Importing important libraries

In [3]:
```
#!pip install imblearn
```

In [4]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sb
from collections import Counter
import imblearn
%matplotlib inline

import warnings
warnings.filterwarnings("ignore")
```

Loading Drybeans dataset

In [5]:
```
drybean = pd.read_excel("Dry_Bean_Dataset.xlsx")
drybean
```

Out[5]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	AspectRation	Eccentricity	ConvexA
0	28395	610.291	208.178117	173.888747	1.197191	0.549812	28
1	28734	638.018	200.524796	182.734419	1.097356	0.411785	29
2	29380	624.110	212.826130	175.931143	1.209713	0.562727	29
3	30008	645.884	210.557999	182.516516	1.153638	0.498616	30
4	30140	620.134	201.847882	190.279279	1.060798	0.333680	30
...	...	...	...	...	...	...	
13606	42097	759.696	288.721612	185.944705	1.552728	0.765002	42
13607	42101	757.499	281.576392	190.713136	1.476439	0.735702	42
13608	42139	759.321	281.539928	191.187979	1.472582	0.734065	42
13609	42147	763.779	283.382636	190.275731	1.489326	0.741055	42
13610	42159	772.237	295.142741	182.204716	1.619841	0.786693	42

13611 rows × 17 columns

This dataset has 13611 sample observations, 16 different feature of beans and a class of beans.

Attribute Information:

1.) Area (A): The area of a bean zone and the number of pixels within its boundaries.

2.) Perimeter (P): Bean circumference is defined as the length of its border.

3.) Major axis length (L): The distance between the ends of the longest line that can be drawn from a bean.

4.) Minor axis length (l): The longest line that can be drawn from the bean while standing perpendicular to the main axis.

5.) Aspect ratio (K): Defines the relationship between L and l.

6.) Eccentricity (Ec): Eccentricity of the ellipse having the same moments as the region.

7.) Convex area (C): Number of pixels in the smallest convex polygon that can contain the area of a bean seed.

8.) Equivalent diameter (Ed): The diameter of a circle having the same area as a bean seed area.

9.) Extent (Ex): The ratio of the pixels in the bounding box to the bean area.

10.)Solidity (S): Also known as convexity. The ratio of the pixels in the convex shell to those found in beans.

11.)Roundness (R): Calculated with the following formula: (4piA)/(P^2)

12.)Compactness (CO): Measures the roundness of an object: Ed/L

13.)ShapeFactor1 (SF1)

14.)ShapeFactor2 (SF2)

15.)ShapeFactor3 (SF3)

16.)ShapeFactor4 (SF4)

17.)Class (Seker, Barbunya, Bombay, Cali, Dermosan, Horoz and Sira)

In [6]:
```
drybean.shape
```

Out[6]:
```
(13611, 17)
```

In [8]:
```
#checking the different types of beans in target feature
drybean.Class.value_counts()
```

Out[8]:
```
DERMASON    3546
SIRA        2636
SEKER       2027
HOROZ       1928
CALI        1630
BARBUNYA    1322
BOMBAY       522
Name: Class, dtype: int64
```

In [9]:
```
drybean.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 13611 entries, 0 to 13610
Data columns (total 17 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   Area             13611 non-null  int64  
 1   Perimeter        13611 non-null  float64
 2   MajorAxisLength  13611 non-null  float64
 3   MinorAxisLength  13611 non-null  float64
 4   AspectRation     13611 non-null  float64
 5   Eccentricity     13611 non-null  float64
 6   ConvexArea       13611 non-null  int64  
 7   EquivDiameter    13611 non-null  float64
 8   Extent           13611 non-null  float64
 9   Solidity         13611 non-null  float64
 10  roundness        13611 non-null  float64
 11  Compactness      13611 non-null  float64
 12  ShapeFactor1     13611 non-null  float64
 13  ShapeFactor2     13611 non-null  float64
```

Total no of observation : 13611 Total no of features : 17

Out of 17 features, 16 features are Numerical and one that is "Class" is categorical Data type

And All are non NAN

In [10]:
```
drybean.nunique()
```

Out[10]:
```
Area               12011
Perimeter          13416
MajorAxisLength    13543
MinorAxisLength    13543
AspectRation       13543
Eccentricity       13543
ConvexArea         12066
EquivDiameter      12011
Extent             13535
Solidity           13526
roundness          13543
Compactness        13543
ShapeFactor1       13543
ShapeFactor2       13543
ShapeFactor3       13543
ShapeFactor4       13543
Class                  7
dtype: int64
```

From the above observation it is clea that there are very less duplicate values in the dataset.
From above, can say that dataset has maximum unique value in each feature

In [11]:
```
1 drybean.isnull().sum()
```

Out[11]:
```
Area              0
Perimeter         0
MajorAxisLength   0
MinorAxisLength   0
AspectRation      0
Eccentricity      0
ConvexArea        0
EquivDiameter     0
Extent            0
Solidity          0
roundness         0
Compactness       0
ShapeFactor1      0
ShapeFactor2      0
ShapeFactor3      0
ShapeFactor4      0
Class             0
dtype: int64
```

There is no any NAN value in the entire dataset means no missing values.

In [9]:
```
1 # Descriptive Analysis
2
3 drybean.describe().T
```

Out[9]:

	count	mean	std	min	25%	50%
Area	13611.0	53048.284549	29324.095717	20420.000000	36328.000000	44652.000000
Perimeter	13611.0	855.283459	214.289696	524.736000	703.523500	794.941000
MajorAxisLength	13611.0	320.141867	85.694186	183.601165	253.303633	296.883367
MinorAxisLength	13611.0	202.270714	44.970091	122.512653	175.848170	192.431733
AspectRation	13611.0	1.583242	0.246678	1.024868	1.432307	1.551124
Eccentricity	13611.0	0.750895	0.092002	0.218951	0.715928	0.764441
ConvexArea	13611.0	53768.200206	29774.915817	20684.000000	36714.500000	45178.000000
EquivDiameter	13611.0	253.064220	59.177120	161.243764	215.068003	238.438026
Extent	13611.0	0.749733	0.049086	0.555315	0.718634	0.759859
Solidity	13611.0	0.987143	0.004660	0.919246	0.985670	0.988283
roundness	13611.0	0.873282	0.059520	0.489618	0.832096	0.883157
Compactness	13611.0	0.799864	0.061713	0.640577	0.762469	0.801277
ShapeFactor1	13611.0	0.006564	0.001128	0.002778	0.005900	0.006645
ShapeFactor2	13611.0	0.001716	0.000596	0.000564	0.001154	0.001694
ShapeFactor3	13611.0	0.643590	0.098996	0.410339	0.581359	0.642044
ShapeFactor4	13611.0	0.995063	0.004366	0.947687	0.993703	0.996386

In [15]:
```
#Checking duplicated item
drybean.duplicated().sum()
```

Out[15]:
```
0
```

There is very less duplicates so we can directily drop them.

In [16]:
```
#droped duplicated items
drybean.drop_duplicates(inplace = True)
```

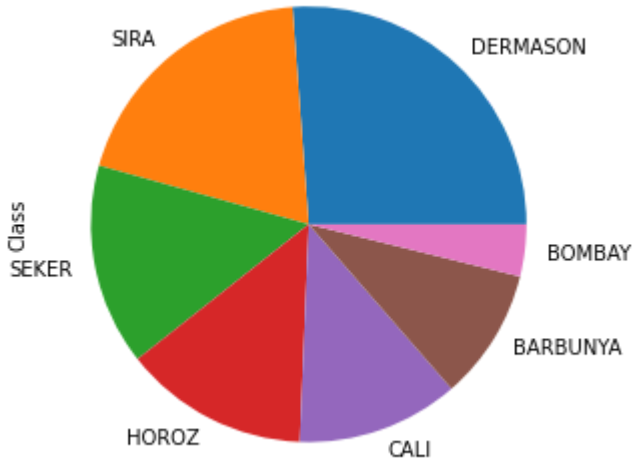
In [17]:
```
#Again checking for confirmation
drybean.duplicated().sum()
```

Out[17]:
```
0
```

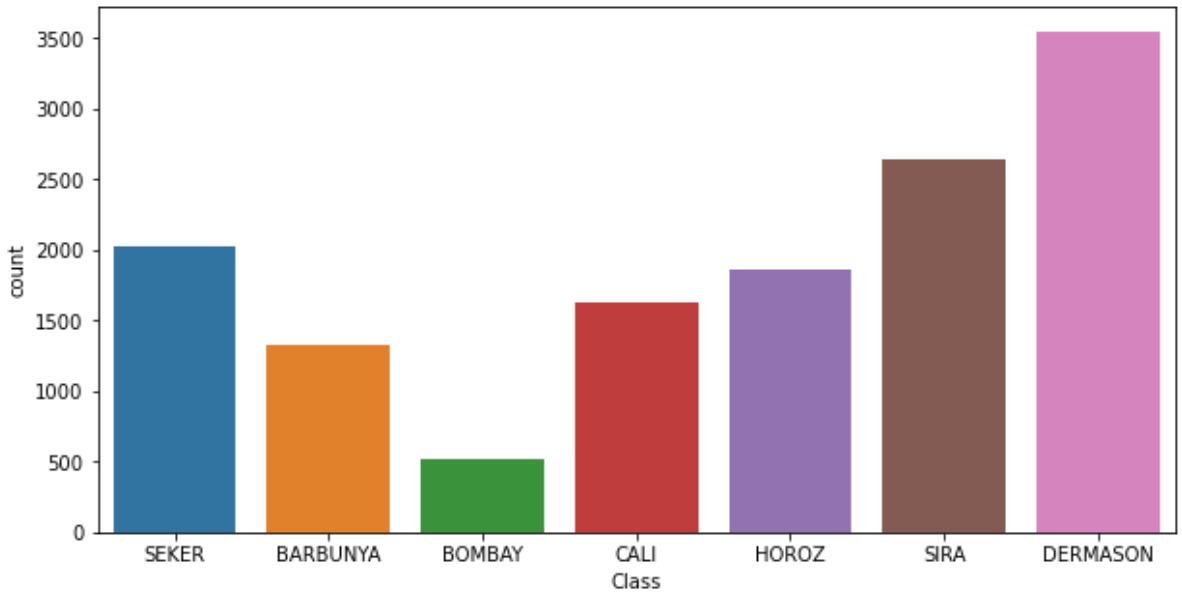
In [18]:
```
#checheing unique value in traget class
drybean.Class.value_counts()
```

Out[18]:
```
DERMASON    3546
SIRA        2636
SEKER       2027
HOROZ       1860
CALI        1630
BARBUNYA    1322
BOMBAY       522
Name: Class, dtype: int64
```

In [19]:
```
 #Visualization of target class seaborn countplot
plt.figure(figsize = (10,5))
drybean.Class.value_counts().plot(kind='pie')
plt.show()
```

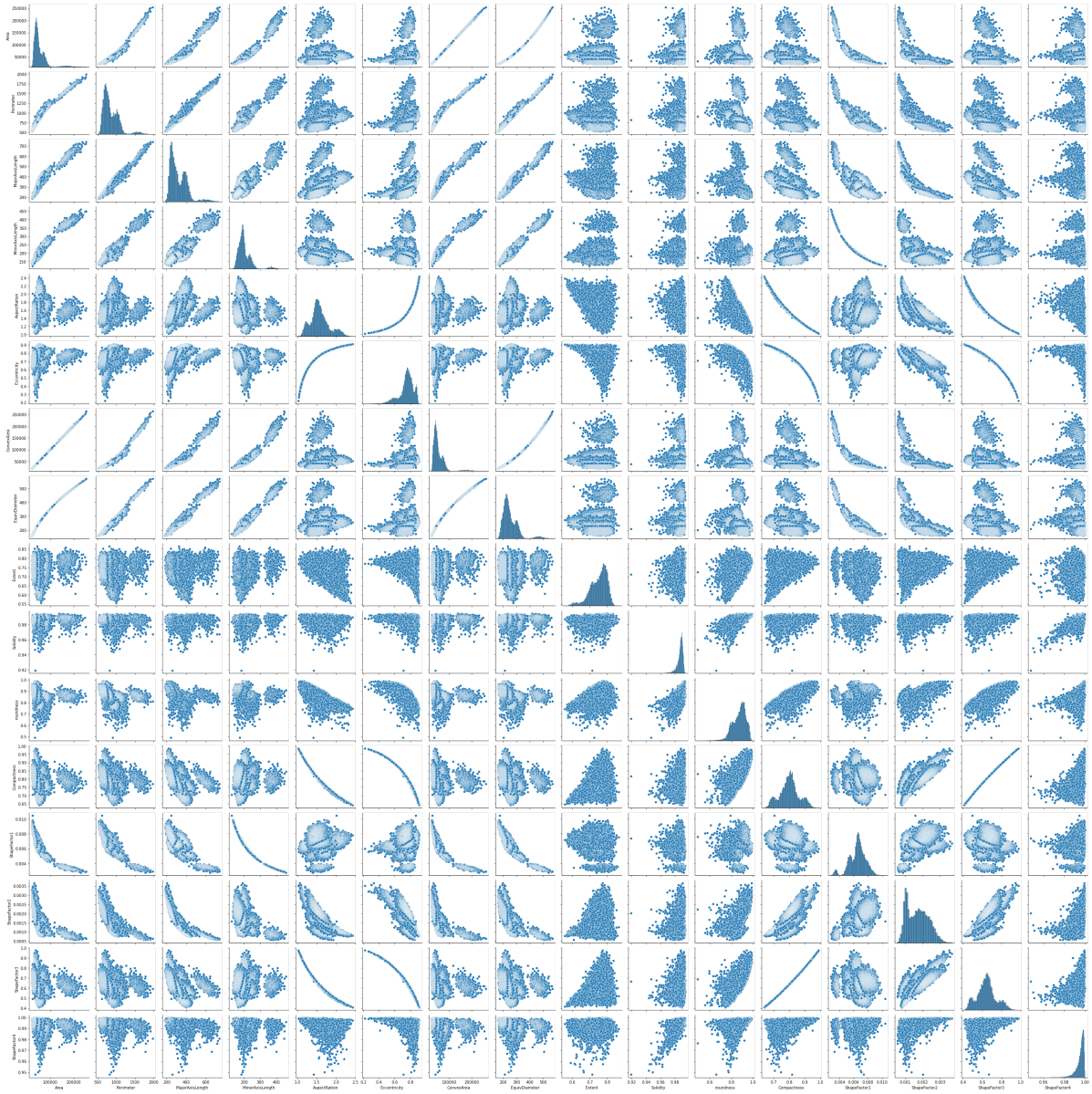


In [20]:
```
#Visualization of target class seaborn countplot
plt.figure(figsize = (10,5))
sb.countplot(x="Class", data = drybean)
plt.show()
```



In [16]:
```
1 sb.pairplot(drybean)
```

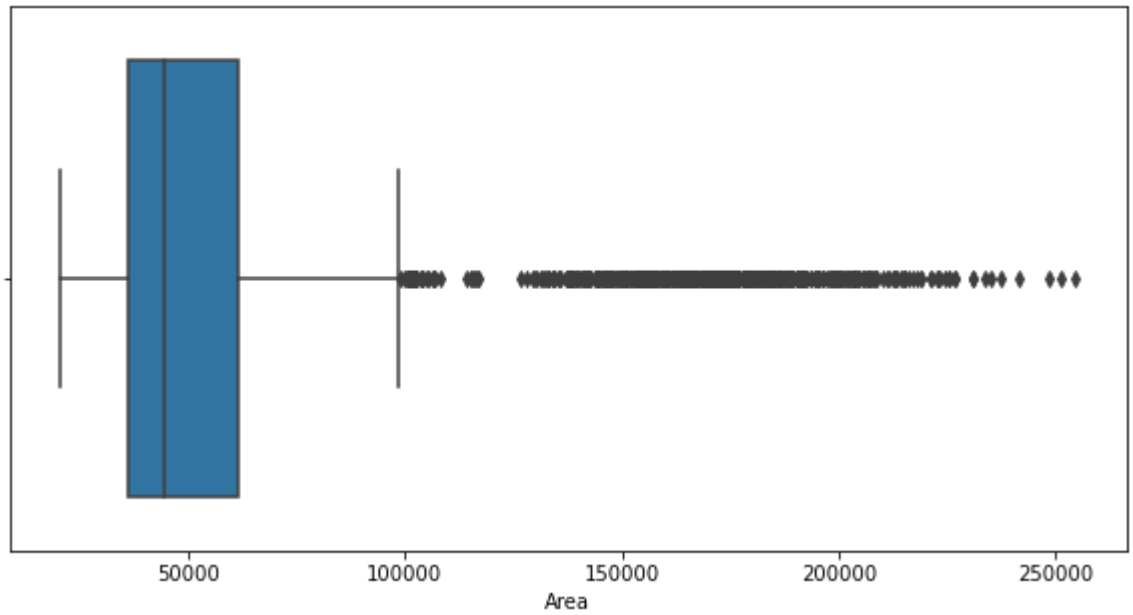
Out[16]: <seaborn.axisgrid.PairGrid at 0x2b868c7aee0>



In [22]:
```
1 plt.savefig('Drybean_Pairplot.png')
```

<Figure size 432x288 with 0 Axes>

In [23]:
```
#checking outlier using box and whisker plot

