Red Wine Quality Prediction Project

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

from sklearn.feature_selection import SelectKBest, f_classif
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split,GridSearchCV
from sklearn.metrics import accuracy_score,classification_report,confusion_matrix,roc_au
from sklearn.svm import SVC
from sklearn.ensemble import AdaBoostClassifier,RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier

import pickle
import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```
df=pd.read_csv('winequality-red.csv')
df.head()
```

Out[2]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	5
1	7.8	0.88	0.00	2.6	0.098	25.0	67.0	0.9968	3.20	0.68	9.8	5
2	7.8	0.76	0.04	2.3	0.092	15.0	54.0	0.9970	3.26	0.65	9.8	5
3	11.2	0.28	0.56	1.9	0.075	17.0	60.0	0.9980	3.16	0.58	9.8	6
4	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	5

In [3]:
```
df.tail()
```

Out[3]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
1594	6.2	0.600	0.08	2.0	0.090	32.0	44.0	0.99490	3.45	0.58	10.5	5
1595	5.9	0.550	0.10	2.2	0.062	39.0	51.0	0.99512	3.52	0.76	11.2	6
1596	6.3	0.510	0.13	2.3	0.076	29.0	40.0	0.99574	3.42	0.75	11.0	6
1597	5.9	0.645	0.12	2.0	0.075	32.0	44.0	0.99547	3.57	0.71	10.2	5
1598	6.0	0.310	0.47	3.6	0.067	18.0	42.0	0.99549	3.39	0.66	11.0	6

In [4]:
```
df.head(14)
```

Out[4]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	5

