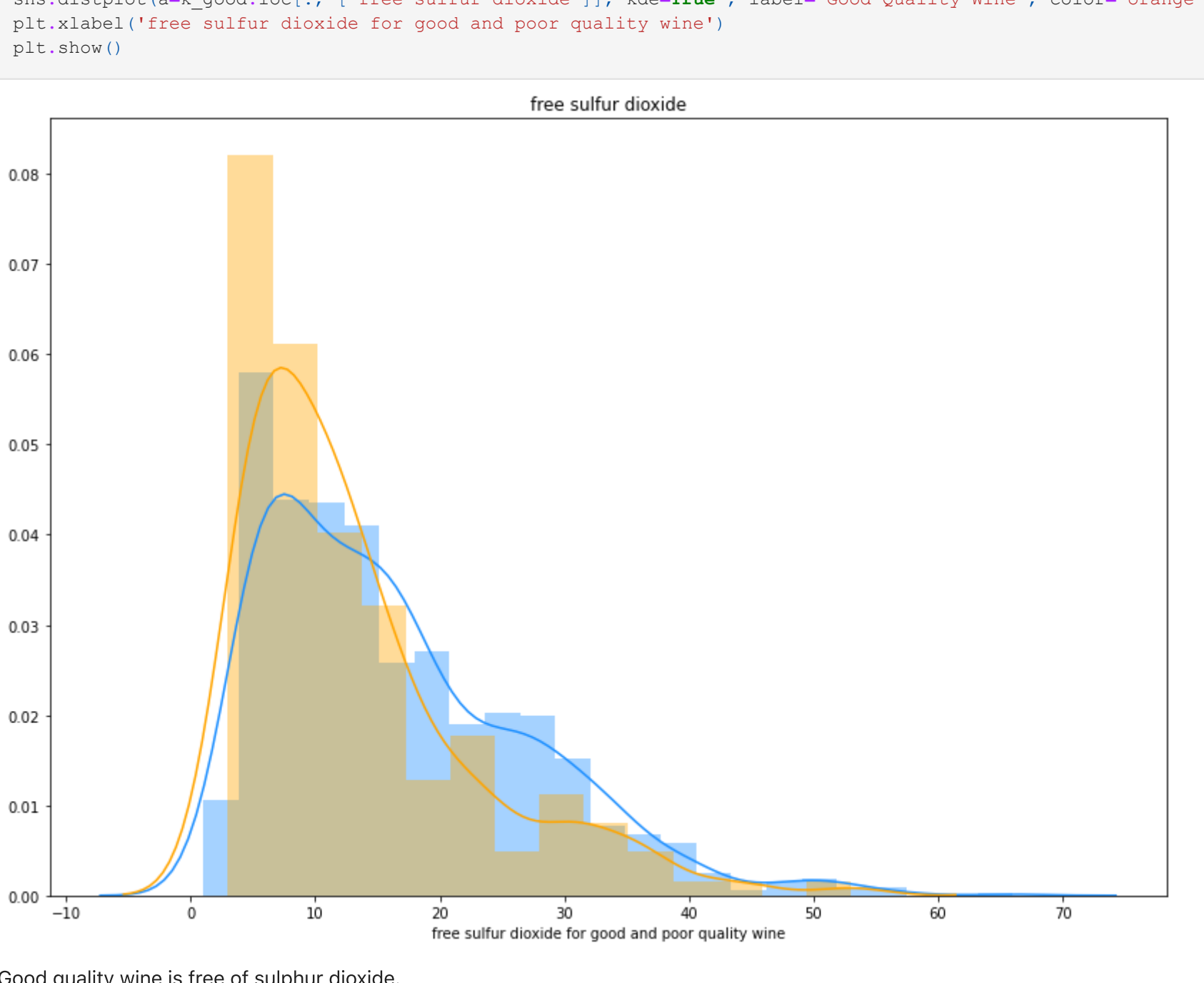
In [29]:
```
plt.figure(figsize=(14,10))
plt.title("Fixed Acidity")
sns.distplot(a=k_poor.loc[:, ['fixed acidity']], kde=True ,label='Poor Quality Wine', color="dodgerblue")
sns.distplot(a=k_good.loc[:, ['fixed acidity']], kde=True , label='Good Quality Wine', color="orange")
plt.xlabel('Fixed Acidity for good and poor quality wine')
plt.show()
```



Poor quality wine has a lot more fixe acidity unlike good quality wine.

In [ ]:

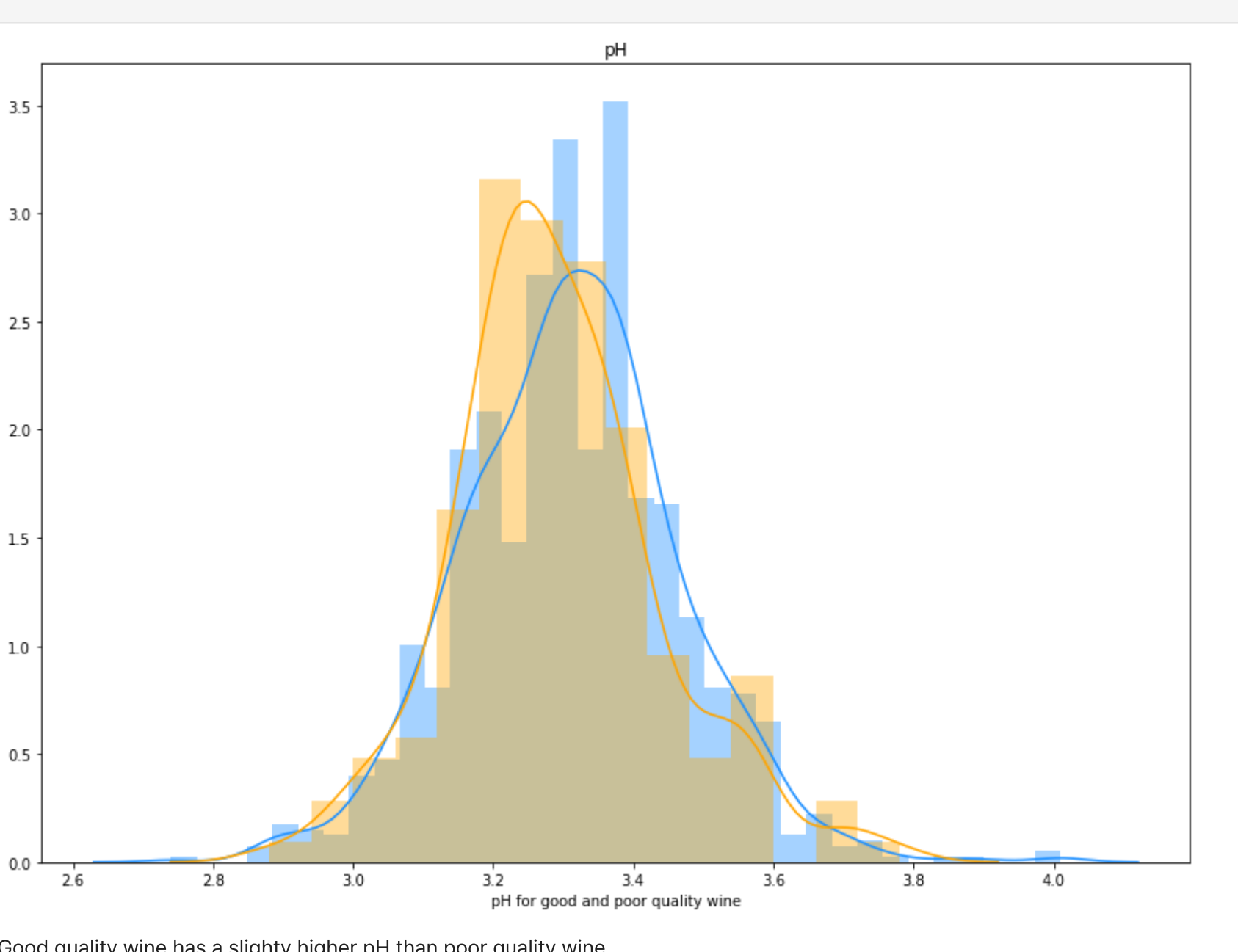
In [30]:
```
plt.figure(figsize=(14,10))
plt.title("free sulfur dioxide")
sns.distplot(a=k_poor.loc[:, ['free sulfur dioxide']], kde=True ,label='Poor Quality Wine', color="dodgerblu
sns.distplot(a=k_good.loc[:, ['free sulfur dioxide']], kde=True , label='Good Quality Wine', color="orange")
plt.xlabel('free sulfur dioxide for good and poor quality wine')
plt.show()
```



Good quality wine is free of sulphur dioxide.

In [ ]:

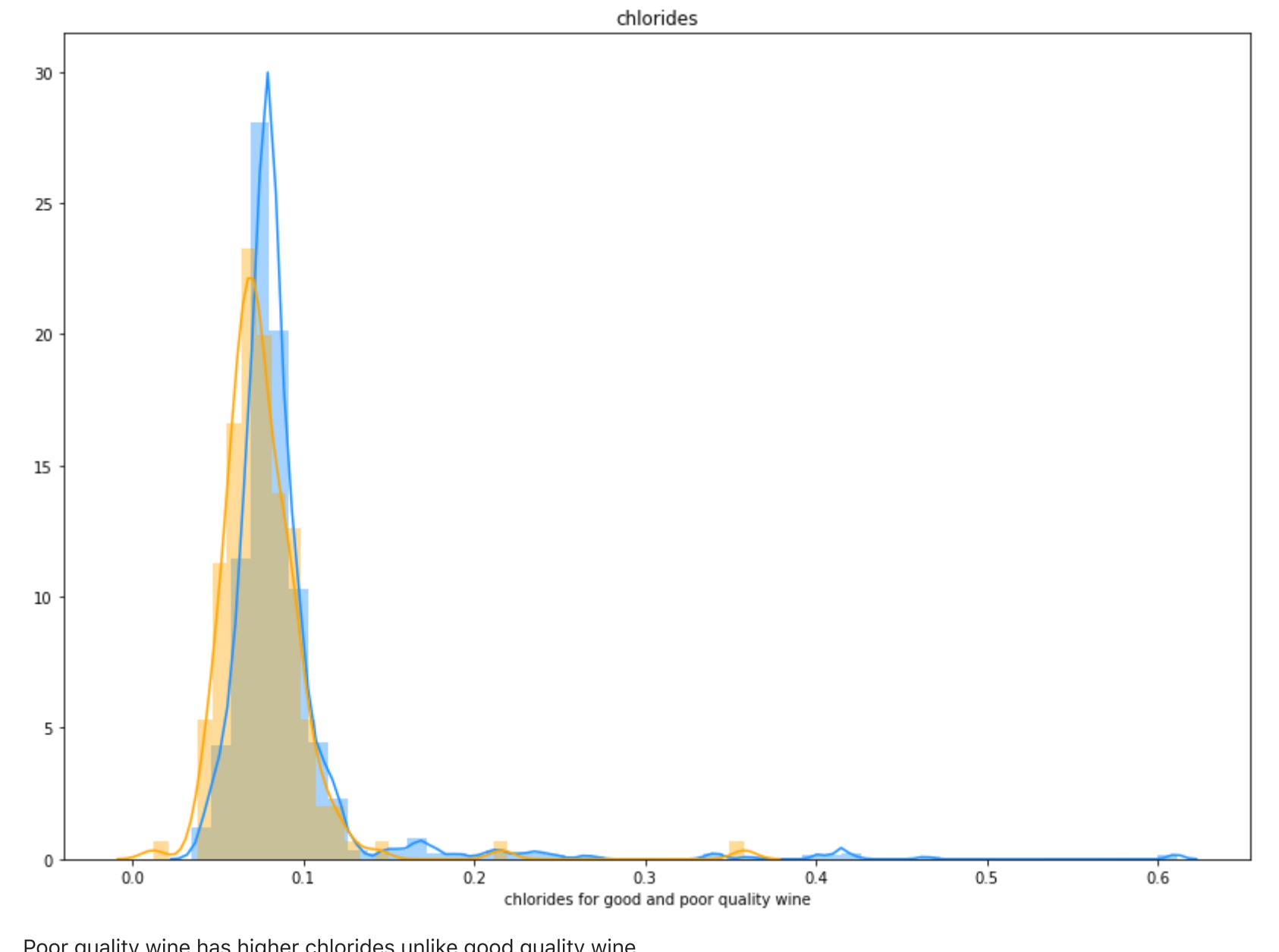
In [31]:
```
plt.figure(figsize=(14,10))
plt.title("pH")
sns.distplot(a=k_poor.loc[:, ['pH']], kde=True ,label='Poor Quality Wine', color="dodgerblue")
sns.distplot(a=k_good.loc[:, ['pH']], kde=True , label='Good Quality Wine', color="orange")
plt.xlabel('pH for good and poor quality wine')
plt.show()
```



Good quality wine has a slighty higher pH than poor quality wine.

In [ ]:

In [32]:
```
plt.figure(figsize=(14,10))
plt.title("chlorides")
sns.distplot(a=k_poor.loc[:, ['chlorides']], kde=True ,label='Poor Quality Wine', color="dodgerblue")
sns.distplot(a=k_good.loc[:, ['chlorides']], kde=True , label='Good Quality Wine', color="orange")
plt.xlabel('chlorides for good and poor quality wine')
plt.show()
```



Poor quality wine has higher chlorides unlike good quality wine.