for features in drybean.columns:
    if features =="Class":
        continue
    else:
        plt.figure(figsize = (10,5))
        sb.boxplot(data = drybean, x = features)
        plt.show()
```



From the above observations, it seems that has alot of outliers.

In [24]:
```
#Mannual Checking of outlier

drybean_Area = drybean["Area"]
Q3 = drybean_Area.quantile(0.75)
Q1 = drybean_Area.quantile(0.25)
median = drybean_Area.quantile(0.50)
IQR = Q3-Q1
lower_limit = Q1-1.5*IQR
upper_limit = Q3+1.5*IQR
Area_outlier = drybean_Area[(drybean_Area<lower_limit) | (drybean_Area>upp
Area_outlier
```

Out[24]:
```
3344    100846
3345    102015
3346    102379
3347    105542
3348    115967
         ...
5496    106806
5497    107911
5498    114858
5499    115608
5500    116272
Name: Area, Length: 551, dtype: int64
```

In [25]:
```
#Mannual Checking of outlier

drybean_EquivDiameter = drybean["EquivDiameter"]
Q3_E = drybean_EquivDiameter.quantile(0.75)
Q1_E = drybean_EquivDiameter.quantile(0.25)
median_E = drybean_EquivDiameter.quantile(0.50)
IQR_E = Q3_E-Q1_E
lower_limit_E = Q1_E-1.5*IQR_E
upper_limit_E = Q3_E+1.5*IQR_E
EquivDiameter_outlier = drybean_EquivDiameter[(drybean_EquivDiameter<lower
EquivDiameter_outlier

#print(type(EquivDiameter_outlier))
```

Out[25]:
```
3348    384.257427
3349    380.991340
3350    386.021135
3351    401.333555
3352    403.887242
           ...
3869    565.803115
3870    569.374358
5498    382.415674
5499    383.662192
5500    384.762405
Name: EquivDiameter, Length: 526, dtype: float64
```

In [26]:
```
#Mannual Checking of outlier

drybean_Perimeter = drybean["Perimeter"]
Q3_P = drybean_Perimeter.quantile(0.75)
Q1_P = drybean_Perimeter.quantile(0.25)
median_P = drybean_Perimeter.quantile(0.50)
IQR_P = Q3_P-Q1_P
lower_limit_P = Q1_P-1.5*IQR_P
upper_limit_P = Q3_P+1.5*IQR_P
Perimeter_outlier = drybean_Perimeter[(drybean_Perimeter<lower_limit_P) |
Perimeter_outlier

#print(type(EquivDiameter_outlier))
```

Out[26]:
```
3364    1391.532
3368    1432.713
3369    1427.056
3371    1417.944
3372    1389.634
          ...
3866    1921.685
3867    1895.940
3868    1884.557
3869    1919.868
3870    1985.370
Name: Perimeter, Length: 500, dtype: float64
```

In [27]:
```
#Mannual Checking of outlier

drybean_MajorAxisLength = drybean["MajorAxisLength"]
Q3_Major = drybean_MajorAxisLength.quantile(0.75)
Q1_Major = drybean_MajorAxisLength.quantile(0.25)
median_Major = drybean_MajorAxisLength.quantile(0.50)
IQR_Major = Q3_Major-Q1_Major
lower_limit_Major = Q1_Major-1.5*IQR_Major
upper_limit_Major = Q3_Major+1.5*IQR_Major
MajorAxisLength_outlier = drybean_MajorAxisLength[(drybean_MajorAxisLength
MajorAxisLength_outlier

#print(type(EquivDiameter_outlier))
```

Out[27]:
```
3426    581.235920
3427    564.968608
3429    563.717847
3431    562.823437
3434    582.438203
           ...
3866    738.144502
3867    726.373493
3868    715.053040
3869    719.125690
3870    738.860153
Name: MajorAxisLength, Length: 379, dtype: float64
```

In [28]:
```
#Mannual Checking of outlier

drybean_MinorAxisLength = drybean["MinorAxisLength"]
Q3_Minor = drybean_MinorAxisLength.quantile(0.75)
Q1_Minor = drybean_MinorAxisLength.quantile(0.25)
median_Minor = drybean_MinorAxisLength.quantile(0.50)
IQR_Minor = Q3_Minor-Q1_Minor
lower_limit_Minor = Q1_Minor-1.5*IQR_Minor
upper_limit_Minor = Q3_Minor+1.5*IQR_Minor
MinorAxisLength_outlier = drybean_MinorAxisLength[(drybean_MinorAxisLength
MinorAxisLength_outlier

#print(type(EquivDiameter_outlier))
```

Out[28]:
```
3088    285.347398
3142    289.499746
3144    280.253937
3171    285.445525
3187    280.276974
           ...
5495    291.873017
5497    279.350337
5498    287.561719
5499    296.898826
5500    279.783414
Name: MinorAxisLength, Length: 567, dtype: float64
```

In [29]:
```
#Mannual Checking of outlier

drybean_AspectRation = drybean["AspectRation"]
Q3_AR = drybean_AspectRation.quantile(0.75)
Q1_AR = drybean_AspectRation.quantile(0.25)
median_AR = drybean_AspectRation.quantile(0.50)
IQR_AR = Q3_AR-Q1_AR
lower_limit_AR = Q1_AR-1.5*IQR_AR
upper_limit_AR = Q3_AR+1.5*IQR_AR
AspectRation_outlier = drybean_AspectRation[(drybean_AspectRation<lower_li
AspectRation_outlier

```

Out[29]:
```
5568    2.166477
5569    2.152470
5571    2.181283
5589    2.143499
5591    2.126985
           ...
7409    2.163426
7413    2.150992
7416    2.211116
7425    2.188484
7427    2.120117
Name: AspectRation, Length: 485, dtype: float64
```

In [31]:
```
#Mannual Checking of outlier

drybean_Eccentricity = drybean["Eccentricity"]
Q3_ECC = drybean_Eccentricity.quantile(0.75)
Q1_ECC = drybean_Eccentricity.quantile(0.25)
median_ECC = drybean_Eccentricity.quantile(0.50)
IQR_ECC = Q3_ECC-Q1_ECC
lower_limit_ECC = Q1_ECC-1.5*IQR_ECC
upper_limit_ECC = Q3_ECC+1.5*IQR_ECC
Eccentricity_outlier = drybean_Eccentricity[(drybean_Eccentricity<lower_li
Eccentricity_outlier
```

Out[31]:
```
0        0.549812
1        0.411785
2        0.562727
3        0.498616
4        0.333680
           ...
10156    0.543073
10342    0.558009
10422    0.564972
11454    0.539964
11564    0.562780
Name: Eccentricity, Length: 833, dtype: float64
```

In [32]:
```
#Mannual Checking of outlier

drybean_Extent = drybean["Extent"]
Q3_ET = drybean_Extent.quantile(0.75)
Q1_ET = drybean_Extent.quantile(0.25)
median_ET = drybean_Extent.quantile(0.50)
IQR_ET = Q3_ET-Q1_ET
lower_limit_ET = Q1_ET-1.5*IQR_ET
upper_limit_ET = Q3_ET+1.5*IQR_ET
Extent_outlier = drybean_Extent[(drybean_Extent<lower_limit_ET) | (drybean
Extent_outlier
```

Out[32]:
```
3829    0.607021
5512    0.604603
5542    0.602807
5551    0.605216
5562    0.604743
          ...
7377    0.578924
7409    0.607037
7416    0.579156
7419    0.605696
7427    0.612852
Name: Extent, Length: 271, dtype: float64
```

In [33]:
```
#Mannual Checking of outlier

drybean_Solidity = drybean["Solidity"]
Q3_S = drybean_Solidity.quantile(0.75)
Q1_S = drybean_Solidity.quantile(0.25)
median_S = drybean_Solidity.quantile(0.50)
IQR_S = Q3_S-Q1_S
lower_limit_S = Q1_S-1.5*IQR_S
upper_limit_S = Q3_S+1.5*IQR_S
Solidity_outlier = drybean_Solidity[(drybean_Solidity<lower_limit_S) | (dr
Solidity_outlier
```

Out[33]:
```
3        0.976696
271      0.919246
278      0.975180
364      0.969160
788      0.976516
           ...
13234    0.972663
13303    0.973551
13326    0.978738
13346    0.974994
13493    0.976974
Name: Solidity, Length: 774, dtype: float64
```

In [34]:
```
#Mannual Checking of outlier

drybean_roundness = drybean["roundness"]
Q3_r = drybean_roundness.quantile(0.75)
Q1_r = drybean_roundness.quantile(0.25)
median_r = drybean_roundness.quantile(0.50)
IQR_r = Q3_r-Q1_r
lower_limit_r = Q1_r-1.5*IQR_r
upper_limit_r = Q3_r+1.5*IQR_r
roundness_outlier = drybean_roundness[(drybean_roundness<lower_limit_r) |
roundness_outlier
```

Out[34]:
```
271      0.658074
1233     0.595048
1352     0.694875
1726     0.698161
1800     0.700102
           ...
10928    0.632321
11459    0.666121
11902    0.691447
11907    0.489618
12116    0.666784
Name: roundness, Length: 98, dtype: float64
```

In [35]:
```
#Mannual Checking of outlier

drybean_Compactness = drybean["Compactness"]
Q3_c = drybean_Compactness.quantile(0.75)
Q1_c = drybean_Compactness.quantile(0.25)
median_c = drybean_Compactness.quantile(0.50)
IQR_c = Q3_c-Q1_c
lower_limit_c = Q1_c-1.5*IQR_c
upper_limit_c = Q3_c+1.5*IQR_c
Compactness_outlier = drybean_Compactness[(drybean_Compactness<lower_limit
Compactness_outlier
```

Out[35]:
```
1       0.953861
4       0.970516
11      0.945254
25      0.956197
30      0.941749
          ...
7030    0.653079
7104    0.655473
7316    0.654380
7329    0.655368
7362    0.653472
Name: Compactness, Length: 124, dtype: float64
```

In [36]:
```
#Mannual Checking of outlier

