Problem 7 (Chapter 10, Exercise 9)

```
import pandas as pd
from sklearn.cluster import AgglomerativeClustering
```

```
us_arrests_df = pd.read_csv("USArrests.csv", index_col=0)
us_arrests_df;
```

Problem 7(a)

```
hc_nonstd = AgglomerativeClustering(n_clusters=3, affinity="Euclidean", linkage="com
hc_nonstd.fit(us_arrests_df);
```

Problem 7(b)

```
for i in range(3):
  print("Cluster %d: " % i, end='')
  for state in us_arrests_df.index[hc_nonstd.labels_ == i]:
    print(state + ", ", end='')
  print()
```

```
Cluster 0: Alabama, Alaska, Arizona, California, Delaware, Florida, Illinois, Lo
Cluster 1: Connecticut, Hawaii, Idaho, Indiana, Iowa, Kansas, Kentucky, Maine, M
Cluster 2: Arkansas, Colorado, Georgia, Massachusetts, Missouri, New Jersey, Okl
```

Problem 7(c)

```
from sklearn.preprocessing import StandardScaler

standard_scaler   = StandardScaler()
us_arrests_df_std = standard_scaler.fit_transform(us_arrests_df)

hc_std = AgglomerativeClustering(n_clusters=3, affinity="Euclidean", linkage="comple
hc_std.fit(us_arrests_df_std);
```

Problem 7(d)

```
for i in range(3):
  print("Cluster %d: " % i, end='')
  for state in us_arrests_df.index[hc_std.labels_ == i]:
    print(state + ", ", end='')
  print()
```

```
Cluster 0: Arkansas, Connecticut, Delaware, Hawaii, Idaho, Indiana, Iowa, Kansas
Cluster 1: Alabama, Alaska, Georgia, Louisiana, Mississippi, North Carolina, Sou
Cluster 2: Arizona, California, Colorado, Florida, Illinois, Maryland, Michigan,
```

```
us_arrests_df.describe()
```

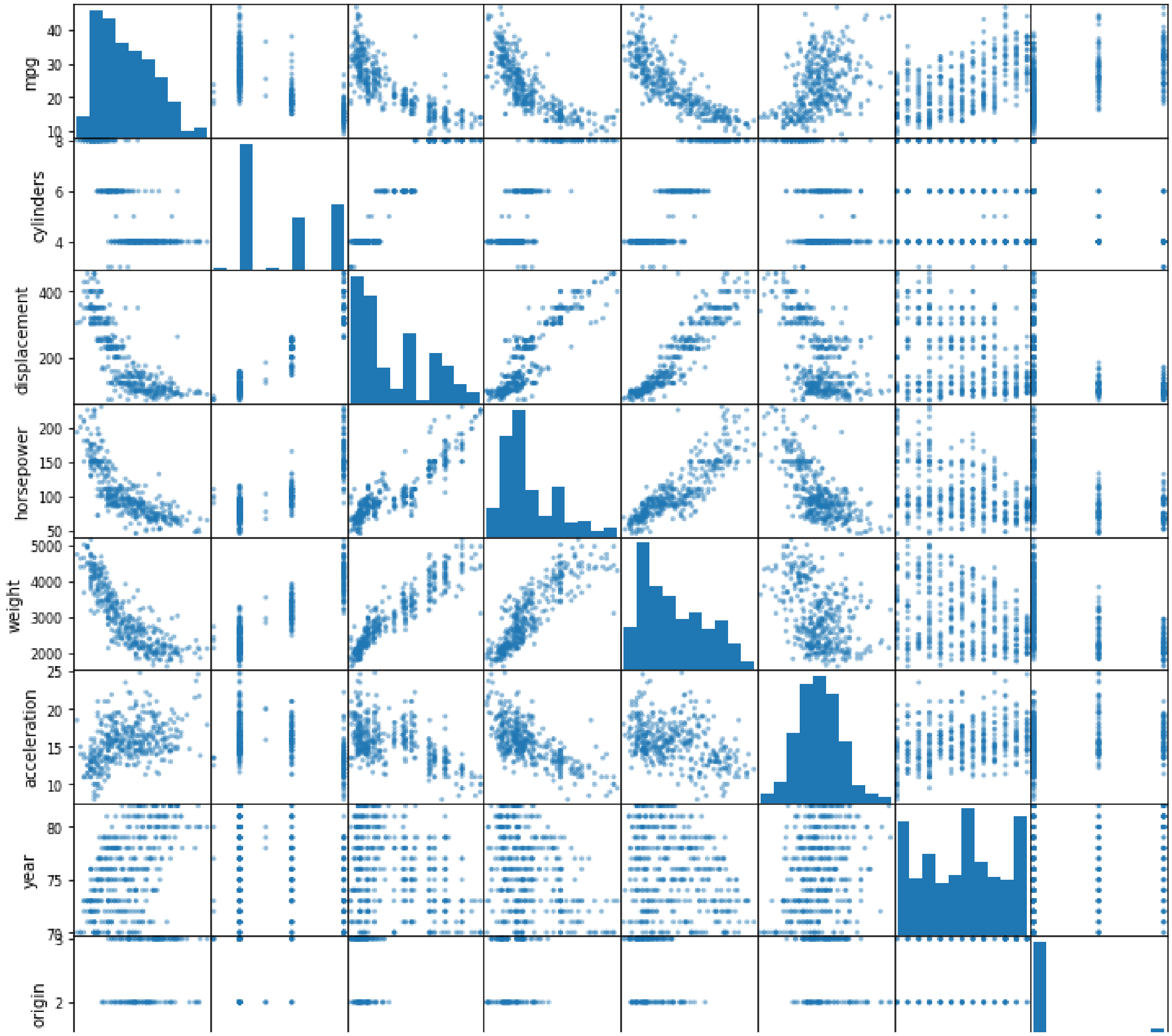
	Murder	Assault	UrbanPop	Rape
count	50.00000	50.000000	50.000000	50.000000
mean	7.78800	170.760000	65.540000	21.232000
std	4.35551	83.337661	14.474763	9.366385
min	0.80000	45.000000	32.000000	7.300000
25%	4.07500	109.000000	54.500000	15.075000
50%	7.25000	159.000000	66.000000	20.100000
75%	11.25000	249.000000	77.750000	26.175000
max	17.40000	337.000000	91.000000	46.000000