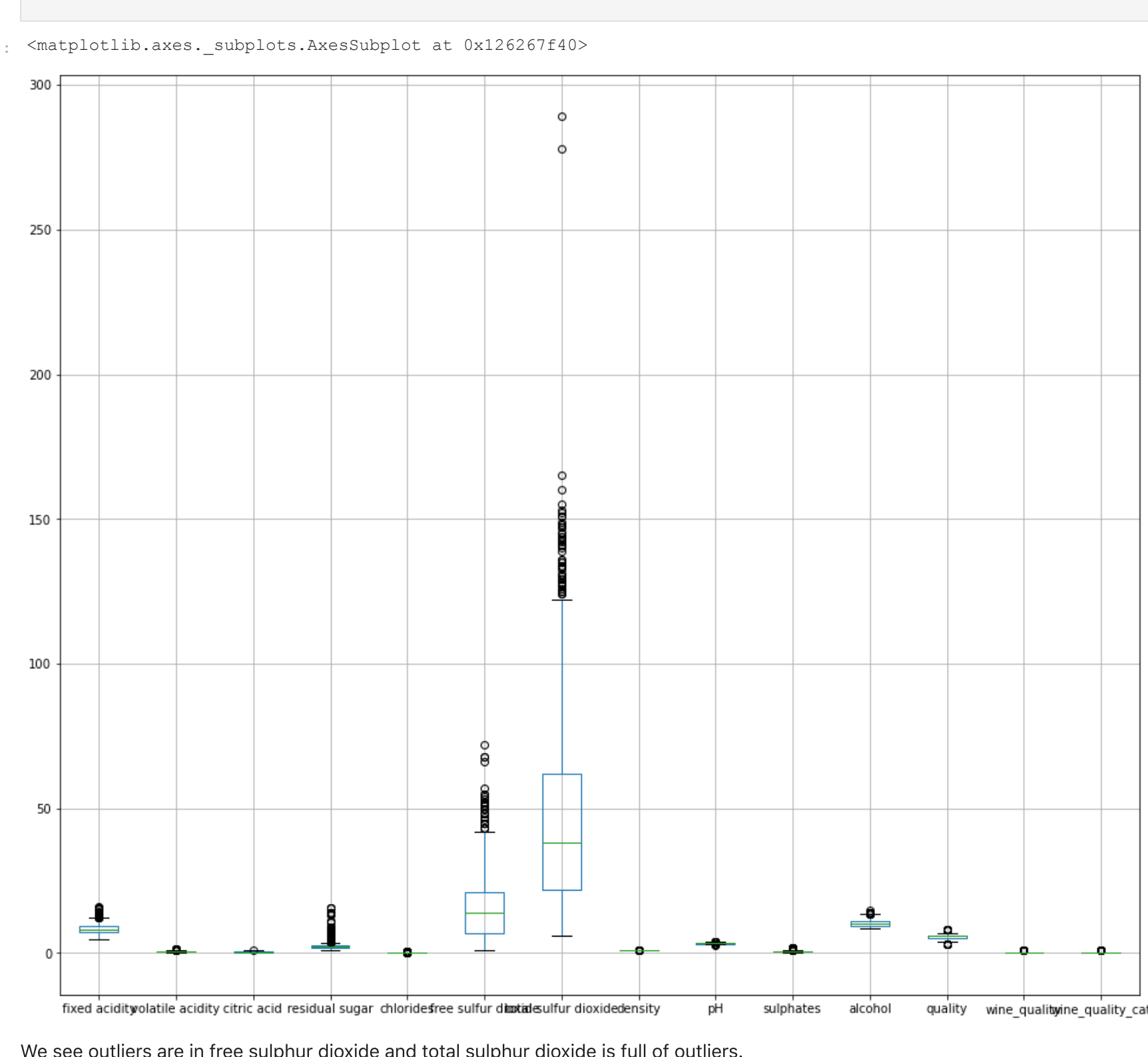
In [ ]:

In [ ]:

BOXPLOT

In [33]:
```
plt.figure(figsize=(16,14))
wine.boxplot()
```

Out[33]: <matplotlib.axes._subplots.AxesSubplot at 0x126267f40>



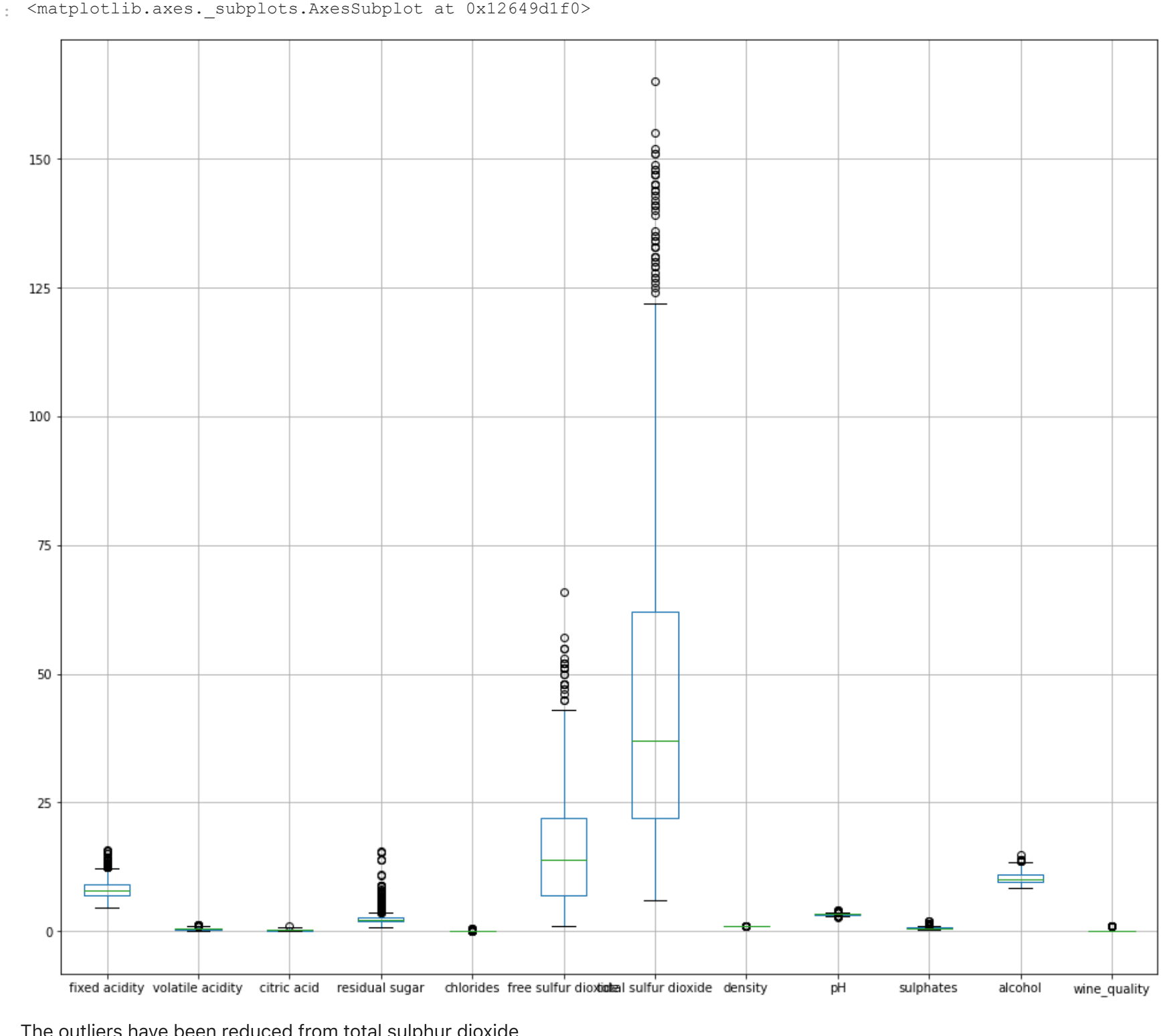
We see outliers are in free sulphur dioxide and total sulphur dioxide is full of outliers.

These outliers have been tackled already. A new data set df and df_binary fom which outliers have been removed have been created from oiginal dataset - wine.

In [ ]:

In [34]:
```
plt.figure(figsize=(16,14))
train_set_strat.boxplot()
```

Out[34]: <matplotlib.axes._subplots.AxesSubplot at 0x12649d1f0>



The outliers have been reduced from total sulphur dioxide

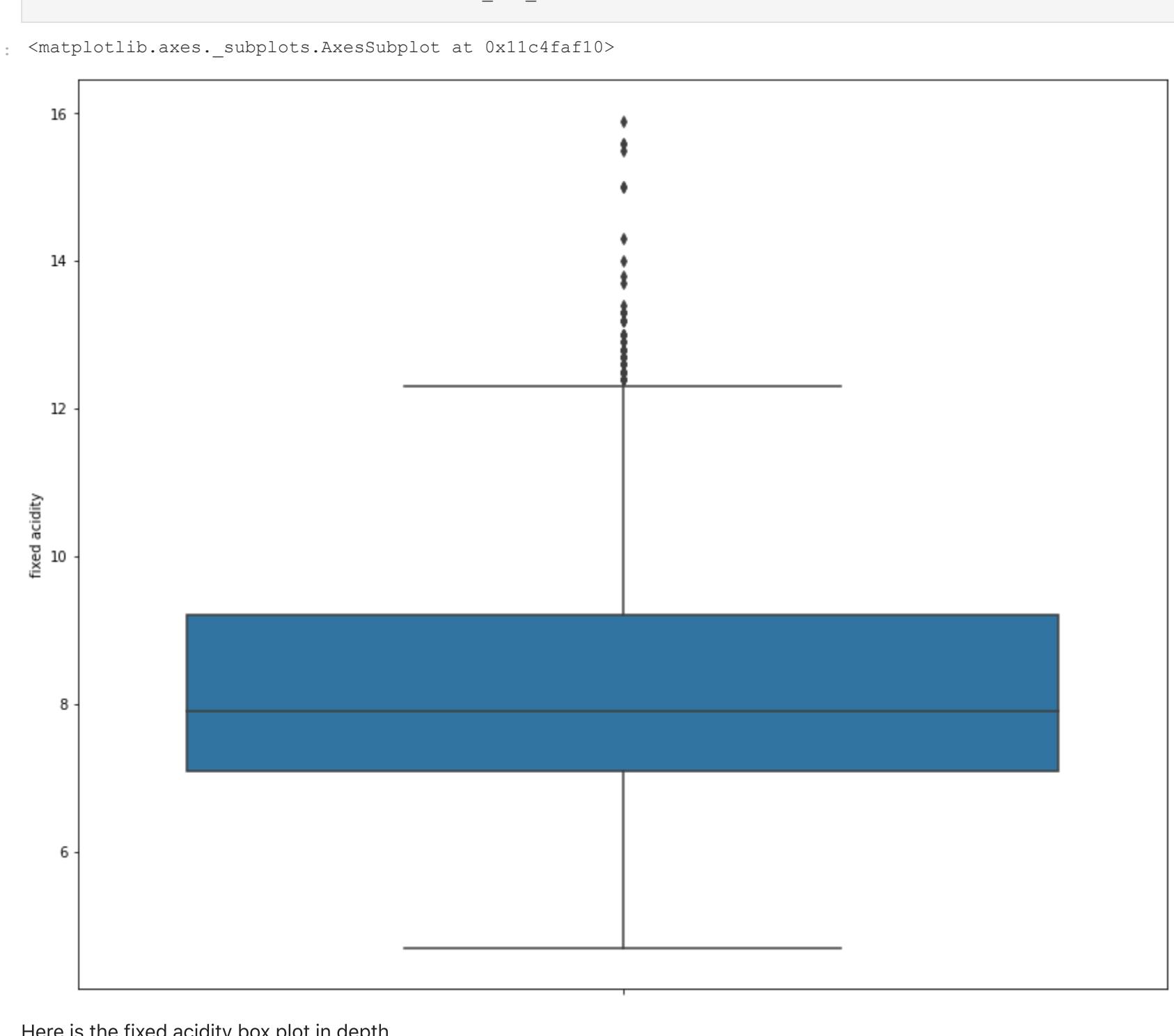
In [ ]:

BOXPLOT OF FIXED ACIDITY IN DETAIL

In [35]:
```
plt.figure(figsize=(14,12))

sns.boxplot(y="fixed acidity", data=train_set_strat)
```

Out[35]: <matplotlib.axes._subplots.AxesSubplot at 0x11c4faf10>



Here is the fixed acidity box plot in depth.

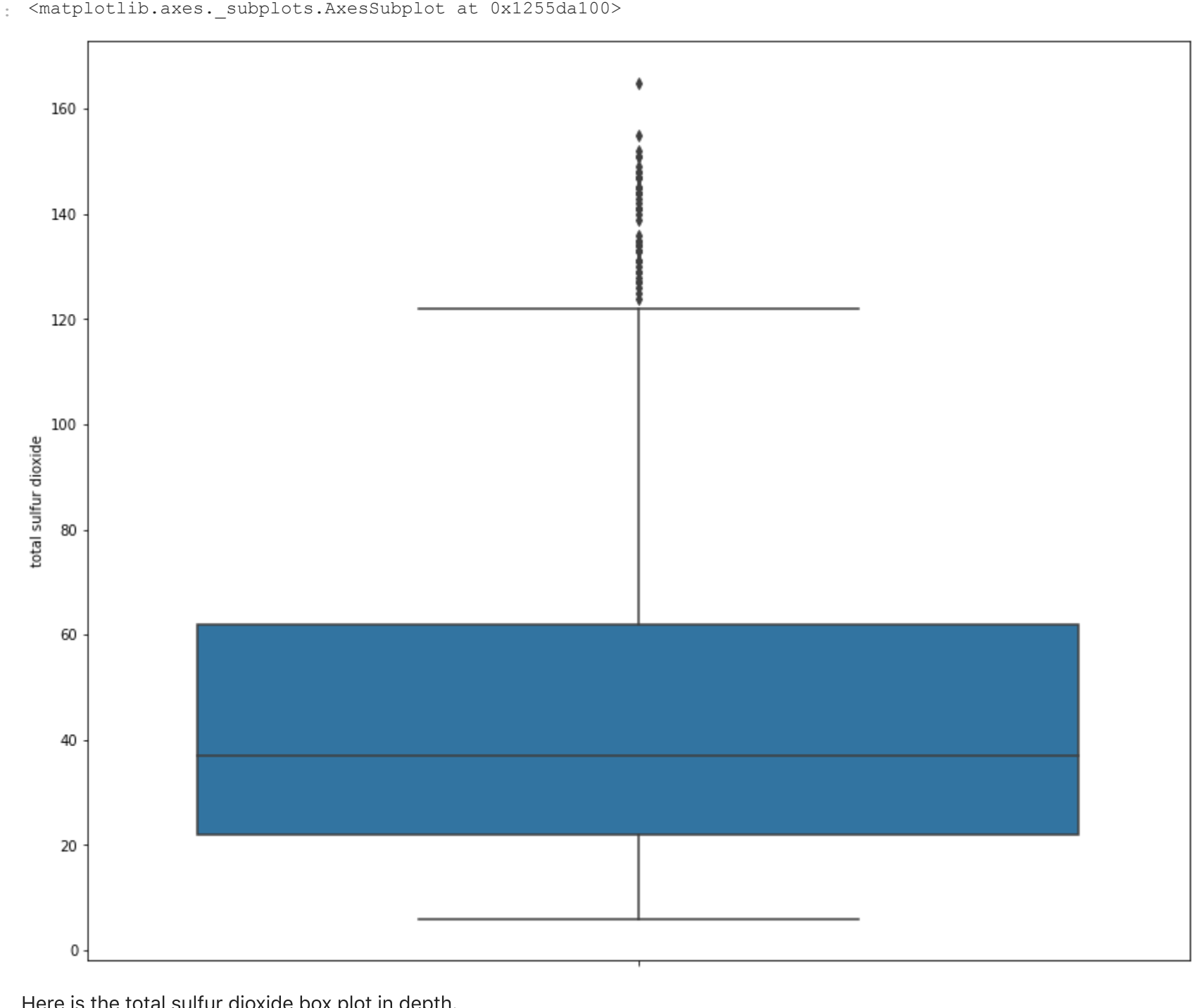
In [ ]:

BOXPLOT OF TOTAL SULFUR DIOXIDE IN DETAIL

In [36]:
```
plt.figure(figsize=(14,12))

sns.boxplot(y="total sulfur dioxide", data=train_set_strat)
```

Out[36]: <matplotlib.axes._subplots.AxesSubplot at 0x1255da100>



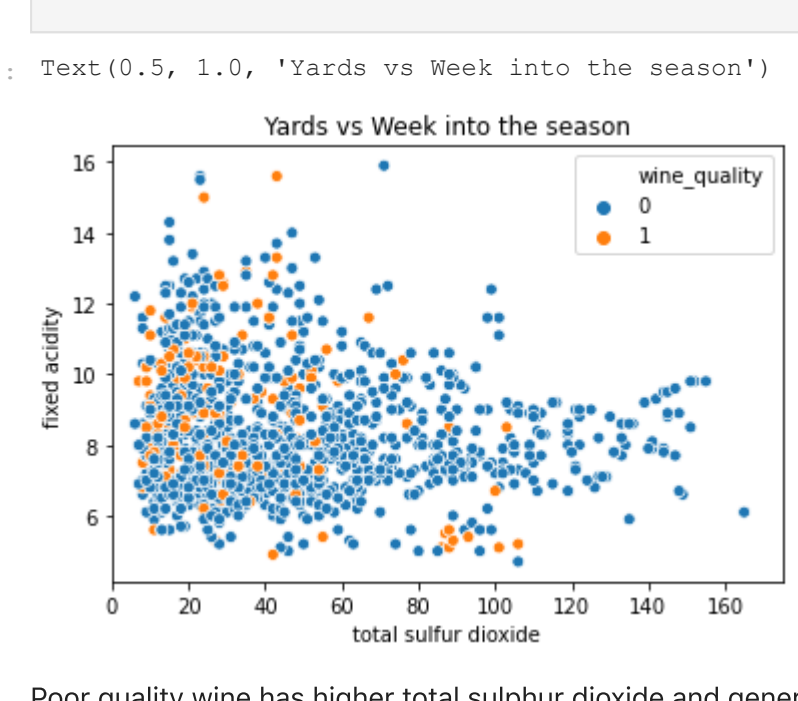
Here is the total sulfur dioxide box plot in depth.