drybean_ShapeFactor1 = drybean["ShapeFactor1"]
Q3_s1 = drybean_ShapeFactor1.quantile(0.75)
Q1_s1 = drybean_ShapeFactor1.quantile(0.25)
median_s1 = drybean_ShapeFactor1.quantile(0.50)
IQR_s1 = Q3_s1-Q1_s1
lower_limit_s1 = Q1_s1-1.5*IQR_s1
upper_limit_s1 = Q3_s1+1.5*IQR_s1
ShapeFactor1_outlier = drybean_ShapeFactor1[(drybean_ShapeFactor1<lower_li
ShapeFactor1_outlier
```

Out[36]:
```
3350     0.003639
3351     0.003761
3353     0.003743
3354     0.003800
3355     0.003742
           ...
10218    0.009612
10223    0.009400
10239    0.009575
10259    0.009662
10344    0.009517
Name: ShapeFactor1, Length: 533, dtype: float64
```

In [37]:
```
#Mannual Checking of outlier

drybean_ShapeFactor2 = drybean["ShapeFactor2"]
Q3_s2 = drybean_ShapeFactor2.quantile(0.75)
Q1_s2 = drybean_ShapeFactor2.quantile(0.25)
median_s2 = drybean_ShapeFactor2.quantile(0.50)
IQR_s2 = Q3_s2-Q1_s2
lower_limit_s2 = Q1_s2-1.5*IQR_s2
upper_limit_s2 = Q3_s2+1.5*IQR_s2
ShapeFactor2_outlier = drybean_ShapeFactor2[(drybean_ShapeFactor2<lower_li
ShapeFactor2_outlier
```

Out[37]:
```
Series([], Name: ShapeFactor2, dtype: float64)
```

In [38]:
```
#Mannual Checking of outlier

drybean_ShapeFactor3 = drybean["ShapeFactor3"]
Q3_s3 = drybean_ShapeFactor3.quantile(0.75)
Q1_s3 = drybean_ShapeFactor3.quantile(0.25)
median_s3 = drybean_ShapeFactor3.quantile(0.50)
IQR_s3 = Q3_s3-Q1_s3
lower_limit_s3 = Q1_s3-1.5*IQR_s3
upper_limit_s3 = Q3_s3+1.5*IQR_s3
ShapeFactor3_outlier = drybean_ShapeFactor3[(drybean_ShapeFactor3<lower_li
ShapeFactor3_outlier
```

Out[38]:
```
1       0.909851
4       0.941900
6       0.871186
11      0.893506
14      0.882132
          ...
1871    0.920886
1995    0.870104
2179    0.877981
2239    0.874340
6186    0.410339
Name: ShapeFactor3, Length: 202, dtype: float64
```

In [39]:
```
#Mannual Checking of outlier

drybean_ShapeFactor4 = drybean["ShapeFactor4"]
Q3_s4 = drybean_ShapeFactor4.quantile(0.75)
Q1_s4 = drybean_ShapeFactor4.quantile(0.25)
median_s4 = drybean_ShapeFactor4.quantile(0.50)
IQR_s4 = Q3_s4-Q1_s4
lower_limit_s4 = Q1_s4-1.5*IQR_s4
upper_limit_s4 = Q3_s4+1.5*IQR_s4
ShapeFactor4_outlier = drybean_ShapeFactor4[(drybean_ShapeFactor4<lower_li
ShapeFactor4_outlier
```

Out[39]:
```
271      0.947687
2132     0.986973
2174     0.982933
2199     0.987370
2235     0.983672
           ...
12121    0.986469
12721    0.987248
13116    0.987121
13346    0.985495
13493    0.987382
Name: ShapeFactor4, Length: 760, dtype: float64
```

In [40]:
```
#Mannual Checking of outlier

drybean_ConvexArea = drybean["ConvexArea"]
Q3_ca = drybean_ConvexArea.quantile(0.75)
Q1_ca = drybean_ConvexArea.quantile(0.25)
median_ca = drybean_ConvexArea.quantile(0.50)
IQR_ca = Q3_ca-Q1_ca
lower_limit_ca = Q1_ca-1.5*IQR_ca
upper_limit_ca = Q3_ca+1.5*IQR_ca
ConvexArea_outlier = drybean_ConvexArea[(drybean_ConvexArea<lower_limit_ca
ConvexArea_outlier
```

Out[40]:
```
3344    102015
3345    103901
3346    104111
3347    107112
3348    118497
          ...
5496    108109
5497    110337
5498    115826
5499    117222
5500    118144
Name: ConvexArea, Length: 549, dtype: int64
```

So total Outliers Detail:

```
1.Area               571
2.Perimeter          500
3.MajorAxisLength    379
4.MinorAxisLength    567
5.AspectRation       485
6.Eccentricity       833
7.ConvexArea         549
8.EquivDiameter      526
9.Extent             271
10.Solidity          774
11.roundness          98
12.Compactness       124
13.ShapeFactor1      533
14.ShapeFactor2        0
15.ShapeFactor3      202
```

In [41]:
```
drybean.Class.replace(["DERMASON","SIRA","SEKER","HOROZ","CALI","BARBUNYA"

drybean.Class
```

Out[41]:
```
0        3
1        3
2        3
3        3
4        3
        ..
13606    1
13607    1
13608    1
13609    1
13610    1
Name: Class, Length: 13543, dtype: int64
```

Here, changed categorical "Class" feature to numerical "Class" feature.

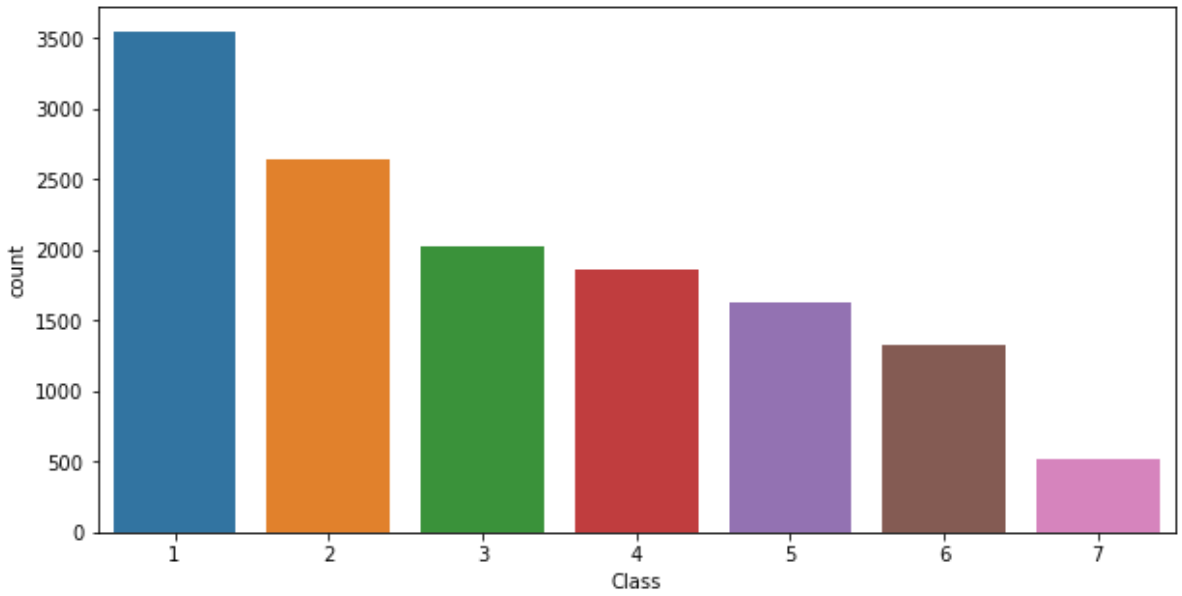
"DERMASON" --> 1 "SIRA" --> 2 "SEKER" --> 3 "HOROZ" --> 4 "CALI" --> 5 "BARBUNYA" --> 6 "BOMBAY" --> 7

In [42]:
```
drybean.head()
```

Out[42]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	AspectRation	Eccentricity	ConvexArea
0	28395	610.291	208.178117	173.888747	1.197191	0.549812	28715
1	28734	638.018	200.524796	182.734419	1.097356	0.411785	29172
2	29380	624.110	212.826130	175.931143	1.209713	0.562727	29690
3	30008	645.884	210.557999	182.516516	1.153638	0.498616	30724
4	30140	620.134	201.847882	190.279279	1.060798	0.333680	30417

In [43]:
```
#Visualization of target class seaborn countplot
plt.figure(figsize = (10,5))
sb.countplot(x="Class", data = drybean)
plt.show()
```



Dataset is imbalance so first need to treate this one.

In [44]:
```
data = drybean.copy()
data
```

Out[44]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	AspectRation	Eccentricity	ConvexA
0	28395	610.291	208.178117	173.888747	1.197191	0.549812	28
1	28734	638.018	200.524796	182.734419	1.097356	0.411785	29
2	29380	624.110	212.826130	175.931143	1.209713	0.562727	29
3	30008	645.884	210.557999	182.516516	1.153638	0.498616	30
4	30140	620.134	201.847882	190.279279	1.060798	0.333680	30
...	...	...	...	...	...	...	
13606	42097	759.696	288.721612	185.944705	1.552728	0.765002	42
13607	42101	757.499	281.576392	190.713136	1.476439	0.735702	42
13608	42139	759.321	281.539928	191.187979	1.472582	0.734065	42
13609	42147	763.779	283.382636	190.275731	1.489326	0.741055	42
13610	42159	772.237	295.142741	182.204716	1.619841	0.786693	42

13543 rows × 17 columns

In [45]:
```
def detect_outliers(data, features):
    outlier_indices = []

    for c in features:
        Q1 = np.percentile(data[c], 25)
        Q3 = np.percentile(data[c], 75)
        IQR = Q3 - Q1
        outlier_step = IQR * 1.5
        outlier_list_col = data[(data[c] < Q1 - outlier_step) | (data[c] >
        outlier_indices.extend(outlier_list_col)

    outlier_indices = Counter(outlier_indices)
    multiple_outliers = list(i for i, v in outlier_indices.items() if v >

    return multiple_outliers


data = data.drop(detect_outliers(data,['Area', 'Perimeter', 'MajorAxisLeng
                                       'ConvexArea', 'EquivDiameter', 'Ext
                                       'ShapeFactor2', 'ShapeFactor3', 'Sh
print('Number of of samples in the dataset after removing outliers: %d' %
```

```
Number of of samples in the dataset after removing outliers: 12144
```

As we can see that data is imbalance to first we need to deal with imbalance data

In [47]:
```
X = data.drop(["Class"], axis = 1)
X
```

Out[47]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	AspectRation	Eccentricity	ConvexA
0	28395	610.291	208.178117	173.888747	1.197191	0.549812	28
1	29380	624.110	212.826130	175.931143	1.209713	0.562727	29
2	30279	634.927	212.560556	181.510182	1.171067	0.520401	30
3	30519	629.727	212.996755	182.737204	1.165591	0.513760	30
4	30685	635.681	213.534145	183.157146	1.165852	0.514081	31
...	...	...	...	...	...	...	
12139	42097	759.696	288.721612	185.944705	1.552728	0.765002	42
12140	42101	757.499	281.576392	190.713136	1.476439	0.735702	42
12141	42139	759.321	281.539928	191.187979	1.472582	0.734065	42
12142	42147	763.779	283.382636	190.275731	1.489326	0.741055	42
12143	42159	772.237	295.142741	182.204716	1.619841	0.786693	42

12144 rows × 16 columns

In [48]:
```
Y = data.Class
Y
```

Out[48]:
```
0        3
1        3
2        3
3        3
4        3
        ..
12139    1
12140    1
12141    1
12142    1
12143    1
Name: Class, Length: 12144, dtype: int64
```

In [49]:
```
from imblearn.under_sampling import RandomUnderSampler

rs = RandomUnderSampler(random_state = 42)

print("Original dataset shape %s" % Counter(Y))

X_res,Y_res = rs.fit_resample(X,Y)

print("After undersample dataset shape %s" % Counter(Y_res))