Problem 9 (Chapter 3, Exercise 9)

```
auto_df = pd.read_csv("Auto.csv", index_col=-1)
auto_df;
```

Problem 9(a)

```
pd.plotting.scatter_matrix(auto_df, figsize=(12,12));
```



Problem 9(b)

```
auto_df.corr()
```

	mpg	cylinders	displacement	horsepower	weight	acceleration
mpg	1.000000	-0.777618	-0.805127	-0.778427	-0.832244	0.423329
cylinders	-0.777618	1.000000	0.950823	0.842983	0.897527	-0.504683
displacement	-0.805127	0.950823	1.000000	0.897257	0.932994	-0.543800
horsepower	-0.778427	0.842983	0.897257	1.000000	0.864538	-0.689196
weight	-0.832244	0.897527	0.932994	0.864538	1.000000	-0.416839
acceleration	0.423329	-0.504683	-0.543800	-0.689196	-0.416839	1.000000
year	0.580541	-0.345647	-0.369855	-0.416361	-0.309120	0.290316
origin	0.565209	-0.568932	-0.614535	-0.455171	-0.585005	0.212746

Problem 9(c)

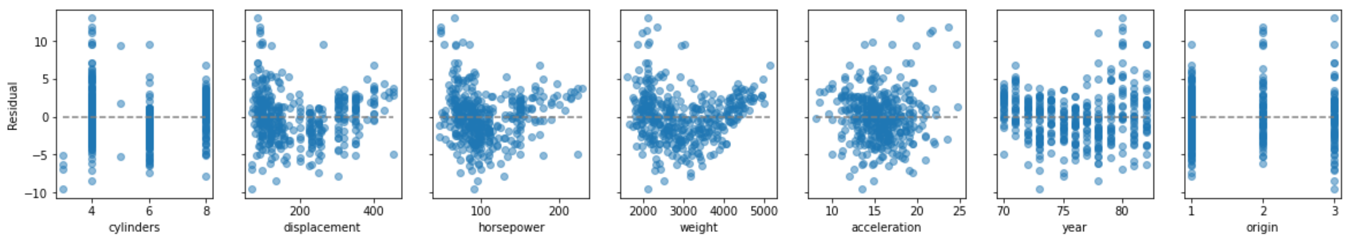
```
import statsmodels.api as sm

X = auto_df.loc[:, auto_df.columns != "mpg"]
y = auto_df["mpg"]

X = sm.add_constant(X)

linear_regression = sm.OLS(y, X)
linear_regression_results = linear_regression.fit()

print(linear_regression_results.summary())
```

```
/usr/local/lib/python3.7/dist-packages/statsmodels/tools/_testing.py:19: FutureWa
  import pandas.util.testing as tm
                            OLS Regression Results
==============================================================================
Dep. Variable:                    mpg   R-squared:                       0.821
Model:                            OLS   Adj. R-squared:                  0.818
Method:                 Least Squares   F-statistic:                     252.4
Date:                Tue, 06 Jul 2021   Prob (F-statistic):          2.04e-139
Time:                        20:33:59   Log-Likelihood:                -1023.5
No. Observations:                 392   AIC:                             2063.
Df Residuals:                     384   BIC:                             2095.
Df Model:                           7
Covariance Type:            nonrobust
================================================================================
                   coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------
const          -17.2184      4.644     -3.707      0.000     -26.350      -8.087
cylinders       -0.4934      0.323     -1.526      0.128      -1.129       0.142
displacement     0.0199      0.008      2.647      0.008       0.005       0.035
horsepower      -0.0170      0.014     -1.230      0.220      -0.044       0.010
weight          -0.0065      0.001     -9.929      0.000      -0.008      -0.005
acceleration     0.0806      0.099      0.815      0.415      -0.114       0.275
year             0.7508      0.051     14.729      0.000       0.651       0.851
origin           1.4261      0.278      5.127      0.000       0.879       1.973
==============================================================================
Omnibus:                       31.906   Durbin-Watson:                   1.309
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               53.100
Skew:                           0.529   Prob(JB):                     2.95e-12
Kurtosis:                       4.460   Cond. No.                     8.59e+04
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
[2] The condition number is large, 8.59e+04. This might indicate that there are
strong multicollinearity or other numerical problems.
```

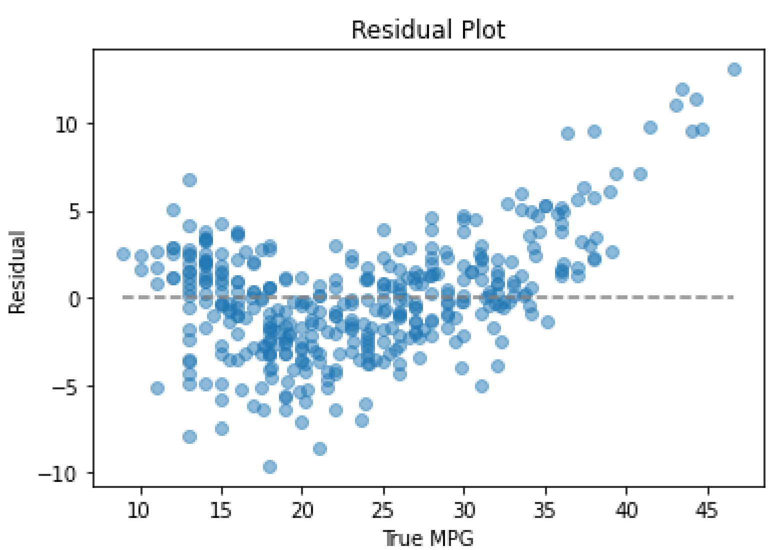
Problem 9(d)

```
auto_df.insert(8, "residuals", linear_regression_results.resid)
```