1	7.8	0.880	0.00	2.6	0.098	25.0	67.0	0.9968	3.20	0.68	9.8	5
2	7.8	0.760	0.04	2.3	0.092	15.0	54.0	0.9970	3.26	0.65	9.8	5
3	11.2	0.280	0.56	1.9	0.075	17.0	60.0	0.9980	3.16	0.58	9.8	6
4	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	5
5	7.4	0.660	0.00	1.8	0.075	13.0	40.0	0.9978	3.51	0.56	9.4	5
6	7.9	0.600	0.06	1.6	0.069	15.0	59.0	0.9964	3.30	0.46	9.4	5
7	7.3	0.650	0.00	1.2	0.065	15.0	21.0	0.9946	3.39	0.47	10.0	7
8	7.8	0.580	0.02	2.0	0.073	9.0	18.0	0.9968	3.36	0.57	9.5	7
9	7.5	0.500	0.36	6.1	0.071	17.0	102.0	0.9978	3.35	0.80	10.5	5
10	6.7	0.580	0.08	1.8	0.097	15.0	65.0	0.9959	3.28	0.54	9.2	5
11	7.5	0.500	0.36	6.1	0.071	17.0	102.0	0.9978	3.35	0.80	10.5	5
12	5.6	0.615	0.00	1.6	0.089	16.0	59.0	0.9943	3.58	0.52	9.9	5
13	7.8	0.610	0.29	1.6	0.114	9.0	29.0	0.9974	3.26	1.56	9.1	5

Labels:

1 - fixed acidity: most acids involved with wine

2 - volatile acidity: -The amount acetic acid in wine at too high can lead to unpleasant taste

3 - Citric acid: citric acid can add freshnees and flavor to wines found in very small quantities

4 - residual sugar: wine after the alcoholic fermentation finishes. It's measured in grams per liter

5 - chlorides : Amount of sallt in wine

6 - free sulfur dioxide: free sulfur dioxide is a key factor in winemaking,It's important to monitor and manage free SO2 levels to ensure wine quality and longevity.