X_res

```

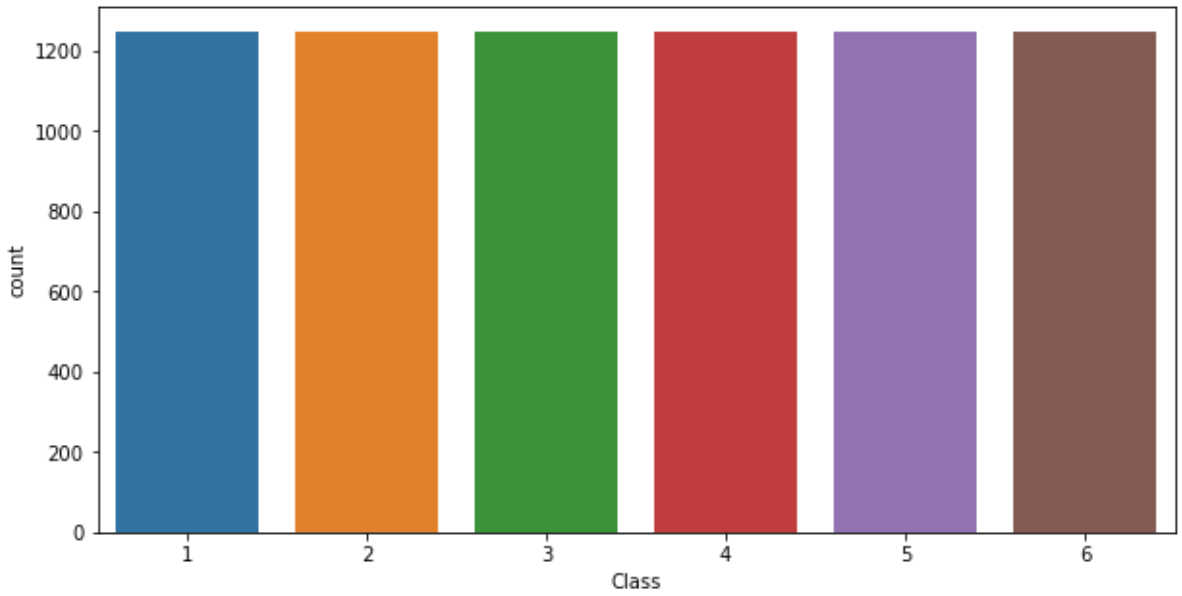
```
Original dataset shape Counter({1: 3525, 2: 2611, 3: 1823, 4: 1535, 5: 1402,
6: 1248})
After undersample dataset shape Counter({1: 1248, 2: 1248, 3: 1248, 4: 1248,
5: 1248, 6: 1248})
```

Out[49]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	AspectRation	Eccentricity	ConvexAr
0	25950	601.233	218.855891	151.319552	1.446316	0.722461	263
1	34283	692.028	256.305533	170.976560	1.499068	0.744985	347
2	40727	749.229	282.862627	183.699092	1.539815	0.760423	412
3	27975	622.083	238.039394	150.061605	1.586278	0.776265	282
4	25792	597.381	214.522310	153.371986	1.398706	0.699179	261
...	...	...	...	...	...	...	
7483	96192	1220.012	448.888428	273.838300	1.639246	0.792373	973
7484	96319	1252.315	434.980462	283.482724	1.534416	0.758465	981
7485	97054	1265.438	428.821897	288.692278	1.485394	0.739441	990
