29.9 Test/Evaluation Time and Space Complexity

For a data point 'x_q' in KNN, in order to classify the label for the data points, we also need to take time and space complexities into consideration.

Here the data points are represented as 'x_q' each and we have to predict their corresponding class label 'y_q'.

Inputs in KNN Algorithm: D_{Train}, K, $x_q \in R^d$

Output: y_q

Pseudo Algorithm

```
KNN_points = []
for each_x_i in D_Train:
    # Compute the distance between each_x_i and 'x_q'. (Takes O(d) as we have to compute the difference for all the 'd' dimensions and square it.
    # Keep the smallest 'K' distances and store them in KNN_points. It takes O(K)

# Let us assume 'K' is small. So let's ignore 'K' in the Time Complexity. Then after this,
    count_positive = 0, count_negative = 0
    for each_x_i in KNN_points:
        if y_i is +ve:
            count_positive += 1
        else:
            count_negative += 1
    if count_positive>count_negative:
        return y_q = 1
    else:
        return y_q = 0
```

Here the time complexity for the execution of the portion of code highlighted in yellow color is O(nd).

(It is because the 'for' loop has to traverse through the entire training dataset 'D_{Train}' of 'n' points which takes O(n) and again it has to compute the difference of the components and square them up, for all the 'd' dimensions, which required O(d). So the total time complexity for this task is O(nd))

The time complexity for the execution of the portion of the code highlighted in blue color is O(K). If 'K' is very small, then it would be O(1).

The time complexity for the execution of the portion of the code highlighted in green color is O(1).

So now the total time complexity to run this code = O(nd) + O(1) + O(1) = O(nd)
If d<<<n, then this total time complexity = O(n).

Now we shall check the space complexity. The space complexity is the total number of space locations needed to run the program. For the testing phase of KNN, the total space needed is O(nd).

Conclusion
Test Time Complexity for KNN = O(nd)
Test Space Complexity for KNN = O(nd)