In [ ]:

SCATTERPLOT

In [37]:
```
sns.scatterplot(x='total sulfur dioxide', y="fixed acidity", hue ='wine_quality', data=train_set_strat)
plt.xlim(0, 175)
plt.title("Yards vs Week into the season")
```

Out[37]: Text(0.5, 1.0, 'Yards vs Week into the season')



Poor quality wine has higher total sulphur dioxide and generally higher fixed acidity.

In [ ]:

In [38]:
```
train_set_strat
```

Out[38]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	wine_quality
0	7.6	0.685	0.23	2.3	0.111	20.0	84.0	0.99640	3.21	0.61	9.3	0
1	5.9	0.440	0.00	1.6	0.042	3.0	11.0	0.99440	3.48	0.85	11.7	0
2	7.9	0.690	0.21	2.1	0.080	33.0	141.0	0.99620	3.25	0.51	9.9	0
3	9.1	0.660	0.15	3.2	0.097	9.0	59.0	0.99976	3.28	0.54	9.6	0
4	7.9	0.720	0.17	2.6	0.096	20.0	38.0	0.99780	3.40	0.53	9.5	0
...	...	...	...	...	...	...	...	...	...	...	...	...
1266	10.0	0.260	0.54	1.9	0.083	42.0	74.0	0.99451	2.98	0.63	11.8	1
1267	5.0	1.020	0.04	1.4	0.045	41.0	85.0	0.99380	3.75	0.48	10.5	0
1268	6.6	0.725	0.20	7.8	0.073	29.0	79.0	0.99770	3.29	0.54	9.2	0
1269	7.0	0.620	0.08	1.8	0.076	8.0	24.0	0.99780	3.48	0.53	9.0	0
1270	7.0	0.380	0.49	2.5	0.097	33.0	85.0	0.99620	3.39	0.77	11.4	0

1271 rows × 12 columns

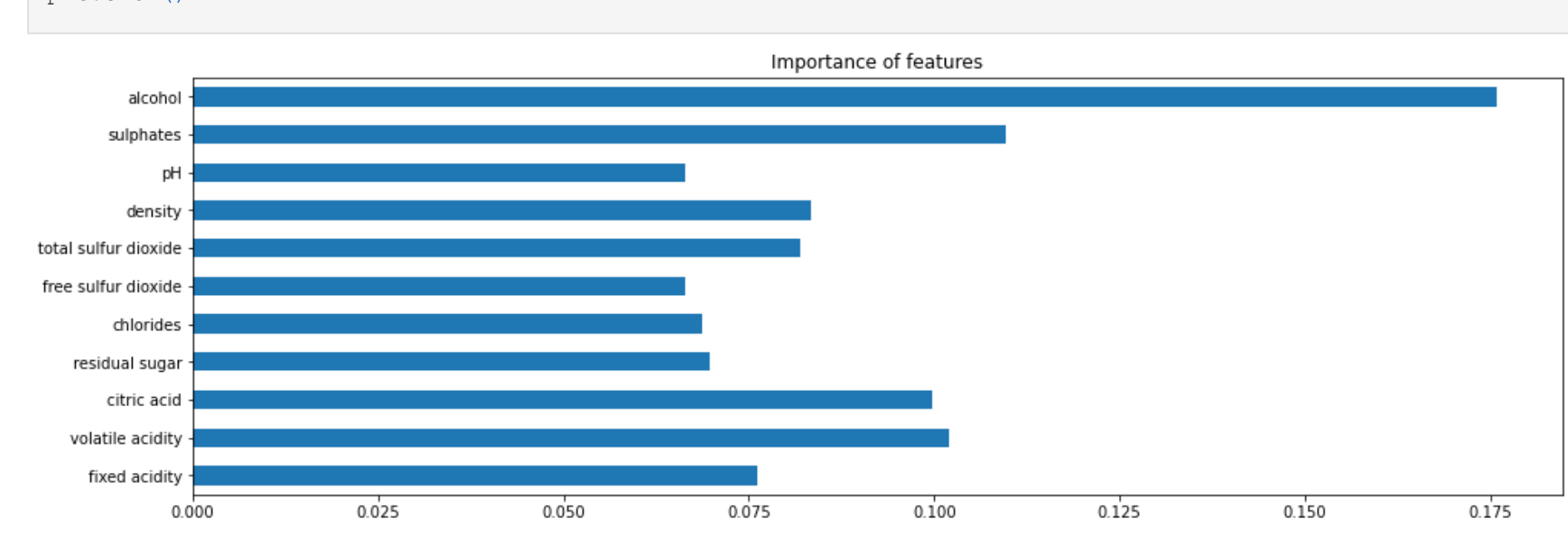
In [ ]:

FEATURE ENGINEERING

In [39]:
```
# Note that drop() creates a copy and does not affect train_set_strat
X_train = train_set_strat.drop("wine_quality", axis=1)# remove target
y_train = train_set_strat["wine_quality"].values# only taget values
```

In [40]:
```
from sklearn.ensemble import ExtraTreesClassifier

X = X_train
Y = y_train
bestfeatures2 = ExtraTreesClassifier()
fit2 = bestfeatures2.fit(X,Y) # model.fit(x,y)
model = pd.Series(fit2.feature_importances_, index=X.columns)
plt.figure(figsize = (16,5))
model.plot(kind='barh')
plt.title("Importance of features")
plt.show()
```



In [ ]:

IMPUTATION

There is no need for imputation

In [ ]:

ONE HOT ENCODING THE NUMBERICAL COLUMN

There is no need for one hot encoding

In [ ]:

STANDARDIZATION OF IMPUTED VARIABLES

In [26]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()#call StandardScaler.
X_train_Std=scaler.fit_transform(X_train)#fit transform
X_train_Std
```

Out[26]:
```
array([[-0.40680364,  0.89357328, -0.20244119, ..., -0.63924901,
        -0.27101354, -1.05451837],
       [-1.37399184, -0.49780233, -1.39245994, ...,  1.10234422,
         1.13709362,  1.20699613],
       [-0.23612337,  0.9219687 , -0.30592108, ..., -0.3812352 ,
        -0.85772486, -0.48913975],
       ...,
       [-0.97573788,  1.12073664, -0.35766103, ..., -0.12322139,
        -0.68171147, -1.14874815],
       [-0.74816419,  0.52443281, -0.97854038, ...,  1.10234422,
        -0.7403826 , -1.33720769],
       [-0.74816419, -0.83854738,  1.1427974 , ...,  0.52181314,
         0.66772457,  0.92430682]])
```

In [27]:
```
X_train_Std.mean()
```

Out[27]: -8.282084298426816e-15

In [28]:
```
X_train_Std.std()
```

Out[28]: 1.0

The mean is 0 and the standard deviation is 1 for the new X_train dataset. So, the X_train dataset is now standardized.

In [29]:
```
X_train_Std = pd.DataFrame(X_train_Std, columns=X_train.columns)#numpy(nmerical data) to pd
#im is numerical dataframe,#X_train_im.columns -use those column names for the newly created data
#im numerical data frame and convert it to pandas
X_train_Std
```

Out[29]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
0	-0.406804	0.893573	-0.202441	-0.156720	0.521691	0.386334	1.175382	-0.170105	-0.639249	-0.271014	-1.054518
1	-1.373992	-0.497802	-1.392460	-0.665695	-0.983945	-1.240546	-1.101113	-1.227544	1.102344	1.137094	1.206996
2	-0.236123	0.921969	-0.305921	-0.302141	-0.154754	1.630419	2.952919	-0.275849	-0.381235	-0.857725	-0.489140
3	0.446598	0.751596	-0.616361	0.497676	0.216199	-0.666353	0.395761	1.606391	-0.187725	-0.681711	-0.771829
4	-0.236123	1.092341	-0.512881	0.061412	0.194379	0.386334	-0.259121	0.570101	0.586317	-0.740383	-0.866059
...	...	...	...	...	...	...	...	...	...	...	...
1266	0.958639	-1.520037	1.401497	-0.447563	-0.089292	2.491708	0.863534	-1.169384	-2.122828	-0.153671	1.301226
1267	-1.886033	2.796066	-1.185500	-0.811116	-0.918483	2.396009	1.206567	-1.544775	2.843937	-1.033738	0.076239
1268	-0.975738	1.120737	-0.357661	3.842368	-0.307500	1.247623	1.019458	0.517230	-0.123221	-0.681711	-1.148748
1269	-0.748164	0.524433	-0.978540	-0.520273	-0.242038	-0.762052	-0.695709	0.570101	1.102344	-0.740383	-1.337208
1270	-0.748164	-0.838547	1.142797	-0.011298	0.216199	1.630419	1.206567	-0.275849	0.521813	0.667725	0.924307

1271 rows × 11 columns

In [ ]:

CONCATANATION of STANRARDIZED DATA AND ONE-HOT ENCODNG column

Not needed

In [ ]:

In [30]:
```
X_train_new = X_train_Std.copy()
```

In [31]:
```
X_train_new.shape
```

Out[31]: (1271, 11)

In [32]:
```
y_train.shape
```

Out[32]: (1271,)

UPSAMPLING

In [33]:
```
df_binary['wine_quality'].value_counts()
```

Out[33]:
```
0    1372
1     217
Name: wine_quality, dtype: int64
```

In [34]:
```
df_minority =df_binary[df_binary['wine_quality']==1]
#df_major = df_majority['wine_quality']
#df_major.value_counts()

df_majority =df_binary[df_binary['wine_quality']==0]
```

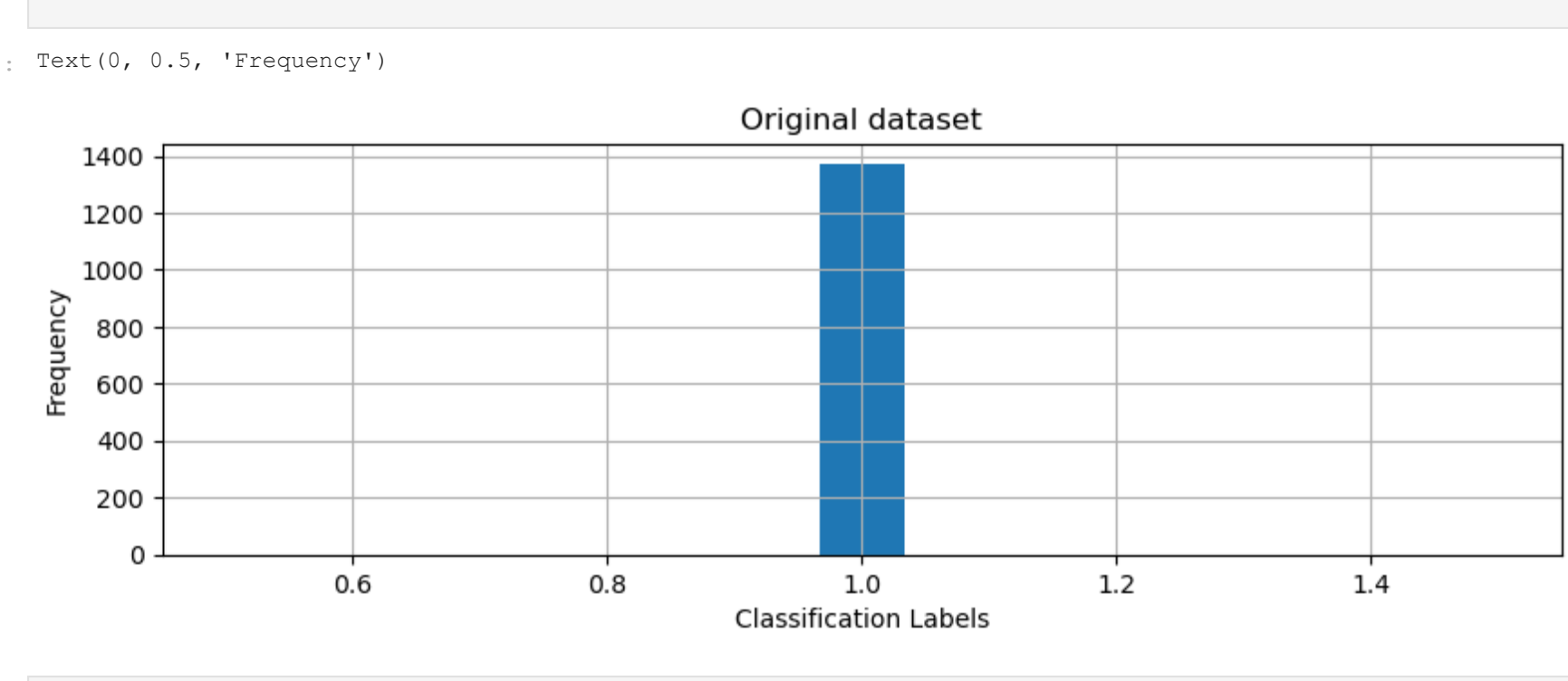
In [35]:
```
from sklearn.utils import resample
df_minority_upsampled = resample(df_minority,
                                 replace=True,     # sample with replacement
                                 n_samples=1372,    # to match majority class
                                 random_state=42) # reproducible results
```

In [36]:
```
font = {'size'   : 10}
matplotlib.rc('font', **font)