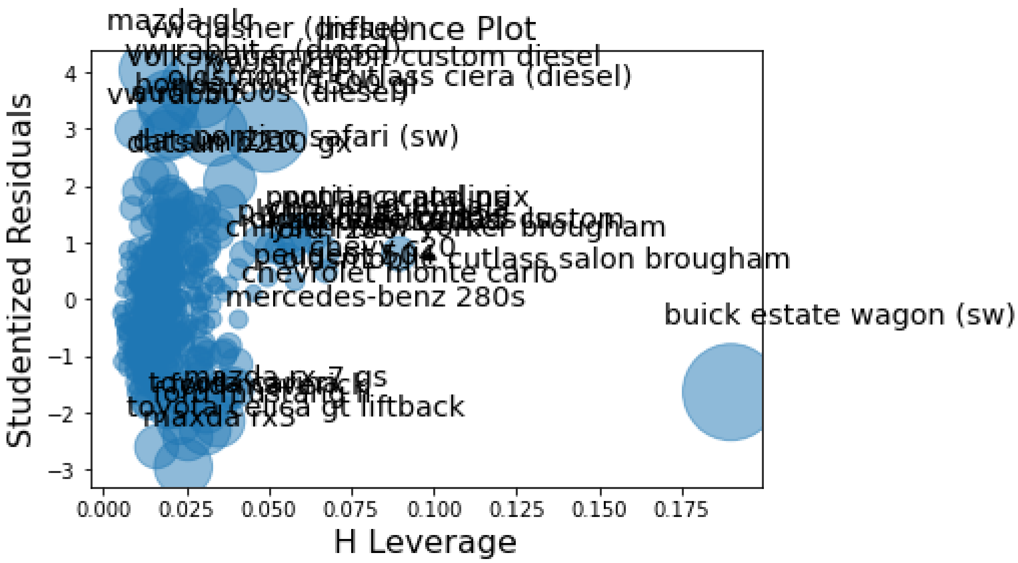
```
import numpy as np
import matplotlib.pyplot as plt

fig, ax = plt.subplots(1, 7, figsize=(20, 3), sharey=True)
ax[0].set_ylabel("Residual")


for i in np.arange(1,8):
  ax[i-1].plot([auto_df.iloc[:, i].min(), auto_df.iloc[:, i].max()], [0, 0], ls="--'
  ax[i-1].scatter(auto_df.iloc[:, i], auto_df["residuals"], alpha=0.5)
  ax[i-1].set_xlabel(auto_df.columns[i])
```



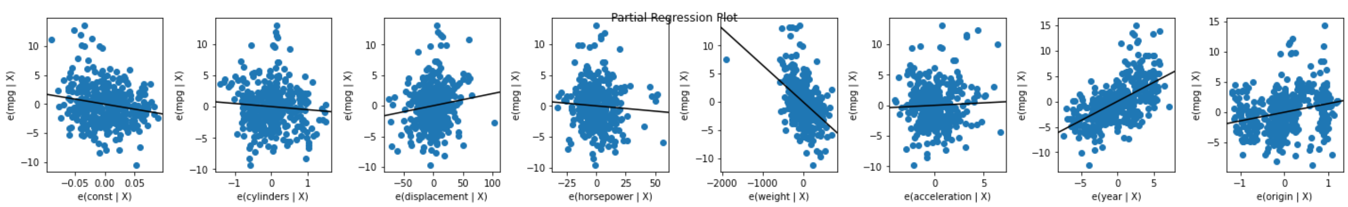

```
plt.plot(  [auto_df["mpg"].min(), auto_df["mpg"].max()], [0, 0], ls="--", c="gray")
plt.scatter(auto_df["mpg"], auto_df["residuals"], alpha=0.5)
plt.xlabel("True MPG")
plt.ylabel("Residual")
plt.title("Residual Plot");
```



```
sm.graphics.influence_plot(linear_regression_results, plot_alpha=0.5);
```




```
fig = plt.figure(figsize=(20,3))
sm.graphics.plot_partregress_grid(linear_regression_results, grid=(1,8), fig=fig);
```