7486	97060	1246.469	407.924022	303.898305	1.342304	0.667078	988
7487	97746	1326.664	447.647212	279.009875	1.604414	0.781998	995

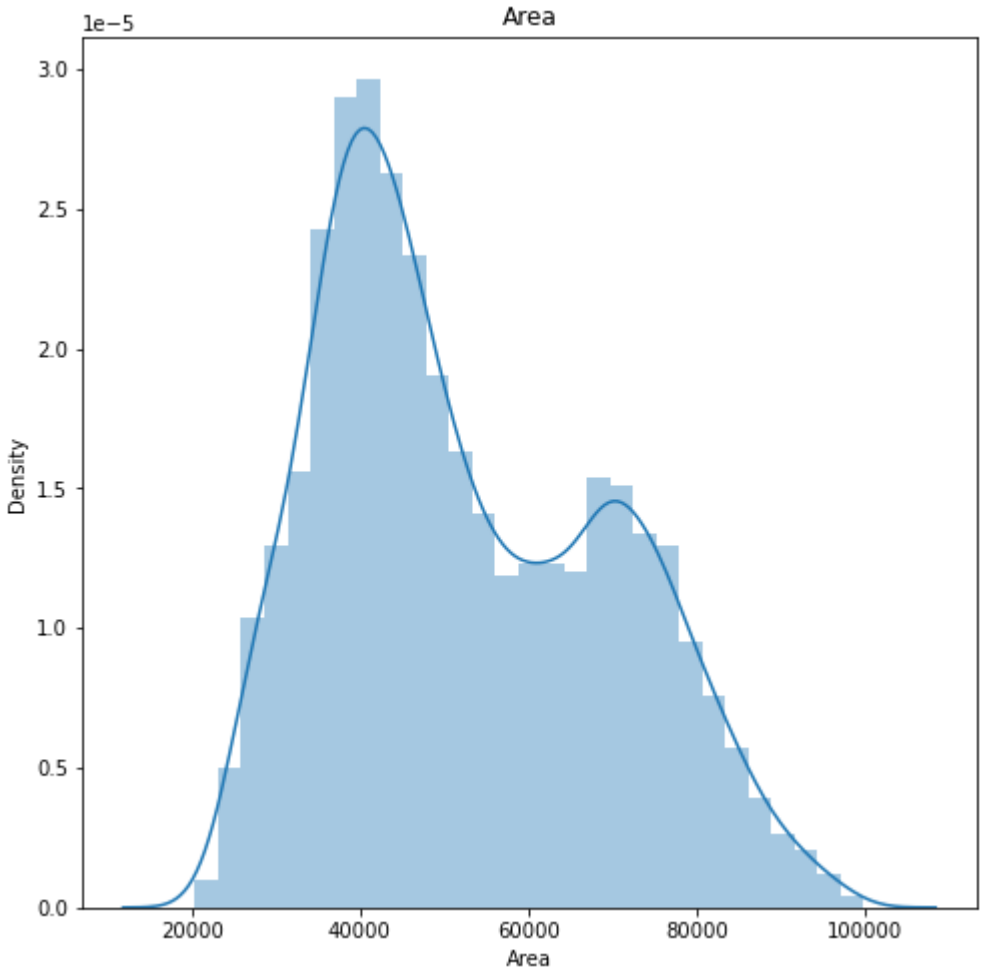
7488 rows × 16 columns

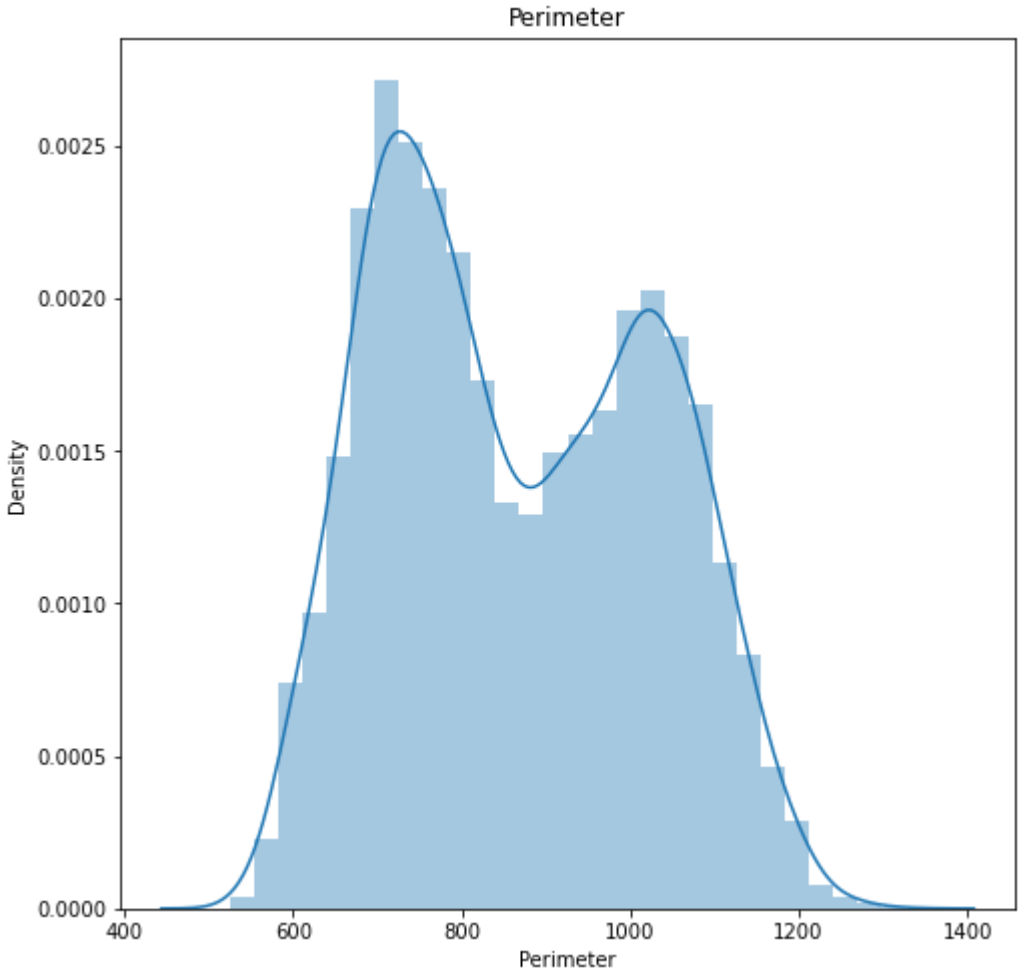
In [50]:
```
#Visualization of target class seaborn countplot
plt.figure(figsize = (10,5))
sb.countplot(x = Y_res)
plt.show()
```

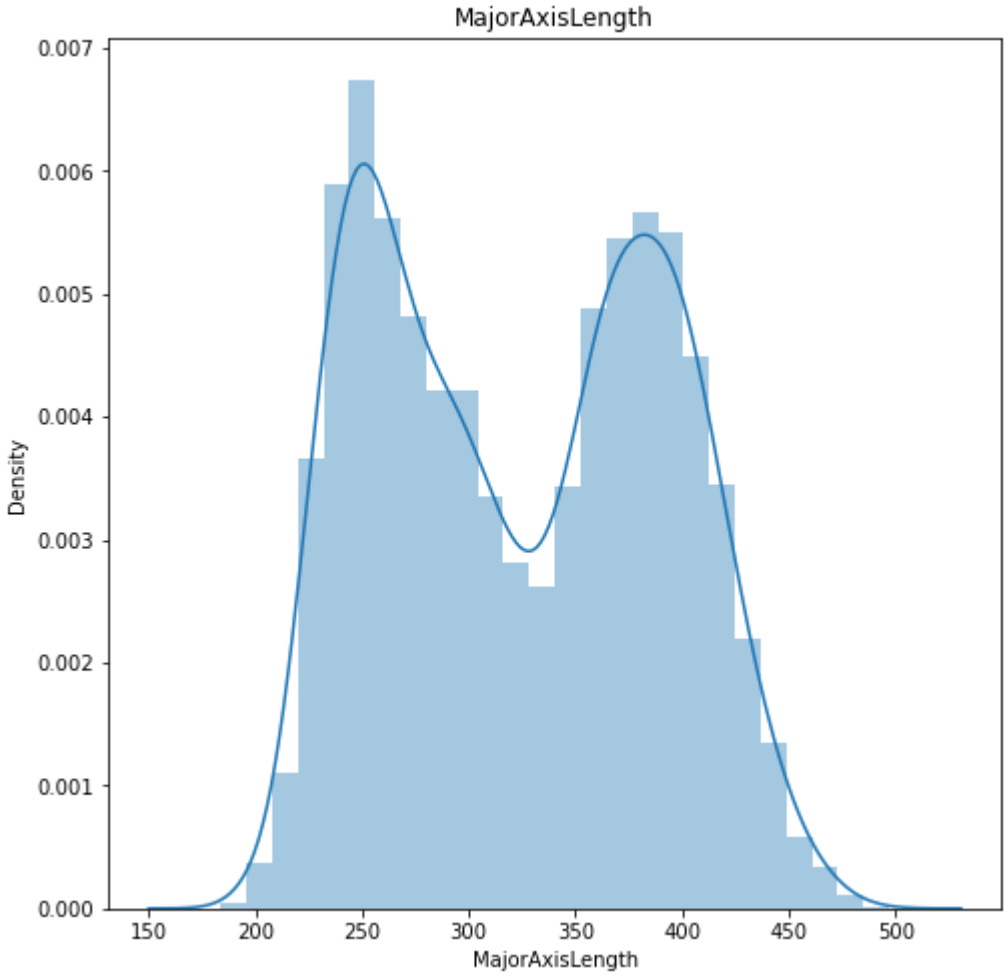


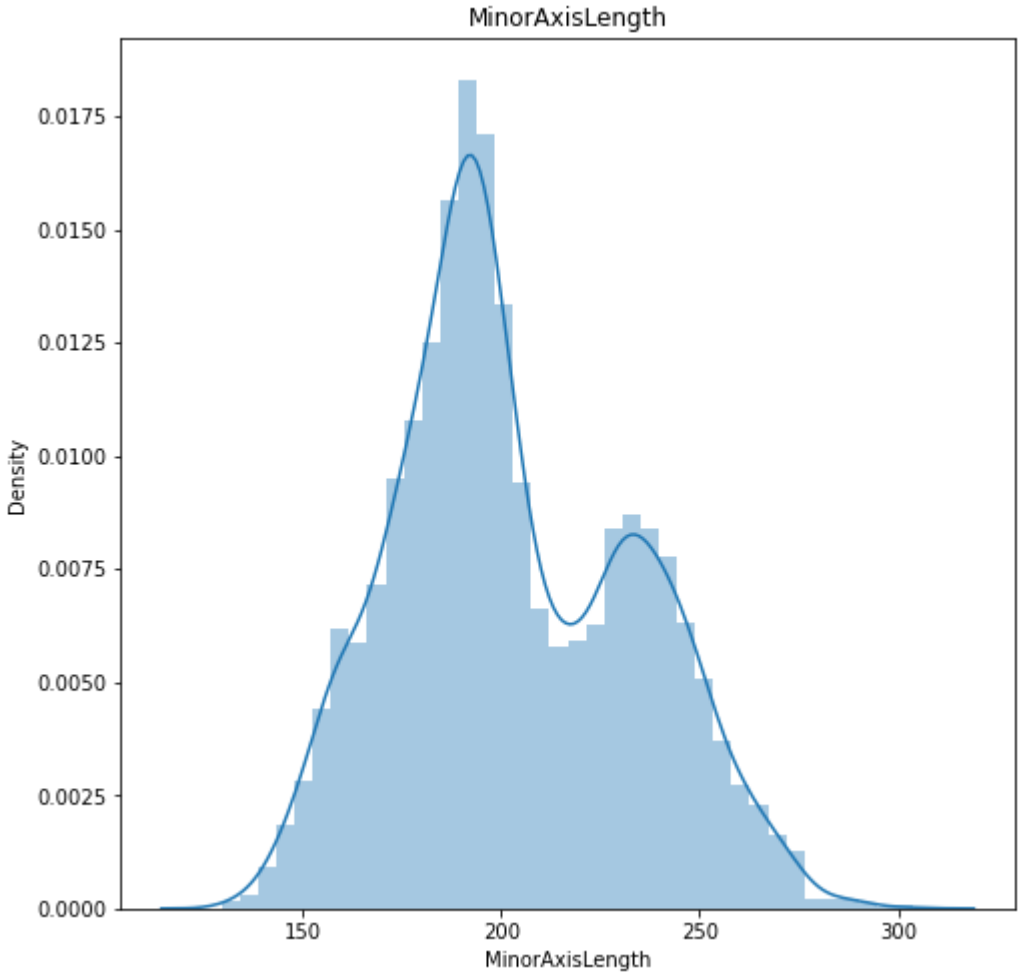
Now my data is balanced so now ML algorithms can be applied.

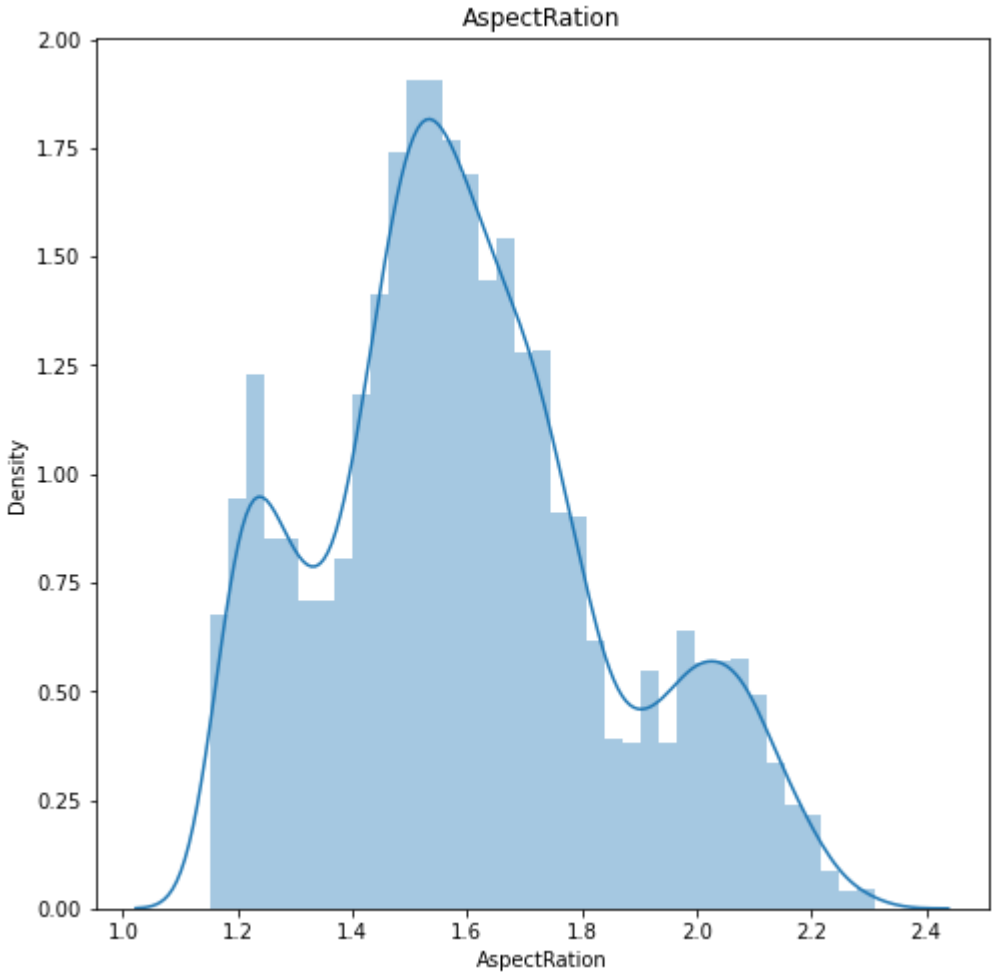
In [60]:
```
for features in X_res.columns:
    plt.figure(figsize = (8,8))
    sb.distplot(X_res[features])
    plt.title(features)
    plt.show()
```

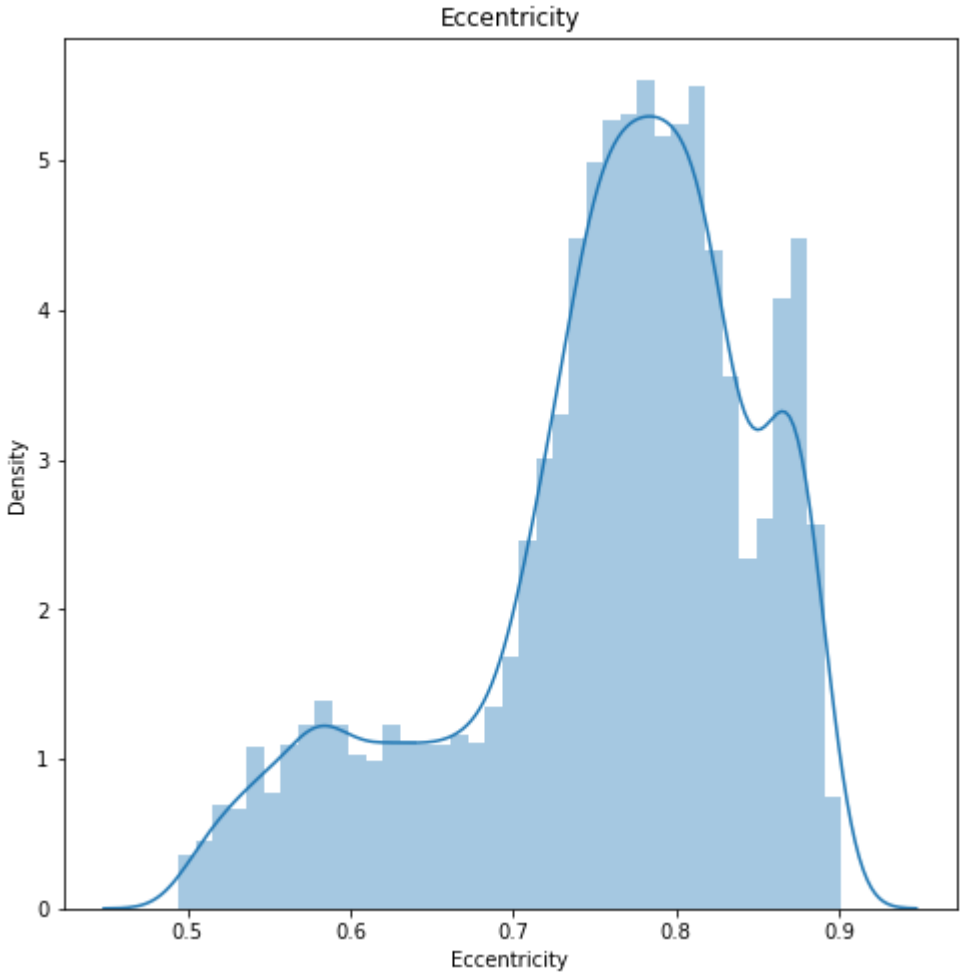


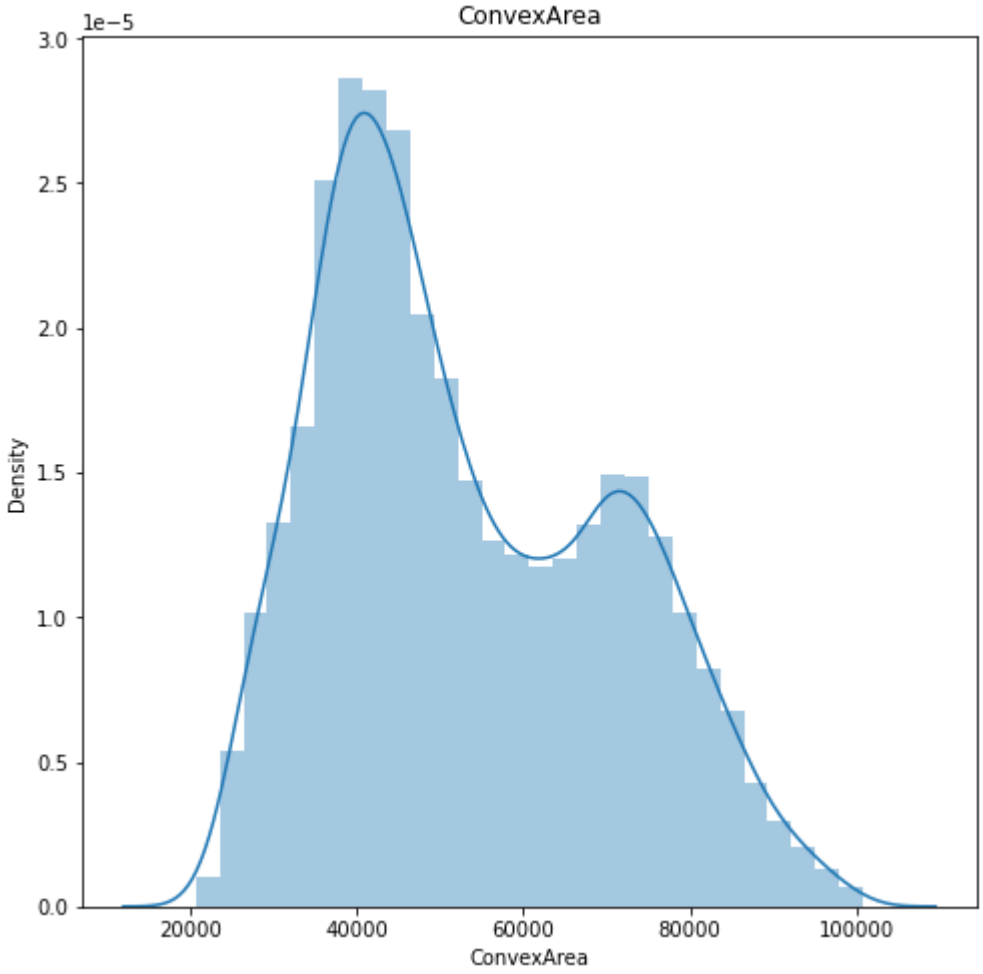

Perimeter
Density
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
