TASK 1:

Here is how the training and testing data looks like:

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 24 entries, 0 to 23
Data columns (total 7 columns):
 #   Column                         Non-Null Count  Dtype 
---  ------                         --------------  ----- 
 0   ID                             24 non-null     int64 
 1   Date                           24 non-null     object
 2   Opponent                       24 non-null     object
 3   Is_Home_or_Away                24 non-null     object
 4   Is_Opponent_in_AP25_Preseason  24 non-null     object
 5   Media                          24 non-null     object
 6   Label                          24 non-null     object
dtypes: int64(1), object(6)
memory usage: 1.4+ KB

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 12 entries, 0 to 11
Data columns (total 7 columns):
 #   Column                         Non-Null Count  Dtype 
---  ------                         --------------  ----- 
 0   ID                             12 non-null     int64 
 1   Date                           12 non-null     object
 2   Opponent                       12 non-null     object
 3   Is_Home_or_Away                12 non-null     object
 4   Is_Opponent_in_AP25_Preseason  12 non-null     object
 5   Media                          12 non-null     object
 6   Label                          12 non-null     object
dtypes: int64(1), object(6)
memory usage: 800.0+ bytes
```

Q1) Here are the definitions of Accuracy, Precision, Recall and F1 score:

Accuracy = (TP+TN)/(TP+FP+FN+TN)
Precision = TP/(TP+FP)
Recall = TP/(TP+FN)
F1 Score = 2*(Recall * Precision) / (Recall + Precision)

Where, TP is true positives, TN is true negatives, FP is false positives and FN is false negatives.

Based on the Naïve Bayes and KNN prediction, Accuracy, Precision, Recall and F1 score are calculated.

```
Naive Bayes Accuracy is: 0.833
KNN Accuracy is: 0.667

Naive Bayes Precision is: 1.000
KNN Precision is: 0.727

Naive Bayes Recall is: 0.778
KNN Recall is: 0.889

Naive Bayes F1_score is: 0.875
KNN F1_score is: 0.800
```

Q2) Naïve Bayes prediction output:

```
Given y labels: [1 0 1 1 1 1 1 1 1 0 1 0]
Naive Bayes: Predicted y labels: [1 0 1 1 1 0 0 1 1 0 1 0]
```

KNN prediction output:

```
Given y labels: [1 0 1 1 1 1 1 1 1 0 1 0]
KNN: Predicted y labels: [1 1 1 1 1 1 1 1 0 1 1 1]
```

In Naïve Bayes prediction, 2 values were predicted wrong. In KNN prediction, 4 values were predicted wrong.

TASK 2:

Here is how the training and testing data set looks like for the Titanic dataset:

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 891 entries, 0 to 890
Data columns (total 12 columns):
 #   Column       Non-Null Count  Dtype
---  ------       --------------  -----
 0   PassengerId  891 non-null    int64
 1   Survived     891 non-null    int64
 2   Pclass       891 non-null    int64
 3   Name         891 non-null    object
 4   Sex          891 non-null    object
 5   Age          714 non-null    float64
 6   SibSp        891 non-null    int64
 7   Parch        891 non-null    int64  
 8   Ticket       891 non-null    object 
 9   Fare         891 non-null    float64
 10  Cabin        204 non-null    object 
 11  Embarked     889 non-null    object 
dtypes: float64(2), int64(5), object(5)
memory usage: 83.7+ KB

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 418 entries, 0 to 417
Data columns (total 11 columns):
 #   Column       Non-Null Count  Dtype  
---  ------       --------------  -----  
 0   PassengerId  418 non-null    int64  
 1   Pclass       418 non-null    int64  
 2   Name         418 non-null    object 
 3   Sex          418 non-null    object 
 4   Age          332 non-null    float64
 5   SibSp        418 non-null    int64  
 6   Parch        418 non-null    int64  
 7   Ticket       418 non-null    object 
 8   Fare         417 non-null    float64
 9   Cabin        91 non-null     object 
 10  Embarked     418 non-null    object 
dtypes: float64(2), int64(4), object(5)
memory usage: 36.0+ KB
```

Some data processing is done before prediction. Empty values of Embarked and Age feature in the training dataset are filled with mode values of the features. Similarly, empty values of the Fare feature in the testing dataset is filled with the mode value of the Fare feature. Cabin feature in both training and testing dataset is dropped since majority of the features are empty. Name and Ticket features from both the training set and the testing set are also dropped as there is no strong correlation with the Survived feature

Q1) The average accuracy, precision, recall and F1 score over five folds using naïve Bayes algorithm is:

```
Average metrics over five folds:

The average accuracy is: 0.7621
The average precision is: 0.6666
The average recall is: 0.7660
The average f1_score is: 0.7112
```

The overall accuracy, precision, recall and F1 score for the entire dataset is:

```
NAIVE BAYES METRICS:

The accuracy on the entire model is: 0.8995
The precision on the entire model is: 0.8056
The recall on the entire model is: 0.9539
The f1 score on the entire model is: 0.8735
```

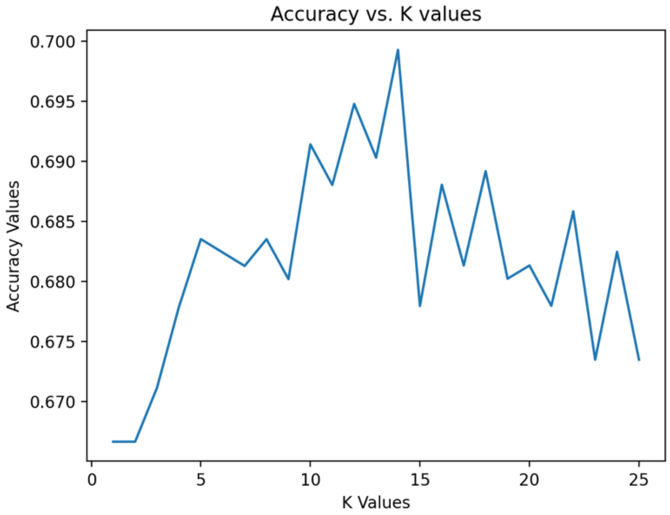
Based on my implementation of the Naïve Bayes algorithm on the football dataset and the Titanic dataset, it was observed that:
Naive Bayes for Football: Accuracy = 83.33%
Naive Bayes for Titanic: Accuracy = 89.95%

Even though the general idea is that Naïve Bayes performs better with smaller datasets, in my implementation better accuracy was found for the Titanic dataset compared to the football dataset. Hence, according to my implementation, Naïve Bayesian model performed better for the larger dataset.

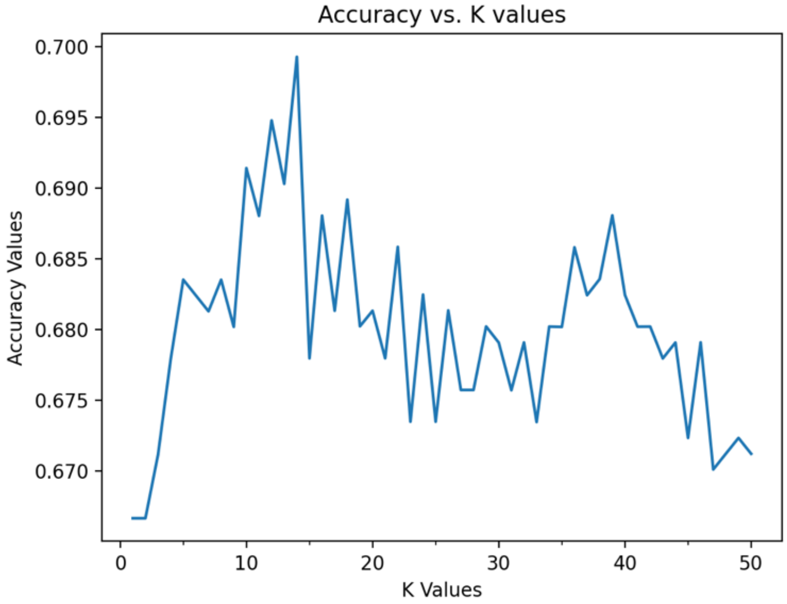
Q2) KNN is implemented from scratch and is used to predict values on the titanic dataset. Five-fold cross validation is done on the Titanic training dataset and for different K values, average accuracies over all five-folds are plotted. Below are the accuracy values for different K values.

Graphs were plotted for K = 1 to 25, K = 1 to 50 and K = 1 to 100 and it was observed that the best K value is at K = 14 with an accuracy of 69.93%

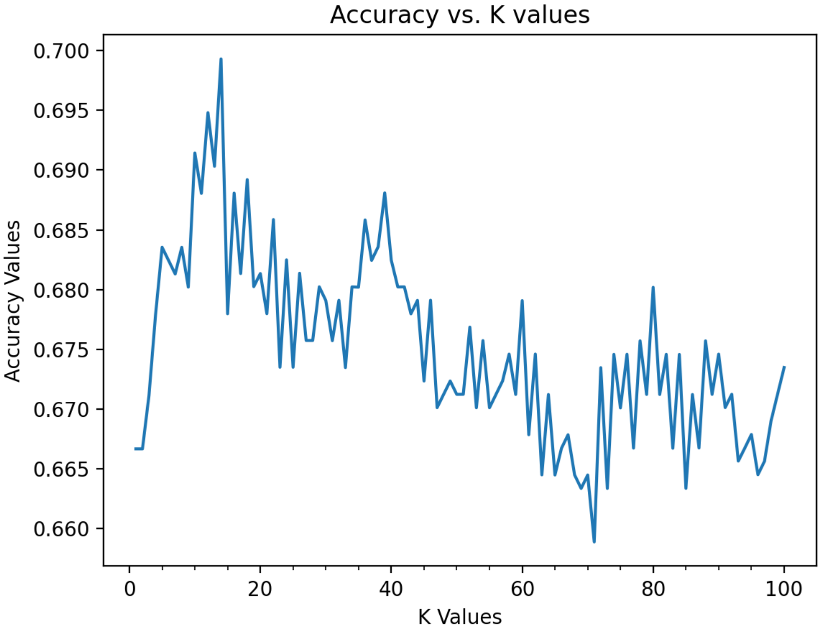
a) K = 1 to 25



b) K = 1 to 50



K = 1 to 100:



The accuracy, precision, recall and F1 score on the entire dataset by taking K = 14 is as follows:

```
KNN METRICS:

The accuracy on the entire model is: 0.6411
The precision on the entire model is: 0.5116
The recall on the entire model is: 0.2895
The f1 score on the entire model is: 0.3697
```

Q3) According to my algorithm implementation and feature engineering, it was observed that the Naïve Bayes had better accuracy compared to KNN for the Titanic dataset.
Naive Bayes for Titanic: Accuracy = 89.95%
KNN for Titanic: Accuracy = 61.72%

This could be due to a variety of reasons including feature engineering and the way data is massaged before passing it to these algorithms. Also, other reasons could include a) fact that KNN's decision boundary can take on any form since KNN is non-parametric and it makes no assumption about the data distribution b) KNN doesn't know which attributes are more important as each attribute normally weighs the same to the total Euclidean distance.

GitHub Link:

https://github.com/monicabernard/CAP-5610_Machine-Learning.git