fig = plt.subplots(figsize=(10, 3), dpi= 100, facecolor='w', edgecolor='k')


df_minority_upsampled['wine_quality'].hist(bins=15)
plt.title("Original dataset")
plt.xlabel("Classification Labels")
plt.ylabel("Frequency")
```

Out[36]: Text(0, 0.5, 'Frequency')



In [37]:
```
df_upsampled = pd.concat([df_majority, df_minority_upsampled])
df_upsampled['wine_quality'].value_counts()
```

Out[37]:
```
1    1372
0    1372
Name: wine_quality, dtype: int64
```

The upsampled dataset has approximately 1372 is classified as good quality wine i.e. 12.6% of the total cases. The original dataset has apprximately 1380 is classified as poor quality wine ie 86.4% of the total cases.

In [38]:
```
df_upsampled
```

Out[38]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	wine_quality
0	7.7	0.56	0.08	2.50	0.114	14.0	46.0	0.99710	3.24	0.66	9.6	0
1	7.8	0.50	0.17	1.60	0.082	21.0	102.0	0.99600	3.39	0.48	9.5	0
2	10.7	0.67	0.22	2.70	0.107	17.0	34.0	1.00040	3.28	0.98	9.9	0
3	8.5	0.46	0.31	2.25	0.078	32.0	58.0	0.99800	3.33	0.54	9.8	0
4	6.7	0.46	0.24	1.70	0.077	18.0	34.0	0.99480	3.39	0.60	10.6	0
...	...	...	...	...	...	...	...	...	...	...	...	...
404	6.4	0.57	0.12	2.30	0.120	25.0	36.0	0.99519	3.47	0.71	11.3	1
812	11.1	0.31	0.53	2.20	0.060	3.0	10.0	0.99572	3.02	0.83	10.9	1
1174	7.9	0.30	0.68	8.30	0.050	37.5	289.0	0.99316	3.01	0.51	12.3	1
1016	10.5	0.24	0.42	1.80	0.077	6.0	22.0	0.99760	3.21	1.05	10.8	1
1045	9.2	0.41	0.50	2.50	0.055	12.0	25.0	0.99520	3.34	0.79	13.3	1

2744 rows × 12 columns

In [39]:
```
X_up = df_upsampled.drop("wine_quality", axis=1)# remove target
y_up = df_upsampled["wine_quality"].values# only taget values
```

In [40]:
```
X_up
```

Out[40]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
0	7.7	0.56	0.08	2.50	0.114	14.0	46.0	0.99710	3.24	0.66	9.6
1	7.8	0.50	0.17	1.60	0.082	21.0	102.0	0.99600	3.39	0.48	9.5
2	10.7	0.67	0.22	2.70	0.107	17.0	34.0	1.00040	3.28	0.98	9.9
3	8.5	0.46	0.31	2.25	0.078	32.0	58.0	0.99800	3.33	0.54	9.8
4	6.7	0.46	0.24	1.70	0.077	18.0	34.0	0.99480	3.39	0.60	10.6
...	...	...	...	...	...	...	...	...	...	...	...
404	6.4	0.57	0.12	2.30	0.120	25.0	36.0	0.99519	3.47	0.71	11.3
812	11.1	0.31	0.53	2.20	0.060	3.0	10.0	0.99572	3.02	0.83	10.9
1174	7.9	0.30	0.68	8.30	0.050	37.5	289.0	0.99316	3.01	0.51	12.3
1016	10.5	0.24	0.42	1.80	0.077	6.0	22.0	0.99760	3.21	1.05	10.8
1045	9.2	0.41	0.50	2.50	0.055	12.0	25.0	0.99520	3.34	0.79	13.3

2744 rows × 11 columns

In [41]:
```
y_up
```

Out[41]: array([0, 0, 0, ..., 1, 1, 1])

In [42]:
```
y_up.shape
```

Out[42]: (2744,)

SPLIT DATA INTO TEST AND TRAINING DATA

In [43]:
```
from sklearn.model_selection import train_test_split
# split again, and we should see the same split
X_train_up, X_test_up, y_train_up, y_test_up = train_test_split(X_up, y_up, test_size=0.2, random_state=42)
```

In [44]:
```
X_train_up
```

Out[44]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
214	7.3	0.550	0.01	1.8	0.093	9.0	15.0	0.99514	3.35	0.58	11.0
933	9.6	0.380	0.31	2.5	0.096	16.0	49.0	0.99820	3.19	0.70	10.0
611	10.4	0.330	0.63	2.8	0.084	5.0	22.0	0.99980	3.26	0.74	11.2
1308	13.3	0.290	0.75	2.8	0.084	23.0	43.0	0.99860	3.04	0.68	11.4
45	10.4	0.240	0.46	1.8	0.075	6.0	21.0	0.99760	3.25	1.02	10.8
...	...	...	...	...	...	...	...	...	...	...	...
1521	7.8	0.320	0.44	2.7	0.104	8.0	17.0	0.99732	3.33	0.78	11.0
1273	7.0	0.500	0.14	1.8	0.078	10.0	23.0	0.99636	3.53	0.61	10.4
1315	7.0	0.220	0.30	1.8	0.065	16.0	20.0	0.99672	3.61	0.82	10.0
1506	6.4	0.865	0.03	3.2	0.071	27.0	58.0	0.99500	3.61	0.49	12.7
1000	12.6	0.410	0.54	2.8	0.103	19.0	41.0	0.99939	3.21	0.76	11.3

2195 rows × 11 columns

In [45]:
```
y_train_up
```

Out[45]: array([1, 1, 1, ..., 0, 0, 0])

In [46]:
```
y_train_up.shape
```

Out[46]: (2195,)

In [47]:
```
y_test_up.shape
```

Out[47]: (549,)

The split between test and train data is 549 and 2195 datasets that is a 20% split.

In [48]:
```
df_upsampled.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 2744 entries, 0 to 1045
Data columns (total 12 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   fixed acidity         2744 non-null   float64
 1   volatile acidity      2744 non-null   float64
 2   citric acid           2744 non-null   float64
 3   residual sugar        2744 non-null   float64
 4   chlorides             2744 non-null   float64
 5   free sulfur dioxide   2744 non-null   float64
 6   total sulfur dioxide  2744 non-null   float64
 7   density               2744 non-null   float64
 8   pH                    2744 non-null   float64
 9   sulphates             2744 non-null   float64
 10  alcohol               2744 non-null   float64
 11  wine_quality          2744 non-null   int64  
dtypes: float64(11), int64(1)
memory usage: 278.7 KB
```

IMPUTATION

There is no need for imputation.

In [ ]:

ONE HOT ENCODING THE NUMBERICAL COLUMN

There is no need for one hot encoding.

In [ ]:

STANDARDIZATION

In [49]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()#call StandardScaler.
X_train_Std_up=scaler.fit_transform(X_train_up)#fit transform
X_train_Std_up
```

Out[49]:
```
array([[-0.68169036,  0.43774834, -1.53403863, ...,  0.34052297,
        -0.70692571,  0.09994553],
       [ 0.57122714, -0.53654884, -0.04185369, ..., -0.70623123,
         0.04733456, -0.76711368],
       [ 1.00702453, -0.82310683,  1.54981025, ..., -0.24827627,
         0.29875465,  0.27335737],
       ...,
       [-0.84511439, -1.45353442, -0.09159319, ...,  2.04149855,
         0.80159483, -0.76711368],
       [-1.17196243,  2.2430637 , -1.43455964, ...,  2.04149855,
        -1.27262092,  1.57394618],
       [ 2.20546737, -0.36461404,  1.10215476, ..., -0.57538696,
         0.42446469,  0.36006329]])
```

In [50]:
```
X_train_Std_up.mean()
```

Out[50]: -6.4915561019391385e-15

In [51]:
```
X_train_Std_up.std()
```

Out[51]: 1.0

The mean is 0 and the standard deviation is 1 for the new X_train dataset. So, the X_train_Std_up dataset is now standardized.

In [52]:
```
X_train_Std_up = pd.DataFrame(X_train_Std_up, columns=X_train_up.columns)#numpy(nmerical data) to pd
#im is numerical dataframe,#X_train_im.columns -use those column names for the newly created data
#im numerical data frame and convert it to pandas
X_train_Std_up
```

Out[52]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
0	-0.681690	0.437748	-1.534039	-0.580181	0.249796	-0.579446	-0.783713	-0.644557	0.340523	-0.706926	0.099946
1	0.571227	-0.536549	-0.041854	-0.096395	0.325189	0.087185	0.206057	0.854439	-0.706231	0.047335	-0.767114
2	1.007025	-0.823107	1.549810	0.110942	0.023619	-0.960377	-0.579937	1.638227	-0.248276	0.298755	0.273357
3	2.586790	-1.052353	2.146684	0.110942	0.023619	0.753815	0.031392	1.050386	-1.687563	-0.078375	0.446769
4	1.007025	-1.338911	0.704239	-0.580181	-0.202557	-0.865144	-0.609048	0.560518	-0.313698	2.058695	-0.073466
...	...	...	...	...	...	...	...	...	...	...	...
2190	-0.409317	-0.880418	0.604760	0.041829	0.526235	-0.674679	-0.725491	0.423355	0.209679	0.550175	0.099946
2191	-0.845114	0.151190	-0.887425	-0.580181	-0.127165	-0.484213	-0.550826	-0.046918	1.518121	-0.518361	-0.420290
2192	-0.845114	-1.453534	-0.091593	-0.580181	-0.453865	0.087185	-0.638158	0.129434	2.041499	0.801595	-0.767114
2193	-1.171962	2.243064	-1.434560	0.387391	-0.303080	1.134747	0.468055	-0.713138	2.041499	-1.272621	1.573946
2194	2.205467	-0.364614	1.102155	0.110942	0.501104	0.372884	-0.026830	1.437381	-0.575387	0.424465	0.360063

2195 rows × 11 columns

In [ ]:

CONCATANATION of STANRARDIZED DATA AND ONE-HOT ENCODNG column

No need to concatenate

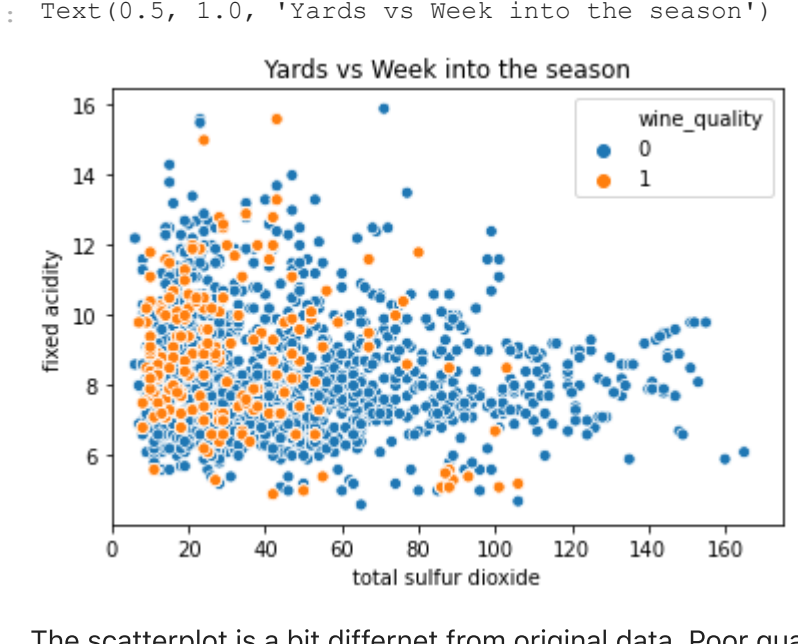
In [ ]:

VISUALIZATIONS

SCATTERPLOT

In [68]:
```
sns.scatterplot(x='total sulfur dioxide', y="fixed acidity", hue ='wine_quality', data=df_upsampled)
plt.xlim(0, 175)
plt.title("Yards vs Week into the season")
```

Out[68]: Text(0.5, 1.0, 'Yards vs Week into the season')

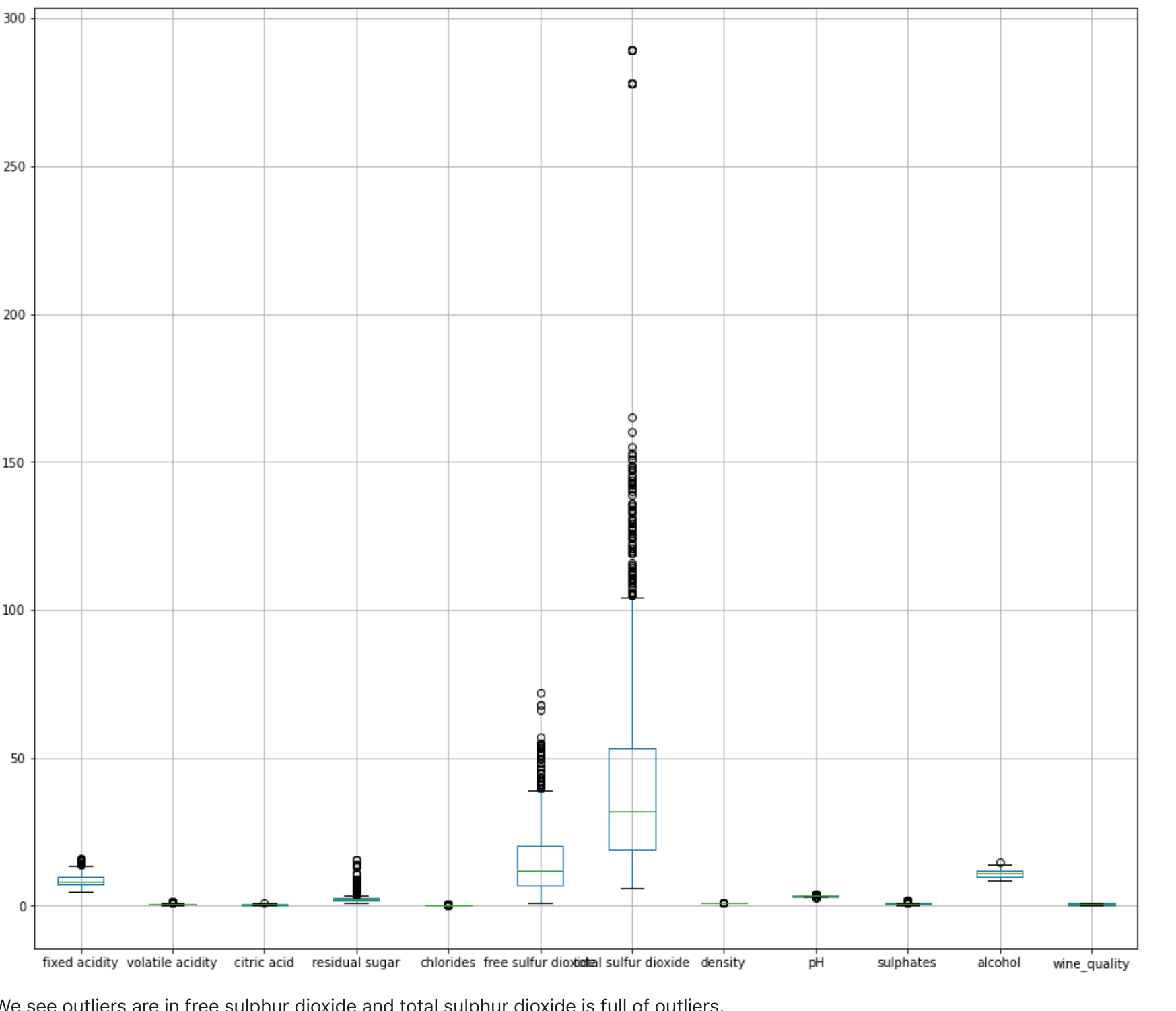


The scatterplot is a bit differnet from original data. Poor quality wine has higher total sulphur dioxide and generally higher fixed acidity.

