

```
In [1]: #Import the Packages
import numpy as np
import pandas as pd
```

```
In [2]: #Read the data
df = pd.read_excel(r"C:\Users\SANKHA\OneDrive\Documents\PR_assignment(VOWEL Data).x
```

```
In [3]: #Show the data
df
```

```
Out[3]:
```

	f1	f2	f3	vowel class
0	700	1500	2600	1
1	550	1550	2400	1
2	700	1500	2600	1
3	700	1600	2700	1
4	550	1600	2600	1
...
866	500	1050	2900	6
867	500	1000	3000	6
868	500	1000	2800	6
869	500	900	2800	6
870	500	950	2700	6

871 rows × 4 columns

```
In [4]: from sklearn.model_selection import train_test_split
```

Implementation of MDC Classifier

```
In [5]: #Initialize accuracy list
accuracy_lst= []
#Define test sizes
test_size_lst = [0.2,0.3,0.4]
#Loop through different testsizes
for ele in test_size_lst:
    #Loop through 10 iterations
    for i in range(10):
        # Split data into train and test sets for each vowel class

        df1 = df[df['vowel class']==1]
        X_1 = df1.drop(columns=['vowel class'])
        y_1 = df1['vowel class']
        X1_train,X1_test,y1_train,y1_test = train_test_split(X_1,y_1,test_size=ele)

        df2 = df[df['vowel class']==2]
        X_2 = df2.drop(columns=['vowel class'])
        y_2 = df2['vowel class']
        X2_train,X2_test,y2_train,y2_test = train_test_split(X_2,y_2,test_size=ele)

        df3 = df[df['vowel class']==3]
        X_3 = df3.drop(columns=['vowel class'])
```

```

y_3 = df3['vowel class']
X3_train,X3_test,y3_train,y3_test = train_test_split(X_3,y_3,test_size=ele)

df4 = df[df['vowel class']==4]
X_4 = df4.drop(columns=['vowel class'])
y_4 = df4['vowel class']
X4_train,X4_test,y4_train,y4_test = train_test_split(X_4,y_4,test_size=ele)

df5 = df[df['vowel class']==5]
X_5 = df5.drop(columns=['vowel class'])
y_5 = df5['vowel class']
X5_train,X5_test,y5_train,y5_test = train_test_split(X_5,y_5,test_size=ele)

df6 = df[df['vowel class']==6]
X_6 = df6.drop(columns=['vowel class'])
y_6 = df6['vowel class']
X6_train,X6_test,y6_train,y6_test = train_test_split(X_6,y_6,test_size=ele)

X_1_ = X1_train.join(y1_train)
X_2_ = X2_train.join(y2_train)
X_3_ = X3_train.join(y3_train)
X_4_ = X4_train.join(y4_train)
X_5_ = X5_train.join(y5_train)
X_6_ = X6_train.join(y6_train)

# Concatenate train sets and prepare train data

train_final = pd.concat([X_1_,X_2_,X_3_,X_4_,X_5_,X_6_])
train_final

X_train = train_final.drop(columns='vowel class')
print(X_train)
y_train = pd.DataFrame(train_final['vowel class'])
print(y_train)

# Concatenate test sets and prepare test data

X_test = pd.concat([X1_test,X2_test,X3_test,X4_test,X5_test,X6_test])
print(X_test)

y_test = pd.concat([y1_test,y2_test,y3_test,y4_test,y5_test,y6_test])
print(y_test)

m1 =np.array(X1_train.mean())
m2 =np.array(X2_train.mean())
m3 =np.array(X3_train.mean())
m4 =np.array(X4_train.mean())
m5 =np.array(X5_train.mean())
m6 =np.array(X6_train.mean())

#Function to calculate Euclidean Distance
def euclidean_distance(x,y):
    return np.sqrt(np.sum((x-y)**2))

#Perform Minimum Distance Classifier

y_pred = []
for testpoint in np.array(X_test):
    d1 = euclidean_distance(testpoint,m1)
    d2 = euclidean_distance(testpoint,m2)
    d3 = euclidean_distance(testpoint,m3)
    d4 = euclidean_distance(testpoint,m4)

```

```
d5 = euclidean_distance(testpoint,m5)
d6 = euclidean_distance(testpoint,m6)
l = [d1,d2,d3,d4,d5,d6]
m = min(l)
i = l.index(m)
pred_class = i+1
y_pred.append(pred_class)
print(y_pred)

y_pred_df = pd.DataFrame({'Pred_class':y_pred})
print(y_pred_df)
y_test_df= pd.DataFrame(y_test)
y_test_df.reset_index(inplace=True)
print(y_test_df)

df_forprediction = y_test_df.join(y_pred_df).drop(columns=['index'])
print(df_forprediction)

#Calculating Accuracy
true_pred = df_forprediction[df_forprediction['vowel class']==df_forprediction['Pred_class']]
accuracy = (true_pred.shape[0]/df_forprediction.shape[0])*100
accuracy_lst.append(accuracy)
print(accuracy_lst)
```

	Pred_class
0	1
1	1

2	1
3	1
4	2
..	...
172	4
173	4
174	4
175	6
176	6

```
[177 rows x 1 columns]
   index  vowel class
0      55          1
1       9          1
2      27          1
3       1          1
4      24          1
..     ...         ...
172   827          6
173   780          6
174   852          6
175   775          6
176   705          6
```

```
[177 rows x 2 columns]
   vowel class  Pred_class
0           1           1
1           1           1
2           1           1
3           1           1
4           1           2
..         ...         ...
172         6           4
173         6           4
174         6           4
175         6           6
176         6           6
```

```
[177 rows x 2 columns]
   f1    f2    f3
26  600 1400 2300
24  600 1200 2300
67  550 1500 2300
13  550 1800 2600
64  500 1900 2300
..   ...   ...   ...
744 500 1200 2300
797 550 1050 2500
810 400 1000 2300
798 550 1000 2600
792 500 1000 2600
```

```
[694 rows x 3 columns]
   vowel class
26           1
24           1
67           1
13           1
64           1
..         ...
744         6
797         6
810         6
798         6
```

792

6

[694 rows x 1 columns]

	f1	f2	f3
14	600	1400	2600
59	650	1300	2300
23	400	1200	2400
54	600	1350	2300
0	700	1500	2600
..
701	600	1150	2700
833	450	950	2100
790	500	1000	2600
748	450	1000	2350
813	400	1050	2300

[177 rows x 3 columns]

14	1	
59	1	
23	1	
54	1	
0	1	
..		
701	6	
833	6	
790	6	
748	6	
813	6	

Name: vowel class, Length: 177, dtype: int64

[1, 2, 6, 1, 1, 1, 5, 1, 5, 2, 1, 1, 1, 1, 1, 2, 2, 2, 6, 2, 2, 2, 2, 2, 2, 6, 2, 1, 2, 1, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 1, 3, 3, 3, 5, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 4, 2, 4, 6, 4, 4, 4, 2, 4, 6, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 6, 6, 5, 1, 1, 3, 5, 3, 3, 1, 5, 1, 5, 6, 5, 5, 5, 5, 5, 3, 3, 5, 5, 5, 5, 5, 5, 6, 3, 3, 5, 6, 5, 3, 1, 1, 5, 5, 5, 3, 5, 5, 3, 5, 6, 2, 6, 6, 4, 1, 6, 2, 6, 4, 6, 2, 6, 6, 4, 2, 6, 6, 6, 6, 4, 6, 6, 6, 4, 6, 6, 4]

Pred_class

0	1
1	2
2	6
3	1
4	1
..	...
172	6
173	4
174	6
175	6
176	4

[177 rows x 1 columns]

	index	vowel class
0	14	1
1	59	1
2	23	1
3	54	1
4	0	1
..
172	701	6
173	833	6
174	790	6
175	748	6
176	813	6

[177 rows x 2 columns]

	vowel	class	Pred_class
0		1	1
1		1	2
2		1	6
3		1	1
4		1	1
..	
172		6	6
173		6	4
174		6	6
175		6	6
176		6	4

[177 rows x 2 columns]

	f1	f2	f3
30	650	1200	2300
16	650	1600	2600
58	700	1300	2300
67	550	1500	2300
57	700	1300	2300
..
763	500	1000	2700
783	450	900	2250
745	400	1200	2400
857	450	900	2900
704	400	1150	2200

[694 rows x 3 columns]

	vowel	class
30		1
16		1
58		1
67		1
57		1
..		...
763		6
783		6
745		6
857		6
704		6

[694 rows x 1 columns]

	f1	f2	f3
47	650	1400	2000
36	500	1450	2400
51	600	1300	1900
13	550	1800	2600
4	550	1600	2600
..
798	550	1000	2600
712	500	1200	2300
849	550	1100	2850
703	400	1000	2200
773	550	1100	2800

[177 rows x 3 columns]

47	1
36	1
51	1
13	1
4	1
..	
798	6
712	6

```

849      6
703      6
773      6
Name: vowel class, Length: 177, dtype: int64
[2, 1, 2, 5, 5, 1, 5, 1, 1, 1, 1, 5, 1, 1, 5, 2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 2,
1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 1, 6, 4, 4, 4, 6, 4, 6, 4, 4, 6, 4, 4, 6,
4, 4, 6, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 5, 5, 3, 5, 5, 5, 1, 3, 5,
3, 1, 5, 3, 1, 1, 5, 1, 5, 1, 3, 5, 3, 5, 1, 3, 3, 3, 5, 5, 5, 5, 5, 5, 3, 1, 5,
3, 5, 5, 1, 5, 5, 2, 6, 4, 6, 6, 2, 4, 6, 6, 6, 6, 6, 4, 2, 4, 6, 6, 6, 6, 6,
6, 2, 6, 6, 1, 4, 6, 2, 2, 6, 6, 2, 6, 4, 6]
      Pred_class
0              2
1              1
2              2
3              5
4              5
..           ...
172            6
173            2
174            6
175            4
176            6

[177 rows x 1 columns]
      index  vowel class
0         47           1
1         36           1
2         51           1
3         13           1
4          4           1
..       ...         ...
172       798           6
173       712           6
174       849           6
175       703           6
176       773           6

[177 rows x 2 columns]
      vowel class  Pred_class
0              1           2
1              1           1
2              1           2
3              1           5
4              1           5
..           ...         ...
172            6           6
173            6           2
174            6           6
175            6           4
176            6           6

[177 rows x 2 columns]
      f1    f2    f3
60    700  1350  2300
45    650  1350  2100
57    700  1300  2300
7     550  1700  2600
11    500  1750  2600
..     ...   ...   ...
695   600  1050  2700
852   400   800  2700
863   500   900  2800
753   600  1200  2300

```



```
764 400 950 2700
```

```
[694 rows x 3 columns]
```

```
vowel class
```

```
60      1
45      1
57      1
7       1
11      1
..      ...
695     6
852     6
863     6
753     6
764     6
```

```
[694 rows x 1 columns]
```

```
      f1      f2      f3
65    700   1300   2300
38    550   1400   2300
48    600   1800   2300
55    700   1400   2300
1     550   1550   2400
..     ...     ...     ...
832   400   1000   2300
742   600   1200   2300
846   500   1000   2750
722   400   1000   2300
816   500    950   2300
```

```
[177 rows x 3 columns]
```

```
65      1
38      1
48      1
55      1
1       1
..
832     6
742     6
846     6
722     6
816     6
```

```
Name: vowel class, Length: 177, dtype: int64
```

```
[2, 1, 1, 1, 1, 1, 1, 2, 1, 6, 1, 2, 1, 2, 2, 2, 2, 2, 2, 2, 6, 6, 1, 2, 2, 6,
1, 2, 1, 2, 2, 2, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 5, 5, 3, 3, 3, 1, 3,
3, 3, 3, 3, 5, 3, 1, 5, 3, 3, 5, 3, 3, 3, 4, 4, 6, 4, 4, 6, 4, 4, 4, 4, 4, 6, 4,
4, 4, 4, 4, 2, 4, 4, 4, 4, 6, 4, 4, 6, 4, 2, 4, 1, 4, 5, 5, 5, 5, 1, 5, 5, 5, 5,
5, 5, 3, 5, 3, 5, 1, 5, 3, 5, 5, 3, 5, 3, 5, 5, 1, 5, 1, 5, 5, 3, 1, 5, 5, 1, 5,
5, 5, 5, 5, 5, 1, 6, 6, 6, 6, 4, 6, 6, 6, 4, 6, 4, 4, 6, 6, 6, 6, 6, 2, 6, 6, 4,
2, 6, 6, 6, 6, 6, 6, 6, 4, 6, 4, 2, 6, 4, 6]
```

```
Pred_class
```

```
0      2
1      1
2      1
3      1
4      1
..      ...
172     4
173     2
174     6
175     4
176     6
```

```
[177 rows x 1 columns]
```

	index	vowel	class
0	65		1
1	38		1
2	48		1
3	55		1
4	1		1
..
172	832		6
173	742		6
174	846		6
175	722		6
176	816		6

[177 rows x 2 columns]

	vowel	class	Pred_class
0		1	2
1		1	1
2		1	1
3		1	1
4		1	1
..	
172		6	4
173		6	2
174		6	6
175		6	4
176		6	6

[177 rows x 2 columns]

	f1	f2	f3
68	650	1200	2300
27	500	1400	2360
11	500	1750	2600
26	600	1400	2300
62	700	1400	2300
..
768	600	1100	2700
845	500	1000	2700
696	450	1100	2700
734	500	1250	2300
799	500	1000	2300

[694 rows x 3 columns]

	vowel	class
68		1
27		1
11		1
26		1
62		1
..		...
768		6
845		6
696		6
734		6
799		6

[694 rows x 1 columns]

	f1	f2	f3
13	550	1800	2600
3	700	1600	2700
64	500	1900	2300
31	550	1200	2360
23	400	1200	2400
..
732	600	1200	2300

```

739 500 1100 2250
844 500 1000 2900
795 500 900 2500
742 600 1200 2300

```

```
[177 rows x 3 columns]
```

```

13      1
3       1
64      1
31      1
23      1
..
732     6
739     6
844     6
795     6
742     6

```

```
Name: vowel class, Length: 177, dtype: int64
```

```

[5, 5, 5, 2, 6, 5, 2, 6, 1, 1, 1, 5, 5, 5, 5, 6, 2, 2, 2, 6, 6, 2, 2, 6, 2, 1, 2,
1, 2, 2, 6, 2, 2, 5, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 1, 3, 3, 3, 3, 5, 5, 3, 3, 3,
3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 5, 4, 4, 4, 4, 4, 6, 2, 4, 6, 4, 4, 4, 4,
6, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 3, 5, 3, 3, 5, 5, 3, 5, 5,
3, 3, 3, 3, 3, 5, 3, 1, 5, 5, 3, 5, 1, 5, 5, 5, 1, 5, 1, 5, 5, 5, 1, 5, 5, 1, 5,
5, 3, 1, 3, 1, 5, 4, 6, 4, 6, 4, 6, 2, 2, 6, 6, 6, 6, 4, 4, 6, 4, 6, 6, 2, 4, 6,
6, 4, 4, 4, 2, 6, 2, 6, 6, 6, 2, 2, 6, 4, 2]

```

```
Pred_class
```

```

0      5
1      5
2      5
3      2
4      6
..
172     2
173     2
174     6
175     4
176     2

```

```
[177 rows x 1 columns]
```

```

index vowel class
0      13      1
1       3      1
2      64      1
3      31      1
4      23      1
..
172    732     6
173    739     6
174    844     6
175    795     6
176    742     6