400
600
800
1000
1200
1400
Perimeter

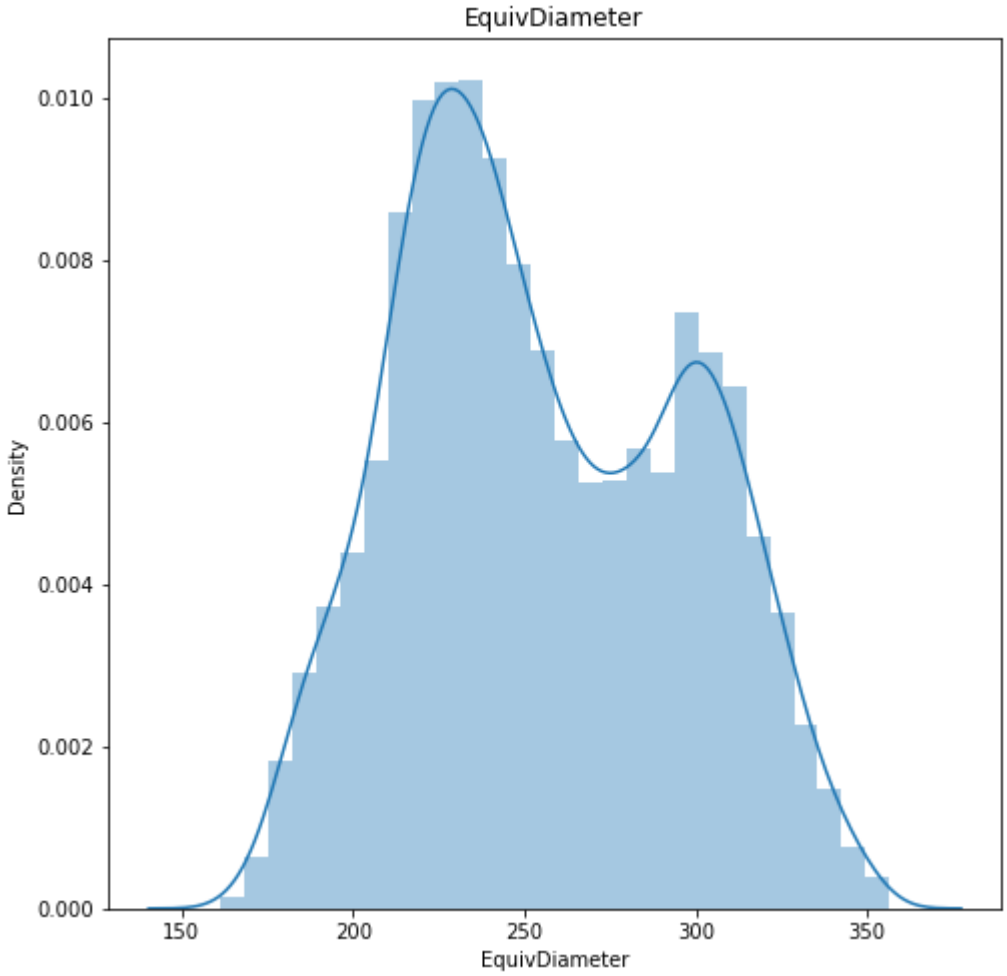

MajorAxisLength
Density
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
150
200
250
300
350
400
450
500
MajorAxisLength

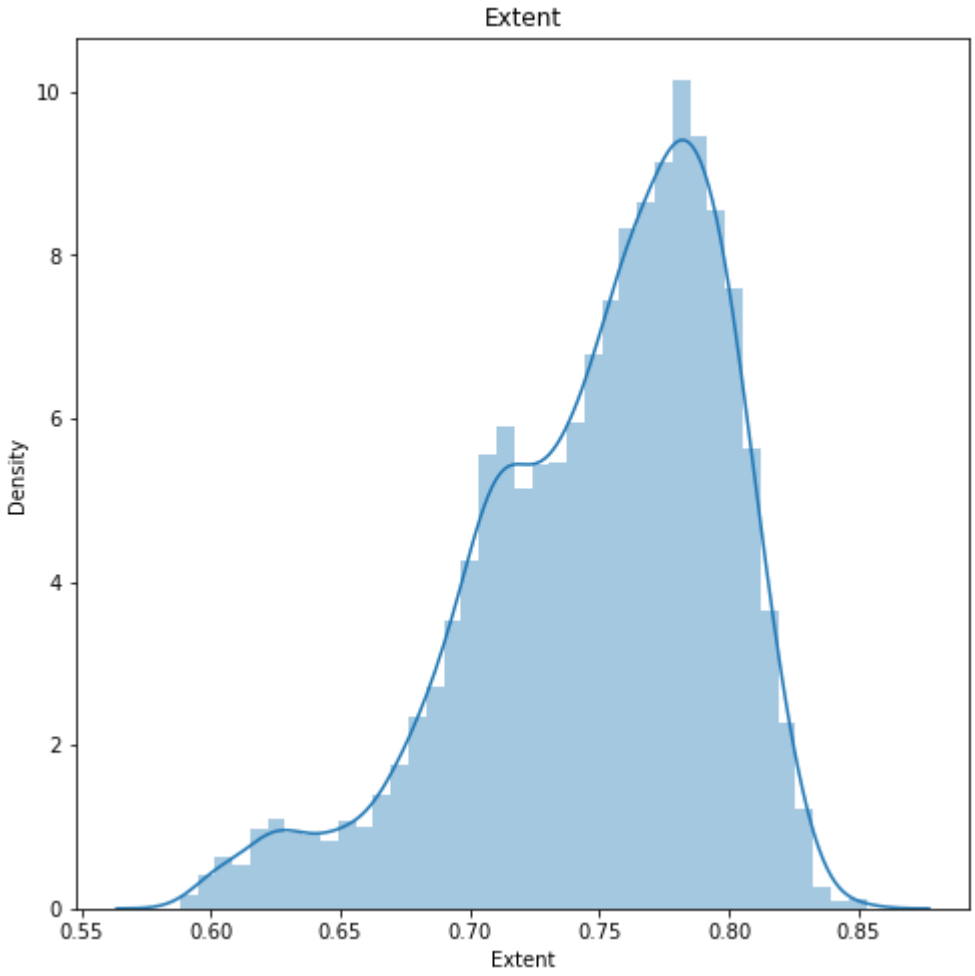

MinorAxisLength
Density
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
150
200
250
300
MinorAxisLength

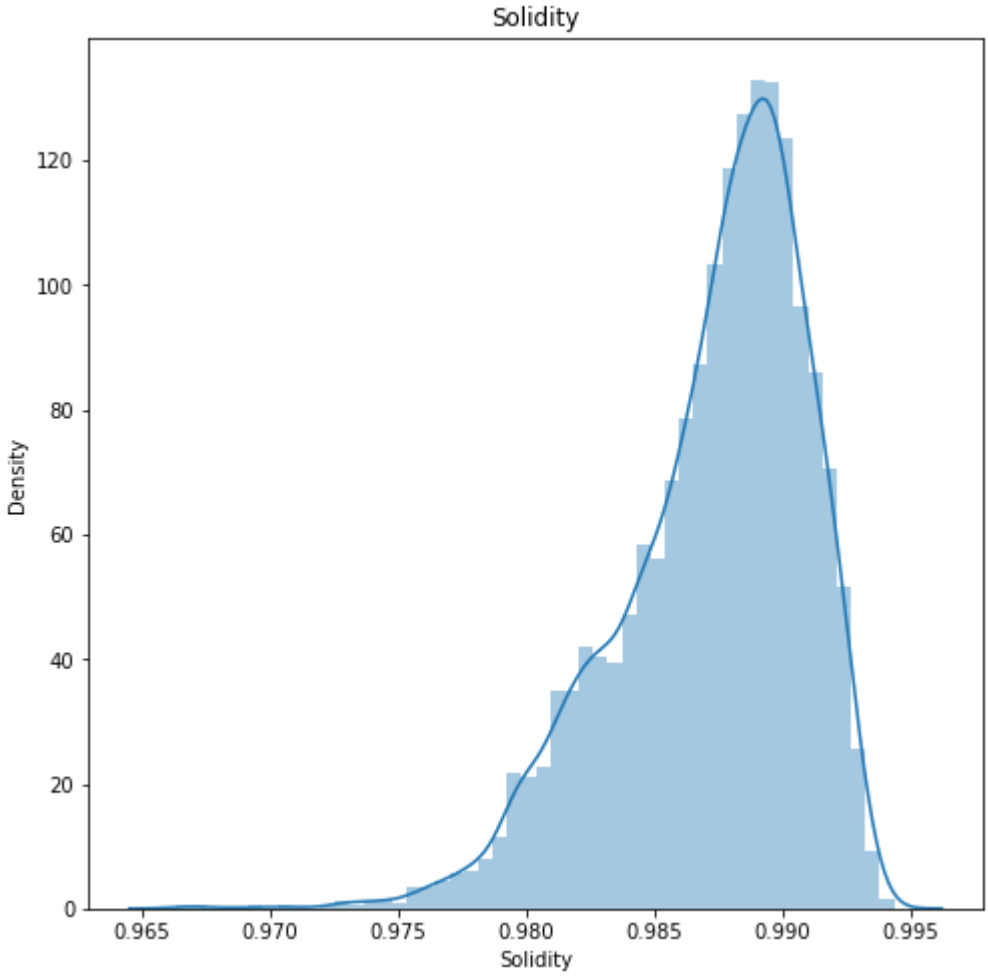

AspectRation
Density
AspectRation
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

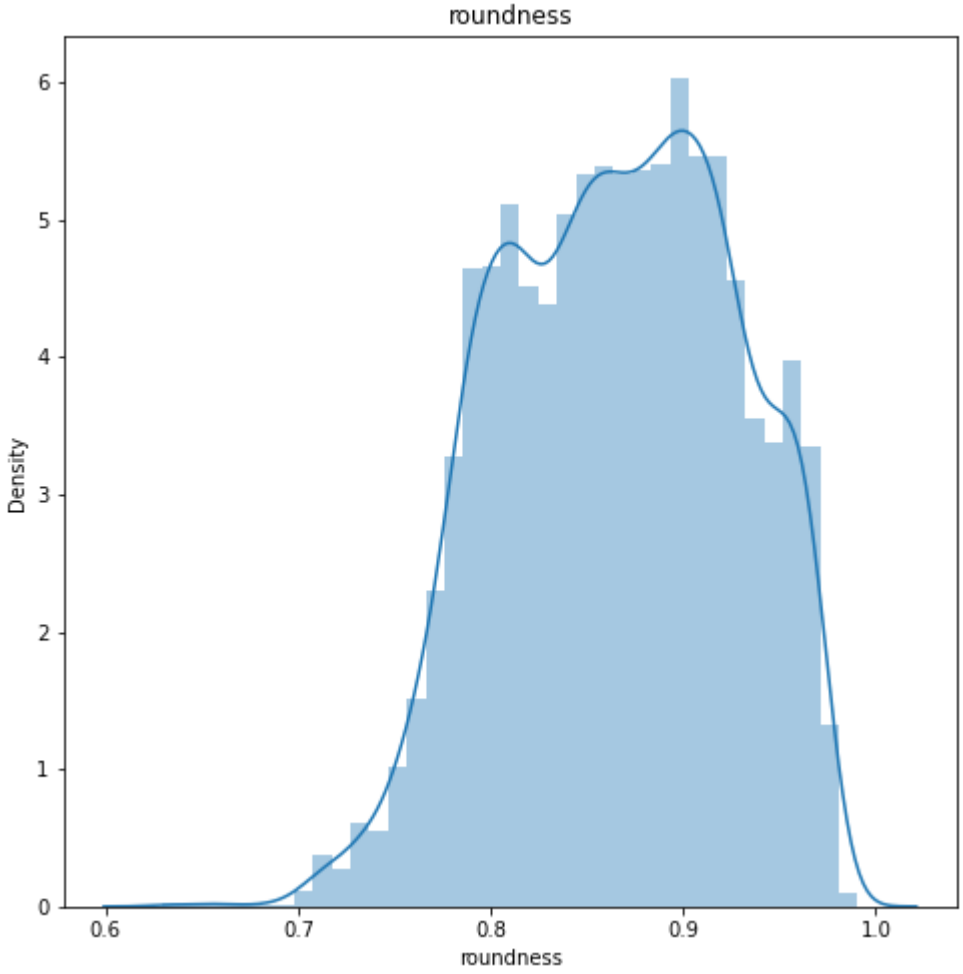

Eccentricity
Density
0
1
2
3
4
5
0.5
0.6
0.7
0.8
0.9
Eccentricity

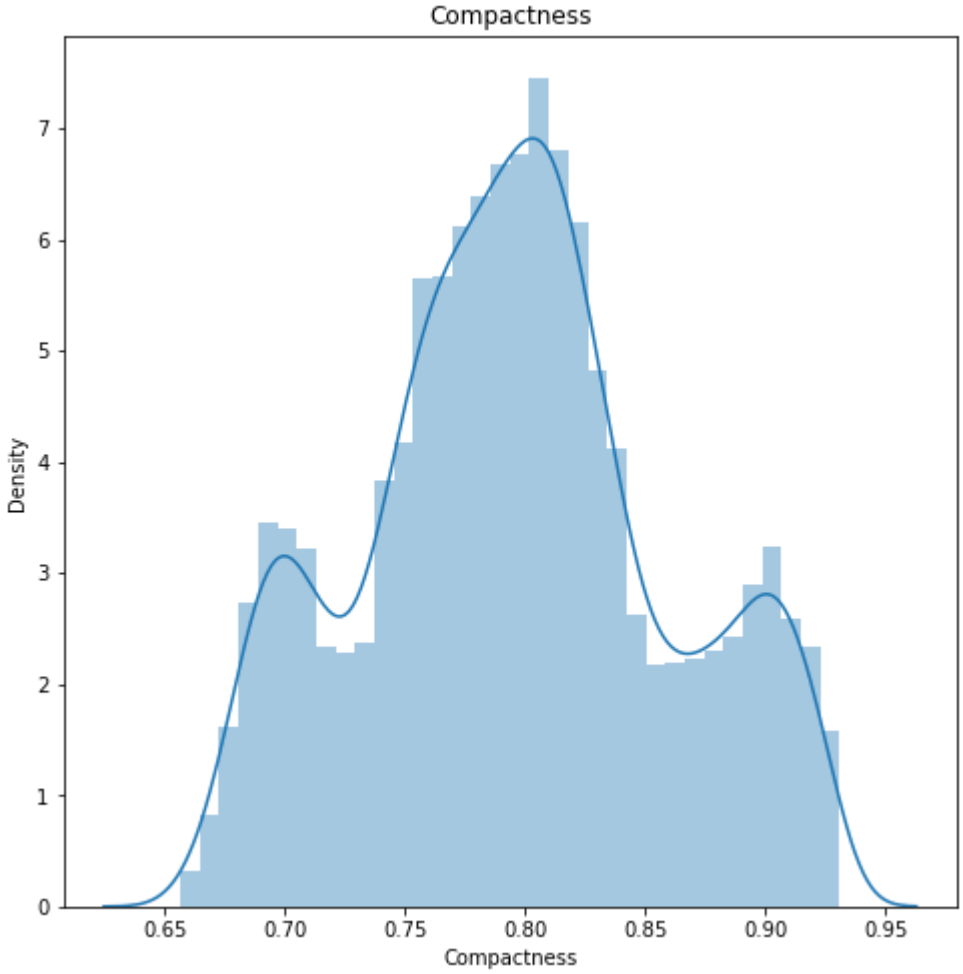

ConvexArea
1e−5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Density
20000
40000
60000
80000
100000
ConvexArea

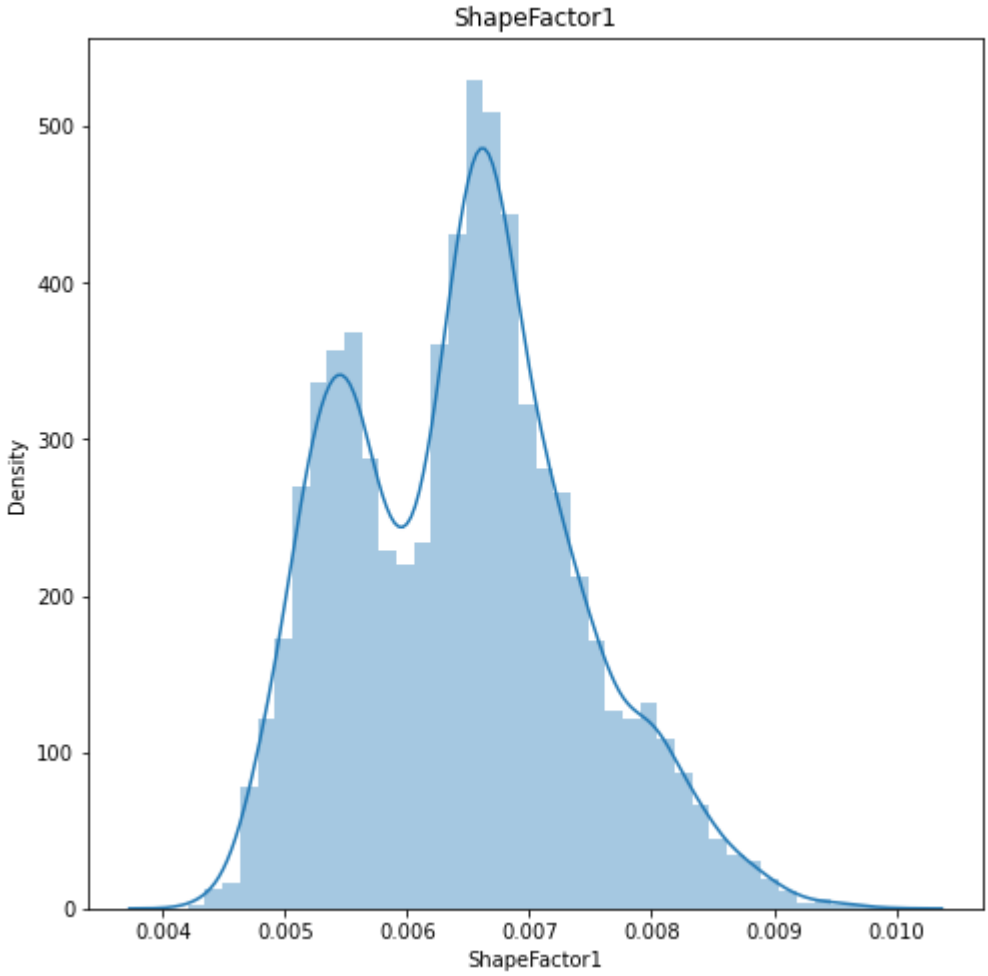

EquivDiameter
Density
0.010
0.008
0.006
0.004