7 - total sulfur dioxide:Winemakers carefully monitor and manage SO2 levels to maintain wine quality and safety.

8 - density: density of water is close to that of water dependning on the percent of alcohol and sugar content

9 - pH: decribes how acidic and basic wine is

10 - sulphates : a wine addictive which can contribute to sulfur dioxide gas(so2) 11 - alcohol : Alcohol Present

Target:

Quality: Since Quality of wine is base don features and scores between 0 -10

Exploratory Data Analysis(EDA)

In [5]:
```
df.shape
```

Out[5]:
```
(1599, 12)
```

Shows Shape of the Dataset

In [6]:
```
#checking null values
df.isna().sum()
```

Out[6]:
```
fixed acidity           0
volatile acidity        0
citric acid             0
residual sugar          0
chlorides               0
free sulfur dioxide     0
total sulfur dioxide    0
density                 0
pH                      0
sulphates               0
alcohol                 0
quality                 0
dtype: int64
```

There are no null values present in our Dataset

In [7]:
```
df.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
```

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

Out[8]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density
count	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
std	1.741096	0.179060	0.194801	1.409928	0.047065	10.460157	32.895324	0.001887
min	4.600000	0.120000	0.000000	0.900000	0.012000	1.000000	6.000000	0.990070
25%	7.100000	0.390000	0.090000	1.900000	0.070000	7.000000	22.000000	0.995600
50%	7.900000	0.520000	0.260000	2.200000	0.079000	14.000000	38.000000	0.996750
75%	9.200000	0.640000	0.420000	2.600000	0.090000	21.000000	62.000000	0.997835

max	15.900000	1.580000	1.000000	15.500000	0.611000	72.000000	289.000000	1.003690

SO using the Describe method i can see that mean,standard value,minimum,maximum and Inter Quantile values of our Data set So As per my observations

1.There is a gap between 75% of residual sugar and maximum residual sugar

2.There is a gap betweeen 75% and max value of free sulfur dioxide

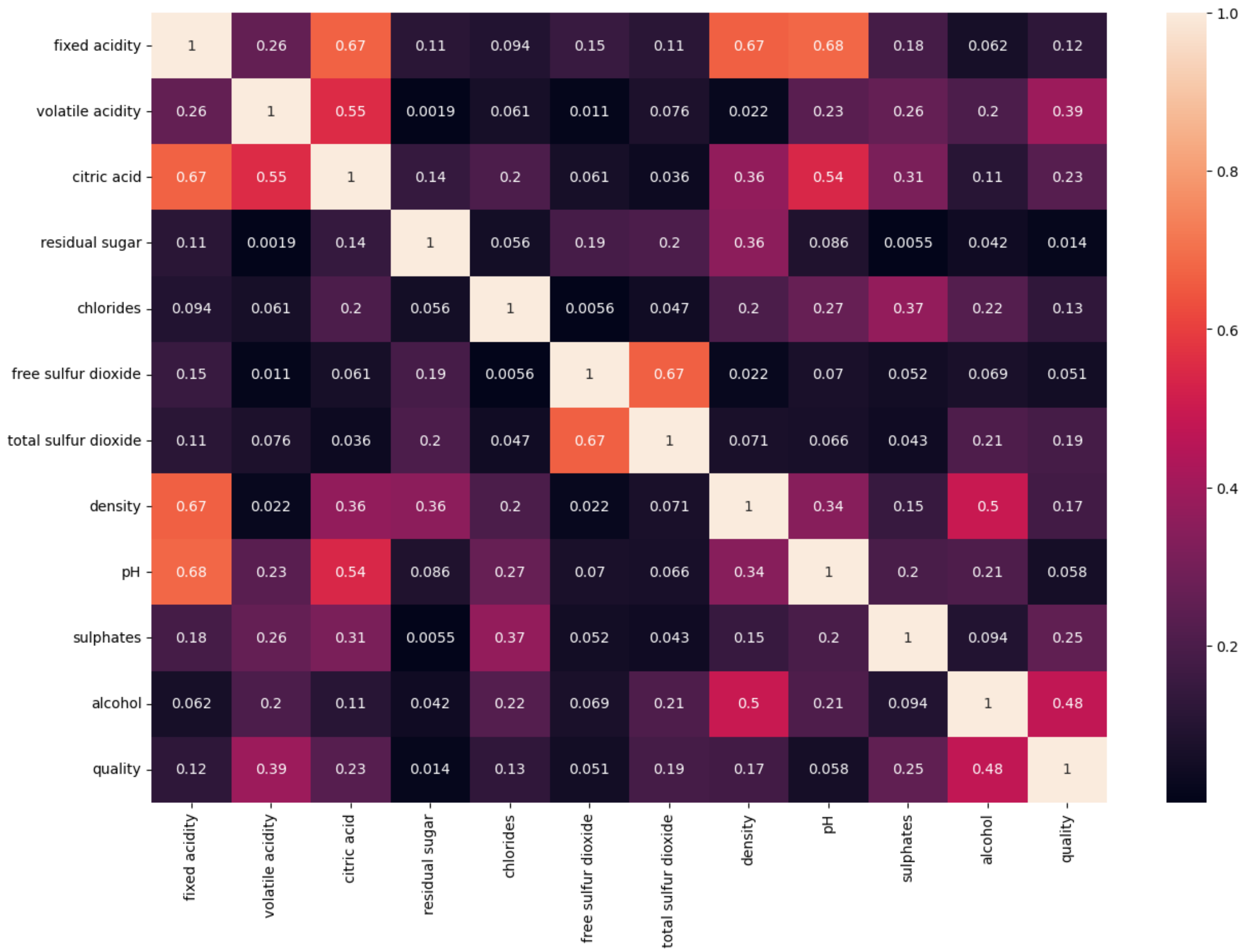
3.There is a gap between 75% and max values of total sulfur dioxide

All These tells us that there is an Outlier present in our dataset which needs to be taken care of for better model accuracy

In [9]:
```
corr = df.corr().abs()
```

Now , will check the multicolinearity between columns

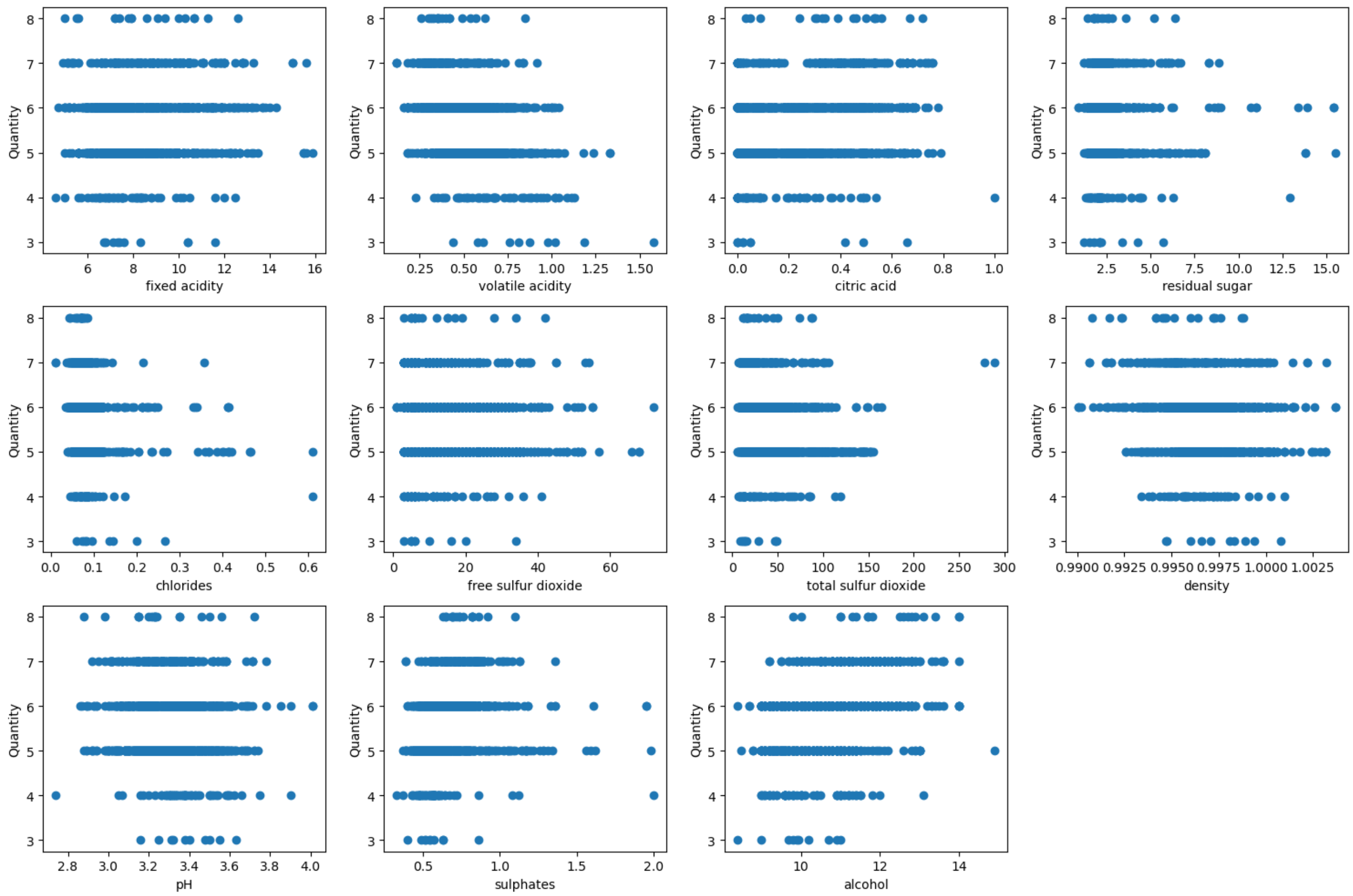
In [10]:
```
plt.figure(figsize=(15,10))
sns.heatmap(corr,annot=True)
plt.show()
```



In [11]:
```
# Seperating the labels as x and target as y
x = df.drop('quality',axis = 1)
y = df.quality
```

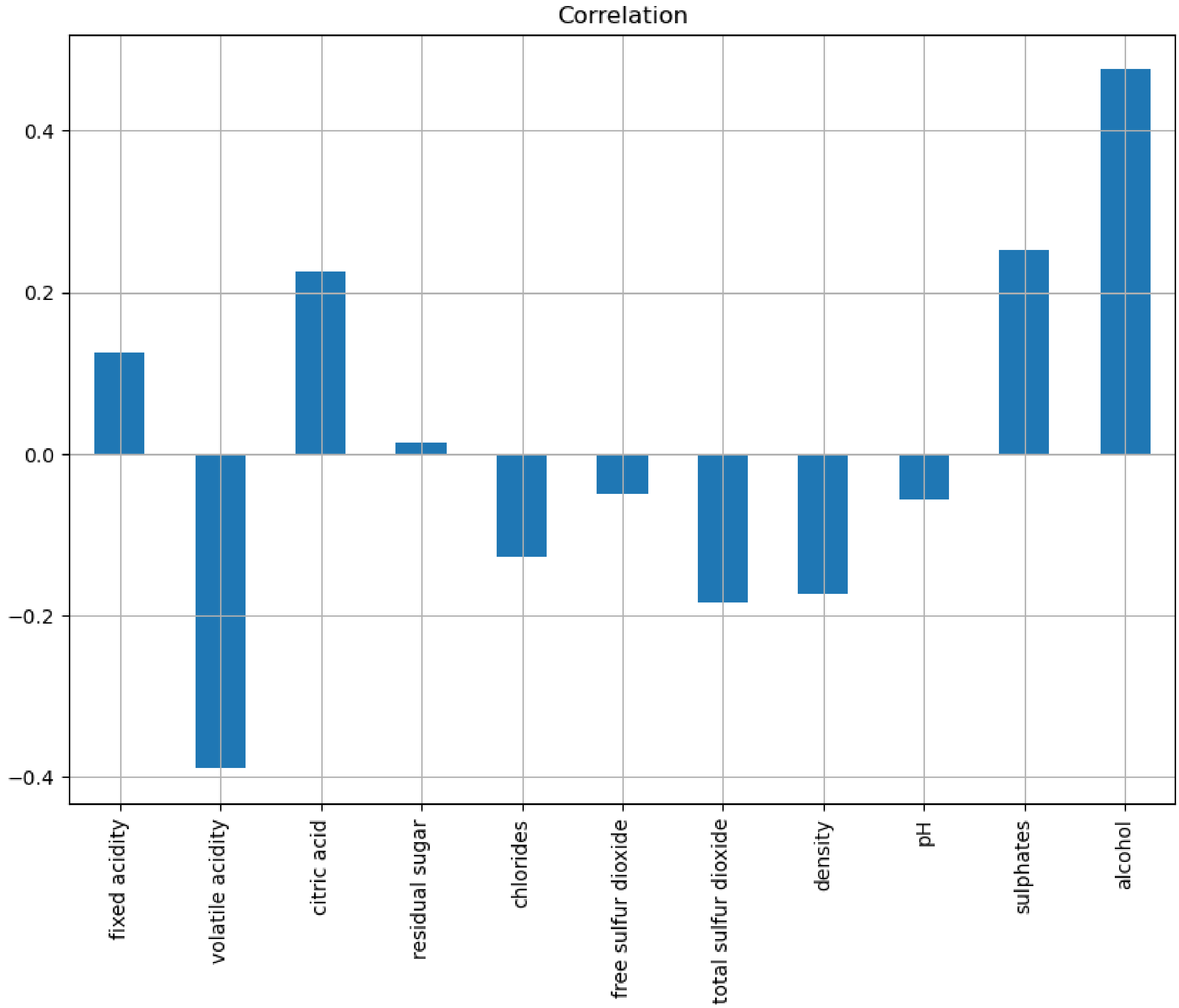
In [12]:

```python
plt.figure(figsize=(15,10))

plotnumber = 1

for column in x:
    if plotnumber <= 12:
        ax = plt.subplot(3,4,plotnumber)
        plt.scatter(x[column],y)
        plt.xlabel(column,fontsize=10)
        plt.ylabel('Quantity',fontsize=10)
        plotnumber +=1
plt.tight_layout()
```



In [13]:

```python
#Checking the realtionship between labels and target using scatterplot
x.corrwith(y).plot(kind = 'bar',grid = True, figsize = (10,7), title = 'Correlation')
plt.show()
```



In [14]:
```
best_feature = SelectKBest(score_func = f_classif, k =11)
fit = best_feature.fit(x,y)
```

In [15]:
```
bst_scores = pd.DataFrame(fit.scores_)
bst_column = pd.DataFrame(x.columns)
```

In [16]:
```
feature_score = pd.concat([bst_column,bst_scores], axis =1)
feature_score.columns = ['feature Name', 'Scores']
feature_score.nlargest(11, 'Scores')
```

Out[16]:

	feature Name	Scores
10	alcohol	115.854797
1	volatile acidity	60.913993
6	total sulfur dioxide	25.478510
9	sulphates	22.273376
2	citric acid	19.690664
7	density	13.396357
0	fixed acidity	6.283081
4	chlorides	6.035639

5	free sulfur dioxide	4.754233
8	pH	4.341764
3	residual sugar	1.053374

In [17]:
```
df['quality'].value_counts()
```

Out[17]:
```
5    681
6    638
7    199
4     53
8     18
3     10
Name: quality, dtype: int64
```

In [18]:
```
#Converting the data into categories i.e quality of range above and equal to 7 will be g
df['quality'] = [1 if x>=7 else 0 for x in df.quality]
```

In [19]:
```
df['quality'].value_counts()
```

Out[19]:
```
0    1382
1     217
Name: quality, dtype: int64
```

In [20]:
```
df.head()
```

Out[20]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	0
1	7.8	0.88	0.00	2.6	0.098	25.0	67.0	0.9968	3.20	0.68	9.8	0
2	7.8	0.76	0.04	2.3	0.092	15.0	54.0	0.9970	3.26	0.65	9.8	0
3	11.2	0.28	0.56	1.9	0.075	17.0	60.0	0.9980	3.16	0.58	9.8	0
4	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	0.56	9.4	0

In [21]:
```
x_fe = df.drop('quality', axis = 1)
y_la = df.quality
```

In [22]:
```
scaler = StandardScaler()
x_scaled = scaler.fit_transform(x_fe)
x_scaled
```

Out[22]:
```
array([[-0.52835961,  0.96187667, -1.39147228, ...,  1.28864292,
        -0.57920652, -0.96024611],
       [-0.29854743,  1.96744245, -1.39147228, ..., -0.7199333 ,
         0.1289504 , -0.58477711],
       [-0.29854743,  1.29706527, -1.18607043, ..., -0.33117661,
        -0.04808883, -0.58477711],
       ...,
       [-1.1603431 , -0.09955388, -0.72391627, ...,  0.70550789,
         0.54204194,  0.54162988],
       [-1.39015528,  0.65462046, -0.77526673, ...,  1.6773996 ,
         0.30598963, -0.20930812],
       [-1.33270223, -1.21684919,  1.02199944, ...,  0.51112954,
         0.01092425,  0.54162988]])
```

-Train Test Split

In [23]:
```
x_train,x_test,y_train,y_test = train_test_split(x_scaled, y_la, test_size = 0.20, rando
```

-Creating The Function for training and testing score so that we can get the result just by calling the function

In [24]:
```
def score(clas, x_train, x_test, y_train, y_test, train = True):
    if train:
        y_pred = clas.predict(x_train)
        print('\n -----Train Result ----- \n')
        print('Accuracy Score:', accuracy_score(y_train,y_pred))
        print('\n ----- Classification Report -----\n', classification_report(y_train,y_
        print('\n ----- COnfusion Matrix -----\n', confusion_matrix(y_train,y_pred))

    elif train == False:
        pred = clas.predict(x_test)
        print('\n ----- Test Result -----\n')
        print('Accuracy_Score:' , accuracy_score(y_test,pred))
        print('\n ----- Classification Report ----- \n', classification_report(y_test,pr
        print('\n ----- Confusion Matrix -----\n' , confusion_matrix(y_test,pred))
```

-Model Instantiating

In [25]:
```
svc = SVC()
ada = AdaBoostClassifier()
knn = KNeighborsClassifier()
rfc = RandomForestClassifier()
```

-Training of the Models

In [26]:
```
svc.fit(x_train,y_train)
ada.fit(x_train,y_train)
knn.fit(x_train,y_train)
rfc.fit(x_train,y_train)
print('Training of all Models')
```

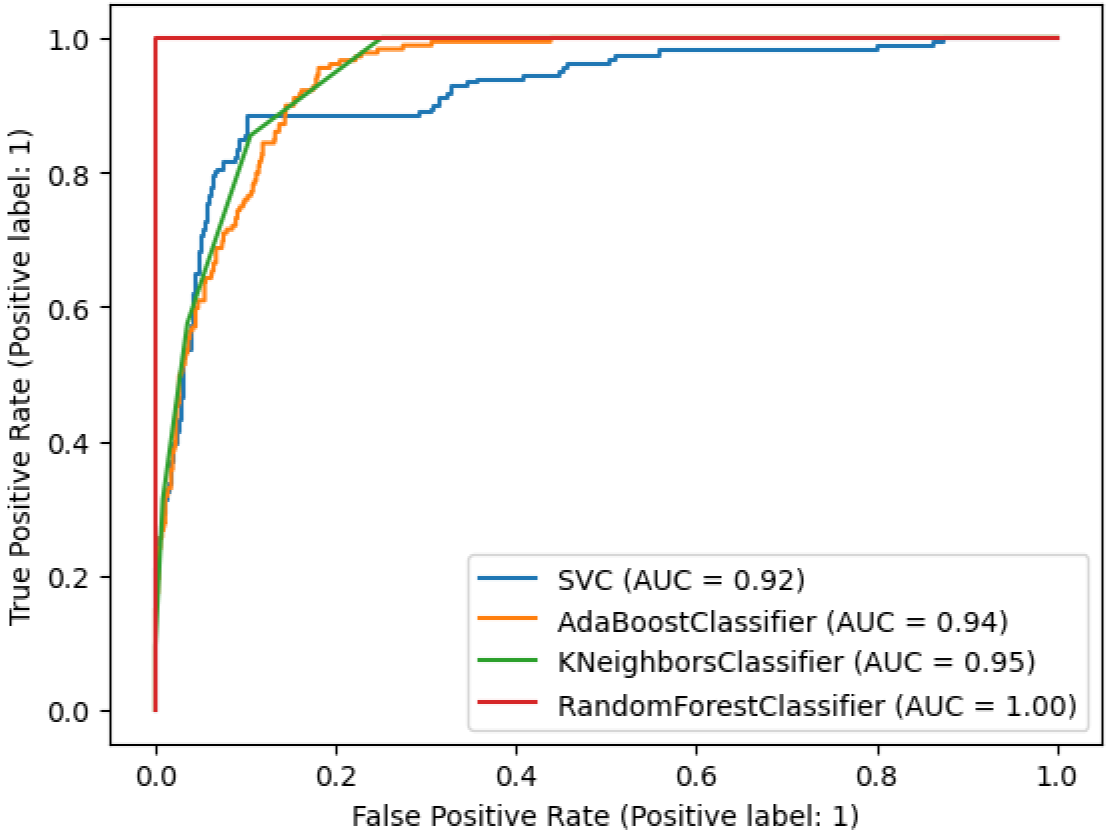
```
Training of all Models
```

-Ploting roc_auc_curve for training

In [27]:
```
from sklearn.metrics import plot_roc_curve
```

In [28]:
```
if hasattr(svc, 'fit'):
    svc.fit(x_train, y_train)
else:
    print("SVC model has not been fitted. Please fit the model before plotting ROC curve
```

In [29]:
```
disp = plot_roc_curve(svc, x_train, y_train)
plot_roc_curve(ada,x_train,y_train, ax = disp.ax_)
plot_roc_curve(knn,x_train,y_train, ax = disp.ax_)
plot_roc_curve(rfc,x_train,y_train, ax = disp.ax_)
plt.legend(prop = {'size': 10}, loc = 'lower right')
plt.show()
```



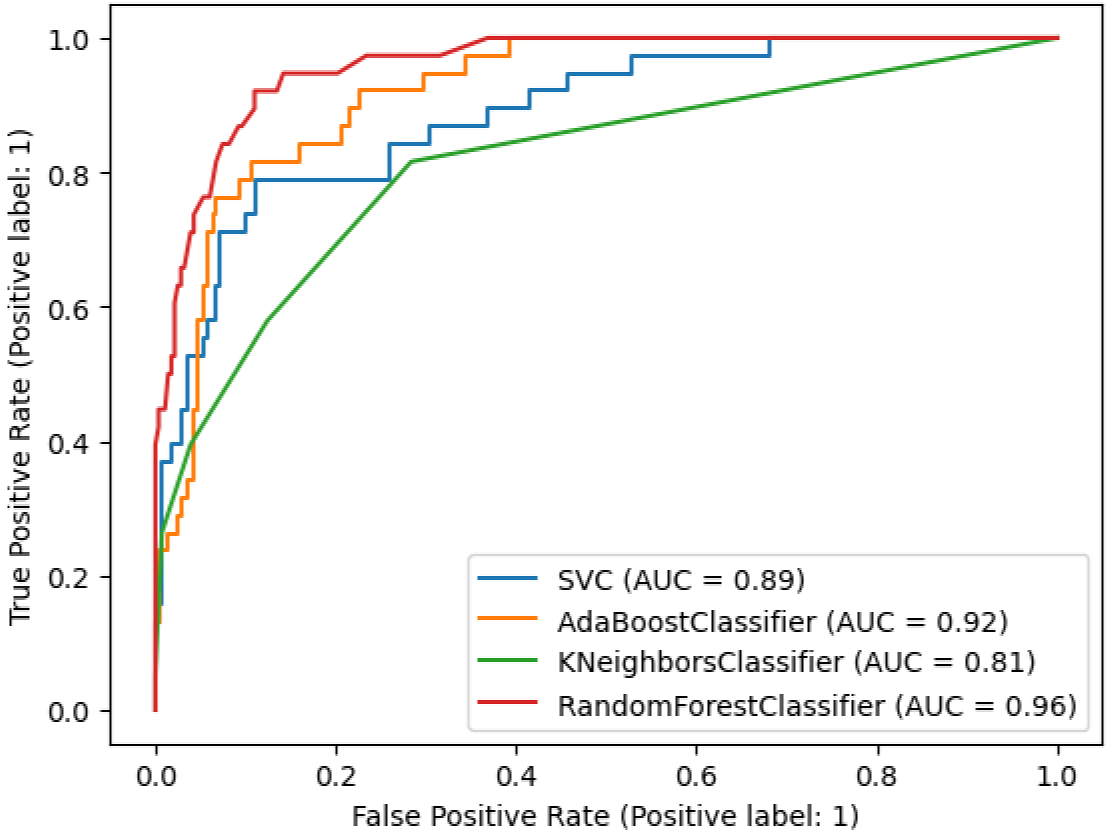
In [30]:

```
#Traning score of each model
print(svc.score(x_train,y_train))
print(ada.score(x_train,y_train))
print(knn.score(x_train,y_train))
```

```
0.8928850664581705
0.9061767005473026
0.910086004691165
```

In [31]:

```
#Plotting roc_auc_curve for testing model
disp = plot_roc_curve(svc, x_test, y_test)
plot_roc_curve(ada,x_test,y_test,ax =disp.ax_)
plot_roc_curve(knn,x_test,y_test,ax =disp.ax_)
plot_roc_curve(rfc,x_test,y_test,ax =disp.ax_)
plt.legend(prop ={'size' :10}, loc = 'lower right')
plt.show()
```



In [32]:
```
print(svc.score(x_test,y_test))
print(ada.score(x_test,y_test))
print(knn.score(x_test,y_test))
print(rfc.score(x_test,y_test))
```

```
0.9125
0.896875
0.89375
0.928125
```

In [33]:
```
# Training score, Testing Score, Classification Report, Confusion matrix of RandomForest
rfc.fit(x_train, y_train)
score(rfc, x_train, x_test, y_train, y_test, train = True)
score(rfc, x_train, x_test, y_train, y_test, train = False)
```

```
 -----Train Result -----

Accuracy Score: 1.0

 ----- Classification Report -----
               precision    recall  f1-score   support

           0       1.00      1.00      1.00      1100
           1       1.00      1.00      1.00       179

    accuracy                           1.00      1279
   macro avg       1.00      1.00      1.00      1279
weighted avg       1.00      1.00      1.00      1279


 ----- COnfusion Matrix -----
 [[1100    0]
 [   0  179]]

 ----- Test Result -----

Accuracy_Score: 0.928125
```

```
 ----- Classification Report -----
              precision    recall  f1-score   support

           0       0.94      0.99      0.96       282
           1       0.83      0.50      0.62        38

    accuracy                           0.93       320
   macro avg       0.88      0.74      0.79       320
weighted avg       0.92      0.93      0.92       320


 ----- Confusion Matrix -----
 [[278   4]
 [ 19  19]]
```

In [34]:
```python
rfc.get_params().keys()
```

Out[34]:
```
dict_keys(['bootstrap', 'ccp_alpha', 'class_weight', 'criterion', 'max_depth', 'max_feat
ures', 'max_leaf_nodes', 'max_samples', 'min_impurity_decrease', 'min_samples_leaf', 'mi
n_samples_split', 'min_weight_fraction_leaf', 'n_estimators', 'n_jobs', 'oob_score', 'ra
ndom_state', 'verbose', 'warm_start'])
```

In [35]:
```python
# Hyperparameter Tuning
param = {
    'n_estimators': range(1, 15),
    'criterion': ['gini', 'entropy'],
    'max_depth': range(2, 10),
    'max_features': range(0, 12),
    'max_leaf_nodes': range(2, 4)
}
```

In [36]:
```python
grid = GridSearchCV(rfc,param_grid = param)
grid.fit(x_train,y_train)
print('Best Params =', grid.best_params_)
```

```
Best Params = {'criterion': 'gini', 'max_depth': 3, 'max_features': 5, 'max_leaf_nodes':
3, 'n_estimators': 4}
```

In [37]:
```python
rfc = RandomForestClassifier(criterion = 'gini', max_depth = 7,max_features =11,max_leaf
```

In [41]:
```python
rfc.fit(x_train,y_train)
score(rfc,x_train,x_test,y_train,y_test,train = True)
score(rfc,x_train,x_test,y_train,y_test,train = False)
```

```
 -----Train Result -----

Accuracy Score: 0.8866301798279906

 ----- Classification Report -----
              precision    recall  f1-score   support

           0       0.90      0.98      0.94      1100
           1       0.70      0.34      0.45       179

    accuracy                           0.89      1279
   macro avg       0.80      0.66      0.69      1279
weighted avg       0.87      0.89      0.87      1279


 ----- COnfusion Matrix -----
 [[1074   26]
 [ 119   60]]

 ----- Test Result -----
```

```
Accuracy_Score: 0.896875

 ----- Classification Report -----
              precision    recall  f1-score   support

           0       0.91      0.99      0.94       282
           1       0.69      0.24      0.35        38

    accuracy                           0.90       320
   macro avg       0.80      0.61      0.65       320
weighted avg       0.88      0.90      0.87       320


 ----- Confusion Matrix -----
 [[278   4]
 [ 29   9]]
```

In [42]:

```
#USing Pickle Method
filename = 'winequality.ipynb'
pickle.dump(rfc,open(filename, 'wb'))
```