In [ ]:

In [69]:
```
plt.figure(figsize=(16,14))
df_upsampled.boxplot()
```

Out[69]: <matplotlib.axes._subplots.AxesSubplot at 0x127bd8040>



We see outliers are in free sulphur dioxide and total sulphur dioxide is full of outliers.

These outliers have been tackled already.

However, we see that following upsampling the data looks a lot like the original data from where outliers were not removed i.e. df dataset.

In [ ]:

In [ ]:

In [ ]:

Model Training and Evaluation

In [ ]:

KNN CLASSIFIER

In [70]:

```
from sklearn.model_selection import RandomizedSearchCV
from scipy.stats import randint
from sklearn.model_selection import cross_val_score

from sklearn.neighbors import KNeighborsClassifier

np.random.seed(42)
model = KNeighborsClassifier()
import warnings
warnings.filterwarnings('ignore')

param_grid = [{
'n_neighbors': randint(low=1, high=20),'metric': ['euclidean', 'mahattan' , 'hamming']
              }]
knn = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 1000, scoring="accuracy", random_state =42)
knn.fit(X_train_new, y_train)
knn.best_params_
```

Out[70]: {'metric': 'euclidean', 'n_neighbors': 4}

In [71]:

```
cvreslt=knn.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

```
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0.8544449590859966 {'metric': 'hamming', 'n_neighbors': 2}
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In [72]:

```python
clf = KNeighborsClassifier(n_neighbors=1, metric='euclidean')
clf.fit(X_train_new,y_train)

KNeighbors_accuracies=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="accuracy")

np.mean( KNeighbors_accuracies)
```

Out[72]: 0.8662405434614792

In [ ]:

KNN UPSAMPLED CLASSIFIER

In [73]:

```python
from sklearn.model_selection import RandomizedSearchCV
from scipy.stats import randint
from sklearn.model_selection import cross_val_score

from sklearn.neighbors import KNeighborsClassifier

np.random.seed(42)
model = KNeighborsClassifier()
#import warnings
#warnings.filterwarnings('ignore')

param_grid = [{
'n_neighbors': randint(low=1, high=20),'metric': ['euclidean', 'mahattan' , 'hamming']
            }]
knn_up = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 1000, scoring="accuracy", random_state =42)
knn_up.fit(X_train_Std_up, y_train_up)
knn_up.best_params_
```

Out[73]: {'metric': 'euclidean', 'n_neighbors': 1}

In [74]:

```python
cvreslt=knn_up.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

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```

In [85]:

```
clf = DecisionTreeClassifier(max_depth=11, min_samples_leaf=39, min_samples_split=10, random_state = 42)
clf.fit(X_train_new,y_train)

Decision_tree_accuracies=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="accuracy")

np.mean(Decision_tree_accuracies)
```

Out[85]: 0.8851165663115641

In [ ]:

DECISION TREE - UPSAMPLED

In [86]:

```
from sklearn.tree import DecisionTreeClassifier
from scipy.stats import randint
np.random.seed(42)
model = DecisionTreeClassifier(random_state =42)
#import warnings
#warnings.filterwarnings('ignore')

param_grid = [{
'max_depth': randint(low=1, high=100),'min_samples_leaf': randint(low=0.1, high=200),
    'min_samples_split': randint(low=0.1, high=200)
              }]
gs = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 1000, scoring="accuracy",random_state=42)
gs.fit(X_train_Std_up, y_train_up)
gs.best_params_
```

Out[86]: {'max_depth': 97, 'min_samples_leaf': 3, 'min_samples_split': 3}

In [87]:

```
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

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In [88]:

```python
clf = DecisionTreeClassifier(max_depth=97, min_samples_leaf=3, min_samples_split=3, random_state = 42)
clf.fit(X_train_Std_up, y_train_up)

Decision_tree_accuracies=cross_val_score(clf,X_train_Std_up, y_train_up, cv=5, scoring="accuracy")

np.mean(Decision_tree_accuracies)
```

Out[88]: 0.9266514806378131

In [ ]:

```python

```

RANDOM FOREST

In [89]:

```python
from sklearn.ensemble import RandomForestClassifier
from scipy.stats import randint
np.random.seed(42)
model_rnd = RandomForestClassifier(random_state =42)


param_grid = [{
'max_depth': randint(low=1, high=100),'n_estimators': randint(low=0.1, high=100), 'min_samples_split': randi
            }]
gs = RandomizedSearchCV(model_rnd,param_grid,cv=5, n_iter = 500, scoring="accuracy", random_state =42)
gs.fit(X_train_new, y_train)
gs.best_params_
```

Out[89]:

```
{'bootstrap': True,
 'max_depth': 96,
 'min_samples_split': 3,
 'n_estimators': 93}
```

In [90]:

```python
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

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In [91]:

```python
rf = RandomForestClassifier(bootstrap = True, max_depth=17, min_samples_split=9 , n_estimators = 64, random_
rf.fit(X_train_new,y_train)

Random_forest_accuracies=cross_val_score(rf,X_train_new,y_train, cv=5, scoring="accuracy")

np.mean(Random_forest_accuracies)
```

Out[91]: 0.8914281303072411

In [ ]:

RANDOM FOREST - UPSAMPLED

In [92]:

```python
from sklearn.ensemble import RandomForestClassifier
from scipy.stats import randint
np.random.seed(42)
model_rnd = RandomForestClassifier(random_state =42)


param_grid = [{
'max_depth': randint(low=1, high=100),'n_estimators': randint(low=0.1, high=100), 'min_samples_split': randi
          }]
gs = RandomizedSearchCV(model_rnd,param_grid,cv=5, n_iter = 500, scoring="accuracy", random_state =42)
gs.fit(X_train_Std_up, y_train_up)
gs.best_params_
```

Out[92]:

```
{'bootstrap': False,
 'max_depth': 30,
 'min_samples_split': 4,
 'n_estimators': 32}
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In [93]:

```python
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

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In [95]:

```python
rf = RandomForestClassifier(bootstrap = False, max_depth=49, min_samples_split=2 , n_estimators = 44, random
rf.fit(X_train_Std_up, y_train_up)

Random_forest_accuracies=cross_val_score(rf,X_train_Std_up, y_train_up, cv=5, scoring="accuracy")

np.mean(Random_forest_accuracies)
```

Out[95]: 0.9735763097949887

In [ ]:

XGBOOST

In [56]:

```python
from sklearn.model_selection import RandomizedSearchCV
from scipy.stats import randint
from sklearn.model_selection import cross_val_score

import xgboost

np.random.seed(42)
model = xgboost.XGBClassifier(random_state=42)

param_grid = [{
'learning_rate': randint(low=0.1, high=100),'n_estimators': randint(low=0.1, high=500), 'max_depth' : randin
            }]
gs = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 1000, scoring="accuracy",random_state=42)
gs.fit(X_train_new, y_train)
gs.best_params_
```

Out[56]: {'learning_rate': 1, 'max_depth': 129, 'n_estimators': 219}

In [57]:

```python
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

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In [58]:

```
clf = xgboost.XGBClassifier(learning_rate=1, n_estimators=219, max_depth = 129, random_state = 42)
clf.fit(X_train_new,y_train)

xbg_accuracies=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="accuracy")

np.mean(xbg_accuracies)
```

Out[58]: 0.8945715609078277

In [ ]:

XGBOOST - UPSAMPLED

In [75]:

```
import xgboost

np.random.seed(42)
model = xgboost.XGBClassifier(random_state=42)

param_grid = [{
'learning_rate': randint(low=0.1, high=100),'n_estimators': randint(low=0.1, high=500), 'max_depth' : randin
              }]
gs = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 1000, scoring="accuracy",random_state=42)
gs.fit(X_train_Std_up, y_train_up)
gs.best_params_
```

Out[75]: {'learning_rate': 1, 'max_depth': 59, 'n_estimators': 150}

In [76]:

```
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

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In [74]:

```
clf = xgboost.XGBClassifier(learning_rate=1, n_estimators=248, max_depth = 474, random_state = 42)
clf.fit(X_train_Std_up, y_train_up)

xbg_accuracies=cross_val_score(clf,X_train_Std_up, y_train_up, cv=5, scoring="accuracy")

np.mean(xbg_accuracies)
```

Out[74]: 0.9599088838268793

In [ ]:

ADAPTIVE BOOSTING WITH RANDOM FOREST

In [70]:

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from scipy.stats import randint
from sklearn.model_selection import GridSearchCV

r_forest = RandomForestClassifier(bootstrap = False, max_depth=49, min_samples_split=2 , n_estimators = 44,


ada_tree = AdaBoostClassifier(r_forest,random_state=42)
params = {'learning_rate':[0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1],
          'algorithm':['SAMME', 'SAMME.R'],
          'n_estimators':list(range(50,150,25))}
ada_tree_search_cv = GridSearchCV(ada_tree, params, cv=5,scoring="accuracy")
ada_tree_search_cv.fit(X_train_new,y_train)

params_ada_tree = ada_tree_search_cv.best_params_
params_ada_tree
```

Out[70]: {'algorithm': 'SAMME', 'learning_rate': 0.1, 'n_estimators': 50}

In [72]:

```
cvreslt=ada_tree_search_cv.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]
```

```
for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

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```

In [73]:

```
clf = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME.R', learning_rate=1, n_
clf.fit(X_train_new,y_train)

Accuracies=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="accuracy")

np.mean(Accuracies)
```

Out[73]: 0.9016581750810561

In [ ]:

ADAPTIVE BOOSTING WITH RANDOM FOREST - UPSAMPLED

In [77]:

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from scipy.stats import randint
from sklearn.model_selection import GridSearchCV
import xgboost


r_forest = RandomForestClassifier(bootstrap = False, max_depth=49, min_samples_split=2 , n_estimators = 44,


ada_tree = AdaBoostClassifier(r_forest,random_state=42)
params = {'learning_rate':[0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1],
          'algorithm':['SAMME', 'SAMME.R'],
          'n_estimators':list(range(50,150,25))}
ada_tree_search_cv = GridSearchCV(ada_tree, params, cv=5,scoring="accuracy")
ada_tree_search_cv.fit(X_train_Std_up, y_train_up)

params_ada_tree = ada_tree_search_cv.best_params_
params_ada_tree
```

Out[77]: {'algorithm': 'SAMME', 'learning_rate': 0.1, 'n_estimators': 50}

In [78]:

```
cvreslt=ada_tree_search_cv.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

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0.9758542141230068 {'algorithm': 'SAMME.R', 'learning_rate': 1, 'n_estimators': 125}
0.9758542141230068 {'algorithm': 'SAMME.R', 'learning_rate': 1, 'n_estimators': 50}
0.9758542141230068 {'algorithm': 'SAMME.R', 'learning_rate': 1, 'n_estimators': 75}
```

In [79]:

```
clf = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME.R', learning_rate=1, n_
clf.fit(X_train_Std_up, y_train_up)

Accuracies=cross_val_score(clf,X_train_Std_up, y_train_up, cv=5, scoring="accuracy")

np.mean(Accuracies)
```

Out[79]: 0.9612756264236901

In [ ]:

RANDOM FOREST IN BAGGING

In [82]:

```
import warnings
warnings.filterwarnings('ignore')
from sklearn.ensemble import BaggingClassifier

np.random.seed(42)
model = BaggingClassifier(RandomForestClassifier(random_state=42), random_state=42)

param_grid = [{
'max_samples': randint(low=0.1, high=30),'n_estimators': randint(low=0.1, high=30),'bootstrap': [True, False
             }]
gs = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 60, scoring="accuracy", random_state =42)
gs.fit(X_train_new, y_train)
gs.best_params_
```

Out[82]: {'bootstrap': False, 'max_samples': 26, 'n_estimators': 2}

In [81]:

```
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

```
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nan {'bootstrap': True, 'max_samples': 23, 'n_estimators': 0}
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nan {'bootstrap': False, 'max_samples': 1, 'n_estimators': 0}
0.8701775513354949 {'bootstrap': False, 'max_samples': 26, 'n_estimators': 2}
```

In [83]:

```
clf = BaggingClassifier(RandomForestClassifier(random_state=42),n_estimators=2, random_state = 42, bootstrap
clf.fit(X_train_new,y_train)

Accuracies=cross_val_score(clf,X_train_new,y_train, cv=5, scoring="accuracy")

np.mean(Accuracies)
```

Out[83]: 0.8701775513354949

In [ ]:

RANDOM FOREST IN BAGGING - UPSAMPLED

In [92]:

```
from sklearn.ensemble import BaggingClassifier

np.random.seed(42)
model = BaggingClassifier(RandomForestClassifier(random_state=42), random_state=42)

param_grid = [{
'max_samples': randint(low=0.1, high=30),'n_estimators': randint(low=0.1, high=200),'bootstrap': [True, False
             }]
gs = RandomizedSearchCV(model,param_grid,cv=5, n_iter = 60, scoring="accuracy", random_state =42)
gs.fit(X_train_Std_up, y_train_up)
gs.best_params_
```

Out[92]: {'bootstrap': True, 'max_samples': 26, 'n_estimators': 136}

In [94]:

```
cvreslt=gs.cv_results_

cvreslt_params=[str(i) for i in cvreslt["params"]]

for accuracy, params in sorted(zip(cvreslt["mean_test_score"], cvreslt_params)):
    print(np.mean(accuracy), params)
```

```
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0.8072892938496583 {'bootstrap': False, 'max_samples': 24, 'n_estimators': 187}
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0.8082004555808655 {'bootstrap': False, 'max_samples': 28, 'n_estimators': 190}
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0.8086560364464692 {'bootstrap': True, 'max_samples': 19, 'n_estimators': 92}
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0.8127562642369022 {'bootstrap': True, 'max_samples': 26, 'n_estimators': 58}
0.8145785876993166 {'bootstrap': True, 'max_samples': 23, 'n_estimators': 116}
0.8164009111617311 {'bootstrap': True, 'max_samples': 26, 'n_estimators': 136}
```

In [89]:

```
clf = BaggingClassifier(RandomForestClassifier(random_state=42),n_estimators=22, random_state = 42, bootstra
clf.fit(X_train_Std_up, y_train_up)

Accuracies=cross_val_score(clf,X_train_Std_up, y_train_up, cv=5, scoring="accuracy")

np.mean(Accuracies)
```

Out[89]: 0.8127562642369022

In [ ]:

FINDING THE TOP THREE CLASSIFIERS FOR HARD AND SOFT VOTING

In [93]:

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
from scipy.stats import randint
from sklearn.pipeline import Pipeline

knn = KNeighborsClassifier(n_neighbors=1, metric='euclidean')
svm = Pipeline([("svm_clf",SVC(kernel="poly", degree=2, coef0=2, C=8, random_state=42))])
dt = DecisionTreeClassifier(max_depth=11, min_samples_leaf=39, min_samples_split=10, random_state = 42)
rf = RandomForestClassifier(bootstrap = True, max_depth=17, min_samples_split=9 , n_estimators = 64, random_
xbg = xgboost.XGBClassifier(learning_rate=1, n_estimators=219, max_depth = 129, random_state = 42)
adaptive_boosting = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME.R', learn
bagging_adaptive_boosting = BaggingClassifier(RandomForestClassifier(random_state=42),n_estimators=2, random


clf=['K_neighbour :', 'Poly_SVC :',
     'Decision_tree :','Random_Forest :', 'Xbg :', 'Adaptive_boosting :',
     'Bagging_random_forest :' ]
i=0
pre_acc=[]
for clfier in (knn,svm, dt,rf,xbg,
               adaptive_boosting,bagging_adaptive_boosting):
    clfier.fit(X_train_new, y_train)
    #y_pred = clfier.predict(X_train_new)
    #acc=accuracy_score(y_train, y_pred)
    acc  = cross_val_score(clfier,X_train_new,y_train, cv=5, scoring="accuracy")

    mean_acc =np.mean(acc)
    pre_acc.append(mean_acc)
    #print(clf[i], mean_acc)
    #pre_acc.append(acc)
    print(clf[i], mean_acc)
    i+=1
```

```
K_neighbour : 0.8662405434614792
Poly_SVC : 0.8748988729350009
Decision_tree : 0.8851165663115641
Random_Forest : 0.8914281303072411
Xbg : 0.8945715609078277
Adaptive_boosting : 0.9016581750810561
Bagging_random_forest : 0.8701775513354949
```

Here we see that Adaptive_boosting, Random_Forest, and XBG

In [ ]:

HARD VOTING

In [95]:

```
from sklearn.ensemble import VotingClassifier
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score

rf = RandomForestClassifier(bootstrap = True, max_depth=17, min_samples_split=9 , n_estimators = 64, random_
xbg = xgboost.XGBClassifier(learning_rate=1, n_estimators=219, max_depth = 129, random_state = 42)
adaptive_boosting = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME.R', learn

hard_voting = VotingClassifier(estimators=[('random_forest', rf ), ('xbg', xbg),
                                           ('adaptive_boosting', adaptive_boosting)],voting='hard')
hard_voting.fit(X_train_new, y_train)

clf=['Random_forest:', 'Xbg:', 'Adaptive_boosting:', 'Hard Voting:']
i=0
for clfier in (rf,xbg,adaptive_boosting, hard_voting):
    clfier.fit(X_train_new, y_train)
    Accuracies=cross_val_score(clfier,X_train_new,y_train, cv=5, scoring="accuracy")
    print(clf[i], np.mean(Accuracies))

    i+=1
```

```
Random_forest: 0.8914281303072411
Xbg: 0.8945715609078277
Adaptive_boosting: 0.9016581750810561
Hard Voting: 0.9024424888065463
```

In [ ]:

SOFT VOTING

In [97]:

```
from sklearn.ensemble import VotingClassifier
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score

rf = RandomForestClassifier(bootstrap = True, max_depth=17, min_samples_split=9 , n_estimators = 64, random_
xbg = xgboost.XGBClassifier(learning_rate=1, n_estimators=219, max_depth = 129, random_state = 42)
adaptive_boosting = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME.R', learn

soft_voting = VotingClassifier(estimators=[('random_forest', rf ), ('xbg', xbg),
                                           ('adaptive_boosting', adaptive_boosting)],voting='soft')
soft_voting.fit(X_train_new, y_train)

clf=['Random_forest:', 'Xbg:', 'Adaptive_boosting:', 'Soft Voting:']
i=0
for clfier in (rf,xbg,adaptive_boosting, soft_voting):
    clfier.fit(X_train_new, y_train)
    Accuracies=cross_val_score(clfier,X_train_new,y_train, cv=5, scoring="accuracy")
    print(clf[i], np.mean(Accuracies))

    i+=1
```

```
Random_forest: 0.8914281303072411
Xbg: 0.8945715609078277
Adaptive_boosting: 0.9016581750810561
Soft Voting: 0.8985023930832176
```

Hard Voting performs better than soft voting.

In [ ]:

MAKING PLOT TOP CLASSIFIERS

In [98]:

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
from scipy.stats import randint
from sklearn.pipeline import Pipeline

knn = KNeighborsClassifier(n_neighbors=1, metric='euclidean')
svm = Pipeline([("svm_clf",SVC(kernel="poly", degree=2, coef0=2, C=8, random_state=42))])
dt = DecisionTreeClassifier(max_depth=11, min_samples_leaf=39, min_samples_split=10, random_state = 42)
rf = RandomForestClassifier(bootstrap = True, max_depth=17, min_samples_split=9 , n_estimators = 64, random_
xbg = xgboost.XGBClassifier(learning_rate=1, n_estimators=219, max_depth = 129, random_state = 42)
adaptive_boosting = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME.R', learn
bagging_adaptive_boosting = BaggingClassifier(RandomForestClassifier(random_state=42),n_estimators=2, random
soft_voting = VotingClassifier(estimators=[('random_forest', rf ), ('xbg', xbg),
                                           ('adaptive_boosting', adaptive_boosting)],voting='soft')
hard_voting = VotingClassifier(estimators=[('random_forest', rf ), ('xbg', xbg),
                                           ('adaptive_boosting', adaptive_boosting)],voting='hard')

clf=['K_neighbour :', 'Poly_SVC :',
     'Decision_tree :','Random_Forest :', 'Xbg :', 'Adaptive_boosting :',
     'Bagging_random_forest :', 'Soft_voting:' ,  'Hard_voting:']
i=0
pre_acc=[]
for clfier in (knn,svm, dt,rf,xbg,
               adaptive_boosting,bagging_adaptive_boosting,soft_voting,hard_voting  ):
    clfier.fit(X_train_new, y_train)
    #y_pred = clfier.predict(X_train_new)
    #acc=accuracy_score(y_train, y_pred)
    acc  = cross_val_score(clfier,X_train_new,y_train, cv=5, scoring="accuracy")

    mean_acc =np.mean(acc)
    pre_acc.append(mean_acc)
    #print(clf[i], mean_acc)
    #pre_acc.append(acc)
    print(clf[i], mean_acc)
    i+=1
```

```
K_neighbour : 0.8662405434614792
Poly_SVC : 0.8748988729350009
Decision_tree : 0.8851165663115641
Random_Forest : 0.8914281303072411
Xbg : 0.8945715609078277
Adaptive_boosting : 0.9016581750810561
Bagging_random_forest : 0.8701775513354949
Soft_voting: 0.8985023930832176
Hard_voting: 0.9024424888065463
```

In [ ]:

In [99]:

```
import matplotlib.patheffects as pe

font = {'size'   :13}
matplotlib.rc('font', **font)
fig, ax1 = plt.subplots(figsize=(13, 5), dpi= 120, facecolor='w', edgecolor='k')

plt.plot(clf,pre_acc,'bs-',linewidth=1,path_effects=[pe.Stroke(linewidth=3, foreground='k'), pe.Normal()],
                                                     markersize=12,label='Accuracy',markeredgecolor=
ax1.bar(clf,pre_acc,lw =2, align='center',width=0.5, alpha=1, ecolor='black', edgecolor='k',capsize=1,color=
plt.ylim((0.2, 0.98))
ax1.set_xticklabels(clf, rotation=25)
ax1.xaxis.grid(color='k', linestyle='--', linewidth=0.8)
ax1.yaxis.grid(color='k', linestyle='--', linewidth=0.8)
plt.ylabel('Accuracy ',fontsize='17')
plt.title('Accuracy for Test set for 7 Classifier',fontsize='18')
plt.show()
```

Hard_voting and adaptive boosting are the best performer on test data.

In [ ]:

DOING THE SAME FOR UPSAMPLED DATA

In [102…

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
from scipy.stats import randint
from sklearn.pipeline import Pipeline

knn_upsampled = KNeighborsClassifier(n_neighbors=1, metric='euclidean')
svm_upsampled = Pipeline([("svm_clf",SVC(kernel="poly", degree=4, coef0=2, C=53, random_state=42))])
dt_upsampled = DecisionTreeClassifier(max_depth=97, min_samples_leaf=3, min_samples_split=3, random_state =
rf_upsampled = RandomForestClassifier(bootstrap = False, max_depth=49, min_samples_split=2 , n_estimators =
xbg_upsampled = xgboost.XGBClassifier(learning_rate=1, n_estimators=248, max_depth = 474, random_state = 42)
adaptive_boosting_upsampled = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME
bagging_random_forest_upsampled = BaggingClassifier(RandomForestClassifier(random_state=42),n_estimators=22,



clf=['K_neighbour :', 'Poly_SVC :',
     'Decision_tree :','Random_Forest :', 'Xbg :', 'Adaptive_boosting :',
     'Bagging_random_forest :' ]
i=0
pre_acc=[]
for clfier in (knn_upsampled,svm_upsampled, dt_upsampled,rf_upsampled,xbg_upsampled,
               adaptive_boosting_upsampled,bagging_random_forest_upsampled):
    clfier.fit(X_train_Std_up, y_train_up)
    #y_pred = clfier.predict(X_train_new)
    #acc=accuracy_score(y_train, y_pred)
    acc  = cross_val_score(clfier,X_train_Std_up, y_train_up, cv=5, scoring="accuracy")

    mean_acc =np.mean(acc)
    pre_acc.append(mean_acc)
    #print(clf[i], mean_acc)
    #pre_acc.append(acc)
    print(clf[i], mean_acc)
    i+=1
```

```
K_neighbour : 0.9480637813211846
Poly_SVC : 0.9334851936218678
Decision_tree : 0.9266514806378131
Random_Forest : 0.9735763097949887
Xbg : 0.961731207289294
Adaptive_boosting : 0.9612756264236901
Bagging_random_forest : 0.8127562642369022
```

Here we see that Adaptive_boosting, Random_Forest, and Xbg

In [ ]:

HARD VOTING

In [106…

```
from sklearn.ensemble import VotingClassifier
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score

rf_upsampled = RandomForestClassifier(bootstrap = False, max_depth=49, min_samples_split=2 , n_estimators =
xbg_upsampled = xgboost.XGBClassifier(learning_rate=1, n_estimators=248, max_depth = 474, random_state = 42)
adaptive_boosting_upsampled = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME

hard_voting = VotingClassifier(estimators=[('random_forest', rf_upsampled ), ('xbg', xbg_upsampled),
                                           ('adaptive_boosting', adaptive_boosting_upsampled)],voting='hard'
hard_voting.fit(X_train_Std_up, y_train_up)

clf=['Random_forest:', 'Xbg:', 'Adaptive_boosting:', 'Hard Voting:']
i=0
for clfier in (rf_upsampled,xbg_upsampled,adaptive_boosting_upsampled, hard_voting):
    clfier.fit(X_train_Std_up, y_train_up)
    Accuracies=cross_val_score(clfier,X_train_Std_up, y_train_up, cv=5, scoring="accuracy")
    print(clf[i], np.mean(Accuracies))

    i+=1
```

```
Random_forest: 0.9735763097949887
Xbg: 0.961731207289294
Adaptive_boosting: 0.9612756264236901
Hard Voting: 0.9699316628701595
```

In [ ]:

SOFT VOTING

In [109…

```
from sklearn.ensemble import VotingClassifier
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score

rf_upsampled = RandomForestClassifier(bootstrap = False, max_depth=49, min_samples_split=2 , n_estimators =
xbg_upsampled = xgboost.XGBClassifier(learning_rate=1, n_estimators=248, max_depth = 474, random_state = 42)
adaptive_boosting_upsampled = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME

soft_voting = VotingClassifier(estimators=[('random_forest', rf_upsampled ), ('xbg', xbg_upsampled),
                                           ('adaptive_boosting', adaptive_boosting_upsampled)],voting='soft'
soft_voting.fit(X_train_Std_up, y_train_up)

clf=['Random_forest:', 'Xbg:', 'Adaptive_boosting:', 'Soft Voting:']
i=0
for clfier in (rf_upsampled,xbg_upsampled,adaptive_boosting_upsampled, soft_voting):
    clfier.fit(X_train_Std_up, y_train_up)
    Accuracies=cross_val_score(clfier,X_train_Std_up, y_train_up, cv=5, scoring="accuracy")
    print(clf[i], np.mean(Accuracies))

    i+=1
```

```
Random_forest: 0.9735763097949887
Xbg: 0.961731207289294
Adaptive_boosting: 0.9612756264236901
Soft Voting: 0.966742596810934
```

In [ ]:

MAKING PLOT FOR UPSAMPLED DATA

In [110…

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
from scipy.stats import randint
from sklearn.pipeline import Pipeline

knn_upsampled = KNeighborsClassifier(n_neighbors=1, metric='euclidean')
svm_upsampled = Pipeline([("svm_clf",SVC(kernel="poly", degree=4, coef0=2, C=53, random_state=42))])
dt_upsampled = DecisionTreeClassifier(max_depth=97, min_samples_leaf=3, min_samples_split=3, random_state =
rf_upsampled = RandomForestClassifier(bootstrap = False, max_depth=49, min_samples_split=2 , n_estimators =
xbg_upsampled = xgboost.XGBClassifier(learning_rate=1, n_estimators=248, max_depth = 474, random_state = 42)
adaptive_boosting_upsampled = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME
bagging_random_forest_upsampled = BaggingClassifier(RandomForestClassifier(random_state=42),n_estimators=22,
soft_voting = VotingClassifier(estimators=[('random_forest', rf_upsampled ), ('xbg', xbg_upsampled),
                                           ('adaptive_boosting', adaptive_boosting_upsampled)],voting='soft'

hard_voting = VotingClassifier(estimators=[('random_forest', rf_upsampled ), ('xbg', xbg_upsampled),
                                           ('adaptive_boosting', adaptive_boosting_upsampled)],voting='hard'

clf=['K_neighbour :', 'Poly_SVC :',
     'Decision_tree :','Random_Forest :', 'Xbg :', 'Adaptive_boosting :',
     'Bagging_random_forest :' , 'Soft_voting :', 'Hard_voting :']
i=0
pre_acc=[]
for clfier in (knn_upsampled,svm_upsampled, dt_upsampled,rf_upsampled,xbg_upsampled,
               adaptive_boosting_upsampled,bagging_random_forest_upsampled , soft_voting , hard_voting):
    clfier.fit(X_train_Std_up, y_train_up)
    #y_pred = clfier.predict(X_train_new)
    #acc=accuracy_score(y_train, y_pred)
    acc  = cross_val_score(clfier,X_train_Std_up, y_train_up, cv=5, scoring="accuracy")

    mean_acc =np.mean(acc)
    pre_acc.append(mean_acc)
    #print(clf[i], mean_acc)
    #pre_acc.append(acc)
    print(clf[i], mean_acc)
    i+=1
```

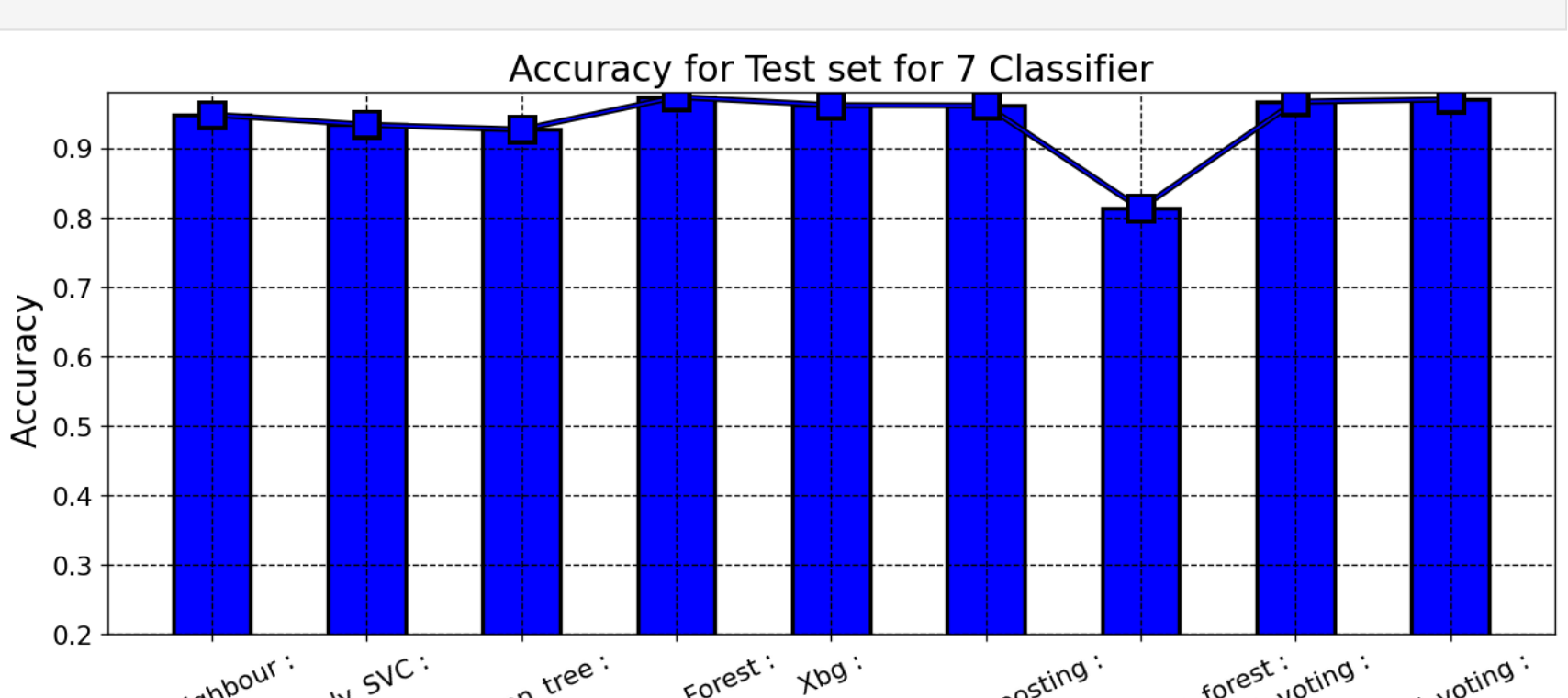
```
K_neighbour : 0.9480637813211846
Poly_SVC : 0.9334851936218678
Decision_tree : 0.9266514806378131
Random_Forest : 0.9735763097949887
Xbg : 0.961731207289294
Adaptive_boosting : 0.9612756264236901
Bagging_random_forest : 0.8127562642369022
Soft_voting : 0.966742596810934
Hard_voting : 0.9699316628701595
```

In [111…

```
import matplotlib.patheffects as pe

font = {'size'   :13}
matplotlib.rc('font', **font)
fig, ax1 = plt.subplots(figsize=(13, 5), dpi= 120, facecolor='w', edgecolor='k')

plt.plot(clf,pre_acc,'bs-',linewidth=1,path_effects=[pe.Stroke(linewidth=3, foreground='k'), pe.Normal()],
                                                     markersize=12,label='Accuracy',markeredgecolor=
ax1.bar(clf,pre_acc,lw =2, align='center',width=0.5, alpha=1, ecolor='black', edgecolor='k',capsize=1,color=
plt.ylim((0.2, 0.98))
ax1.set_xticklabels(clf, rotation=25)
ax1.xaxis.grid(color='k', linestyle='--', linewidth=0.8)
ax1.yaxis.grid(color='k', linestyle='--', linewidth=0.8)
plt.ylabel('Accuracy ',fontsize='17')
plt.title('Accuracy for Test set for 7 Classifier',fontsize='18')
plt.show()
```



Random_Forest and Hard_voting are the best performer in upsampled training data.

In [ ]:

In [ ]:

TESTING

In [112…

```
test_set_strat
```

Out[112…

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	wine_quality
0	6.6	0.735	0.02	7.9	0.122	68.0	124.0	0.99940	3.47	0.53	9.9	0
1	6.9	0.550	0.15	2.2	0.076	19.0	40.0	0.99610	3.41	0.59	10.1	0

2	11.9	0.380	0.51	2.0	0.121	7.0	20.0	0.99960	3.24	0.76	10.4	0
3	5.6	0.500	0.09	2.3	0.049	17.0	99.0	0.99370	3.63	0.63	13.0	0
4	7.1	0.430	0.42	5.5	0.071	28.0	128.0	0.99730	3.42	0.71	10.5	0
...	...	...	...	...	...	...	...	...	...	...	...	...
313	7.4	0.490	0.27	2.1	0.071	14.0	25.0	0.99388	3.35	0.63	12.0	0
314	12.2	0.480	0.54	2.6	0.085	19.0	64.0	1.00000	3.10	0.61	10.5	0
315	8.0	0.500	0.39	2.6	0.082	12.0	46.0	0.99850	3.43	0.62	10.7	0
316	5.6	0.660	0.00	2.2	0.087	3.0	11.0	0.99378	3.71	0.63	12.8	1
317	8.7	0.700	0.24	2.5	0.226	5.0	15.0	0.99910	3.32	0.60	9.0	0

318 rows × 12 columns

In [113…

```
# Note that drop() creates a copy and does not affect train_set_strat
X_test = test_set_strat.drop("wine_quality", axis=1)# remove target
y_test = test_set_strat["wine_quality"].values# only taget values
```

In [114…

```
X_test
```

Out[114…

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
0	6.6	0.735	0.02	7.9	0.122	68.0	124.0	0.99940	3.47	0.53	9.9
1	6.9	0.550	0.15	2.2	0.076	19.0	40.0	0.99610	3.41	0.59	10.1
2	11.9	0.380	0.51	2.0	0.121	7.0	20.0	0.99960	3.24	0.76	10.4
3	5.6	0.500	0.09	2.3	0.049	17.0	99.0	0.99370	3.63	0.63	13.0
4	7.1	0.430	0.42	5.5	0.071	28.0	128.0	0.99730	3.42	0.71	10.5
...	...	...	...	...	...	...	...	...	...	...	...
313	7.4	0.490	0.27	2.1	0.071	14.0	25.0	0.99388	3.35	0.63	12.0
314	12.2	0.480	0.54	2.6	0.085	19.0	64.0	1.00000	3.10	0.61	10.5
315	8.0	0.500	0.39	2.6	0.082	12.0	46.0	0.99850	3.43	0.62	10.7
316	5.6	0.660	0.00	2.2	0.087	3.0	11.0	0.99378	3.71	0.63	12.8
317	8.7	0.700	0.24	2.5	0.226	5.0	15.0	0.99910	3.32	0.60	9.0

318 rows × 11 columns

In [115…

```
y_test
```

Out[115…

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

STANDRADIZATION OF VARIABLES

In [116…

```
#from sklearn.preprocessing import StandardScaler
#scaler = StandardScaler()#call StandardScaler.
X_test_im_Std=scaler.transform(X_test)#fit transform
X_test_im_Std
```

Out[116…

```
array([[-1.06301308,  1.49801292, -1.48429913, ...,  1.12558862,
        -1.02120083, -0.8538196 ],
       [-0.89958906,  0.43774834, -0.83768566, ...,  0.7330558 ,
        -0.64407069, -0.68040776],
       [ 1.82414465, -0.53654884,  0.95293627, ..., -0.37912054,
         0.42446469, -0.42029   ],
       ...,
       [-0.30036765,  0.15119035,  0.35606229, ...,  0.86390007,
        -0.45550562, -0.16017224],
       [-1.60775983,  1.06817593, -1.58377813, ...,  2.69571993,
        -0.3926506 ,  1.6606521 ],
       [ 0.08095507,  1.29742232, -0.39003018, ...,  0.14425656,
        -0.58121567, -1.63417289]])
```

In [117…

```
X_test_new = pd.DataFrame(X_test_im_Std)
X_test_new [0:10]
```

Out[117…

	0	1	2	3	4	5	6	7	8	9	10
0	-1.063013	1.498013	-1.484299	3.635668	0.978589	5.039296	2.389374	1.442280	1.125589	-1.021201	-0.853820
1	-0.899589	0.437748	-0.837686	-0.303732	-0.177427	0.372884	-0.055941	-0.174284	0.733056	-0.644071	-0.680408
2	1.824145	-0.536549	0.952936	-0.441957	0.953458	-0.769911	-0.638158	1.540253	-0.379121	0.424465	-0.420290
3	-1.607760	0.151190	-1.136123	-0.234620	-0.855957	0.182418	1.661602	-1.349966	2.172343	-0.392651	1.834064
4	-0.790640	-0.249991	0.505281	1.976974	-0.303080	1.229980	2.505818	0.413558	0.798478	0.110190	-0.333584
5	-0.354842	1.010864	-1.534039	-0.096395	-0.127165	0.182418	-0.114162	-0.076310	0.275101	0.298755	0.706887
6	-0.409317	0.380437	-0.290551	-0.441957	0.124143	0.753815	0.176946	0.805452	0.733056	0.298755	-1.460761
7	-0.790640	1.010864	-0.688467	-0.580181	-0.328211	-0.198514	-0.055941	0.266597	0.929322	-0.581216	-1.547467
8	-0.681690	-0.622516	0.853457	-0.096395	0.124143	2.277542	1.865378	0.070650	0.405945	0.550175	0.099946
9	-0.954064	0.552372	-1.583778	-0.096395	-0.277950	1.610911	0.642721	-0.757226	0.863900	-0.832636	0.273357

In [124…

```
X_test = X_test_new.rename({0: 'fixed acidity', 1: 'volatile acidity', 2: 'citric acid', 3: 'residual sugar'
X_test
```

Out[124…

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
0	-1.063013	1.498013	-1.484299	3.635668	0.978589	5.039296	2.389374	1.442280	1.125589	-1.021201	-0.853820
1	-0.899589	0.437748	-0.837686	-0.303732	-0.177427	0.372884	-0.055941	-0.174284	0.733056	-0.644071	-0.680408
2	1.824145	-0.536549	0.952936	-0.441957	0.953458	-0.769911	-0.638158	1.540253	-0.379121	0.424465	-0.420290
3	-1.607760	0.151190	-1.136123	-0.234620	-0.855957	0.182418	1.661602	-1.349966	2.172343	-0.392651	1.834064
4	-0.790640	-0.249991	0.505281	1.976974	-0.303080	1.229980	2.505818	0.413558	0.798478	0.110190	-0.333584
...	...	...	...	...	...	...	...	...	...	...	...
313	-0.627216	0.093879	-0.240812	-0.372844	-0.303080	-0.103281	-0.492604	-1.261790	0.340523	-0.392651	0.967005
314	1.987569	0.036567	1.102155	-0.027283	0.048750	0.372884	0.642721	1.736200	-1.295030	-0.518361	-0.333584
315	-0.300368	0.151190	0.356062	-0.027283	-0.026642	-0.293747	0.118725	1.001399	0.863900	-0.455506	-0.160172
316	-1.607760	1.068176	-1.583778	-0.303732	0.099012	-1.150843	-0.900156	-1.310777	2.695720	-0.392651	1.660652
317	0.080955	1.297422	-0.390030	-0.096395	3.592188	-0.960377	-0.783713	1.295319	0.144257	-0.581216	-1.634173

318 rows × 11 columns

In [ ]:

```
final_algo = pd.DataFrame({'']})
```

In [126…

```
y_test
```

Out[126…

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

In [127…

```
y_test = pd.DataFrame(y_test)
y_test = y_test.rename({0: 'Y_test'}, axis=1)
y_test
```

Out[127…

	Y_test
0	0
1	0
2	0
3	0
4	0
...	...
313	0
314	0
315	0
316	1
317	0

318 rows × 1 columns

In [130…

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
from scipy.stats import randint
from sklearn.pipeline import Pipeline

knn = KNeighborsClassifier(n_neighbors=1, metric='euclidean')
svm = Pipeline([("svm_clf",SVC(kernel="poly", degree=2, coef0=2, C=8, random_state=42))])
dt = DecisionTreeClassifier(max_depth=11, min_samples_leaf=39, min_samples_split=10, random_state = 42)
rf = RandomForestClassifier(bootstrap = True, max_depth=17, min_samples_split=9 , n_estimators = 64, random_
xbg = xgboost.XGBClassifier(learning_rate=1, n_estimators=219, max_depth = 129, random_state = 42)
adaptive_boosting = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME.R', learn
bagging_random_forest = BaggingClassifier(RandomForestClassifier(random_state=42),n_estimators=2, random_sta
soft_voting = VotingClassifier(estimators=[('random_forest', rf ), ('xbg', xbg),
                                           ('adaptive_boosting', adaptive_boosting)],voting='soft')
hard_voting = VotingClassifier(estimators=[('random_forest', rf ), ('xbg', xbg),
                                           ('adaptive_boosting', adaptive_boosting)],voting='hard')

clf=['K_neighbour :', 'Poly_SVC :',
     'Decision_tree :','Random_Forest :', 'Xbg :', 'Adaptive_boosting :',
     'Bagging_random_forest :' , 'Soft_voting :', 'Hard_voting :']
i=0
pre_acc=[]
for clfier in (knn,svm, dt,rf,xbg,
               adaptive_boosting,bagging_random_forest , soft_voting , hard_voting):
    clfier.fit(X_test , y_test)
    #y_pred = clfier.predict(X_train_new)
    #acc=accuracy_score(y_train, y_pred)
    acc  = cross_val_score(clfier,X_test, y_test, cv=5, scoring="accuracy")

    mean_acc =np.mean(acc)
    pre_acc.append(mean_acc)
    #print(clf[i], mean_acc)
    #pre_acc.append(acc)
    print(clf[i], mean_acc)
    i+=1
```

```
K_neighbour : 0.7988095238095237
Poly_SVC : 0.8615079365079363
Decision_tree : 0.8648313492063492
Random_Forest : 0.8773809523809524
Xbg : 0.883531746031746
Adaptive_boosting : 0.8805059523809524
Bagging_random_forest : 0.8680059523809524
Soft_voting : 0.8930555555555555
Hard_voting : 0.8867559523809524
```

Soft_voting, Hard_voting are the best performer on test data. Hard Voting is the best performer on both traing and test data.