0.002
0.000
150
200
250
300
350
EquivDiameter

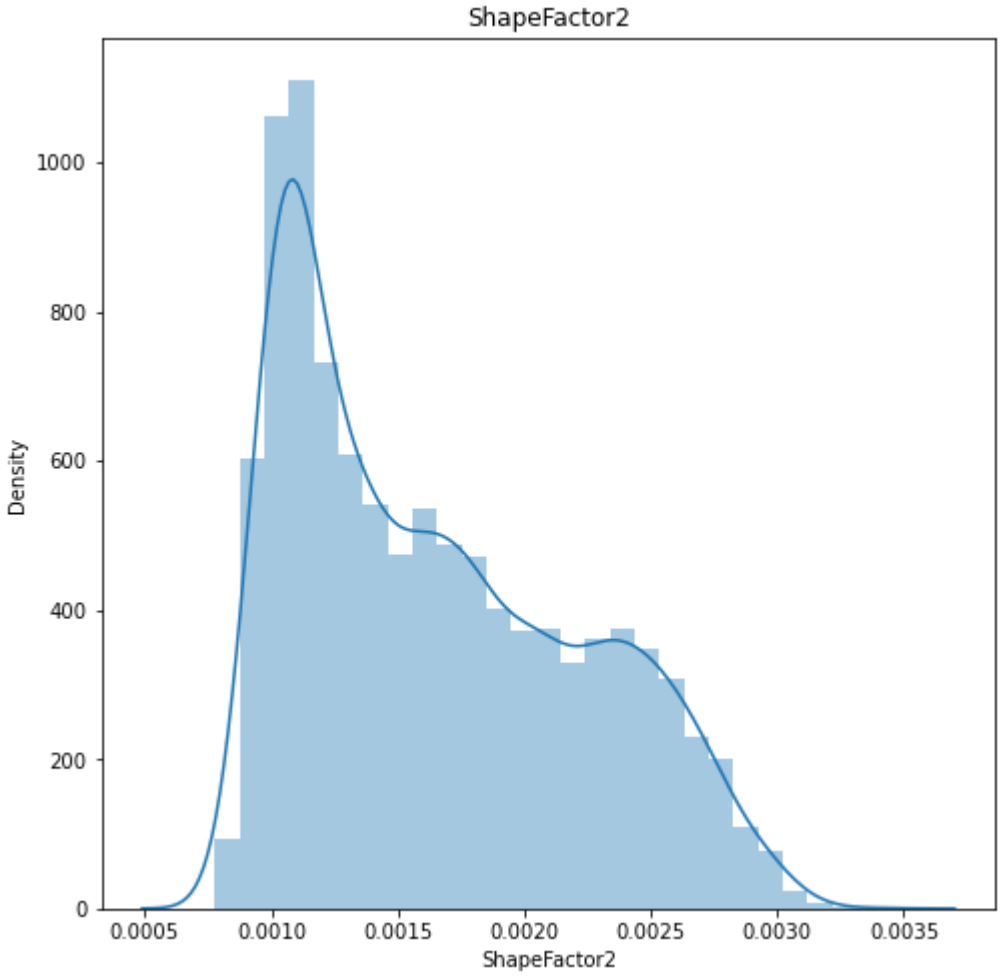

Extent
Density
Extent
0
2
4
6
8
10
0.55
0.60
0.65
0.70
0.75
0.80
0.85

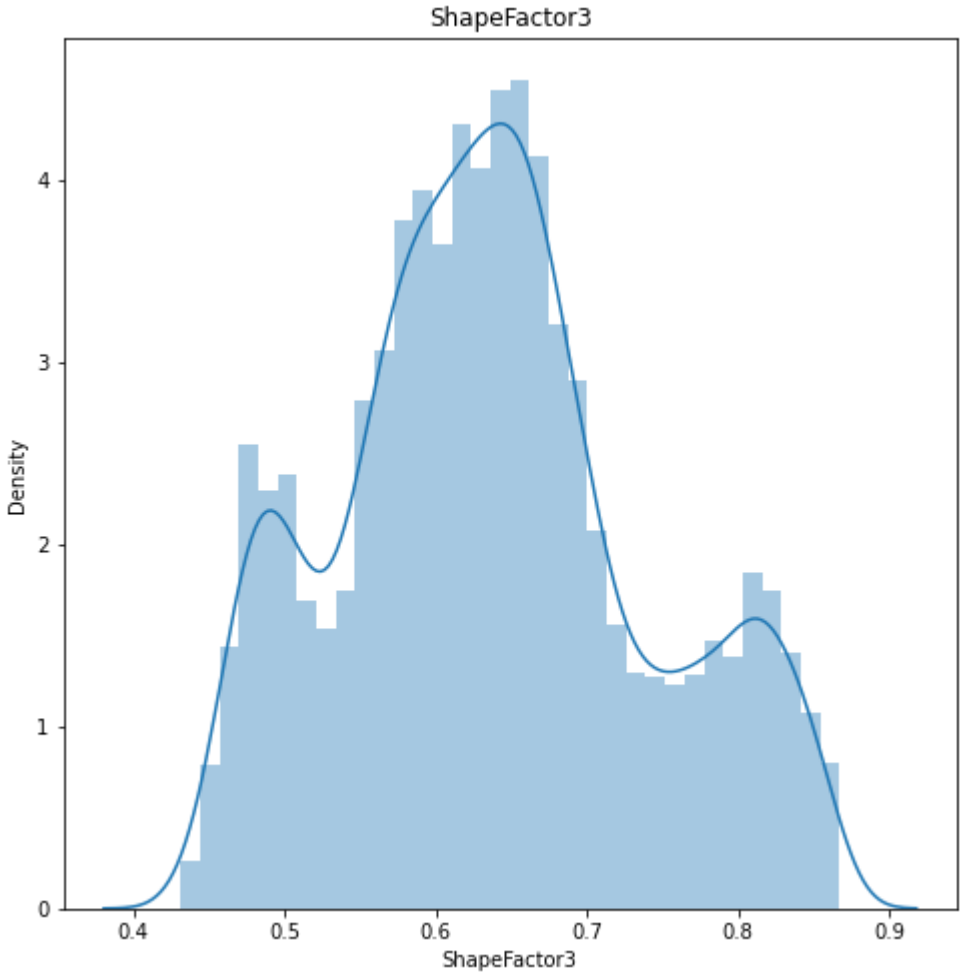

Solidity
Density
0
20
40
60
80
100
120
0.965
0.970
0.975
0.980
0.985
0.990
0.995
Solidity

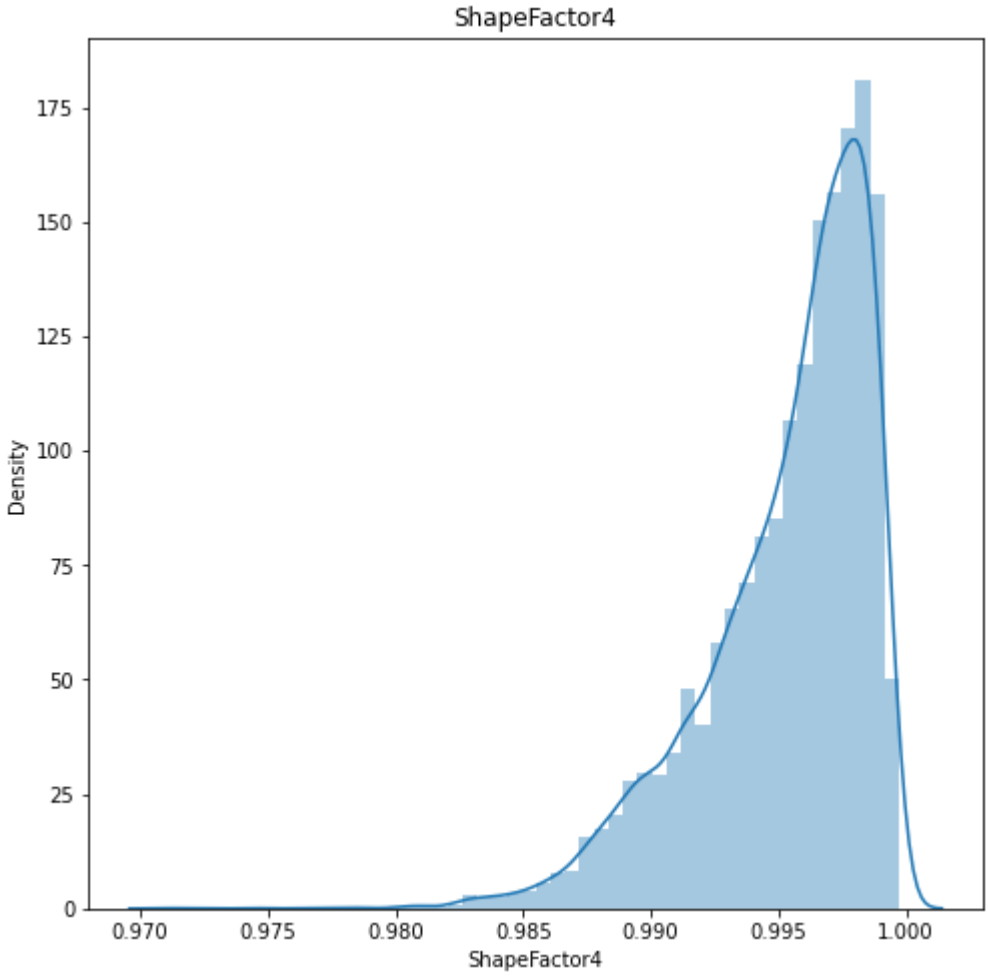

roundness
Density
0
1
2
3
4
5
6
0.6
0.7
0.8
0.9
1.0
roundness


Compactness
Density
0
1
2
3
4
5
6
7
0.65
0.70
0.75
0.80
0.85
0.90
0.95
Compactness


ShapeFactor1
Density
0
100
200
300
400
500
0.004
0.005
0.006
0.007
0.008
0.009
0.010
ShapeFactor1

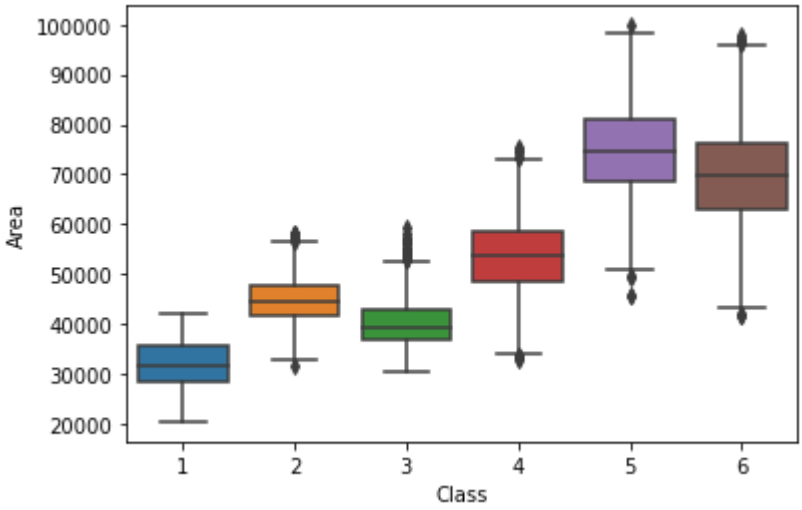

ShapeFactor2
Density
1000
800
600
400
200
0
0.0005
0.0010
0.0015
0.0020
0.0025
0.0030
0.0035
ShapeFactor2


ShapeFactor3
Density
0
1
2
3
4
0.4
0.5
0.6
0.7
0.8
0.9
ShapeFactor3



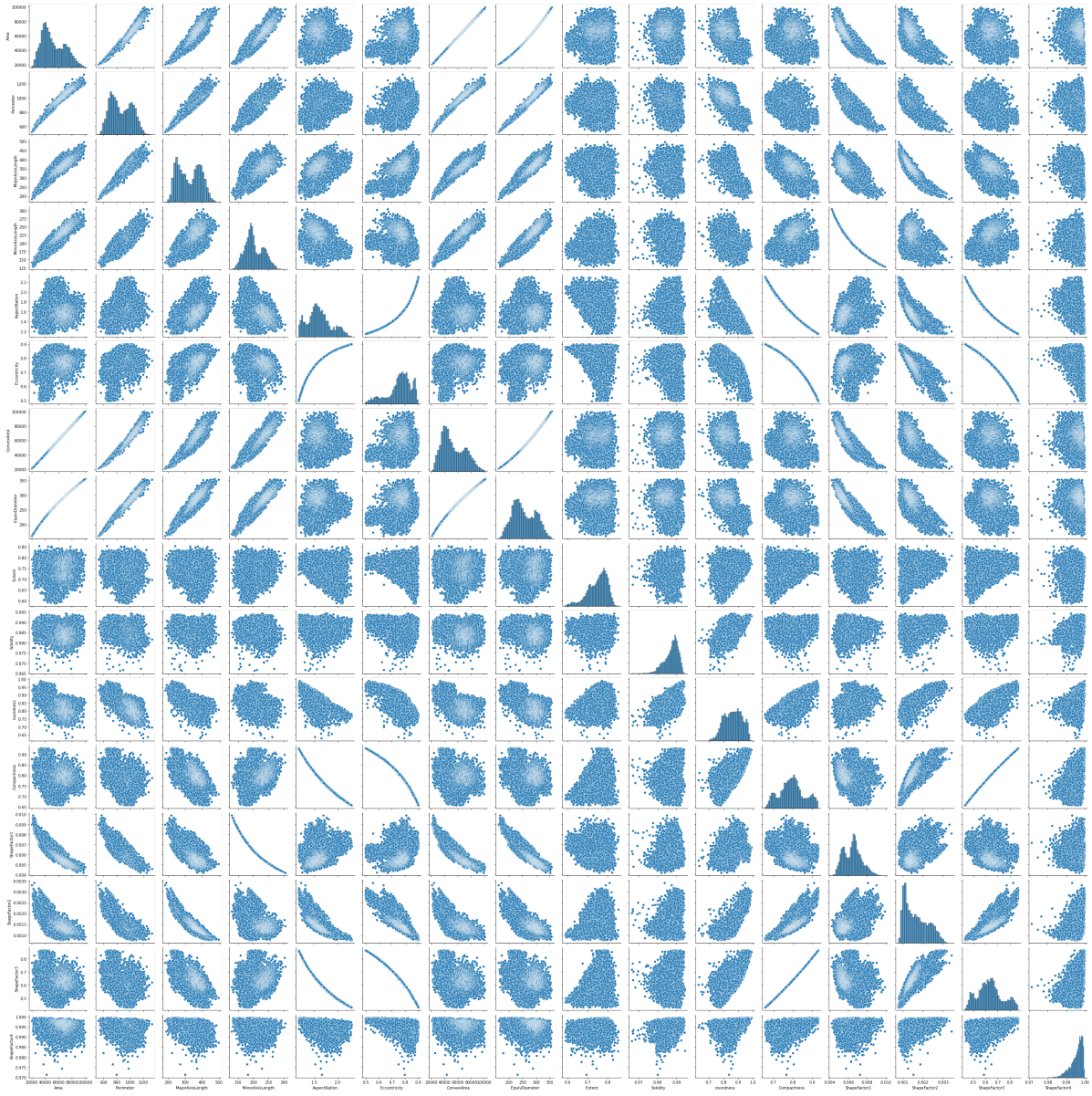
In [51]:

```
#Checking the Outlier in the independent feature

for feature in X_res.columns:
    sb.boxplot(x = Y_res, y = X_res[feature])
    plt.show()

```



In [52]:
```
1 sb.pairplot(X_res)
```

Out[52]: <seaborn.axisgrid.PairGrid at 0x1ae4d8ea9a0>



In [53]:
```
df = X_res.copy()
df["Class"] = Y_res
df
```

Out[53]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	AspectRation	Eccentricity	ConvexAr
0	25950	601.233	218.855891	151.319552	1.446316	0.722461	263
1	34283	692.028	256.305533	170.976560	1.499068	0.744985	347
2	40727	749.229	282.862627	183.699092	1.539815	0.760423	412
3	27975	622.083	238.039394	150.061605	1.586278	0.776265	282
4	25792	597.381	214.522310	153.371986	1.398706	0.699179	261
...	...	...	...	...	...	...	
7483	96192	1220.012	448.888428	273.838300	1.639246	0.792373	973
7484	96319	1252.315	434.980462	283.482724	1.534416	0.758465	981
7485	97054	1265.438	428.821897	288.692278	1.485394	0.739441	990
7486	97060	1246.469	407.924022	303.898305	1.342304	0.667078	988
7487	97746	1326.664	447.647212	279.009875	1.604414	0.781998	995

7488 rows × 17 columns

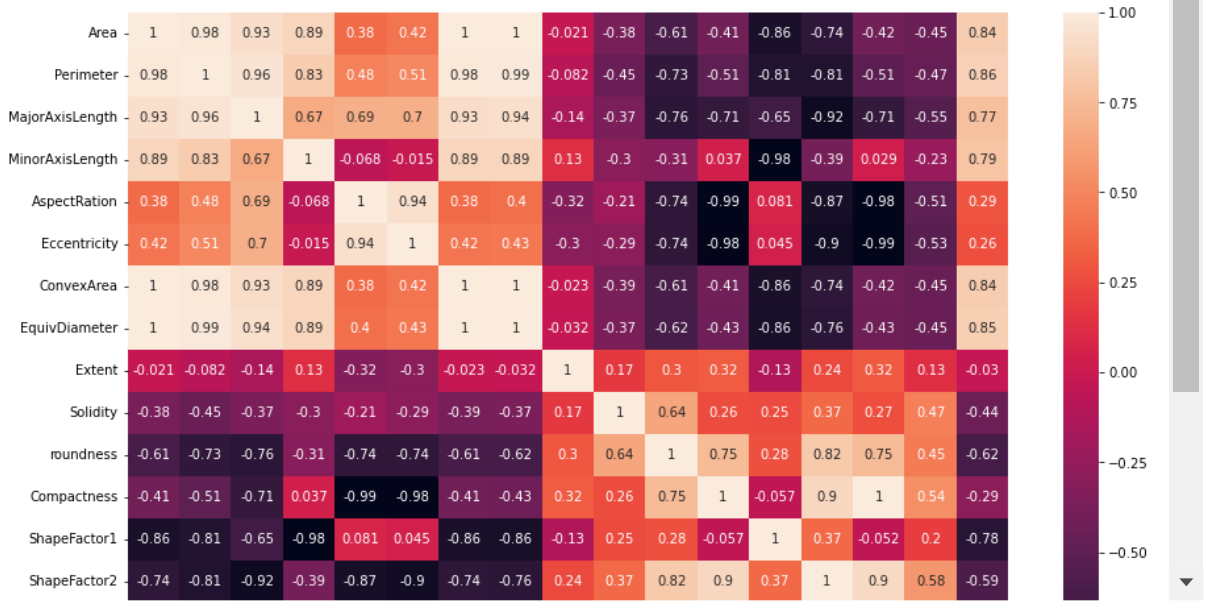
In [54]:
```
1 df.corr()
```

Out[54]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	AspectRation	Eccentr
Area	1.000000	0.983496	0.930228	0.887897	0.382028	0.423
Perimeter	0.983496	1.000000	0.957044	0.834064	0.478413	0.507
MajorAxisLength	0.930228	0.957044	1.000000	0.669910	0.690154	0.695
MinorAxisLength	0.887897	0.834064	0.669910	1.000000	-0.068096	-0.014
AspectRation	0.382028	0.478413	0.690154	-0.068096	1.000000	0.940
Eccentricity	0.423788	0.507231	0.695284	-0.014798	0.940096	1.000
ConvexArea	0.999924	0.984344	0.929966	0.887929	0.381775	0.424
EquivDiameter	0.996711	0.988134	0.938030	0.885165	0.399397	0.434
Extent	-0.021335	-0.081661	-0.143404	0.125044	-0.323857	-0.301
Solidity	-0.375855	-0.449495	-0.369085	-0.299706	-0.212039	-0.294
roundness	-0.605715	-0.729999	-0.756881	-0.310244	-0.737841	-0.739
Compactness	-0.414721	-0.505851	-0.710302	0.036748	-0.989553	-0.978
ShapeFactor1	-0.855996	-0.808911	-0.649738	-0.984266	0.080825	0.044
ShapeFactor2	-0.744468	-0.811095	-0.922494	-0.391261	-0.865429	-0.900
ShapeFactor3	-0.420897	-0.510276	-0.711572	0.029192	-0.981858	-0.986
ShapeFactor4	-0.447165	-0.468471	-0.553493	-0.230168	-0.505484	-0.528
Class	0.838541	0.860913	0.770832	0.792416	0.287195	0.264

In [55]:
```
1 plt.figure(figsize=(15,10))
2 sb.heatmap(df.corr(),annot=True)
```

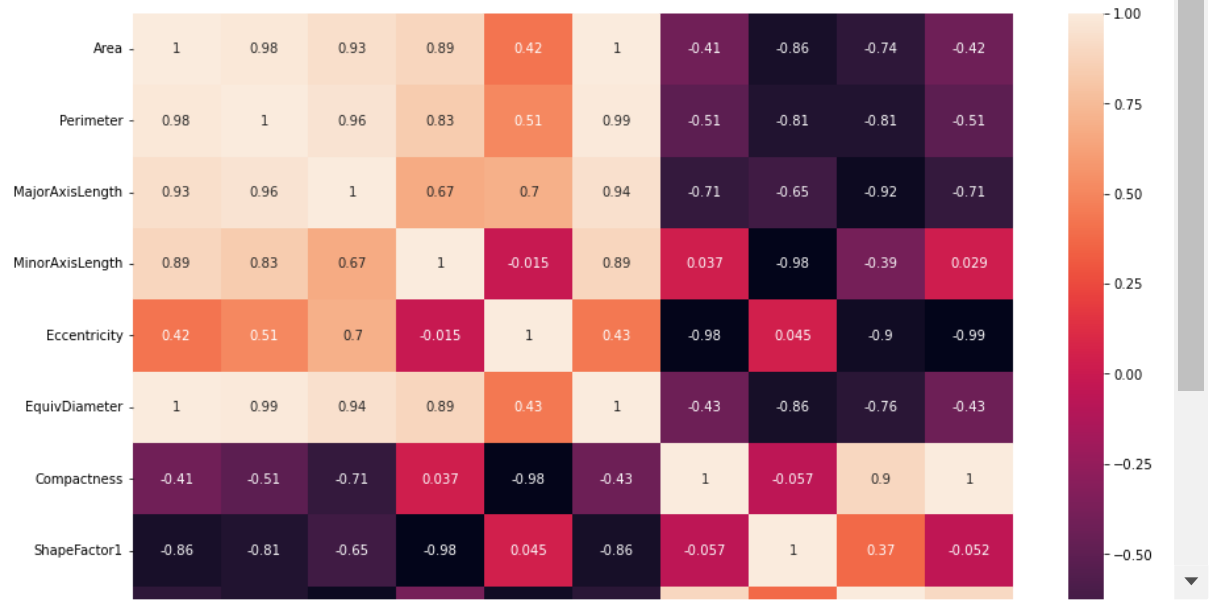
Out[55]: <AxesSubplot:>



In [56]:
```
X_res.drop(['ConvexArea','Solidity', 'roundness','ShapeFactor4','Extent',
```

In [74]:
```
plt.figure(figsize=(15,10))
sb.heatmap(X_res.corr(),annot=True)
```

Out[74]: <AxesSubplot:>



In [57]:
```
from sklearn.model_selection import train_test_split

x_train,x_test,y_train,y_test = train_test_split(X_res,Y_res,test_size=0.2

from sklearn.linear_model import LogisticRegression

from sklearn import metrics

lr = LogisticRegression()

lr.fit(x_train,y_train)
```

Out[57]: LogisticRegression()

In [58]:
```
x_train.shape, y_train.shape,x_test.shape,y_test.shape
```

Out[58]: ((5616, 10), (5616,), (1872, 10), (1872,))

In [59]:
```
pred_y = lr.predict(x_test)
pred_y
```

Out[59]: array([1, 3, 6, ..., 2, 2, 4], dtype=int64)

In [60]:
```
1 x_test
```

Out[60]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	Eccentricity	EquivDiameter	Compact
700	29307	627.269	228.296004	163.728085	0.696894	193.170472	0.84
3100	35736	684.029	235.661573	193.377658	0.571541	213.308435	0.90
6736	67437	1041.175	380.647880	226.566395	0.803568	293.024667	0.76
6689	66354	1007.809	342.848693	247.084100	0.693268	290.662238	0.84
7392	84185	1175.084	408.720527	263.644898	0.764141	327.395283	0.80
...	...	...	...	...	...	...	
2051	44355	789.387	300.714314	188.435193	0.779321	237.643725	0.79
6394	58191	959.247	341.437891	217.441200	0.770996	272.196771	0.79
2257	47162	822.039	314.056865	192.494523	0.790138	245.048002	0.78
1441	47881	826.804	323.841214	189.497886	0.810920	246.908855	0.76
4607	47937	853.142	337.153758	184.183667	0.837596	247.053201	0.73

1872 rows × 10 columns

In [61]:
```
1 from sklearn.metrics import classification_report
2 report=classification_report(y_test,pred_y)
3 print(report)
```

```
              precision    recall  f1-score   support

           1       0.83      0.86      0.84       303
           2       0.78      0.80      0.79       315
           3       0.88      0.89      0.89       313
           4       0.94      0.92      0.93       316
           5       0.90      0.92      0.91       307
           6       0.88      0.83      0.85       318

    accuracy                           0.87      1872
   macro avg       0.87      0.87      0.87      1872
weighted avg       0.87      0.87      0.87      1872
```

In [62]:
```
1 from sklearn.metrics import accuracy_score
2
3 pred_y = lr.predict(x_test)
4
5 score =accuracy_score(y_test,pred_y)
```

In [63]:
```
1 score
```

Out[63]: 0.8696581196581197

In [ ]:
```
1
```