```

```
[177 rows x 2 columns]
```

```

vowel class Pred_class
0          1          5
1          1          5
2          1          5
3          1          2
4          1          6
..
172         6          2
173         6          2
174         6          6
175         6          4

```

```
[2, 1, 2, 2, 1, 1, 2, 1, 5, 1, 2, 1, 1, 1, 5, 1, 2, 2, 2, 2, 2, 6, 2, 2, 2, 2, 1, 2,
2, 2, 2, 2, 2, 3, 3, 5, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 4, 6, 4, 6, 4, 6, 2, 4, 4, 4, 4, 4, 6,
4, 4, 4, 4, 4, 4, 4, 4, 6, 6, 4, 4, 4, 4, 6, 4, 4, 5, 3, 5, 6, 5, 5, 5, 1, 3,
3, 3, 5, 2, 5, 3, 5, 5, 5, 5, 5, 5, 1, 5, 5, 5, 5, 5, 5, 5, 1, 5, 5, 5, 3, 5,
5, 5, 5, 3, 3, 5, 4, 4, 2, 4, 6, 4, 4, 1, 6, 2, 4, 6, 6, 1, 6, 2, 6, 4, 6, 2, 6,
4, 4, 4, 4, 2, 4, 2, 6, 6, 2, 6, 2, 2, 6, 6]
```

Pred_class

0	2
1	1
2	2
3	2
4	1
..	...
172	6
173	2
174	2
175	6
176	6

[177 rows x 1 columns]

	index	vowel	class
0	59		1
1	32		1
2	29		1
3	58		1
4	42		1
..
172	699		6
173	805		6
174	720		6
175	851		6
176	710		6

[177 rows x 2 columns]

	vowel	class	Pred_class
0		1	2
1		1	1
2		1	2
3		1	2
4		1	1
..	
172		6	6
173		6	2
174		6	2
175		6	6
176		6	6

[177 rows x 2 columns]

	f1	f2	f3
40	550	1500	2360
68	650	1200	2300
18	600	1400	2600
67	550	1500	2300
56	600	1400	2300
..
767	500	1100	2700
777	500	1050	2560
843	500	1000	2700
700	400	1200	2700
863	500	900	2800

[694 rows x 3 columns]

	vowel	class
40		1
68		1
18		1
67		1
56		1
..		...
767		6

777	6
843	6
700	6
863	6

[694 rows x 1 columns]

	f1	f2	f3
63	500	1900	2300
57	700	1300	2300
44	650	1400	2100
24	600	1200	2300
65	700	1300	2300
..
791	500	950	2600
722	400	1000	2300
737	400	1000	2300
746	450	1000	2350
822	500	850	2300

[177 rows x 3 columns]

63	1
57	1
44	1
24	1
65	1
..	..
791	6
722	6
737	6
746	6
822	6

Name: vowel class, Length: 177, dtype: int64

[5, 2, 1, 2, 2, 2, 1, 5, 2, 6, 6, 1, 5, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 1, 2, 2, 2, 6, 5, 3, 3, 3, 5, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 5, 3, 5, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 6, 4, 4, 4, 4, 6, 4, 4, 4, 6, 6, 6, 4, 4, 4, 4, 2, 4, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 6, 4, 4, 4, 5, 3, 5, 1, 6, 5, 5, 3, 3, 3, 5, 5, 3, 1, 5, 5, 1, 3, 5, 1, 3, 1, 5, 5, 1, 5, 5, 3, 5, 5, 5, 1, 5, 5, 5, 5, 3, 5, 3, 5, 5, 1, 4, 6, 6, 6, 2, 6, 6, 2, 6, 4, 6, 4, 2, 6, 2, 6, 4, 4, 6, 6, 6, 2, 2, 4, 4, 4, 4, 6, 6, 6, 6, 6, 6, 4, 4, 4, 4]

Pred_class

0	5
1	2
2	1
3	2
4	2
..	...
172	6
173	4
174	4
175	4
176	4

[177 rows x 1 columns]

	index	vowel class
0	63	1
1	57	1
2	44	1
3	24	1
4	65	1
..
172	791	6
173	722	6
174	737	6
175	746	6

176 822 6

```
[177 rows x 2 columns]
vowel class  Pred_class
0           1           5
1           1           2
2           1           1
3           1           2
4           1           2
..         ...         ...
172         6           6
173         6           4
174         6           4
175         6           4
176         6           4
```

```
[177 rows x 2 columns]
f1    f2    f3
47   650  1400  2000
70   650  1600  2300
32   500  1350  2360
21   600  1400  2200
31   550  1200  2360
..   ...   ...   ...
847  500  1000  2700
850  500  1000  2800
731  600  1200  2300
740  400  1100  2300
746  450  1000  2350
```

```
[694 rows x 3 columns]
vowel class
47           1
70           1
32           1
21           1
31           1
..         ...
847         6
850         6
731         6
740         6
746         6
```

```
[694 rows x 1 columns]
f1    f2    f3
37   700  1550  2360
56   600  1400  2300
38   550  1400  2300
50   700  1750  2300
13   550  1800  2600
..   ...   ...   ...
752  500  1100  2250
782  500   950  2560
739  500  1100  2250
783  450   900  2250
816  500   950  2300
```

```
[177 rows x 3 columns]
37    1
56    1
38    1
50    1
13    1
```

```

..
752    6
782    6
739    6
783    6
816    6
Name: vowel class, Length: 177, dtype: int64
[1, 1, 1, 1, 5, 1, 1, 1, 2, 1, 5, 1, 2, 1, 5, 1, 2, 2, 2, 2, 1, 2, 2, 6, 1, 2, 6,
2, 2, 6, 2, 2, 2, 3, 3, 3, 3, 3, 3, 5, 3, 3, 5, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 5, 5, 3, 3, 3, 3, 3, 3, 4, 4, 4, 4, 1, 4, 4, 4, 4, 4, 4, 4,
4, 6, 4, 6, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 1, 5, 5, 5, 1, 1, 5, 3, 5,
5, 5, 5, 1, 5, 5, 3, 5, 6, 3, 3, 5, 6, 1, 5, 1, 5, 5, 3, 5, 6, 5, 5, 2, 3, 1, 3,
3, 5, 3, 3, 3, 3, 6, 6, 6, 6, 4, 6, 6, 4, 4, 4, 6, 2, 4, 6, 6, 6, 6, 6, 6, 6,
6, 4, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 4, 6]
Pred_class
0          1
1          1
2          1
3          1
4          5
..         ...
172         6
173         6
174         6
175         4
176         6

[177 rows x 1 columns]
   index  vowel class
0      37          1
1      56          1
2      38          1
3      50          1
4      13          1
..     ...      ...
172    752          6
173    782          6
174    739          6
175    783          6
176    816          6

[177 rows x 2 columns]
   vowel class  Pred_class
0           1           1
1           1           1
2           1           1
3           1           1
4           1           5
..          ...          ...
172          6           6
173          6           6
174          6           6
175          6           4
176          6           6

[177 rows x 2 columns]
   f1    f2    f3
15  550  1400  2600
10  550  2000  2700
27  500  1400  2360
8   550  1400  2550
70  650  1600  2300
..   ...   ...   ...
718 400  1100  2300

```


176

6

[177 rows x 1 columns]

	index	vowel class
0	45	1
1	47	1
2	56	1
3	36	1
4	71	1
..
172	868	6
173	780	6
174	746	6
175	783	6
176	762	6

[177 rows x 2 columns]

	vowel class	Pred_class
0	1	2
1	1	2
2	1	1
3	1	1
4	1	2
..
172	6	6
173	6	4
174	6	6
175	6	4
176	6	6

[177 rows x 2 columns]

	f1	f2	f3
62	700	1400	2300
23	400	1200	2400
13	550	1800	2600
35	450	1650	2400
60	700	1350	2300
..
748	450	1000	2350
760	600	1150	2720
735	500	1000	2300
739	500	1100	2250
740	400	1100	2300

[694 rows x 3 columns]

	vowel class
62	1
23	1
13	1
35	1
60	1
..	...
748	6
760	6
735	6
739	6
740	6

[694 rows x 1 columns]

	f1	f2	f3
54	600	1350	2300
11	500	1750	2600
70	650	1600	2300
55	700	1400	2300

```

56    600    1400    2300
..     ...     ...     ...
786    500    1900    2250
709    400    1300    2300
858    500    1000    2800
782    500     950    2560
853    600    1050    2850

```

```
[177 rows x 3 columns]
```

```

54      1
11      1
70      1
55      1
56      1

```

```

..
786     6
709     6
858     6
782     6
853     6

```

```
Name: vowel class, Length: 177, dtype: int64
```

```

[1, 5, 1, 1, 1, 2, 1, 1, 5, 1, 1, 1, 1, 1, 2, 2, 6, 2, 2, 2, 6, 2, 2, 2, 2, 2, 6,
2, 2, 6, 1, 2, 2, 3, 3, 1, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5,
3, 3, 3, 5, 5, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 4, 6, 4, 6, 4, 1, 6, 4,
4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 2, 4, 4, 4, 4, 4, 4, 5, 5, 5, 1, 1, 5, 5, 3, 6,
1, 5, 5, 1, 5, 5, 5, 3, 5, 1, 5, 1, 1, 5, 5, 5, 5, 3, 5, 5, 3, 3, 5, 5, 1, 5, 6,
3, 3, 5, 5, 5, 5, 6, 6, 5, 6, 6, 2, 6, 6, 6, 6, 6, 6, 6, 6, 4, 2, 6, 4, 6, 6,
6, 6, 2, 6, 6, 6, 6, 6, 6, 6, 5, 1, 6, 6, 6]

```

```
Pred_class
```

```

0      1
1      5
2      1
3      1
4      1
..     ...
172     5
173     1
174     6
175     6
176     6

```

```
[177 rows x 1 columns]
```

```

index vowel class
0      54      1
1      11      1
2      70      1
3      55      1
4      56      1
..     ...     ...
172    786      6
173    709      6
174    858      6
175    782      6
176    853      6

```

```
[177 rows x 2 columns]
```

```

vowel class Pred_class
0      1      1
1      1      5
2      1      1
3      1      1
4      1      1
..     ...     ...
172     6      5

```

173	6	1
174	6	6
175	6	6
176	6	6

[177 rows x 2 columns]

```
[67.79661016949152, 70.05649717514125, 70.05649717514125, 70.62146892655367, 59.88
7005649717516, 67.79661016949152, 63.2768361581921, 70.62146892655367, 70.62146892
655367, 74.57627118644068]
```

	f1	f2	f3
14	600	1400	2600
19	700	1350	2600
11	500	1750	2600
18	600	1400	2600
44	650	1400	2100
..
726	400	1100	2300
759	600	1100	2720
814	450	900	2300
868	500	1000	2800
710	450	1150	2300

[607 rows x 3 columns]

	vowel	class
14		1
19		1
11		1
18		1
44		1
..		...
726		6
759		6
814		6
868		6
710		6

[607 rows x 1 columns]

	f1	f2	f3
3	700	1600	2700
23	400	1200	2400
15	550	1400	2600
58	700	1300	2300
22	550	1600	2200
..
853	600	1050	2850
711	600	1200	2300
720	550	1100	2300
741	500	1200	2300
863	500	900	2800

[264 rows x 3 columns]

3	1
23	1
15	1
58	1
22	1
..	
853	6
711	6
720	6
741	6
863	6

Name: vowel class, Length: 264, dtype: int64

[5, 6, 1, 2, 1, 1, 2, 5, 6, 6, 2, 5, 1, 5, 1, 1, 1, 1, 1, 2, 2, 2, 6, 2, 2, 2,

	f1	f2	f3
49	750	1350	2100
47	650	1400	2000
9	600	1600	2600
64	500	1900	2300
34	700	1400	2360
..
787	500	900	2700
729	400	1300	2300
819	450	1000	2300
803	400	1000	2300
800	450	1200	2300

vowel class

49	1
47	1
9	1
64	1
34	1
..	...
787	6
729	6
819	6
803	6
800	6

f1 f2 f3

39	750	1500	2360
28	500	1400	2360
48	600	1800	2300
37	700	1550	2360
15	550	1400	2600
..
838	500	900	2800
813	400	1050	2300
750	450	950	2100
796	500	1000	2400
756	500	1000	2720

39	1
28	1
48	1
37	1
15	1

```

      ..
838    6
813    6
750    6
796    6
756    6

```

[1, 1, 5, 1, 1, 1, 1, 5, 1, 1, 5, 1, 1, 1, 1, 2, 5, 2, 1, 5, 2, 1, 2, 2, 6, 2, 2,
2, 1, 2, 2, 2, 2, 2, 2, 2, 2, 1, 2, 2, 2, 2, 6, 2, 2, 2, 1, 2, 6, 5, 5, 3, 3, 3,
5, 3, 3, 3, 3, 5, 3, 3, 3, 5, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 4, 4, 2, 4, 4, 4, 4,
4, 6, 4, 4, 4, 6, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 4, 6, 6, 4,
4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 6, 5, 5, 6, 1, 5, 3, 5, 5, 3, 1, 3, 5, 5, 5, 5,
5, 1, 1, 5, 1, 5, 5, 1, 5, 5, 1, 5, 5, 3, 1, 3, 5, 5, 5, 3, 5, 3, 5, 5, 5, 5, 1,
5, 3, 1, 1, 5, 1, 1, 3, 5, 5, 5, 5, 5, 5, 6, 1, 5, 5, 1, 3, 6, 6, 6, 6, 6, 6,
6, 4, 6, 6, 2, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 4, 4, 6, 4, 4, 6, 6, 6, 6,
4, 2, 6, 6, 2, 6, 6, 2, 6, 6, 2, 6, 6, 4, 6, 6, 6, 4, 4, 6, 6]

0	1
1	1
2	5
3	1
4	1
...	...
259	6
260	4
261	4
262	6
263	6

[264 rows x 1 columns]

	index	vowel	class
0	39		1
1	28		1
2	48		1
3	37		1
4	15		1
..
259	838		6
260	813		6
261	750		6
262	796		6
263	756		6

[264 rows x 2 columns]

	vowel	class	Pred_class
0		1	1
1		1	1
2		1	5
3		1	1
4		1	1
..	
259		6	6
260		6	4
261		6	4
262		6	6
263		6	6

[264 rows x 2 columns]

	f1	f2	f3
46	600	1700	2300
23	400	1200	2400
2	700	1500	2600
17	550	1700	2600
63	500	1900	2300
..
813	400	1050	2300
862	500	1000	2900
842	500	1000	2700
776	500	1000	2560
834	500	1000	2300

[607 rows x 3 columns]

	vowel	class
46		1
23		1
2		1
17		1
63		1
..		...
813		6
862		6
842		6
776		6
834		6

[607 rows x 1 columns]

	f1	f2	f3
28	500	1400	2360
13	550	1800	2600
38	550	1400	2300
27	500	1400	2360
64	500	1900	2300
..

```

840 500 900 2750
713 550 1250 2300
829 450 1050 2300
735 500 1000 2300
770 600 1100 2750

```

```
[264 rows x 3 columns]
```

```

28      1
13      1
38      1
27      1
64      1
..
840     6
713     6
829     6
735     6
770     6

```

```
Name: vowel class, Length: 264, dtype: int64
```

```

[1, 5, 1, 1, 5, 2, 1, 1, 1, 2, 1, 1, 2, 2, 2, 1, 1, 1, 1, 6, 1, 5, 2, 1, 2, 6, 2,
6, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 6, 2, 1, 2, 2, 2, 2, 3, 3, 3, 5, 5,
3, 3, 3, 5, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 5, 5, 5, 3, 3, 3, 5, 3, 3, 2, 4, 4, 4, 4, 4, 4,
4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 2, 4, 4, 4,
4, 4, 6, 4, 4, 6, 4, 4, 4, 4, 4, 4, 1, 3, 5, 1, 5, 1, 5, 3, 5, 5, 5, 1, 3, 5, 5,
1, 1, 6, 3, 5, 5, 5, 5, 5, 3, 1, 5, 5, 5, 5, 3, 5, 5, 5, 3, 3, 5, 1, 6, 5, 3, 5,
5, 5, 3, 1, 5, 5, 1, 3, 5, 3, 1, 1, 1, 1, 5, 5, 5, 5, 3, 5, 3, 4, 6, 6, 4, 6, 6,
6, 6, 4, 6, 4, 4, 4, 4, 6, 6, 6, 2, 2, 6, 6, 6, 6, 6, 6, 6, 2, 4, 6, 6, 6, 6, 6,
6, 6, 6, 6, 4, 6, 2, 4, 6, 4, 4, 6, 6, 4, 2, 6, 6, 2, 6, 6, 6]

```

```
Pred_class
```

```

0      1
1      5
2      1
3      1
4      5
..
259     6
260     2
261     6
262     6
263     6

```

```
[264 rows x 1 columns]
```

```

index vowel class
0      28      1
1      13      1
2      38      1
3      27      1
4      64      1
..
259    840      6
260    713      6
261    829      6
262    735      6
263    770      6

```

```
[264 rows x 2 columns]
```

```

vowel class Pred_class
0      1      1
1      1      5
2      1      1
3      1      1
4      1      5
..