In [ ]:

STACKING

In [134…

```
from sklearn.model_selection import cross_val_predict

xbg = xgboost.XGBClassifier(learning_rate=1, n_estimators=219, max_depth = 129, random_state = 42)
adaptive_boosting = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME.R', learn

soft_voting = VotingClassifier(estimators=[('random_forest', rf ), ('xbg', xbg),
                                           ('adaptive_boosting', adaptive_boosting)],voting='soft')
hard_voting = VotingClassifier(estimators=[('random_forest', rf ), ('xbg', xbg),
                                           ('adaptive_boosting', adaptive_boosting)],voting='hard')

estimators=[xbg ,adaptive_boosting,soft_voting , hard_voting ]
x_Predictions = np.zeros((len(X_train), len(estimators)), dtype=np.float32)

# Apply estimators on Validation data set
for index, estimator in enumerate(estimators):
    estimator.fit(X_train, y_train)#applying predictiosn on training datset
    y_pred = cross_val_predict(estimator, X_train, y_train, cv=5)
    x_Predictions[:, index] = np.ravel(y_pred)#predcitions r now assumed as. a new dataset

# Train a new Random Forest for prediction
New_rnd = RandomForestClassifier()#always a good idea
New_rnd.fit(x_Predictions, y_train)#fit the new model to X_predictions and taget of the training set

#TEST
# Predict result by stacking on test set
x_test_predictions = np.zeros((len(X_test), len(estimators)), dtype=np.float32)
for index, estimator in enumerate(estimators):
    x_test_predictions[:, index] = np.ravel(estimator.predict(X_test))

y_pred = New_rnd.predict(x_test_predictions)
acc=accuracy_score(y_test, y_pred)

pre_acc.append(acc)

clf=clf+['stacking']
print('Stacking ', acc)
```

```
Stacking  0.8490566037735849
```

In [ ]:

In [ ]:

TEST TRAINING UPSAMPLED

In [135…

```
X_test_up
```

Out[135…

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
999	6.9	0.49	0.10	2.30	0.074	12.0	30.0	0.99590	3.42	0.58	10.20
1400	8.7	0.48	0.30	2.80	0.066	10.0	28.0	0.99640	3.33	0.67	11.20
1536	6.8	0.64	0.10	2.10	0.085	18.0	101.0	0.99560	3.34	0.52	10.20
1568	6.9	0.84	0.21	4.10	0.074	16.0	65.0	0.99842	3.53	0.72	9.25
449	11.6	0.53	0.66	3.65	0.121	6.0	14.0	0.99780	3.05	0.74	11.50
...	...	...	...	...	...	...	...	...	...	...	...
997	8.9	0.75	0.14	2.50	0.086	9.0	30.0	0.99824	3.34	0.64	10.50
474	7.3	0.48	0.32	2.10	0.062	31.0	54.0	0.99728	3.30	0.65	10.00
1566	8.2	0.28	0.40	2.40	0.052	4.0	10.0	0.99356	3.33	0.70	12.80
1023	7.8	0.57	0.09	2.30	0.065	34.0	45.0	0.99417	3.46	0.74	12.70
479	8.6	0.22	0.36	1.90	0.064	53.0	77.0	0.99604	3.47	0.87	11.00

549 rows × 11 columns

In [136…

```
y_test_up
```

Out[136…

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

In [ ]:

STANDRADIZATION OF VARIABLES

In [137…

```
#from sklearn.preprocessing import StandardScaler
#scaler = StandardScaler()#call StandardScaler.
X_test_im_Std_up=scaler.transform(X_test_up)#fit transform
X_test_im_Std_up
```

Out[137…

```
array([[-0.89958906,  0.09387875, -1.08638315, ...,  0.79847794,
        -0.70692571, -0.59370184],
       [ 0.08095507,  0.03656715, -0.09159319, ...,  0.2096787 ,
        -0.14123051,  0.27335737],
       [-0.95406374,  0.95355273, -1.08638315, ...,  0.27510083,
        -1.08405585, -0.59370184],
       ...,
       [-0.1914183 , -1.10966482,  0.40580179, ...,  0.2096787 ,
         0.04733456,  1.6606521 ],
       [-0.40931699,  0.55237154, -1.13612265, ...,  1.06016649,
         0.29875465,  1.57394618],
       [ 0.0264804 , -1.45353442,  0.2068438 , ...,  1.12558862,
         1.11586994,  0.09994553]])
```

In [138…

```
X_test_new_up = pd.DataFrame(X_test_im_Std_up)
X_test_new_up [0:10]
```

Out[138…

	0	1	2	3	4	5	6	7	8	9	10
0	-0.899589	0.093879	-1.086383	-0.234620	-0.227688	-0.293747	-0.347050	-0.272257	0.798478	-0.706926	-0.593702
1	0.080955	0.036567	-0.091593	0.110942	-0.428734	-0.484213	-0.405271	-0.027323	0.209679	-0.141231	0.273357
2	-0.954064	0.953553	-1.086383	-0.372844	0.048750	0.277651	1.719824	-0.419217	0.275101	-1.084056	-0.593702
3	-0.899589	2.099785	-0.539249	1.009402	-0.227688	0.087185	0.671832	0.962209	1.518121	0.173045	-1.417408
4	1.660721	0.323125	1.699029	0.698396	0.953458	-0.865144	-0.812824	0.658492	-1.622141	0.298755	0.533475
5	-1.063013	2.099785	-1.434560	-0.234620	-0.604650	1.610911	0.176946	-0.615164	1.452699	-0.832636	1.227122
6	-0.409317	0.552372	-1.136123	-0.234620	-0.453865	1.801377	0.089614	-1.119728	1.060166	0.298755	1.573946
7	-0.790640	1.583980	-1.534039	-0.303732	-0.604650	-0.388980	-0.696380	-1.976997	0.602212	-1.838316	1.660652
8	0.189904	-1.052353	0.157104	-0.511069	-0.403604	0.944281	0.438944	0.266597	-0.771653	4.195766	-0.506996
9	1.061499	0.208502	1.599550	-0.165507	0.601627	-0.865144	-0.783713	0.413558	-1.360453	-0.204086	0.793593

In [139…

```
X_test_up = X_test_new_up.rename({0: 'fixed acidity', 1: 'volatile acidity', 2: 'citric acid', 3: 'residual
X_test_up
```

Out[139…

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
0	-0.899589	0.093879	-1.086383	-0.234620	-0.227688	-0.293747	-0.347050	-0.272257	0.798478	-0.706926	-0.593702
1	0.080955	0.036567	-0.091593	0.110942	-0.428734	-0.484213	-0.405271	-0.027323	0.209679	-0.141231	0.273357
2	-0.954064	0.953553	-1.086383	-0.372844	0.048750	0.277651	1.719824	-0.419217	0.275101	-1.084056	-0.593702
3	-0.899589	2.099785	-0.539249	1.009402	-0.227688	0.087185	0.671832	0.962209	1.518121	0.173045	-1.417408
4	1.660721	0.323125	1.699029	0.698396	0.953458	-0.865144	-0.812824	0.658492	-1.622141	0.298755	0.533475
...	...	...	...	...	...	...	...	...	...	...	...
544	0.189904	1.583980	-0.887425	-0.096395	0.073881	-0.579446	-0.347050	0.874033	0.275101	-0.329796	-0.333584
545	-0.681690	0.036567	0.007886	-0.372844	-0.529257	1.515678	0.351612	0.403760	0.013412	-0.266941	-0.767114
546	-0.191418	-1.109665	0.405802	-0.165507	-0.780565	-1.055610	-0.929267	-1.418547	0.209679	0.047335	1.660652
547	-0.409317	0.552372	-1.136123	-0.234620	-0.453865	1.801377	0.089614	-1.119728	1.060166	0.298755	1.573946
548	0.026480	-1.453534	0.206844	-0.511069	-0.478996	3.610803	1.021162	-0.203676	1.125589	1.115870	0.099946

549 rows × 11 columns

In [146…

```
y_test_up = pd.DataFrame(y_test_up)
y_test_up = y_test_up.rename({0: 'Y_test_up'}, axis=1)
y_test_up
```

Out[146…

	Y_test
0	0
1	1
2	0
3	0
4	1
...	...
544	0
545	1
546	1
547	1
548	1

549 rows × 1 columns

In [143…

```
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
from scipy.stats import randint
from sklearn.pipeline import Pipeline

knn_upsampled = KNeighborsClassifier(n_neighbors=1, metric='euclidean')
svm_upsampled = Pipeline([("svm_clf",SVC(kernel="poly", degree=4, coef0=2, C=53, random_state=42))])
dt_upsampled = DecisionTreeClassifier(max_depth=97, min_samples_leaf=3, min_samples_split=3, random_state =
rf_upsampled = RandomForestClassifier(bootstrap = False, max_depth=49, min_samples_split=2 , n_estimators =
xbg_upsampled = xgboost.XGBClassifier(learning_rate=1, n_estimators=248, max_depth = 474, random_state = 42)
adaptive_boosting_upsampled = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME
bagging_random_forest_upsampled = BaggingClassifier(RandomForestClassifier(random_state=42),n_estimators=22,
soft_voting = VotingClassifier(estimators=[('random_forest', rf_upsampled ), ('xbg', xbg_upsampled),
                                           ('adaptive_boosting', adaptive_boosting_upsampled)],voting='soft'

hard_voting = VotingClassifier(estimators=[('random_forest', rf_upsampled ), ('xbg', xbg_upsampled),
                                           ('adaptive_boosting', adaptive_boosting_upsampled)],voting='hard'

clf=['K_neighbour :', 'Poly_SVC :',
     'Decision_tree :','Random_Forest :', 'Xbg :', 'Adaptive_boosting :',
     'Bagging_random_forest :' , 'Soft_voting :', 'Hard_voting :']
i=0
pre_acc=[]
for clfier in (knn_upsampled,svm_upsampled, dt_upsampled,rf_upsampled,xbg_upsampled,
               adaptive_boosting_upsampled,bagging_random_forest_upsampled , soft_voting , hard_voting):
    clfier.fit(X_test , y_test)
    #y_pred = clfier.predict(X_train_new)
    #acc=accuracy_score(y_train, y_pred)
    acc  = cross_val_score(clfier,X_test_up, y_test_up, cv=5, scoring="accuracy")

    mean_acc =np.mean(acc)
    pre_acc.append(mean_acc)
    #print(clf[i], mean_acc)
    #pre_acc.append(acc)
    print(clf[i], mean_acc)
    i+=1
```

```
K_neighbour : 0.866955796497081
Poly_SVC : 0.8540950792326939
Decision_tree : 0.8251042535446207
Random_Forest : 0.8832860717264387
Xbg : 0.872393661384487
Adaptive_boosting : 0.8941951626355296
Bagging_random_forest : 0.7794995829858216
Soft_voting : 0.8869557964970809
Hard_voting : 0.8851042535446204
```

Adaptive_boosting, Soft and Hard Voting is best performer for upsampled test data. Hard_voting are the best performer in upsampled data.

In [ ]:

STACKING

In [144…

```
soft_voting = VotingClassifier(estimators=[('random_forest', rf_upsampled ), ('xbg', xbg_upsampled),
                                           ('adaptive_boosting', adaptive_boosting_upsampled)],voting='soft'

hard_voting = VotingClassifier(estimators=[('random_forest', rf_upsampled ), ('xbg', xbg_upsampled),
                                           ('adaptive_boosting', adaptive_boosting_upsampled)],voting='hard'

xbg_upsampled = xgboost.XGBClassifier(learning_rate=1, n_estimators=248, max_depth = 474, random_state = 42)
adaptive_boosting_upsampled = AdaBoostClassifier(RandomForestClassifier(random_state=42), algorithm = 'SAMME


estimators=[soft_voting,hard_voting,xbg_upsampled,adaptive_boosting_upsampled]
x_Predictions = np.zeros((len(X_train_up), len(estimators)), dtype=np.float32)

# Apply estimators on Validation data set
for index, estimator in enumerate(estimators):
    estimator.fit(X_train_up, y_train_up)#applying predictiosn on training datset
    y_pred = cross_val_predict(estimator, X_train_up, y_train_up, cv=5)
    x_Predictions[:, index] = np.ravel(y_pred)#predcitions r now assumed as. a new dataset

# Train a new Random Forest for prediction
New_rnd = RandomForestClassifier()#always a good idea
New_rnd.fit(x_Predictions, y_train_up)#fit the new model to X_predictions and taget of the training set

#TEST
# Predict result by stacking on test set
x_test_predictions = np.zeros((len(X_test_up), len(estimators)), dtype=np.float32)
for index, estimator in enumerate(estimators):
    x_test_predictions[:, index] = np.ravel(estimator.predict(X_test_up))

y_pred = New_rnd.predict(x_test_predictions)
acc=accuracy_score(y_test_up, y_pred)

pre_acc.append(acc)

clf=clf+['stacking']
print('Stacking ', acc)
```

```
Stacking  0.5136612021857924
```

There is poor performance with stacking.

In [ ]:

CONCLUSIONS:

- Upsampled data performs better.

GIVEN DATA

- The performance on training data is 90%.
- The performance on upsampled test data is 89%.
- Hard Voting is the best performer on both training and test data.

UPSAMPLED DATA

- The performance on upsampled training data is 97%.
- The performance on upsampled test data is 89%.
- Hard_voting are the best performer in upsampled training and test data.

In [ ]: