COMP4220: Machine Learning, Spring 2022, Assignment 3

Please submit one pdf file for all questions.

```
#importing the libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

df = pd.read_csv("wine.csv")
df
```

```
      fixed acidity  volatile acidity  citric acid  residual sugar
chlorides  \
0               7.4             0.700         0.00             1.9
0.076
1               7.8             0.880         0.00             2.6
0.098
2               7.8             0.760         0.04             2.3
0.092
3              11.2             0.280         0.56             1.9
0.075
4               7.4             0.700         0.00             1.9
0.076
...             ...               ...          ...             ...
...
1594            6.2             0.600         0.08             2.0
0.090
1595            5.9             0.550         0.10             2.2
0.062
1596            6.3             0.510         0.13             2.3
0.076
1597            5.9             0.645         0.12             2.0
0.075
1598            6.0             0.310         0.47             3.6
0.067

      free sulfur dioxide  total sulfur dioxide  density    pH
sulphates  \
0                    11.0                  34.0  0.99780  3.51
0.56
1                    25.0                  67.0  0.99680  3.20
0.68
2                    15.0                  54.0  0.99700  3.26
0.65
3                    17.0                  60.0  0.99800  3.16
0.58
4                    11.0                  34.0  0.99780  3.51
0.56
```

```
...                   ...                   ...      ...   ...
...
1594                  32.0                  44.0  0.99490  3.45
0.58
1595                  39.0                  51.0  0.99512  3.52
0.76
1596                  29.0                  40.0  0.99574  3.42
0.75
1597                  32.0                  44.0  0.99547  3.57
0.71
1598                  18.0                  42.0  0.99549  3.39
0.66

      alcohol  quality
0         9.4        5
1         9.8        5
2         9.8        5
3         9.8        6
4         9.4        5
...       ...      ...
1594     10.5        5
1595     11.2        6
1596     11.0        6
1597     10.2        5
1598     11.0        6

[1599 rows x 12 columns]
```

variables (based on physicochemical tests):

Tips

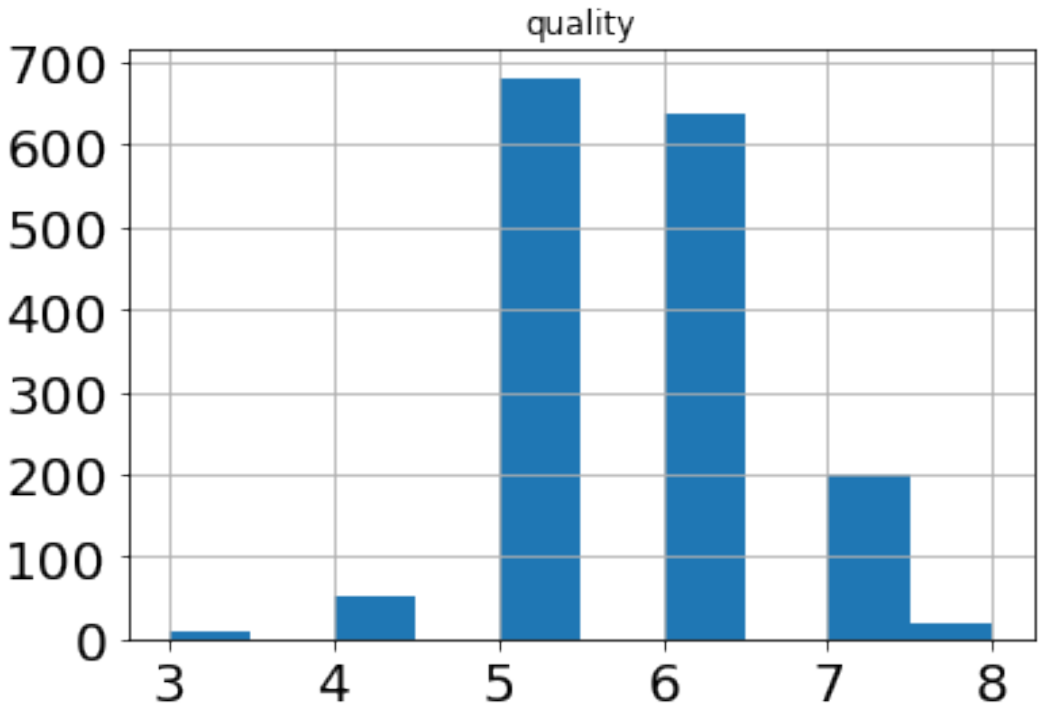
An interesting thing to do is to set an arbitrary cutoff for your dependent variable (wine quality): 7 or higher getting classified as '1' and the remainder as '0'.

This allows you to convert this problem into a classification problem.

1. Since we want to classify the wine base on the quality so we want to look at the distribution of the wine quality

Make a histogram plot for the quality column to see the distribution of the wine quality

```
plot = df.hist(column='quality',xlabelsize=20, ylabelsize=20,bins=10)
```



2. Show the number of null values using sum() method. If there are null values then remove them from the dataset

```
df.isna().sum()
```

```
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
```

3. Since we want to categorize the dependent variable (wine quality)

Change the quality column to 1 if the quality >= 7, and 0 if the quality is < 7

Show the dataset after making this change

Hint: the quality column should only have 0s and 1s after the change

```
#df.loc[df['quality'] < 7, 'quality'] = 0
df['quality'] = df['quality'].apply(lambda x: 1 if x >= 7 else 0)
df
```

```
      fixed acidity  volatile acidity  citric acid  residual sugar
chlorides  \
0               7.4             0.700         0.00             1.9
0.076
1               7.8             0.880         0.00             2.6
0.098
2               7.8             0.760         0.04             2.3
0.092
3              11.2             0.280         0.56             1.9
0.075
4               7.4             0.700         0.00             1.9
0.076
...             ...               ...          ...             ...
...
1594            6.2             0.600         0.08             2.0
0.090
1595            5.9             0.550         0.10             2.2
0.062
1596            6.3             0.510         0.13             2.3
0.076
1597            5.9             0.645         0.12             2.0
0.075
1598            6.0             0.310         0.47             3.6
0.067

      free sulfur dioxide  total sulfur dioxide  density    pH
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0                    11.0                  34.0  0.99780  3.51
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0.68
2                    15.0                  54.0  0.99700  3.26
0.65
3                    17.0                  60.0  0.99800  3.16
0.58
4                    11.0                  34.0  0.99780  3.51
0.56
...                   ...                   ...      ...   ...
...
```

```
1594                32.0                 44.0  0.99490  3.45
0.58
1595                39.0                 51.0  0.99512  3.52
0.76
1596                29.0                 40.0  0.99574  3.42
0.75
1597                32.0                 44.0  0.99547  3.57
0.71
1598                18.0                 42.0  0.99549  3.39
0.66

      alcohol  quality
0         9.4        0
1         9.8        0
2         9.8        0
3         9.8        0
4         9.4        0
...       ...      ...
1594     10.5        0
1595     11.2        0
1596     11.0        0
1597     10.2        0
1598     11.0        0

[1599 rows x 12 columns]
```

4. Create y as the quality column and X as everything but the quality column

```
X = df.drop(['quality'], axis=1).to_numpy() # Drop quality column and
make rest numpy array
y = df['quality'].to_numpy() # The labels for machine learning.
X.shape, y.shape
```

```
((1599, 11), (1599,))
```

5. Split the dataset into the training and test set using "train_test_split".

Split the training and test set into 70-30 ratio

```
from sklearn.model_selection import train_test_split, KFold
from sklearn.pipeline import Pipeline
from sklearn.preprocessing import PolynomialFeatures, StandardScaler
from sklearn.linear_model import LogisticRegression


from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=1/3)
```

6. Apply Feature Scaling method for X_train and X_test with "StandardScaler" from "sklearn.preprocessing"

Hint: use StandardScaler.fit_transform for "X_train" and use StandardScaler.transform for "X_test"

```
scaler = StandardScaler()
scaler.fit_transform(X_train)
scaler.transform(X_test)

#pipe = Pipeline([
#                 ('scaler', StandardScaler()),
#                 ('regressor', LogisticRegression())
#])
#pipe.fit(X_train, y_train)
```

```
array([[-0.29462956,  0.35128877, -0.47837618, ...,  0.76163337,
        -0.3845304 , -0.40133102],
       [-1.28909349, -1.73354099,  0.64880941, ..., -0.40750432,
        -0.3845304 ,  1.34056514],
       [-0.9966041 , -0.1424867 , -1.19567611, ...,  0.50182499,
        -0.08312643, -0.95140348],
       ...,
       [ 0.17335347,  1.09195198, -0.17096193, ...,  0.04716034,
         2.50894779, -1.04308223],
       [ 0.23185135, -1.18490158,  0.95622367, ...,  0.30696871,
         0.64024312, -0.30965227],
       [-0.29462956,  0.29642483, -0.73455473, ..., -0.47245641,
        -0.74621518,  0.69881392]])
```

7. Train the logistic regression model on the training set using (solver='lbfgs', random_state = 42, max_iter = 1000)

```
log_reg = LogisticRegression(solver='lbfgs', random_state=42,
max_iter=1000)
log_reg.fit(X_train, y_train)
```

```
LogisticRegression(max_iter=1000, random_state=42)
```

8.Predict the results of x_test

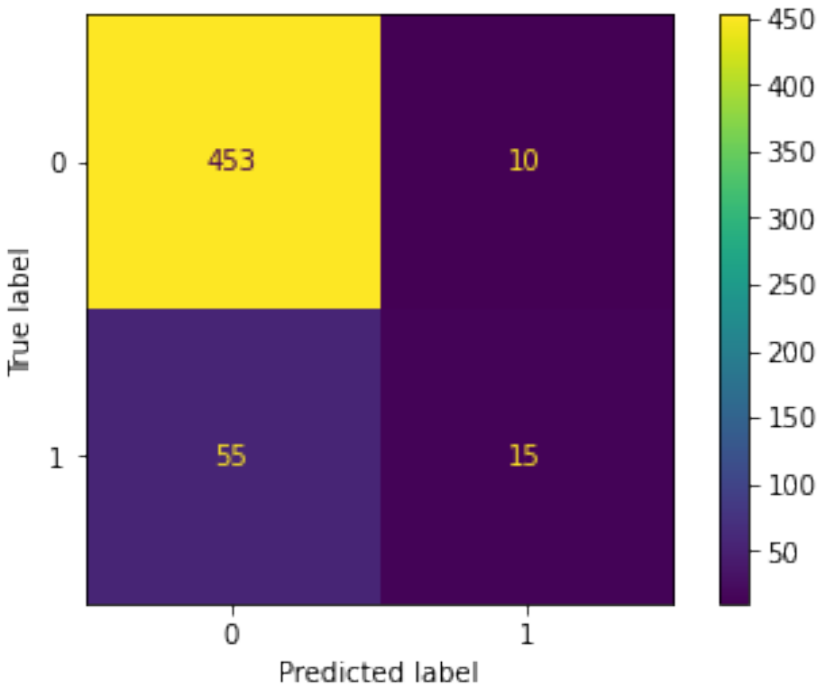
```
y_pred = log_reg.predict(X_test)
print(y_pred)
```

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

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

9.Make the confusion matrix and show the result

```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import ConfusionMatrixDisplay
confusion_matrix(y_test, y_pred)
cm = confusion_matrix(y_test, y_pred)
cm_display = ConfusionMatrixDisplay(cm).plot()
```



10. find the precision_score, recall_score, and f1_score and print them

```
from sklearn.metrics import classification_report
from sklearn.metrics import precision_score, recall_score
print(classification_report(y_test, y_pred))
#precision_score(y_test, y_pred)
#recall_score(y_test, y_pred)
```

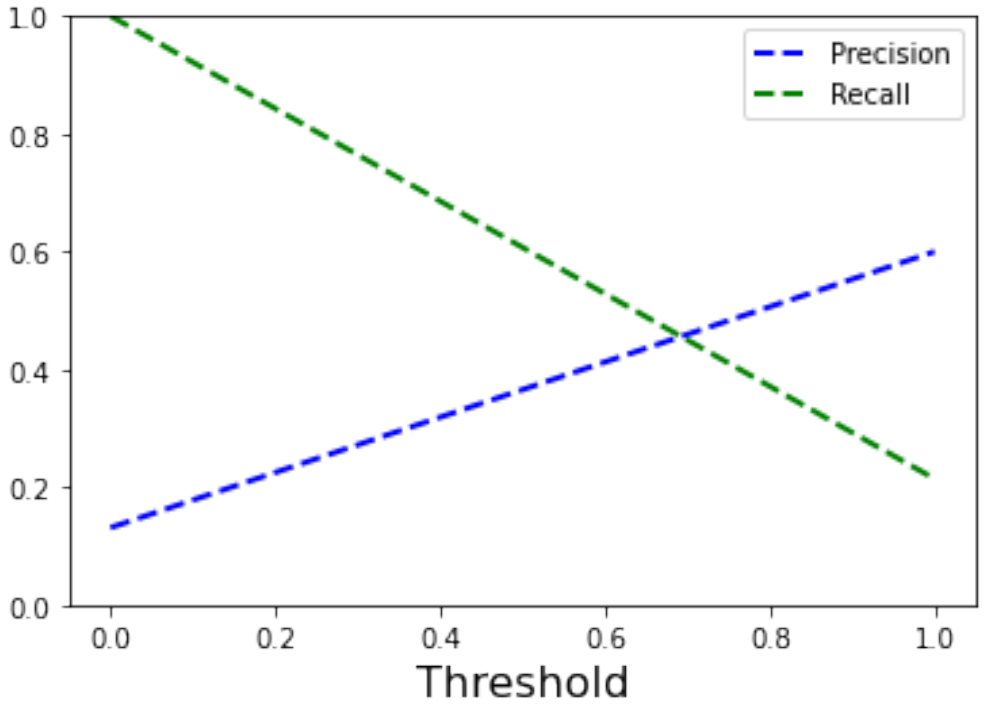
```
              precision    recall  f1-score   support

           0       0.89      0.98      0.93       463
           1       0.60      0.21      0.32        70

    accuracy                           0.88       533
   macro avg       0.75      0.60      0.62       533
weighted avg       0.85      0.88      0.85       533
```

11. Use the precision_recall_curve() function to compute precision and recall for all possible thresholds

```
from sklearn.metrics import precision_recall_curve,
PrecisionRecallDisplay
precisions, recalls, thresholds = precision_recall_curve(y_test,
y_pred)
```

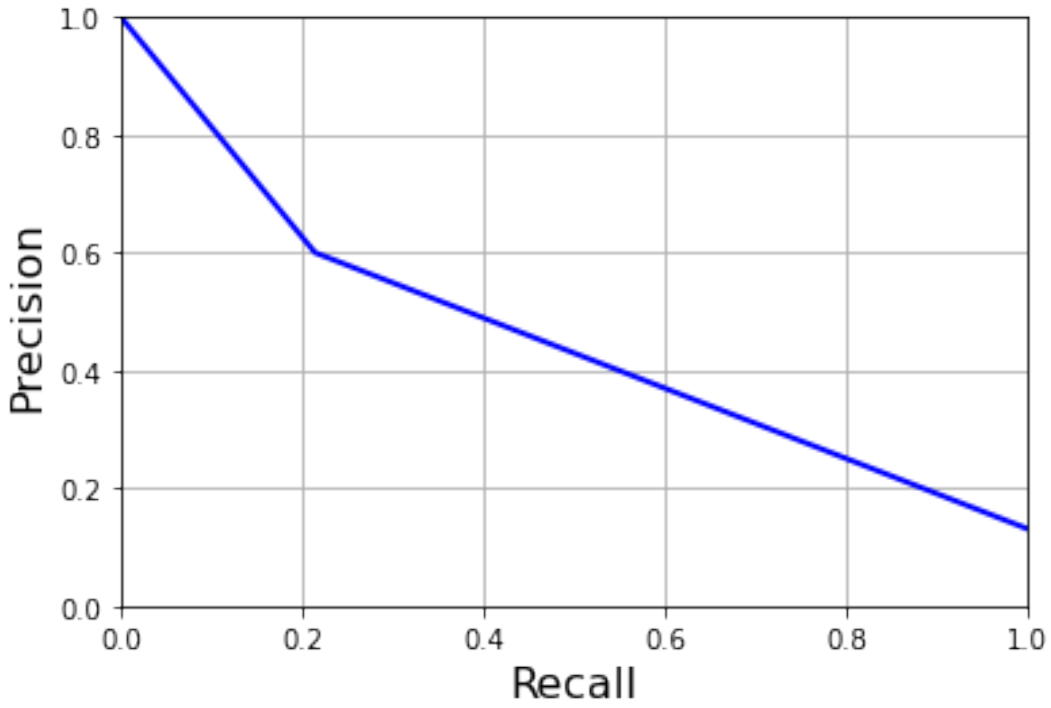
12. Use Matplotlib to plot precision and recall as functions of the threshold value

```
from sklearn.metrics import precision_recall_curve

def plot_precision_recall_vs_threshold(precisions, recalls,
thresholds):
    plt.plot(thresholds, precisions[:-1], 'b--', label='Precision',
linewidth=2)
    plt.plot(thresholds, recalls[:-1], 'g--', label = 'Recall',
linewidth=2)
    plt.xlabel('Threshold', fontsize=16)
    plt.legend(loc="upper right", fontsize=10)
    plt.ylim([0,1])

plot_precision_recall_vs_threshold(precisions, recalls, thresholds)
plt.show()
```



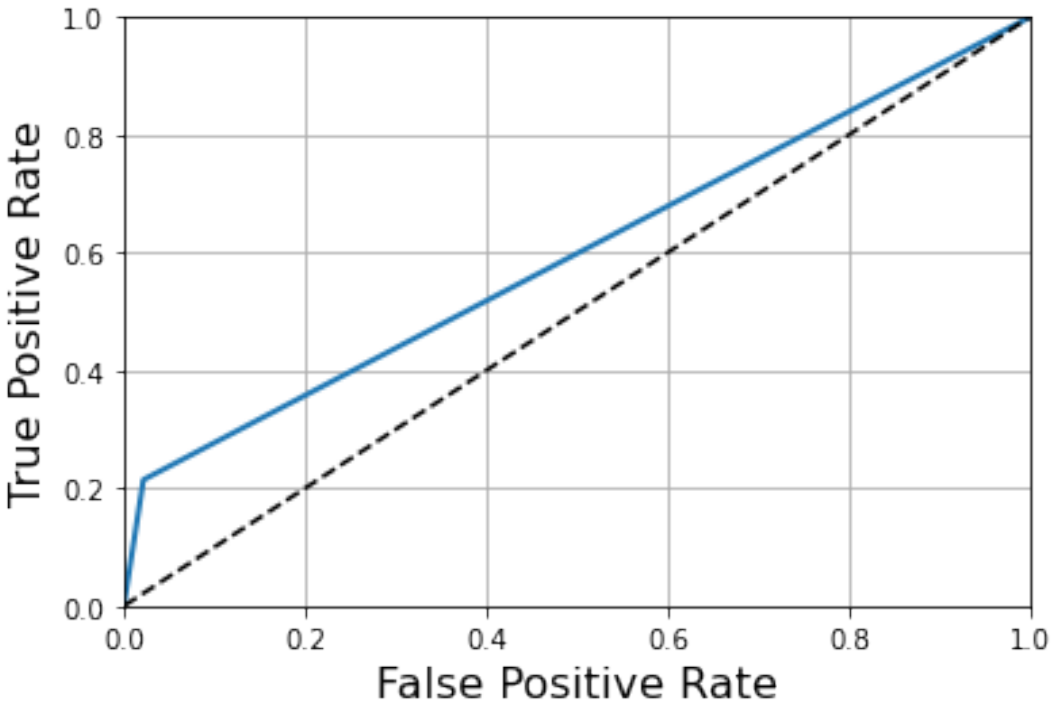
13. Plot the precision vs recall plot

```
def plot_precision_vs_recall(precisions, recalls):
    plt.plot(recalls, precisions, "b-", linewidth=2)
    plt.xlabel("Recall", fontsize=16)
    plt.ylabel("Precision", fontsize=16)
    plt.axis([0, 1, 0, 1])
    plt.grid(True)

plot_precision_vs_recall(precisions, recalls)
plt.show()
```



14. Plot the ROC Curve

```
from sklearn.metrics import roc_curve

fpr, tpr, thresholds = roc_curve(y_test, y_pred)

def plot_roc_curve(fpr, tpr, label=None):
    plt.plot(fpr, tpr, linewidth=2, label=label)
    plt.plot([0, 1], [0, 1], 'k--')
    plt.axis([0, 1, 0, 1])
    plt.xlabel('False Positive Rate', fontsize=16)
    plt.ylabel('True Positive Rate', fontsize=16)
    plt.grid(True)

plot_roc_curve(fpr, tpr, label=None)
plt.show()
```



15. Find the area under the ROC Curve

```
from sklearn.metrics import roc_auc_score
print(roc_auc_score(y_test, y_pred))
```

```
0.5963437210737427
```