```


259	6	6
260	6	2
261	6	6
262	6	6
263	6	6

[264 rows x 2 columns]

	f1	f2	f3
20	550	1350	2200
9	600	1600	2600
42	600	1400	2360
45	650	1350	2100
29	550	1300	2300
..
856	500	1100	2800
699	450	1100	2700
728	450	1100	2300
745	400	1200	2400
837	600	1000	2700

[607 rows x 3 columns]

	vowel	class
20		1
9		1
42		1
45		1
29		1
..		...
856		6
699		6
728		6
745		6
837		6

[607 rows x 1 columns]

	f1	f2	f3
22	550	1600	2200
38	550	1400	2300
39	750	1500	2360
16	650	1600	2600
53	550	1500	2600
..
823	400	900	2300
818	400	850	2300
829	450	1050	2300
739	500	1100	2250
721	400	900	2300

[264 rows x 3 columns]

22	1
38	1
39	1
16	1
53	1
..	
823	6
818	6
829	6
739	6
721	6

Name: vowel class, Length: 264, dtype: int64

[1, 1, 1, 1, 1, 2, 5, 1, 1, 2, 5, 1, 5, 1, 1, 1, 1, 1, 5, 2, 2, 1, 2, 2, 2, 2, 1, 2, 2, 2, 1, 2, 2, 2, 2, 2, 6, 2, 2, 6, 2, 2, 2, 2, 2, 2, 2, 6, 6, 3, 3, 3, 3, 3, 5, 3, 3, 5, 3, 3, 3, 1, 3, 3, 3, 3, 3, 3, 5, 3, 5, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3,

3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 6, 6, 4, 4, 4, 4, 6,
 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 6,
 4, 6, 4, 4, 4, 4, 4, 4, 6, 4, 4, 5, 5, 5, 1, 1, 3, 5, 5, 5, 5, 1, 3, 5, 5, 1,
 3, 3, 3, 5, 5, 1, 5, 3, 5, 1, 5, 1, 3, 5, 3, 5, 6, 5, 5, 5, 5, 5, 5, 3, 3, 5,
 5, 5, 1, 5, 5, 5, 5, 5, 3, 5, 1, 5, 1, 5, 5, 5, 2, 1, 5, 6, 4, 6, 4, 6, 2,
 6, 6, 6, 2, 1, 6, 6, 6, 6, 4, 2, 4, 6, 6, 6, 6, 2, 6, 4, 6, 6, 6, 6, 6, 4,
 6, 4, 6, 2, 4, 2, 4, 6, 6, 6, 6, 4, 6, 6, 6, 6, 4, 4, 6, 6, 4]

Pred_class

0	1
1	1
2	1
3	1
4	1
..	...
259	4
260	4
261	6
262	6
263	4

[264 rows x 1 columns]

	index	vowel class
0	22	1
1	38	1
2	39	1
3	16	1
4	53	1
..
259	823	6
260	818	6
261	829	6
262	739	6
263	721	6

[264 rows x 2 columns]

	vowel class	Pred_class
0	1	1
1	1	1
2	1	1
3	1	1
4	1	1
..
259	6	4
260	6	4
261	6	6
262	6	6
263	6	4

[264 rows x 2 columns]

	f1	f2	f3
50	700	1750	2300
3	700	1600	2700
29	550	1300	2300
20	550	1350	2200
61	650	1600	2300
..
823	400	900	2300
776	500	1000	2560
824	500	1050	2300
782	500	950	2560
778	550	1050	2560

[607 rows x 3 columns]

vowel class

50	1
3	1
29	1
20	1
61	1
..	...
823	6
776	6
824	6
782	6
778	6

[607 rows x 1 columns]

	f1	f2	f3
14	600	1400	2600
39	750	1500	2360
32	500	1350	2360
4	550	1600	2600
43	650	1350	2360
..
792	500	1000	2600
862	500	1000	2900
717	500	1200	2300
704	400	1150	2200
702	450	1150	2700

[264 rows x 3 columns]

14	1
39	1
32	1
4	1
43	1
..	..
792	6
862	6
717	6
704	6
702	6

Name: vowel class, Length: 264, dtype: int64

[1, 1, 1, 5, 2, 2, 6, 1, 1, 2, 1, 1, 5, 5, 6, 1, 1, 1, 1, 5, 2, 5, 2, 1, 6, 6, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 6, 2, 6, 2, 2, 2, 2, 2, 6, 6, 6, 2, 2, 3, 3, 3, 3, 5, 3, 1, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 5, 3, 4, 6, 4, 6, 4, 6, 4, 4, 4, 4, 4, 4, 4, 6, 6, 6, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 6, 6, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 1, 4, 5, 5, 5, 1, 3, 3, 5, 5, 3, 1, 1, 6, 5, 5, 5, 5, 5, 6, 5, 1, 1, 5, 5, 3, 6, 3, 3, 3, 3, 3, 5, 5, 5, 5, 5, 5, 3, 5, 5, 1, 3, 5, 5, 5, 5, 5, 5, 5, 5, 3, 5, 3, 5, 3, 5, 3, 5, 5, 3, 5, 5, 5, 1, 3, 5, 4, 4, 6, 4, 6, 4, 6, 4, 6, 6, 6, 1, 6, 4, 6, 6, 4, 4, 2, 6, 6, 6, 6, 6, 4, 6, 6, 6, 6, 6, 6, 1, 6, 6, 4, 6, 6, 6, 6, 6, 6, 6, 2, 4, 2, 6, 6, 6, 2, 6, 6, 6, 2, 6, 6]

Pred_class

0	1
1	1
2	1
3	5
4	2
..	...
259	6
260	6
261	2
262	6
263	6

[264 rows x 1 columns]

index vowel class

0	14	1
1	39	1
2	32	1
3	4	1
4	43	1
..
259	792	6
260	862	6
261	717	6
262	704	6
263	702	6

[264 rows x 2 columns]

	vowel class	Pred_class
0	1	1
1	1	1
2	1	1
3	1	5
4	1	2
..
259	6	6
260	6	6
261	6	2
262	6	6
263	6	6

[264 rows x 2 columns]

	f1	f2	f3
68	650	1200	2300
46	600	1700	2300
48	600	1800	2300
38	550	1400	2300
65	700	1300	2300
..
756	500	1000	2720
709	400	1300	2300
724	450	1050	2300
787	500	900	2700
847	500	1000	2700

[607 rows x 3 columns]

	vowel class
68	1
46	1
48	1
38	1
65	1
..	...
756	6
709	6
724	6
787	6
847	6

[607 rows x 1 columns]

	f1	f2	f3
64	500	1900	2300
58	700	1300	2300
9	600	1600	2600
62	700	1400	2300
8	550	1400	2550
..
749	450	1100	2300
812	500	1050	2300

```

771  550  1500  2800
836  500   1100  2760
851  450   900   2750

```

```
[264 rows x 3 columns]
```

```

64      1
58      1
9       1
62      1
8       1

```

```

..
749     6
812     6
771     6
836     6
851     6

```

```
Name: vowel class, Length: 264, dtype: int64
```

```

[5, 2, 1, 1, 1, 1, 1, 1, 1, 5, 5, 5, 1, 6, 5, 1, 1, 1, 2, 1, 2, 5, 2, 1, 2, 2, 2,
2, 2, 2, 2, 6, 2, 2, 6, 2, 2, 2, 6, 6, 2, 2, 2, 2, 6, 2, 2, 2, 6, 3, 3, 3, 3, 3,
3, 5, 5, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 1, 3, 3, 3, 3, 3, 3, 3, 3, 1, 3, 3, 4, 4, 4, 4, 4, 4, 6,
4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 6, 4, 4, 4, 4, 4, 4, 4, 6, 2, 2, 6,
4, 4, 6, 4, 4, 4, 4, 4, 6, 4, 2, 5, 1, 3, 5, 1, 5, 5, 1, 3, 5, 5, 3, 3, 5, 5,
3, 1, 5, 3, 1, 5, 5, 5, 5, 5, 5, 1, 1, 1, 5, 5, 3, 3, 5, 5, 1, 5, 3, 5, 5, 6, 5,
3, 5, 1, 1, 5, 5, 6, 3, 1, 5, 1, 5, 5, 5, 5, 5, 1, 1, 1, 5, 5, 6, 6, 6, 6, 6,
4, 6, 6, 6, 6, 6, 6, 6, 2, 6, 4, 6, 2, 6, 6, 4, 6, 6, 6, 5, 6, 6, 6, 6, 4, 6, 6,
2, 6, 4, 4, 6, 4, 6, 6, 2, 6, 6, 6, 6, 6, 6, 6, 6, 6, 5, 6, 4]

```

```
Pred_class
```

```

0      5
1      2
2      1
3      1
4      1
..     ...
259     6
260     6
261     5
262     6
263     4

```

```
[264 rows x 1 columns]
```

```

index  vowel class
0      64          1
1      58          1
2       9          1
3      62          1
4       8          1
..     ...      ...
259    749          6
260    812          6
261    771          6
262    836          6
263    851          6

```

```
[264 rows x 2 columns]
```

```

vowel class  Pred_class
0            1           5
1            1           2
2            1           1
3            1           1
4            1           1
..           ...        ...
259          6           6
260          6           6

```

261	6	5
262	6	6
263	6	4

[264 rows x 2 columns]

	f1	f2	f3
3	700	1600	2700
48	600	1800	2300
70	650	1600	2300
36	500	1450	2400
35	450	1650	2400
..
727	400	1000	2300
800	450	1200	2300
715	500	1000	2300
735	500	1000	2300
801	500	1050	2300

[607 rows x 3 columns]

	vowel	class
3		1
48		1
70		1
36		1
35		1
..		...
727		6
800		6
715		6
735		6
801		6

[607 rows x 1 columns]

	f1	f2	f3
23	400	1200	2400
41	500	1500	2360
53	550	1500	2600
55	700	1400	2300
11	500	1750	2600
..
709	400	1300	2300
808	500	1000	2300
724	450	1050	2300
868	500	1000	2800
752	500	1100	2250

[264 rows x 3 columns]

23	1	
41	1	
53	1	
55	1	
11	1	
..		
709	6	
808	6	
724	6	
868	6	
752	6	

Name: vowel class, Length: 264, dtype: int64

[6, 1, 1, 2, 5, 5, 2, 1, 2, 5, 1, 2, 1, 2, 2, 2, 2, 5, 2, 2, 6, 2, 6, 2, 2, 6, 2,
2, 2, 2, 2, 2, 6, 2, 6, 2, 2, 6, 6, 2, 6, 2, 2, 2, 2, 2, 1, 2, 5, 3, 3, 3, 3,
3, 5, 3, 3, 3, 3, 5, 3, 5, 3, 3, 3, 3, 5, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 6, 4, 4, 4, 4, 2, 4,
6, 6, 4, 4, 4, 4, 4, 6, 4, 6, 4, 4, 4, 4, 6, 6, 4, 4, 4, 4, 4, 4, 4, 6, 6, 6,

4, 4, 4, 4, 6, 4, 6, 4, 4, 4, 4, 4, 5, 5, 1, 5, 1, 3, 5, 1, 5, 5, 5, 3, 5, 5, 5,
 1, 5, 5, 3, 5, 5, 5, 3, 5, 5, 5, 3, 5, 5, 3, 5, 3, 3, 5, 5, 5, 3, 1, 3, 5, 3, 5,
 5, 5, 1, 3, 3, 3, 5, 3, 5, 5, 5, 5, 5, 5, 1, 5, 1, 5, 5, 3, 5, 6, 2, 2, 6, 6, 4,
 6, 6, 6, 6, 6, 6, 6, 2, 2, 4, 6, 6, 6, 6, 6, 6, 4, 6, 6, 6, 6, 6, 4, 6, 2, 4, 6,
 2, 6, 6, 6, 6, 6, 6, 4, 6, 6, 6, 4, 4, 4, 6, 6, 1, 6, 6, 6, 6]

Pred_class

0	6
1	1
2	1
3	2
4	5
..	...
259	1
260	6
261	6
262	6
263	6

[264 rows x 1 columns]

	index	vowel class
0	23	1
1	41	1
2	53	1
3	55	1
4	11	1
..
259	709	6
260	808	6
261	724	6
262	868	6
263	752	6

[264 rows x 2 columns]

	vowel class	Pred_class
0	1	6
1	1	1
2	1	1
3	1	2
4	1	5
..
259	6	1
260	6	6
261	6	6
262	6	6
263	6	6

[264 rows x 2 columns]

	f1	f2	f3
16	650	1600	2600
26	600	1400	2300
5	600	1250	2700
61	650	1600	2300
70	650	1600	2300
..
719	500	1200	2300
751	500	1000	2300
862	500	1000	2900
728	450	1100	2300
725	400	1000	2300

[607 rows x 3 columns]

	vowel class
16	1
26	1

```

5          1
61         1
70         1
..         ...
719        6
751        6
862        6
728        6
725        6

```

```
[607 rows x 1 columns]
```

```

      f1    f2    f3
32  500  1350  2360
23  400  1200  2400
50  700  1750  2300
6   550  1200  2500
56  600  1400  2300
..   ...   ...   ...
787 500   900  2700
732 600  1200  2300
699 450  1100  2700
843 500  1000  2700
848 400  1000  2800

```

```
[264 rows x 3 columns]
```

```

32      1
23      1
50      1
6       1
56      1
..
787     6
732     6
699     6
843     6
848     6

```

```
Name: vowel class, Length: 264, dtype: int64
```

```

[1, 6, 1, 6, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 1, 5, 5, 2, 2, 1, 1, 2, 2, 2, 2, 2, 2,
6, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 6, 2, 2, 2, 2, 6, 2, 2, 6, 2, 2, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 5, 5, 3, 3, 3, 3, 5, 3,
3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 4, 4, 4, 4, 4, 4,
6, 4, 4, 2, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 6, 4, 4, 4,
1, 4, 6, 4, 4, 4, 4, 4, 4, 4, 4, 4, 5, 3, 3, 1, 5, 5, 5, 3, 5, 5, 5, 5, 5, 5, 5,
5, 3, 5, 5, 3, 5, 3, 3, 1, 3, 5, 5, 5, 5, 3, 5, 5, 1, 3, 6, 5, 1, 3, 5, 5, 1, 5,
3, 5, 5, 3, 3, 5, 1, 1, 5, 6, 5, 1, 3, 3, 5, 3, 3, 3, 6, 3, 5, 6, 6, 6, 2, 6, 4,
6, 6, 6, 6, 6, 6, 6, 6, 4, 6, 6, 4, 6, 6, 6, 4, 6, 6, 6, 6, 6, 6, 6, 6, 4, 6,
6, 6, 6, 4, 6, 6, 6, 6, 6, 6, 6, 4, 6, 6, 4, 2, 6, 2, 6, 6, 4]

```

```
Pred_class
```

```

0          1
1          6
2          1
3          6
4          1
..         ...
259        6
260        2
261        6
262        6
263        4

```

```
[264 rows x 1 columns]
```

```

      index  vowel class
0         32          1
1         23          1

```


2	50	1
3	6	1
4	56	1
..
259	787	6
260	732	6
261	699	6
262	843	6
263	848	6

[264 rows x 2 columns]

	vowel class	Pred_class
0	1	1
1	1	6
2	1	1
3	1	6
4	1	1
..
259	6	6
260	6	2
261	6	6
262	6	6
263	6	4

[264 rows x 2 columns]

	f1	f2	f3
17	550	1700	2600
3	700	1600	2700
10	550	2000	2700
69	600	1850	2300
65	700	1300	2300
..
739	500	1100	2250
768	600	1100	2700
753	600	1200	2300
712	500	1200	2300
716	400	1000	2300

[607 rows x 3 columns]

	vowel class
17	1
3	1
10	1
69	1
65	1
..	...
739	6
768	6
753	6
712	6
716	6

[607 rows x 1 columns]

	f1	f2	f3
24	600	1200	2300
68	650	1200	2300
54	600	1350	2300
0	700	1500	2600
19	700	1350	2600
..
732	600	1200	2300
858	500	1000	2800
822	500	850	2300
842	500	1000	2700

[illegible]

5, 5, 5, 5, 3, 5, 1, 5, 5, 5, 5, 1, 3, 5, 5, 5, 5, 5, 3, 5, 5, 4, 6, 6, 6, 6, 2, 6, 6, 6, 4, 6, 6, 2, 2, 2, 6, 6, 6, 4, 6, 6, 6, 6, 6, 6, 6, 6, 4, 4, 4, 6, 4, 6, 6, 4, 2, 6, 6, 4, 6, 6, 6, 6, 6, 6, 4, 6, 4, 4, 6, 6, 6, 2]

Pred_class

0	1
1	1
2	5
3	1
4	5
..	...
259	4
260	6
261	6
262	6
263	2

[264 rows x 1 columns]

	index	vowel class
0	19	1
1	21	1
2	4	1
3	39	1
4	69	1
..
259	809	6
260	706	6
261	813	6
262	816	6
263	733	6

[264 rows x 2 columns]

	vowel class	Pred_class
0	1	1
1	1	1
2	1	5
3	1	1
4	1	5
..
259	6	4
260	6	6
261	6	6
262	6	6
263	6	2

[264 rows x 2 columns]

[67.79661016949152, 70.05649717514125, 70.05649717514125, 70.62146892655367, 59.887005649717516, 67.79661016949152, 63.2768361581921, 70.62146892655367, 70.62146892655367, 74.57627118644068, 66.28787878787878, 73.10606060606061, 71.21212121212122, 71.5909090909091, 69.6969696969697, 71.21212121212122, 67.42424242424242, 73.10606060606061, 75.0, 72.72727272727273]

	f1	f2	f3
13	550	1800	2600
35	450	1650	2400
24	600	1200	2300
28	500	1400	2360
15	550	1400	2600
..
691	400	900	2700
815	400	850	2300
785	500	1100	2500
765	500	1000	2650
698	500	1250	2700

[521 rows x 3 columns]

```
vowel class
13      1
35      1
24      1
28      1
15      1
..      ...
691     6
815     6
785     6
765     6
698     6
```

```
[521 rows x 1 columns]
```

```
      f1    f2    f3
0      700  1500  2600
50     700  1750  2300
55     700  1400  2300
9      600  1600  2600
26     600  1400  2300
..     ...   ...   ...
787    500   900  2700
732    600  1200  2300
859    550  1100  2750
716    400  1000  2300
845    500  1000  2700
```

```
[350 rows x 3 columns]
```

```
0      1
50     1
55     1
9      1
26     1
..
787    6
732    6
859    6
716    6
845    6
```

```
Name: vowel class, Length: 350, dtype: int64
```

```
[1, 1, 1, 1, 1, 2, 1, 1, 6, 2, 1, 1, 1, 1, 1, 2, 1, 1, 2, 1, 2, 1, 5, 1, 2, 1, 6,
1, 5, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 6, 2, 6, 2, 1, 6, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 1, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 5,
3, 3, 3, 3, 3, 3, 1, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 1, 3, 3, 3, 3, 3,
3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 5, 3, 3, 3, 3, 4,
4, 4, 6, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4,
4, 4, 6, 4, 4, 4, 4, 6, 4, 4, 4, 4, 6, 4, 6, 4, 6, 4, 4, 6, 4, 4, 4, 4, 6, 4, 4,
4, 4, 4, 4, 2, 4, 5, 5, 5, 5, 5, 5, 5, 3, 5, 3, 5, 3, 3, 1, 5, 5, 1, 5, 5, 1, 3,
6, 3, 1, 3, 3, 5, 5, 5, 3, 1, 3, 3, 6, 5, 2, 5, 5, 1, 3, 1, 1, 1, 1, 5, 5, 5, 5,
3, 5, 5, 5, 5, 1, 5, 1, 3, 5, 1, 3, 3, 5, 3, 5, 5, 3, 5, 5, 1, 5, 5, 3, 5, 5, 5,
5, 6, 5, 5, 3, 5, 3, 5, 4, 6, 6, 4, 6, 4, 1, 6, 4, 4, 2, 6, 2, 4, 2, 6, 2, 2, 6,
6, 6, 6, 4, 6, 4, 1, 6, 4, 2, 6, 6, 6, 6, 4, 4, 5, 6, 6, 4, 2, 4, 2, 6, 2, 6, 6,
4, 6, 6, 6, 2, 4, 4, 6, 6, 6, 6, 2, 6, 2, 2, 6, 4, 6, 6, 6, 6, 6, 2, 6, 4, 6]
```

```
Pred_class
0      1
1      1
2      1
3      1
4      1
..      ...
345     6
346     2
347     6
348     4
```

349 6

[350 rows x 1 columns]

	index	vowel class
0	0	1
1	50	1
2	55	1
3	9	1
4	26	1
..
345	787	6
346	732	6
347	859	6
348	716	6
349	845	6

[350 rows x 2 columns]

	vowel class	Pred_class
0	1	1
1	1	1
2	1	1
3	1	1
4	1	1
..
345	6	6
346	6	2
347	6	6
348	6	4
349	6	6

[350 rows x 2 columns]

	f1	f2	f3
52	550	1700	2300
6	550	1200	2500
59	650	1300	2300
18	600	1400	2600
66	700	1400	2300
..
764	400	950	2700
745	400	1200	2400
722	400	1000	2300
705	400	1160	2600
750	450	950	2100

[521 rows x 3 columns]

	vowel class
52	1
6	1
59	1
18	1
66	1
..	...
764	6
745	6
722	6
705	6
750	6

[521 rows x 1 columns]

	f1	f2	f3
39	750	1500	2360
16	650	1600	2600
41	500	1500	2360
10	550	2000	2700

```

49    750    1350    2100
..    ...    ...    ...
825    450    1000    2350
843    500    1000    2700
762    500    1000    2600
694    500    1100    2700
862    500    1000    2900

```

```
[350 rows x 3 columns]
```

```

39      1
16      1
41      1
10      1
49      1
..
825     6
843     6
762     6
694     6
862     6

```

```
Name: vowel class, Length: 350, dtype: int64
```

```

[1, 1, 1, 5, 2, 2, 2, 5, 1, 5, 1, 1, 2, 1, 1, 5, 1, 2, 5, 1, 1, 1, 1, 1, 2, 1, 1,
1, 1, 2, 2, 6, 2, 2, 2, 2, 2, 2, 6, 2, 2, 1, 2, 2, 6, 2, 2, 2, 2, 2, 2, 2, 2, 6,
6, 2, 2, 2, 2, 2, 1, 2, 2, 1, 6, 3, 3, 5, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 5, 3, 3, 3, 3, 3, 5, 3, 5, 3, 3, 3,
3, 3, 3, 3, 3, 3, 5, 5, 3, 3, 5, 3, 5, 3, 3, 3, 3, 3, 1, 3, 3, 3, 3, 3, 6,
4, 4, 4, 4, 4, 4, 4, 4, 2, 4, 6, 4, 4, 4, 6, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 4,
4, 4, 4, 4, 4, 4, 6, 4, 2, 6, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 6,
4, 6, 6, 4, 4, 4, 5, 5, 5, 5, 5, 3, 1, 3, 5, 1, 3, 5, 5, 5, 3, 3, 3, 3, 5, 3, 5,
5, 5, 5, 5, 3, 5, 5, 5, 5, 5, 5, 5, 3, 5, 5, 5, 5, 5, 3, 5, 5, 5, 5, 5, 3, 5,
3, 5, 3, 5, 5, 5, 3, 1, 6, 1, 1, 5, 5, 3, 5, 5, 5, 1, 1, 5, 5, 1, 1, 5, 6, 3, 5,
5, 5, 5, 3, 1, 3, 1, 3, 6, 6, 6, 6, 1, 6, 6, 4, 6, 6, 6, 4, 6, 6, 6, 6, 6, 6,
6, 6, 5, 4, 6, 6, 2, 6, 6, 6, 4, 4, 6, 6, 6, 4, 6, 6, 6, 4, 6, 6, 6, 4, 6, 6,
4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 2, 6, 4, 5, 6, 6, 4, 6, 6, 6, 6, 6, 4]

```

```
Pred_class
```

```

0      1
1      1
2      1
3      5
4      2
..
345     6
346     6
347     6
348     6
349     4

```

```
[350 rows x 1 columns]
```

```

index  vowel class
0      39          1
1      16          1
2      41          1
3      10          1
4      49          1
..
345    825          6
346    843          6
347    762          6
348    694          6
349    862          6

```

```
[350 rows x 2 columns]
```

```

vowel class  Pred_class
0            1          1

```

1	1	1
2	1	1
3	1	5
4	1	2
..
345	6	6
346	6	6
347	6	6
348	6	6
349	6	4

[350 rows x 2 columns]

	f1	f2	f3
4	550	1600	2600
55	700	1400	2300
35	450	1650	2400
70	650	1600	2300
30	650	1200	2300
..
828	450	1050	2300
805	450	1200	2300
746	450	1000	2350
821	500	1000	2300
767	500	1100	2700

[521 rows x 3 columns]

	vowel	class
4		1
55		1
35		1
70		1
30		1
..		...
828		6
805		6
746		6
821		6
767		6

[521 rows x 1 columns]

	f1	f2	f3
38	550	1400	2300
58	700	1300	2300
60	700	1350	2300
21	600	1400	2200
37	700	1550	2360
..
869	500	900	2800
743	550	1100	2300
856	500	1100	2800
860	500	950	2700
825	450	1000	2350

[350 rows x 3 columns]

38	1
58	1
60	1
21	1
37	1
..	..
869	6
743	6
856	6
860	6

825 6

Name: vowel class, Length: 350, dtype: int64

```
[1, 2, 2, 1, 1, 1, 1, 2, 1, 2, 1, 5, 2, 6, 2, 1, 1, 2, 1, 1, 5, 1, 1, 1, 5, 2, 5,
1, 1, 2, 2, 2, 1, 1, 2, 2, 2, 2, 6, 2, 6, 2, 1, 2, 2, 2, 2, 2, 2, 2, 2, 6, 2,
2, 2, 1, 6, 1, 2, 2, 2, 2, 2, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3,
3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 4,
6, 4, 4, 4, 4, 6, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 4, 4, 6, 6, 4, 6, 6, 4, 4, 6, 4,
4, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 6, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 6, 4,
4, 6, 2, 4, 4, 4, 6, 5, 6, 5, 3, 5, 5, 5, 1, 6, 5, 5, 3, 3, 5, 3, 5, 5, 3, 5, 1,
5, 5, 1, 5, 5, 5, 5, 3, 1, 1, 5, 5, 1, 1, 3, 5, 5, 1, 6, 3, 3, 3, 3, 5, 5, 5, 5,
1, 5, 1, 3, 3, 1, 3, 5, 5, 5, 5, 1, 3, 5, 5, 1, 5, 5, 3, 5, 3, 5, 3, 5, 3, 5, 5,
6, 5, 3, 3, 5, 3, 5, 1, 6, 6, 6, 4, 6, 6, 2, 6, 6, 4, 6, 6, 2, 6, 6, 6, 4, 6, 4,
6, 6, 4, 4, 6, 4, 4, 6, 6, 6, 2, 6, 6, 6, 6, 6, 6, 6, 4, 4, 6, 6, 6, 6, 2, 2,
2, 6, 6, 4, 4, 2, 2, 2, 6, 4, 6, 6, 6, 6, 6, 4, 6, 4, 6, 4, 6, 6, 2, 6, 6, 4]
```

Pred_class

```
0 1
1 2
2 2
3 1
4 1
.. ...
345 6
346 2
347 6
348 6
349 4
```

[350 rows x 1 columns]

```
index vowel class
0 38 1
1 58 1
2 60 1
3 21 1
4 37 1
.. ...
345 869 6
346 743 6
347 856 6
348 860 6
349 825 6
```

[350 rows x 2 columns]

```
vowel class Pred_class
0 1 1
1 1 2
2 1 2
3 1 1
4 1 1
.. ...
345 6 6
346 6 2
347 6 6
348 6 6
349 6 4
```

[350 rows x 2 columns]

```
f1 f2 f3
16 650 1600 2600
32 500 1350 2360
19 700 1350 2600
68 650 1200 2300
5 600 1250 2700
.. ...
```

\emptyset	1
1	1
2	1

```

3          1
4          1
..         ...
345        4
346        4
347        6
348        2
349        2

```

```

[350 rows x 1 columns]
      index  vowel class
0         35          1
1         14          1
2          9          1
3         28          1
4         27          1
..         ...         ...
345       832          6
346       814          6
347       777          6
348       739          6
349       734          6

```

```

[350 rows x 2 columns]
      vowel class  Pred_class
0              1           1
1              1           1
2              1           1
3              1           1
4              1           1
..             ...         ...
345            6           4
346            6           4
347            6           6
348            6           2
349            6           2

```

```

[350 rows x 2 columns]
      f1    f2    f3
38  550  1400  2300
31  550  1200  2360
35  450  1650  2400
43  650  1350  2360
42  600  1400  2360
..   ...   ...   ...
799 500  1000  2300
751 500  1000  2300
779 500  1000  2560
805 450  1200  2300
754 500  1200  2300

```

```

[521 rows x 3 columns]
      vowel class
38              1
31              1
35              1
43              1
42              1
..             ...
799            6
751            6
779            6
805            6
754            6

```

	f1	f2	f3
5	600	1250	2700
30	650	1200	2300
55	700	1400	2300
62	700	1400	2300
16	650	1600	2600
..
789	500	1050	2600
703	400	1000	2200
827	400	1000	2400
823	400	900	2300
791	500	950	2600

5	1
30	1
55	1
62	1
16	1
	..
789	6
703	6
827	6
823	6
791	6

[6, 2, 2, 2, 1, 1, 2, 2, 2, 1, 1, 1, 1, 1, 5, 2, 5, 1, 1, 1, 1, 6, 1, 2, 1, 1,
6, 1, 2, 6, 2, 2, 2, 6, 2, 2, 6, 2, 2, 2, 2, 6, 2, 6, 2, 2, 2, 2, 6, 2, 2, 2, 1,
2, 2, 2, 2, 2, 2, 2, 2, 2, 6, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3,
3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 5, 3, 3, 4,
6, 4, 1, 4, 4, 4, 4, 4, 6, 4, 6, 6, 4, 4, 6, 4, 6, 4, 4, 4, 4, 4, 4, 4, 4, 2,
4, 6, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 6, 4, 4, 4, 6, 2, 6, 4, 4, 4, 4, 4, 6,
4, 4, 4, 4, 4, 6, 3, 1, 3, 3, 3, 5, 3, 5, 1, 1, 5, 5, 3, 6, 5, 6, 5, 5, 5, 1, 3,
5, 1, 5, 5, 5, 1, 1, 5, 3, 5, 3, 5, 5, 5, 1, 5, 1, 5, 5, 3, 5, 5, 5, 5, 5, 1,
3, 3, 5, 5, 5, 5, 6, 5, 5, 3, 3, 5, 6, 3, 1, 3, 5, 3, 5, 1, 5, 1, 5, 5, 1, 5, 5,
2, 3, 1, 3, 3, 5, 5, 3, 6, 6, 6, 2, 6, 6, 4, 4, 6, 6, 2, 4, 6, 4, 6, 6, 6, 6, 6,
6, 6, 4, 4, 4, 6, 6, 6, 2, 4, 6, 6, 4, 6, 6, 4, 4, 6, 6, 2, 6, 6, 4, 6, 4, 4, 6,
6, 4, 2, 4, 2, 4, 6, 6, 4, 6, 6, 6, 6, 2, 6, 4, 4, 6, 6, 4, 6, 6, 4, 4, 4, 6]

0	6
1	2
2	2
3	2
4	1
..	...
345	6
346	4
347	4
348	4
349	6

	index	vowel class
0	5	1
1	30	1
2	55	1
3	62	1
4	16	1
..
345	789	6
346	703	6

347	827	6
348	823	6
349	791	6

```
[350 rows x 2 columns]
vowel class  Pred_class
0           1           6
1           1           2
2           1           2
3           1           2
4           1           1
..         ...         ...
345         6           6
346         6           4
347         6           4
348         6           4
349         6           6
```

```
[350 rows x 2 columns]
f1  f2  f3
50  700 1750 2300
36  500 1450 2400
21  600 1400 2200
24  600 1200 2300
14  600 1400 2600
..  ...  ...  ...
766 550 1250 2600
779 500 1000 2560
860 500  950 2700
803 400 1000 2300
732 600 1200 2300
```

```
[521 rows x 3 columns]
vowel class
50           1
36           1
21           1
24           1
14           1
..         ...
766         6
779         6
860         6
803         6
732         6
```

```
[521 rows x 1 columns]
f1  f2  f3
38  550 1400 2300
28  500 1400 2360
34  700 1400 2360
15  550 1400 2600
40  550 1500 2360
..  ...  ...  ...
723 450 1050 2300
765 500 1000 2650
696 450 1100 2700
858 500 1000 2800
822 500  850 2300
```

```
[350 rows x 3 columns]
38  1
28  1
34  1
```

```

15      1
40      1
..
723     6
765     6
696     6
858     6
822     6
Name: vowel class, Length: 350, dtype: int64
[1, 1, 1, 1, 1, 5, 1, 1, 5, 5, 5, 1, 5, 1, 1, 2, 5, 2, 2, 1, 1, 5, 5, 1, 1, 2, 5,
1, 1, 6, 2, 2, 2, 2, 2, 6, 2, 6, 2, 2, 2, 2, 1, 2, 2, 2, 1, 6, 6, 1, 2, 2, 2, 6,
2, 2, 6, 2, 2, 2, 1, 1, 2, 2, 2, 3, 3, 5, 3, 3, 3, 3, 3, 3, 5, 3, 3, 5, 3, 3, 3,
5, 3, 3, 5, 5, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 5, 3, 3, 3, 3, 3, 5, 5, 3,
3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 1, 3, 3, 3, 3, 3, 5, 3, 5, 3, 3, 3, 3, 5, 3, 4,
4, 4, 6, 4, 4, 4, 4, 6, 4, 4, 4, 2, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 4, 6, 6, 4, 4,
6, 4, 4, 6, 4, 6, 4, 6, 4, 1, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 2, 4, 4, 4, 4,
4, 4, 4, 4, 4, 4, 1, 3, 5, 5, 3, 6, 5, 5, 1, 5, 5, 5, 3, 3, 3, 5, 5, 1, 5, 5, 5,
5, 6, 5, 5, 5, 5, 5, 5, 1, 5, 5, 3, 5, 3, 5, 5, 1, 1, 5, 1, 5, 5, 1, 5, 5, 6, 3,
5, 5, 1, 5, 3, 5, 5, 3, 5, 5, 5, 5, 5, 3, 3, 5, 5, 5, 3, 6, 5, 5, 5, 3, 5, 5, 5,
3, 1, 3, 5, 5, 5, 1, 5, 6, 4, 4, 6, 4, 6, 5, 2, 6, 6, 5, 4, 4, 1, 6, 4, 2, 6, 6,
6, 2, 6, 4, 6, 4, 6, 6, 6, 4, 4, 4, 6, 2, 6, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 2,
6, 2, 6, 6, 2, 6, 6, 4, 6, 6, 6, 6, 6, 2, 6, 6, 2, 6, 6, 2, 2, 6, 6, 6, 6, 4]

```

```

Pred_class
0      1
1      1
2      1
3      1
4      1
..     ...
345     6
346     6
347     6
348     6
349     4

```

```

[350 rows x 1 columns]
index  vowel class
0      38          1
1      28          1
2      34          1
3      15          1
4      40          1
..     ...      ...
345    723          6
346    765          6
347    696          6
348    858          6
349    822          6

```

```

[350 rows x 2 columns]
vowel class  Pred_class
0            1           1
1            1           1
2            1           1
3            1           1
4            1           1
..           ...       ...
345          6           6
346          6           6
347          6           6
348          6           6
349          6           4

```

```

[350 rows x 2 columns]

```

```
[350 rows x 3 columns]
```

[2, 6, 1, 2, 1, 2, 1, 1, 1, 2, 5, 1, 1, 1, 2, 2, 5, 1, 1, 5, 1, 1, 2, 5, 5, 5, 2,
1, 2, 2, 2, 2, 2, 2, 2, 2, 6, 6, 2, 2, 2, 2, 6, 2, 2, 6, 2, 6, 6, 2, 6, 2, 2,
2, 2, 2, 2, 6, 2, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 5,
3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
3, 3, 5, 3, 3, 3, 5, 3, 5, 3, 3, 5, 3, 3, 5, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 4,
4, 4, 4, 4, 4, 4, 6, 4, 4, 6, 4, 4, 4, 4, 4, 4, 4, 4, 6, 6, 4, 4, 4, 4, 4, 4, 2,
4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 6, 6, 4, 6, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 6,
4, 4, 4, 6, 4, 4, 1, 3, 5, 5, 3, 5, 5, 1, 5, 5, 5, 3, 1, 3, 5, 5, 3, 3, 5, 6, 3,
5, 5, 5, 3, 3, 6, 1, 1, 3, 5, 5, 5, 5, 5, 5, 1, 5, 1, 6, 3, 1, 5, 3, 6, 5, 5, 1,
3, 1, 5, 1, 5, 5, 5, 5, 1, 3, 3, 5, 5, 3, 5, 1, 5, 5, 3, 1, 5, 1, 5, 5, 3, 3, 5,

5, 5, 5, 3, 5, 5, 5, 5, 6, 4, 6, 6, 6, 2, 6, 6, 6, 4, 6, 4, 6, 1, 6, 6, 6, 4, 6,
 6, 6, 6, 4, 6, 2, 4, 6, 6, 6, 4, 1, 6, 6, 6, 6, 4, 6, 6, 2, 6, 4, 4, 6, 6, 2, 6,
 6, 6, 6, 6, 6, 6, 6, 6, 6, 4, 4, 6, 4, 6, 4, 6, 4, 2, 6, 4, 4, 6, 4, 6, 4, 2]

Pred_class

0	2
1	6
2	1
3	2
4	1
..	...
345	6
346	4
347	6
348	4
349	2

[350 rows x 1 columns]

	index	vowel class
0	51	1
1	5	1
2	35	1
3	29	1
4	14	1
..
345	836	6
346	727	6
347	841	6
348	737	6
349	734	6

[350 rows x 2 columns]

	vowel class	Pred_class
0	1	2
1	1	6
2	1	1
3	1	2
4	1	1
..
345	6	6
346	6	4
347	6	6
348	6	4
349	6	2

[350 rows x 2 columns]

	f1	f2	f3
68	650	1200	2300
19	700	1350	2600
39	750	1500	2360
35	450	1650	2400
15	550	1400	2600
..
776	500	1000	2560
758	500	1150	2720
746	450	1000	2350
778	550	1050	2560
774	450	1250	2850

[521 rows x 3 columns]

	vowel class
68	1
19	1
39	1
35	1


```

15          1
..          ...
776         6
758         6
746         6
778         6
774         6

```

```
[521 rows x 1 columns]
```

```

      f1    f2    f3
56   600  1400  2300
69   600  1850  2300
10   550  2000  2700
64   500  1900  2300
28   500  1400  2360
..   ...   ...   ...
755  500  1050  2720
709  400  1300  2300
780  500   850  2560
772  600  1300  2800
745  400  1200  2400

```

```
[350 rows x 3 columns]
```

```

56      1
69      1
10      1
64      1
28      1
..
755     6
709     6
780     6
772     6
745     6

```

```
Name: vowel class, Length: 350, dtype: int64
```

```

[1, 5, 5, 5, 1, 1, 1, 1, 1, 1, 5, 1, 5, 2, 5, 1, 1, 1, 1, 1, 1, 1, 6, 2, 2, 1,
1, 1, 2, 2, 2, 2, 2, 1, 1, 2, 6, 2, 2, 2, 2, 2, 2, 1, 2, 6, 2, 2, 2, 2, 1, 2,
2, 2, 2, 6, 2, 2, 6, 2, 6, 6, 2, 3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 5, 3, 3,
3, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 5, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 5, 5, 3,
3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 3, 5, 3, 3, 3, 5, 3, 3, 3, 5, 3, 3, 3, 4,
4, 4, 4, 4, 4, 4, 2, 4, 4, 1, 4, 4, 4, 6, 4, 4, 4, 4, 2, 1, 4, 4, 4, 4, 4, 6,
4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 2, 4, 4, 4, 4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 4,
4, 4, 4, 4, 6, 4, 5, 5, 5, 6, 5, 5, 1, 1, 5, 6, 5, 3, 3, 1, 1, 5, 5, 3, 5, 5, 5,
1, 1, 1, 5, 1, 3, 3, 6, 5, 5, 5, 1, 3, 1, 5, 3, 1, 3, 5, 5, 5, 5, 5, 5, 3, 5, 5,
5, 5, 3, 5, 3, 6, 5, 3, 5, 5, 5, 5, 3, 3, 1, 5, 1, 5, 5, 1, 1, 3, 5, 5, 1, 5, 3,
1, 2, 5, 5, 5, 5, 1, 3, 6, 6, 6, 6, 6, 6, 6, 6, 4, 4, 6, 4, 6, 6, 6, 4, 6, 6, 6,
6, 2, 4, 6, 4, 4, 4, 6, 4, 4, 4, 6, 2, 6, 4, 6, 2, 6, 6, 6, 5, 6, 6, 2, 6, 6, 6,
4, 4, 4, 6, 6, 4, 6, 4, 4, 6, 4, 6, 6, 6, 2, 6, 6, 6, 4, 6, 6, 6, 1, 4, 6, 6]

```

```
Pred_class
```

```

0      1
1      5
2      5
3      5
4      1
..
345     6
346     1
347     4
348     6
349     6

```

```
[350 rows x 1 columns]
```

```

      index  vowel class
0         56          1

```

1	69	1
2	10	1
3	64	1
4	28	1
..
345	755	6
346	709	6
347	780	6
348	772	6
349	745	6

```
[350 rows x 2 columns]
vowel class  Pred_class
0           1           1
1           1           5
2           1           5
3           1           5
4           1           1
..          ...          ...
345         6           6
346         6           1
347         6           4
348         6           6
349         6           6
```

```
[350 rows x 2 columns]
f1  f2  f3
71  750 1250 2300
56  600 1400 2300
46  600 1700 2300
68  650 1200 2300
59  650 1300 2300
..  ...  ...  ...
785 500 1100 2500
860 500  950 2700
729 400 1300 2300
806 450 1200 2300
830 450 1000 2350
```

```
[521 rows x 3 columns]
vowel class
71           1
56           1
46           1
68           1
59           1
..          ...
785         6
860         6
729         6
806         6
830         6
```

```
[521 rows x 1 columns]
f1  f2  f3
32  500 1350 2360
7   550 1700 2600
15  550 1400 2600
25  600 1350 2300
12  650 1600 2700
..  ...  ...  ...
808 500 1000 2300
754 500 1200 2300
844 500 1000 2900
```

804 450 1150 2300
846 500 1000 2750

[350 rows x 3 columns]

32 1
7 1
15 1
25 1
12 1

..

808 6
754 6
844 6
804 6
846 6

Name: vowel class, Length: 350, dtype: int64

[1, 5, 1, 2, 5, 6, 2, 1, 2, 1, 1, 1, 6, 1, 1, 1, 1, 1, 2, 1, 2, 1, 1, 2, 1, 5, 1,
2, 2, 2, 2, 1, 2, 2, 2, 2, 6, 2, 1, 6, 1, 1, 6, 2, 6, 2, 2, 6, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 6, 2, 2, 2, 2, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5,
3,
3, 3, 3, 5, 5, 3, 3, 3, 3, 3, 3, 3, 3, 5, 5, 3, 5, 3, 3, 3, 3, 3, 3, 5, 3, 3, 3, 4,
4, 4, 4, 4, 4, 4, 2, 4, 4, 4, 4, 4, 4, 4, 4, 6, 4, 4, 6, 4, 4, 4, 6, 4, 4, 4, 6, 6,
6, 4, 4, 4, 4, 4, 4, 6, 6, 4, 4, 4, 4, 6, 4, 4, 4, 6, 6, 4, 4, 4, 6, 4, 4, 4, 4,
4, 6, 4, 6, 2, 1, 5, 3, 5, 6, 1, 5, 3, 6, 5, 1, 1, 5, 5, 5, 6, 5, 1, 5, 3, 5, 5,
5, 5, 1, 5, 5, 5, 3, 5, 5, 5, 3, 5, 5, 5, 3, 3, 5, 5, 5, 5, 3, 1, 5, 5, 5, 1, 6,
3, 1, 5, 3, 3, 5, 3, 5, 6, 5, 5, 5, 5, 1, 5, 5, 1, 3, 6, 5, 5, 5, 5, 3, 3, 5, 5,
5, 6, 5, 6, 3, 5, 5, 5, 6, 6, 4, 6, 6, 4, 6, 6, 6, 2, 6, 2, 4, 6, 6, 6, 2, 2, 6,
5, 6, 6, 6, 6, 6, 6, 2, 6, 6, 2, 6, 6, 6, 6, 6, 4, 6, 4, 6, 6, 6, 6, 6, 6, 6,
4, 6, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 2, 6, 6, 6]

Pred_class

0 1
1 5
2 1
3 2
4 5
..
345 6
346 2
347 6
348 6
349 6

[350 rows x 1 columns]

	index	vowel class
0	32	1
1	7	1
2	15	1
3	25	1
4	12	1
..
345	808	6
346	754	6
347	844	6
348	804	6
349	846	6

[350 rows x 2 columns]

	vowel class	Pred_class
0	1	1
1	1	5
2	1	1
3	1	2
4	1	5
..


```
[350 rows x 2 columns]
[67.79661016949152, 70.05649717514125, 70.05649717514125, 70.62146892655367, 59.88
7005649717516, 67.79661016949152, 63.2768361581921, 70.62146892655367, 70.62146892
655367, 74.57627118644068, 66.28787878787878, 73.10606060606061, 71.2121212121212
2, 71.5909090909091, 69.6969696969697, 71.21212121212122, 67.42424242424242, 73.10
606060606061, 75.0, 72.72727272727273, 69.14285714285714, 73.14285714285714, 68.28
571428571428, 74.28571428571429, 67.42857142857143, 67.71428571428572, 67.71428571
428572, 68.57142857142857, 71.71428571428572, 74.0]
```

```

Test_size = 0.2
0      67.796610
1      70.056497
2      70.056497
3      70.621469
4      59.887006
5      67.796610
6      63.276836
7      70.621469
8      70.621469
9      74.576271

```

```

In [7]: df_b_mdc = pd.DataFrame({'Test_size = 0.3':np.array(accuracy_lst[10:20])})
        print(df_b_mdc)

```

```

Test_size = 0.3
0      66.287879
1      73.106061
2      71.212121
3      71.590909
4      69.696970
5      71.212121
6      67.424242
7      73.106061
8      75.000000
9      72.727273

```

```

In [8]: df_c_mdc = pd.DataFrame({'Test_size = 0.4':np.array(accuracy_lst[20:])})
        print(df_c_mdc)

```

```

Test_size = 0.4
0      69.142857
1      73.142857
2      68.285714
3      74.285714
4      67.428571
5      67.714286
6      67.714286
7      68.571429
8      71.714286
9      74.000000

```

Accuracy of Bayes Classifier for different test sizes for 10 iterations

```

In [9]: result_mdc= df_a_mdc.join([df_b_mdc,df_c_mdc])
        print(result_mdc)

```

```

Test_size = 0.2  Test_size = 0.3  Test_size = 0.4
0      67.796610      66.287879      69.142857
1      70.056497      73.106061      73.142857
2      70.056497      71.212121      68.285714
3      70.621469      71.590909      74.285714
4      59.887006      69.696970      67.428571
5      67.796610      71.212121      67.714286
6      63.276836      67.424242      67.714286
7      70.621469      73.106061      68.571429
8      70.621469      75.000000      71.714286
9      74.576271      72.727273      74.000000

```

Mean Accuracy of MDC Classifier for different test sizes

In [10]: `result_mdc.mean()`

Out[10]: Test_size = 0.2 68.531073
 Test_size = 0.3 71.136364
 Test_size = 0.4 70.200000
 dtype: float64

Implementation of Bayes Classifier

```
In [12]: #Initialize accuracy list
accuracy_lst= []
#Define test sizes
test_size_lst = [0.2,0.3,0.4]
#Loop through different testsizes
for ele in test_size_lst:
    #Loop through 10 iterations
    for i in range(10):

        # Split data into train and test sets for each vowel class

        df1 = df[df['vowel class']==1]
        X_1 = df1.drop(columns=['vowel class'])
        y_1 = df1['vowel class']
        X1_train,X1_test,y1_train,y1_test = train_test_split(X_1,y_1,test_size=ele)

        df2 = df[df['vowel class']==2]
        X_2 = df2.drop(columns=['vowel class'])
        y_2 = df2['vowel class']
        X2_train,X2_test,y2_train,y2_test = train_test_split(X_2,y_2,test_size=ele)

        df3 = df[df['vowel class']==3]
        X_3 = df3.drop(columns=['vowel class'])
        y_3 = df3['vowel class']
        X3_train,X3_test,y3_train,y3_test = train_test_split(X_3,y_3,test_size=ele)

        df4 = df[df['vowel class']==4]
        X_4 = df4.drop(columns=['vowel class'])
        y_4 = df4['vowel class']
        X4_train,X4_test,y4_train,y4_test = train_test_split(X_4,y_4,test_size=ele)

        df5 = df[df['vowel class']==5]
        X_5 = df5.drop(columns=['vowel class'])
        y_5 = df5['vowel class']
        X5_train,X5_test,y5_train,y5_test = train_test_split(X_5,y_5,test_size=ele)

        df6 = df[df['vowel class']==6]
        X_6 = df6.drop(columns=['vowel class'])
        y_6 = df6['vowel class']
        X6_train,X6_test,y6_train,y6_test = train_test_split(X_6,y_6,test_size=ele)

        X_1_ = X1_train.join(y1_train)
        X_2_ = X2_train.join(y2_train)
        X_3_ = X3_train.join(y3_train)
        X_4_ = X4_train.join(y4_train)
        X_5_ = X5_train.join(y5_train)
        X_6_ = X6_train.join(y6_train)

        # Concatenate train sets and prepare train data

        X_train_resultant = pd.concat([X_1_,X_2_,X_3_,X_4_,X_5_,X_6_])
        print(X_train_resultant)

        X_train = X_train_resultant.drop(columns='vowel class')
```

```

print(X_train)
y_train = pd.DataFrame(X_train_resultant['vowel class'])
print(y_train)

X_t1 = X1_test.join(y1_test)
X_t2 = X2_test.join(y2_test)
X_t3 = X3_test.join(y3_test)
X_t4 = X4_test.join(y4_test)
X_t5 = X5_test.join(y5_test)
X_t6 = X6_test.join(y6_test)

# Concatenate test sets and prepare test data

X_t = pd.concat([X_t1,X_t2,X_t3,X_t4,X_t5,X_t6])
X_test_resultant = X_t.drop(columns='vowel class')
y_test_resultant = X_t['vowel class']

#Function to calculate class conditional probability

def class_conditional_prob(x,mu,cov):
    exponent = (-0.5) * np.dot(np.dot((x - mu).T, np.linalg.inv(cov)), (x - mu))
    normalization = 1 / ((2 * np.pi) ** (3 / 2) * np.linalg.det(cov) ** 0.5)
    probability = normalization * np.exp(exponent)
    return probability

#Calculating mean vector and variance-covariance matrix of different training sets

m1 =np.array( X1_train.mean())
m2 =np.array( X2_train.mean())
m3 =np.array( X3_train.mean())
m4 =np.array( X4_train.mean())
m5 =np.array( X5_train.mean())
m6 =np.array( X6_train.mean())

cov1 = np.array(X1_train.cov())
cov2 = np.array(X2_train.cov())
cov3 = np.array(X3_train.cov())
cov4 = np.array(X4_train.cov())
cov5 = np.array(X5_train.cov())
cov6 = np.array(X6_train.cov())

#Calculating Prior Probabilities

P1 = X1_train.shape[0]/X_train_resultant.shape[0]
P2 = X2_train.shape[0]/X_train_resultant.shape[0]
P3 = X3_train.shape[0]/X_train_resultant.shape[0]
P4 = X4_train.shape[0]/X_train_resultant.shape[0]
P5 = X5_train.shape[0]/X_train_resultant.shape[0]
P6 = X6_train.shape[0]/X_train_resultant.shape[0]

#Performing Bayes Classification

y_pred = []
for testpoint in np.array(X_test_resultant):
    p1 = class_conditional_prob(testpoint,m1,cov1)
    p2 = class_conditional_prob(testpoint,m2,cov2)
    p3 = class_conditional_prob(testpoint,m3,cov3)
    p4 = class_conditional_prob(testpoint,m4,cov4)
    p5 = class_conditional_prob(testpoint,m5,cov5)
    p6 = class_conditional_prob(testpoint,m6,cov6)
    l = [p1*P1,p2*P2,p3*P3,p4*P4,p5*P5,p6*P6]
    m = max(l)
    i = l.index(m)
    pred_class = i+1

```



```
y_pred.append(pred_class)
print(y_pred)

y_pred_df = pd.DataFrame({'Pred_class':y_pred})
y_test = pd.DataFrame(y_test_resultant)
y_test.reset_index(inplace=True)

df_forprediction = y_test.join(y_pred_df).drop(columns=['index'])
print(df_forprediction)

#Calculating Accuracy
true_pred = df_forprediction[df_forprediction['vowel class']==df_forprediction['Pred_class']]
accuracy = (true_pred.shape[0]/df_forprediction.shape[0])*100
#print(accuracy)
accuracy_lst.append(accuracy)
print(accuracy_lst)
```

```

[177] rows x 5 columns
      f1      f2      f3 vowel class
0  0.000  0.000  0.000   0         0
1  0.000  0.000  0.000   0         0
2  0.000  0.000  0.000   0         0
3  0.000  0.000  0.000   0         0
4  0.000  0.000  0.000   0         0

```


41	500	1500	2360	1
21	600	1400	2200	1
18	600	1400	2600	1
14	600	1400	2600	1
..
708	450	1100	2300	6
758	500	1150	2720	6
820	500	1000	2300	6
833	450	950	2100	6
706	400	1100	2300	6

```
[694 rows x 4 columns]
```

	f1	f2	f3
20	550	1350	2200
41	500	1500	2360
21	600	1400	2200
18	600	1400	2600
14	600	1400	2600
..
708	450	1100	2300
758	500	1150	2720
820	500	1000	2300
833	450	950	2100
706	400	1100	2300

```
[694 rows x 3 columns]
```

	vowel class
20	1
41	1
21	1
18	1
14	1
..	...
708	6
758	6
820	6
833	6
706	6

```
[694 rows x 1 columns]
```

[1, 1, 5, 2, 6, 2, 1, 2, 5, 5, 1, 5, 2, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 6, 2,
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4, 4, 4, 6, 6, 4, 4, 6, 6, 6, 6, 6, 6, 2, 6]

	vowel class	Pred_class
0	1	1
1	1	1
2	1	5
3	1	2
4	1	6
..
172	6	6
173	6	6
174	6	6
175	6	2
176	6	6

```
[177 rows x 2 columns]
```

	f1	f2	f3	vowel class
47	650	1400	2000	1
27	500	1400	2360	1

	f1	f2	f3	vowel	class
11	500	1750	2600		1
52	550	1700	2300		1
53	550	1500	2600		1

	f1	f2	f3	vowel	class
65	700	1300	2300		1
13	550	1800	2600		1
18	600	1400	2600		1
31	550	1200	2360		1

	f1	f2	f3	vowel	class
16	650	1600	2600		1
52	550	1700	2300		1
9	600	1600	2600		1
61	650	1600	2300		1
37	700	1550	2360		1

	f1	f2	f3	vowel	class
23	400	1200	2400		1
40	550	1500	2360		1
69	600	1850	2300		1
57	700	1300	2300		1
65	700	1300	2300		1
...

734	500	1250	2300	6
783	450	900	2250	6
808	500	1000	2300	6

```
[694 rows x 4 columns]
```

	f1	f2	f3
66	700	1400	2300
31	550	1200	2360
0	700	1500	2600
6	550	1200	2500
44	650	1400	2100
..
868	500	1000	2800
822	500	850	2300
734	500	1250	2300
783	450	900	2250
808	500	1000	2300

```
[694 rows x 3 columns]
```

	vowel class
66	1
31	1
0	1
6	1
44	1
..	...
868	6
822	6
734	6
783	6
808	6

```
[694 rows x 1 columns]
```

[1, 1, 2, 5, 6, 5, 1, 5, 2, 2, 6, 5, 2, 2, 1, 2, 2, 2, 2, 2, 2, 2, 1, 2, 1, 1,
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4, 4, 4, 6, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 5, 5, 5, 5, 5, 5, 5, 1,
3, 3, 5, 5, 6, 5, 5, 5, 5, 5, 5, 5, 5, 5, 3, 3, 5, 5, 1, 5, 5, 5, 5, 5, 5, 3, 5,
5, 5, 5, 5, 3, 6, 6, 6, 6, 6, 6, 6, 6, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 4, 6, 6,
6, 6, 6, 2, 6, 6, 4, 6, 4, 6, 6, 6, 6, 6]

	vowel	class	Pred_class
0		1	1
1		1	1
2		1	2
3		1	5
4		1	6
..	
172		6	6
173		6	6
174		6	6
175		6	6
176		6	6

```
[177 rows x 2 columns]
```

[77.40112994350282, 80.7909604519774, 77.96610169491525, 82.48587570621469, 81.35593220338984, 76.27118644067797, 78.53107344632768, 82.48587570621469, 82.48587570621469, 81.92090395480226]

	f1	f2	f3	vowel	class
22	550	1600	2200		1
20	550	1350	2200		1
9	600	1600	2600		1
58	700	1300	2300		1
37	700	1550	2360		1
..

859	550	1100	2750	6
791	500	950	2600	6
808	500	1000	2300	6
737	400	1000	2300	6
722	400	1000	2300	6

```
[607 rows x 4 columns]
```

	f1	f2	f3
22	550	1600	2200
20	550	1350	2200
9	600	1600	2600
58	700	1300	2300
37	700	1550	2360
..
859	550	1100	2750
791	500	950	2600
808	500	1000	2300
737	400	1000	2300
722	400	1000	2300

```
[607 rows x 3 columns]
```

	vowel class
22	1
20	1
9	1
58	1
37	1
..	...
859	6
791	6
808	6
737	6
722	6

```
[607 rows x 1 columns]
```

[5, 1, 1, 5, 5, 5, 2, 5, 5, 1, 1, 5, 1, 1, 2, 1, 1, 5, 2, 5, 1, 2, 2, 2, 1, 2, 2,
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4, 4, 4, 4, 5, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 6, 6, 4, 4, 6, 4,
4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 5, 5, 6, 5, 5, 5, 5, 5, 5, 5, 3, 5, 5, 5, 5,
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3, 5, 5, 5, 5, 5, 5, 5, 5, 5, 3, 3, 5, 5, 6, 5, 5, 5, 3, 5, 5, 6, 6, 4, 6, 6, 6,
6, 6, 6, 2, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 4, 4, 6, 6, 6, 6, 5, 6, 6, 6, 6, 6, 4,
6, 6, 6, 6, 6, 6, 6, 6, 4, 6, 6, 6, 6, 6, 4, 6, 6, 5, 6, 4, 4]

	vowel class	Pred_class
0	1	5
1	1	1
2	1	1
3	1	5
4	1	5
..
259	6	6
260	6	5
261	6	6
262	6	4
263	6	4

```
[264 rows x 2 columns]
```

	f1	f2	f3	vowel class
60	700	1350	2300	1
39	750	1500	2360	1
57	700	1300	2300	1
41	500	1500	2360	1

	f1	f2	f3	vowel class
9	600	1600	2600	1
54	600	1350	2300	1

f1	f2	f3	vowel	class
----	----	----	-------	-------

	f1	f2	f3	vowel	class
34	700	1400	2360		1
25	600	1350	2300		1
70	650	1600	2300		1
71	750	1250	2300		1
6	550	1200	2500		1
..
746	450	1000	2350		6
711	600	1200	2300		6
854	550	1000	2800		6
782	500	950	2560		6
810	400	1000	2300		6

	f1	f2	f3
34	700	1400	2360
25	600	1350	2300
70	650	1600	2300
71	750	1250	2300
6	550	1200	2500
..
746	450	1000	2350
711	600	1200	2300
854	550	1000	2800
782	500	950	2560
810	400	1000	2300

	vowel class
34	1
25	1
70	1
71	1
6	1
..	...
746	6
711	6
854	6
782	6
810	6

	vowel	class	Pred_class
0		1	2
1		1	5
2		1	5
3		1	5
4		1	1
..
259		6	6
260		6	6
261		6	6
262		6	5

[264 rows x 2 columns]					
	f1	f2	f3	vowel	class
54	600	1350	2300		1
31	550	1200	2360		1
23	400	1200	2400		1
26	600	1400	2300		1
15	550	1400	2600		1
..
762	500	1000	2600		6
849	550	1100	2850		6
747	400	1000	2400		6
695	600	1050	2700		6
702	450	1150	2700		6

```
[607 rows x 4 columns]
```

	f1	f2	f3
54	600	1350	2300
31	550	1200	2360
23	400	1200	2400
26	600	1400	2300
15	550	1400	2600
..
762	500	1000	2600
849	550	1100	2850
747	400	1000	2400
695	600	1050	2700
702	450	1150	2700

```
[607 rows x 3 columns]
  vowel class
54          1
31          1
23          1
26          1
15          1
..          ...
762         6
849         6
747         6
695         6
702         6
```

localhost:8888/nbconvert/html/Implementation of 'Baves Classifier' %2C 'Minimum Distance Classifier' and 'K-NN Classifier' on Vowel Data Set... 73/94

[264 rows x 2 columns]				
	f1	f2	f3	vowel class
33	500	1200	2300	1
23	400	1200	2400	1
56	600	1400	2300	1
30	650	1200	2300	1
53	550	1500	2600	1
..
830	450	1000	2350	6
787	500	900	2700	6
862	500	1000	2900	6
819	450	1000	2300	6
691	400	900	2700	6

```
[607 rows x 3 columns]
vowel class
33          1
23          1
56          1
30          1
53          1
..          ...
830         6
787         6
862         6
819         6
691         6
```

```
[607 rows x 1 columns]
[1, 2, 5, 5, 2, 1, 1, 2, 2, 5, 2, 5, 2, 1, 1, 5, 5, 5, 1, 2, 1, 6, 2, 2, 2, 2, 2,
2, 6, 2, 2, 2, 2, 2, 2, 1, 2, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 3, 3, 5, 3, 3,
5, 3, 3, 3, 3, 3, 3, 3, 5, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5, 3,
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4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 4, 6, 2, 4, 6, 6, 6]
```

	vowel	class	Pred_class
0		1	1
1		1	2
2		1	5
3		1	5

```
[607 rows x 1 columns]
[2, 5, 1, 1, 2, 1, 5, 5, 2, 5, 6, 6, 1, 2, 1, 1, 2, 2, 6, 5, 5, 1, 1, 2, 2, 2, 1,
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6, 6, 6, 6, 6, 6, 6, 4, 4, 6, 6, 4, 2, 2, 6, 6, 6, 2, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6,
4, 4, 6, 6, 4, 4, 4, 6, 4, 6, 6, 4, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6]

vowel class  Pred_class
0            1            2
1            1            5
```

2	1	1
3	1	1
4	1	2
..
259	6	6
260	6	6
261	6	6
262	6	6
263	6	6

[264 rows x 2 columns]

	f1	f2	f3	vowel	class
47	650	1400	2000		1
70	650	1600	2300		1
7	550	1700	2600		1
46	600	1700	2300		1
26	600	1400	2300		1
..
825	450	1000	2350		6
852	400	800	2700		6
746	450	1000	2350		6
702	450	1150	2700		6
731	600	1200	2300		6

[607 rows x 4 columns]

	f1	f2	f3
47	650	1400	2000
70	650	1600	2300
7	550	1700	2600
46	600	1700	2300
26	600	1400	2300
..
825	450	1000	2350
852	400	800	2700
746	450	1000	2350
702	450	1150	2700
731	600	1200	2300

[607 rows x 3 columns]

	vowel	class
47		1
70		1
7		1
46		1
26		1
..		...
825		6
852		6
746		6
702		6
731		6

[607 rows x 1 columns]

[5, 2, 6, 1, 5, 4, 2, 5, 2, 6, 5, 1, 2, 1, 1, 1, 1, 1, 2, 1, 2, 5, 2, 2, 2, 2, 2,		
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6, 6, 6, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 4, 4, 6, 6, 4, 6]		
vowel	class	Pred_class

0	1	5
1	1	2
2	1	6
3	1	1
4	1	5
..
259	6	4
260	6	6
261	6	6
262	6	4
263	6	6

[264 rows x 2 columns]

```
[77.40112994350282, 80.7909604519774, 77.96610169491525, 82.48587570621469, 81.355
93220338984, 76.27118644067797, 78.53107344632768, 82.48587570621469, 82.485875706
21469, 81.92090395480226, 81.81818181818183, 79.16666666666666, 81.81818181818183,
77.65151515151516, 80.68181818181817, 77.65151515151516, 80.68181818181817, 81.060
606060606, 76.13636363636364, 78.4090909090909]
```

	f1	f2	f3	vowel	class
3	700	1600	2700		1
12	650	1600	2700		1
58	700	1300	2300		1
49	750	1350	2100		1
36	500	1450	2400		1
..
734	500	1250	2300		6
722	400	1000	2300		6
746	450	1000	2350		6
695	600	1050	2700		6
835	450	1050	2760		6

[521 rows x 4 columns]

	f1	f2	f3
3	700	1600	2700
12	650	1600	2700
58	700	1300	2300
49	750	1350	2100
36	500	1450	2400
..
734	500	1250	2300
722	400	1000	2300
746	450	1000	2350
695	600	1050	2700
835	450	1050	2760

[521 rows x 3 columns]

	vowel	class
3		1
12		1
58		1
49		1
36		1
..		...
734		6
722		6
746		6
695		6
835		6

[521 rows x 1 columns]

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6, 6, 4, 4, 6, 4, 6, 6, 6, 6, 6, 4, 6, 6, 2, 6, 6, 4, 6, 6, 6, 5, 6, 6, 6, 4]

	vowel class	Pred_class
0	1	1
1	1	1
2	1	5
3	1	1
4	1	1
..
345	6	5
346	6	6
347	6	6
348	6	6
349	6	4

[350 rows x 2 columns]

	f1	f2	f3	vowel class
70	650	1600	2300	1
6	550	1200	2500	1
32	500	1350	2360	1
34	700	1400	2360	1
15	550	1400	2600	1
..
706	400	1100	2300	6
845	500	1000	2700	6
710	450	1150	2300	6
815	400	850	2300	6
696	450	1100	2700	6

[521 rows x 4 columns]

	f1	f2	f3
70	650	1600	2300
6	550	1200	2500
32	500	1350	2360
34	700	1400	2360
15	550	1400	2600
..
706	400	1100	2300
845	500	1000	2700
710	450	1150	2300
815	400	850	2300
696	450	1100	2700

[521 rows x 3 columns]

	vowel class
70	1
6	1
32	1
34	1
15	1
..	...
706	6
845	6
710	6
815	6
696	6

[521 rows x 1 columns]

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6, 4, 4, 6, 4, 4, 6, 6, 6, 6, 4, 6, 4, 4, 6, 6, 6, 6, 6, 6, 4, 4, 6, 4, 4, 6]
```

	vowel class	Pred_class
0	1	5
1	1	1
2	1	1
3	1	2
4	1	1
..
345	6	4
346	6	6
347	6	4
348	6	4
349	6	6

[350 rows x 2 columns]

	f1	f2	f3	vowel class
44	650	1400	2100	1
54	600	1350	2300	1
28	500	1400	2360	1
64	500	1900	2300	1
35	450	1650	2400	1
..
721	400	900	2300	6
769	550	1300	2800	6
776	500	1000	2560	6
734	500	1250	2300	6
863	500	900	2800	6

[521 rows x 4 columns]

	f1	f2	f3
44	650	1400	2100
54	600	1350	2300
28	500	1400	2360
64	500	1900	2300
35	450	1650	2400
..
721	400	900	2300
769	550	1300	2800
776	500	1000	2560
734	500	1250	2300
863	500	900	2800

[521 rows x 3 columns]

	vowel class
44	1
54	1
28	1
64	1
35	1
..	...
721	6


```

769          6
776          6
734          6
863          6

```

```
[521 rows x 1 columns]
```

```

[5, 2, 1, 5, 4, 5, 2, 1, 5, 5, 5, 2, 1, 6, 1, 1, 2, 1, 1, 1, 5, 2, 6, 5, 5, 5, 5,
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```

```

      vowel class  Pred_class
0          1          5
1          1          2
2          1          1
3          1          5
4          1          4
..          ...          ...
345         6          6
346         6          6
347         6          2
348         6          6
349         6          6

```

```
[350 rows x 2 columns]
```

```

      f1    f2    f3  vowel class
20   550  1350  2200          1
44   650  1400  2100          1
24   600  1200  2300          1
49   750  1350  2100          1
8    550  1400  2550          1
..    ...    ...    ...          ...
819  450  1000  2300          6
701  600  1150  2700          6
697  550  1250  2700          6
838  500   900  2800          6
834  500  1000  2300          6

```

```
[521 rows x 4 columns]
```

```

      f1    f2    f3
20   550  1350  2200
44   650  1400  2100
24   600  1200  2300
49   750  1350  2100
8    550  1400  2550
..    ...    ...    ...
819  450  1000  2300
701  600  1150  2700
697  550  1250  2700
838  500   900  2800
834  500  1000  2300

```

```
[521 rows x 3 columns]
```

```

      vowel class
20          1
44          1

```

```

24          1
49          1
8           1
..          ...
819         6
701         6
697         6
838         6
834         6

```

[521 rows x 1 columns]

```

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4, 6, 6, 6, 4, 6, 6, 6, 6, 4, 4, 6, 4, 4, 6, 6, 6, 6, 6, 6, 6, 4, 6, 6, 6, 6]

```

```

      vowel class  Pred_class
0          1          1
1          1          1
2          1          2
3          1          2
4          1          4
..          ...          ...
345         6          4
346         6          6
347         6          6
348         6          6
349         6          6

```

[350 rows x 2 columns]

```

      f1    f2    f3  vowel class
39   750  1500  2360          1
5    600  1250  2700          1
34   700  1400  2360          1
64   500  1900  2300          1
11   500  1750  2600          1
..    ...    ...    ...          ...
790  500  1000  2600          6
691  400   900  2700          6
789  500  1050  2600          6
826  400  1000  2300          6
864  500  1050  2800          6

```

[521 rows x 4 columns]

```

      f1    f2    f3
39   750  1500  2360
5    600  1250  2700
34   700  1400  2360
64   500  1900  2300
11   500  1750  2600
..    ...    ...    ...
790  500  1000  2600
691  400   900  2700
789  500  1050  2600
826  400  1000  2300
864  500  1050  2800

```



```

701 600 1150 2700
709 400 1300 2300
753 600 1200 2300
869 500 900 2800
822 500 850 2300

```

```
[521 rows x 3 columns]
```

```

vowel class
60          1
42          1
63          1
20          1
2           1
..          ...
701         6
709         6
753         6
869         6
822         6

```

```
[521 rows x 1 columns]
```

```

[6, 1, 5, 2, 1, 1, 1, 2, 1, 5, 1, 6, 5, 2, 5, 5, 5, 1, 1, 1, 6, 1, 1, 5, 2, 1, 1,
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```

```

vowel class  Pred_class
0           1           6
1           1           1
2           1           5
3           1           2
4           1           1
..          ...          ...
345         6           4
346         6           6
347         6           4
348         6           4
349         6           6

```

```
[350 rows x 2 columns]
```

```

f1  f2  f3  vowel class
14  600 1400 2600          1
29  550 1300 2300          1
21  600 1400 2200          1
20  550 1350 2200          1
41  500 1500 2360          1
..  ...  ...  ...          ...
802 450 1000 2300          6
775 500 1000 2560          6
870 500 950 2700          6
790 500 1000 2600          6
864 500 1050 2800          6

```

```
[521 rows x 4 columns]
```

```

f1  f2  f3
14  600 1400 2600

```

```

29  550  1300  2300
21  600  1400  2200
20  550  1350  2200
41  500  1500  2360
..   ...   ...   ...
802 450  1000  2300
775 500  1000  2560
870 500   950  2700
790 500  1000  2600
864 500  1050  2800

```

[521 rows x 3 columns]

```

vowel class
14          1
29          1
21          1
20          1
41          1
..          ...
802         6
775         6
870         6
790         6
864         6

```

[521 rows x 1 columns]

```

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```

```

vowel class  Pred_class
0           1           5
1           1           5
2           1           1
3           1           2
4           1           2
..          ...          ...
345         6           6
346         6           6
347         6           6
348         6           6
349         6           6

```

[350 rows x 2 columns]

```

f1  f2  f3  vowel class
53  550  1500  2600          1
37  700  1550  2360          1
21  600  1400  2200          1
5   600  1250  2700          1
52  550  1700  2300          1
..   ...   ...   ...          ...
866 500  1050  2900          6
840 500   900  2750          6
691 400   900  2700          6
706 400  1100  2300          6

```

6

f1 f2 f3

37 700 1550 2360

21 600 1400 2200

5	600	1250	2700
---	-----	------	------

52 550 1700 2300

• • • • •

866 500 1050 2900

840	500	900	2750
-----	-----	-----	------

691	400	900	2700
-----	-----	-----	------

706	400	1100	2300
-----	-----	------	------

801	500	1050	2300
-----	-----	------	------

vowel class

53 1

37 1

21 1

5 1

52 1

• • • • •

866 6

840 6

691 6

706 6

801 6

[4, 5, 2, 6, 5, 2, 1, 5, 5, 2, 5, 1, 2, 1, 2, 5, 5, 1, 2, 1, 2, 2, 2, 6, 6, 5, 5,
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2, 2, 2, 6, 2, 2, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3,
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6, 6, 6, 6, 6, 6, 6, 4, 6, 6, 6, 6, 6, 6, 6, 2, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6,
6, 6, 6, 6, 6, 6, 6, 4, 6, 6, 6, 4, 6, 6, 6, 2, 6, 6, 6, 4, 6, 6, 6, 6, 6]

vowel class Pred class

$$0 \qquad \qquad \qquad 1 \qquad \qquad \qquad - \qquad \qquad \qquad 4$$

1 1 5

2 1 2

3 1 6

4 1 5

• • • • •

345 6 6

346 6 6

347 6 6

348 6 6

349 6 6

f1	f2	f3	vowel class
----	----	----	-------------

36	500	1450	2400	1
----	-----	------	------	---

44	650	1400	2100	1
----	-----	------	------	---

68 650 1200 2300 1

37	700	1550	2360	1
----	-----	------	------	---

1	550	1550	2400	1
---	-----	------	------	---

```

..      ...      ...      ...      ...
795  500   900   2500           6
701  600  1150   2700           6
708  450  1100   2300           6
714  500  1000   2300           6
729  400  1300   2300           6

```

[521 rows x 4 columns]

```

      f1      f2      f3
36   500  1450  2400
44   650  1400  2100
68   650  1200  2300
37   700  1550  2360
1    550  1550  2400
..      ...      ...      ...
795  500   900   2500
701  600  1150   2700
708  450  1100   2300
714  500  1000   2300
729  400  1300   2300

```

[521 rows x 3 columns]

```

      vowel class
36              1
44              1
68              1
37              1
1               1
..              ...
795             6
701             6
708             6
714             6
729             6

```

[521 rows x 1 columns]

```

[6, 5, 5, 5, 2, 5, 1, 6, 1, 1, 2, 1, 2, 5, 5, 5, 2, 5, 2, 2, 1, 1, 1, 1, 1, 1, 5,
2, 5, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 1, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 3, 3, 3, 5, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 5,
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4, 4, 4, 4, 4, 4, 5, 5, 3, 4, 5, 5, 5, 5, 3, 5, 5, 5, 5, 5, 5, 5, 5, 3, 3, 5, 3,
5, 5, 5, 5, 5, 5, 5, 5, 3, 5, 1, 5, 5, 5, 5, 3, 5, 5, 5, 3, 5, 3, 3, 5, 5, 5,
5, 5, 5, 5, 4, 3, 5, 3, 5, 5, 5, 6, 3, 5, 5, 1, 5, 5, 3, 5, 5, 3, 5, 5, 5, 5,
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6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 4, 6, 4, 6, 6, 6, 6, 6, 4, 6, 6, 6, 6,
6, 6, 4, 6, 6, 6, 6, 6, 4, 4, 4, 6, 6, 4, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 4]

```

```

      vowel class  Pred_class
0              1           6
1              1           5
2              1           5
3              1           5
4              1           2
..              ...         ...
345             6           6
346             6           6
347             6           6
348             6           6
349             6           4

```

[350 rows x 2 columns]

```

      f1      f2      f3  vowel class

```


348	6	6
349	6	6

```
[350 rows x 2 columns]
[77.40112994350282, 80.7909604519774, 77.96610169491525, 82.48587570621469, 81.355
93220338984, 76.27118644067797, 78.53107344632768, 82.48587570621469, 82.485875706
21469, 81.92090395480226, 81.818181818183, 79.16666666666666, 81.818181818183,
77.65151515151516, 80.681818181817, 77.65151515151516, 80.681818181817, 81.060
60606060606, 76.13636363636364, 78.4090909090909, 82.28571428571428, 78.0, 79.7142
8571428572, 79.42857142857143, 82.0, 77.71428571428571, 78.28571428571428, 80.2857
1428571428, 80.57142857142857, 79.71428571428572]
```

```
In [13]: df_a_bayes = pd.DataFrame({'Test_size': np.array(accuracy_lst[:10])})
print(df_a_bayes)
```

```
Test_size = 0.2
0      77.401130
1      80.790960
2      77.966102
3      82.485876
4      81.355932
5      76.271186
6      78.531073
7      82.485876
8      82.485876
9      81.920904
```

```
In [14]: df_b_bayes = pd.DataFrame({'Test_size': np.array(accuracy_lst[10:20])})
print(df_b_bayes)
```

```
Test_size = 0.3
0      81.818182
1      79.166667
2      81.818182
3      77.651515
4      80.681818
5      77.651515
6      80.681818
7      81.060606
8      76.136364
9      78.409091
```

```
In [15]: df_c_bayes = pd.DataFrame({'Test_size': np.array(accuracy_lst[20:])})
print(df_c_bayes)
```

```
Test_size = 0.4
0      82.285714
1      78.000000
2      79.714286
3      79.428571
4      82.000000
5      77.714286
6      78.285714
7      80.285714
8      80.571429
9      79.714286
```

Accuracy of MDC Classifier for different test sizes for 10 iterations

```
In [16]: result_bayes = df_a_bayes.join([df_b_bayes, df_c_bayes])
print(result_bayes)
```

	Test_size = 0.2	Test_size = 0.3	Test_size = 0.4
0	77.401130	81.818182	82.285714
1	80.790960	79.166667	78.000000
2	77.966102	81.818182	79.714286
3	82.485876	77.651515	79.428571
4	81.355932	80.681818	82.000000
5	76.271186	77.651515	77.714286
6	78.531073	80.681818	78.285714
7	82.485876	81.060606	80.285714
8	82.485876	76.136364	80.571429
9	81.920904	78.409091	79.714286

Mean Accuracy of Bayes Classifier for different test sizes

In [17]: `result_bayes.mean()`

Out[17]:

Test_size = 0.2	80.169492
Test_size = 0.3	79.507576
Test_size = 0.4	79.800000

dtype: float64

In [20]:

```

k_values = [3, 5, 7]
accuracy_results = {}
test_size_lst = [0.2,0.3,0.4]
for k in k_values:
    accuracy_lst= []
    for testsize in test_size_lst:
        for i in range(10):
            df1 = df[df['vowel class']==1]
            X_1 = df1.drop(columns=['vowel class'])
            y_1 = df1['vowel class']
            X1_train,X1_test,y1_train,y1_test = train_test_split(X_1,y_1,test_size=

            df2 = df[df['vowel class']==2]
            X_2 = df2.drop(columns=['vowel class'])
            y_2 = df2['vowel class']
            X2_train,X2_test,y2_train,y2_test = train_test_split(X_2,y_2,test_size=

            df3 = df[df['vowel class']==3]
            X_3 = df3.drop(columns=['vowel class'])
            y_3 = df3['vowel class']
            X3_train,X3_test,y3_train,y3_test = train_test_split(X_3,y_3,test_size=

            df4 = df[df['vowel class']==4]
            X_4 = df4.drop(columns=['vowel class'])
            y_4 = df4['vowel class']
            X4_train,X4_test,y4_train,y4_test = train_test_split(X_4,y_4,test_size=

            df5 = df[df['vowel class']==5]
            X_5 = df5.drop(columns=['vowel class'])
            y_5 = df5['vowel class']
            X5_train,X5_test,y5_train,y5_test = train_test_split(X_5,y_5,test_size=

            df6 = df[df['vowel class']==6]
            X_6 = df6.drop(columns=['vowel class'])
            y_6 = df6['vowel class']
            X6_train,X6_test,y6_train,y6_test = train_test_split(X_6,y_6,test_size=

            X_1_ = X1_train.join(y1_train)
            X_2_ = X2_train.join(y2_train)
            X_3_ = X3_train.join(y3_train)
            X_4_ = X4_train.join(y4_train)
            X_5_ = X5_train.join(y5_train)

```

```

X_6_ = X6_train.join(y6_train)

train_final = pd.concat([X_1_,X_2_,X_3_,X_4_,X_5_,X_6_])
#print(train_final)

X_train = train_final.drop(columns='vowel class')
#print(X_train)
y_train = pd.DataFrame(train_final['vowel class'])
#print(y_train)

X_test = pd.concat([X1_test,X2_test,X3_test,X4_test,X5_test,X6_test])
#print(X_test)

y_test = pd.concat([y1_test,y2_test,y3_test,y4_test,y5_test,y6_test])
#print(y_test)

def euclidean_distance(x,y):
    return np.sqrt(np.sum((x-y)**2))

y_pred = []
for testpoint in np.array(X_test):
    distance_list = [euclidean_distance(testpoint,x) for x in np.array(X_train)]
    df_dist = pd.DataFrame({'dist': distance_list, 'vowel class': y_train})
    df_dist = df_dist.sort_values(by='dist', ascending=True)
    df_knn = df_dist.iloc[:k]
    most_common_label = df_knn['vowel class'].mode().iloc[0]
    y_pred.append(most_common_label)
#print(y_pred)

y_pred_df = pd.DataFrame({'Pred_class':y_pred})
#print(y_pred_df)
y_test_df= pd.DataFrame(y_test)
y_test_df.reset_index(inplace=True)
#print(y_test_df)

df_foraccuracy = y_test_df.join(y_pred_df).drop(columns=['index'])
#print(df_foraccuracy)

#Calculating Accuracy
true_pred = df_foraccuracy[df_foraccuracy['vowel class']==df_foraccuracy['Pred_class']]
accuracy = (true_pred.shape[0]/df_foraccuracy.shape[0])*100
#print(accuracy)
accuracy_lst.append(accuracy)
accuracy_results[k] = accuracy_lst
for k, accuracies in accuracy_results.items():
    print(f"Accuracy results for k={k}: {accuracies}")

```

Accuracy results for k=3: [86.4406779661017, 89.26553672316385, 84.18079096045197, 86.4406779661017, 85.31073446327684, 81.92090395480226, 82.48587570621469, 81.92090395480226, 82.48587570621469, 85.31073446327684, 84.0909090909091, 87.87878787878788, 85.22727272727273, 88.63636363636364, 86.74242424242425, 85.22727272727273, 84.0909090909091, 86.74242424242425, 84.84848484848484, 87.87878787878788, 85.71428571428571, 83.71428571428572, 85.42857142857143, 86.57142857142858, 84.28571428571429, 86.0, 83.42857142857143, 86.57142857142858, 83.71428571428572, 87.14285714285714]

Accuracy results for k=5: [87.57062146892656, 89.83050847457628, 87.00564971751412, 87.57062146892656, 87.00564971751412, 84.18079096045197, 89.26553672316385, 85.87570621468926, 88.13559322033898, 82.48587570621469, 87.12121212121212, 86.74242424242425, 82.95454545454545, 85.60606060606061, 87.87878787878788, 88.25757575757575, 86.74242424242425, 83.71212121212122, 85.60606060606061, 85.98484848484848, 86.57142857142858, 83.42857142857143, 84.57142857142857, 83.14285714285714, 85.71428571428571, 84.0, 84.85714285714285, 88.0, 86.85714285714286, 87.42857142857143]

Accuracy results for k=7: [87.00564971751412, 90.96045197740112, 88.13559322033898, 78.53107344632768, 87.00564971751412, 81.92090395480226, 87.00564971751412, 86.4406779661017, 84.7457627118644, 87.57062146892656, 85.60606060606061, 89.01515151515152, 83.33333333333334, 86.74242424242425, 86.36363636363636, 86.36363636363636, 85.22727272727273, 85.22727272727273, 81.43939393939394, 86.74242424242425, 85.42857142857143, 86.57142857142858, 88.28571428571429, 88.28571428571429, 84.57142857142857, 86.85714285714286, 84.85714285714285, 85.42857142857143, 89.42857142857143, 84.85714285714285]

Mean Accuracy of kNN Classifier for different test sizes, where k = 3

```
In [24]: k_3_accuracy_lst = accuracy_results[3]
df_a_k_3nn = pd.DataFrame({'Test_size = 0.2':np.array(k_3_accuracy_lst[:10])})
df_b_k_3nn = pd.DataFrame({'Test_size = 0.3':np.array(k_3_accuracy_lst[10:20])})
df_c_k_3nn = pd.DataFrame({'Test_size = 0.4':np.array(k_3_accuracy_lst[20:])})
result_k_3nn= df_a_k_3nn.join([df_b_k_3nn,df_c_k_3nn])
print(result_k_3nn)
print(result_k_3nn.mean())
```

	Test_size = 0.2	Test_size = 0.3	Test_size = 0.4
0	86.440678	84.090909	85.714286
1	89.265537	87.878788	83.714286
2	84.180791	85.227273	85.428571
3	86.440678	88.636364	86.571429
4	85.310734	86.742424	84.285714
5	81.920904	85.227273	86.000000
6	82.485876	84.090909	83.428571
7	81.920904	86.742424	86.571429
8	82.485876	84.848485	83.714286
9	85.310734	87.878788	87.142857
Test_size = 0.2	84.576271		
Test_size = 0.3	86.136364		
Test_size = 0.4	85.257143		

dtype: float64

Mean Accuracy of kNN Classifier for different test sizes, where k = 5

```
In [25]: k_5_accuracy_lst = accuracy_results[5]
df_a_k_5nn = pd.DataFrame({'Test_size = 0.2':np.array(k_5_accuracy_lst[:10])})
df_b_k_5nn = pd.DataFrame({'Test_size = 0.3':np.array(k_5_accuracy_lst[10:20])})
df_c_k_5nn = pd.DataFrame({'Test_size = 0.4':np.array(k_5_accuracy_lst[20:])})
result_k_5nn= df_a_k_5nn.join([df_b_k_5nn,df_c_k_5nn])
print(result_k_5nn)
print(result_k_5nn.mean())
```

	Test_size = 0.2	Test_size = 0.3	Test_size = 0.4
0	87.570621	87.121212	86.571429
1	89.830508	86.742424	83.428571
2	87.005650	82.954545	84.571429
3	87.570621	85.606061	83.142857
4	87.005650	87.878788	85.714286
5	84.180791	88.257576	84.000000
6	89.265537	86.742424	84.857143
7	85.875706	83.712121	88.000000
8	88.135593	85.606061	86.857143
9	82.485876	85.984848	87.428571
Test_size = 0.2	86.892655		
Test_size = 0.3	86.060606		
Test_size = 0.4	85.457143		

dtype: float64

Mean Accuracy of kNN Classifier for different test sizes,where k = 7

```
In [27]: k_7_accuracy_lst = accuracy_results[7]
df_a_k_7nn = pd.DataFrame({'Test_size = 0.2':np.array(k_7_accuracy_lst[:10])})
df_b_k_7nn = pd.DataFrame({'Test_size = 0.3':np.array(k_7_accuracy_lst[10:20])})
df_c_k_7nn = pd.DataFrame({'Test_size = 0.4':np.array(k_7_accuracy_lst[20:])})
result_k_7nn= df_a_k_7nn.join([df_b_k_7nn,df_c_k_7nn])
print(result_k_7nn)
print(result_k_7nn.mean())
```

	Test_size = 0.2	Test_size = 0.3	Test_size = 0.4
0	87.005650	85.606061	85.428571
1	90.960452	89.015152	86.571429
2	88.135593	83.333333	88.285714
3	78.531073	86.742424	88.285714
4	87.005650	86.363636	84.571429
5	81.920904	86.363636	86.857143
6	87.005650	85.227273	84.857143
7	86.440678	85.227273	85.428571
8	84.745763	81.439394	89.428571
9	87.570621	86.742424	84.857143
Test_size = 0.2	85.932203		
Test_size = 0.3	85.606061		
Test_size = 0.4	86.457143		

dtype: float64

Remark:

In Vowel data set , there are six classes and each class have different no. of instances.It's an imbalanced dataset. So,instead of doing train_test_split on the whole dataset, we first split the whole dataset based on the differnt classes and then do train_test_split on each of the 6 parts of the data test and from that we construct our finalized trining set and test set. After performing three classifications namely 'Minimum Distance Classification','Bayes Classification','K-NN Classification' and observing their average accuracy over different test sizes , we conclude that: i) KNN classifier takes a lot of time to perform compare to other algorithms. It's like a lazy algorithm. ii) Based on the performance on this particular dataset we can order this three classifiers as follows: MDC< Bayes Classifier < K-NN

Classifier iii) But it doesn't conclude that K-NN classifier always performs best compare to other classsifiers.