Problem 9(e)

```
from statsmodels.formula.api import ols

linear_regression_w_interaction = ols(formula='mpg ~ cylinders + displacement + hors
                                          ' + weight + acceleration + year + origin + '
                                          'cylinders*displacement + cylinders*horsepowe
                                          'cylinders*weight + horsepower*displacement',
linear_regression_w_interaction_results = linear_regression_w_interaction.fit()

print(linear_regression_w_interaction_results.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    mpg   R-squared:                       0.867
Model:                            OLS   Adj. R-squared:                  0.863
Method:                 Least Squares   F-statistic:                     224.9
```

```
Date:                  Tue, 06 Jul 2021   Prob (F-statistic):          7.99e-159
Time:                          20:34:03   Log-Likelihood:                -965.98
No. Observations:                   392   AIC:                             1956.
Df Residuals:                       380   BIC:                             2004.
Df Model:                            11
Covariance Type:              nonrobust
==============================================================================
                              coef    std err          t      P>|t|      [0.025
------------------------------------------------------------------------------
Intercept                   7.5536      5.571      1.356      0.176      -3.401
cylinders                  -2.2358      1.147     -1.949      0.052      -4.491
displacement               -0.0178      0.026     -0.673      0.502      -0.070
horsepower                 -0.2092      0.050     -4.204      0.000      -0.307
weight                     -0.0082      0.002     -3.695      0.000      -0.013
acceleration               -0.1597      0.096     -1.668      0.096      -0.348
year                        0.7515      0.045     16.793      0.000       0.664
origin                      0.7382      0.262      2.815      0.005       0.223
cylinders:displacement     -0.0045      0.003     -1.390      0.165      -0.011
cylinders:horsepower        0.0103      0.010      1.022      0.307      -0.010
cylinders:weight            0.0007      0.000      2.311      0.021       0.000
horsepower:displacement     0.0003      0.000      3.047      0.002       0.000
==============================================================================
Omnibus:                       48.397   Durbin-Watson:                   1.543
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               97.726
Skew:                           0.684   Prob(JB):                     6.01e-22
Kurtosis:                       5.028   Cond. No.                     1.46e+06
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
[2] The condition number is large, 1.46e+06. This might indicate that there are
strong multicollinearity or other numerical problems.
```

Problem 9(f)

```
linear_regression_w_transformation = ols(formula='mpg ~ cylinders + displacement + h
                                     ' + weight + acceleration + year + origin + '
                                     'np.power(cylinders, 2) + np.power(displacemen
                                     'np.power(horsepower, 2) + np.power(weight, 2)
                                     data=auto_df)
linear_regression_w_transformation_results = linear_regression_w_transformation.fit(

print(linear_regression_w_transformation_results.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    mpg   R-squared:                       0.865
Model:                            OLS   Adj. R-squared:                  0.861
Method:                 Least Squares   F-statistic:                     222.0
Date:                Tue, 06 Jul 2021   Prob (F-statistic):          6.80e-158
Time:                        20:34:03   Log-Likelihood:                -968.20
No. Observations:                 392   AIC:                             1960.
Df Residuals:                     380   BIC:                             2008.
```

```
Df Model:                          11
Covariance Type:            nonrobust
==============================================================================
                                 coef    std err          t      P>|t|      [0.02
------------------------------------------------------------------------------
Intercept                      4.3655      6.025      0.725      0.469      -7.48
cylinders                      0.0748      1.470      0.051      0.959      -2.81
displacement                  -0.0329      0.022     -1.487      0.138      -0.07
horsepower                    -0.1941      0.043     -4.564      0.000      -0.27
weight                        -0.0106      0.003     -4.084      0.000      -0.01
acceleration                  -0.1735      0.101     -1.726      0.085      -0.37
year                           0.7683      0.045     16.950      0.000       0.67
origin                         0.5859      0.269      2.180      0.030       0.05
np.power(cylinders, 2)         0.0279      0.119      0.235      0.814      -0.20
np.power(displacement, 2)   5.919e-05   3.87e-05      1.528      0.127    -1.7e-0
np.power(horsepower, 2)        0.0005      0.000      3.733      0.000       0.00
np.power(weight, 2)         1.038e-06   3.51e-07      2.957      0.003    3.48e-0
==============================================================================
Omnibus:                       39.818   Durbin-Watson:                   1.524
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               82.175
Skew:                           0.564   Prob(JB):                     1.43e-18
Kurtosis:                       4.939   Cond. No.                     4.59e+08
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
[2] The condition number is large, 4.59e+08. This might indicate that there are
strong multicollinearity or other numerical problems.
```

Problem 10 (Chapter 3, Exercise 14)

Problem 10(a)

```
data = pd.read_csv("ch3_q14.csv")
data
```

	x1	x2	y
0	0.265509	0.172565	3.032974
1	0.372124	0.124859	2.763146
2	0.572853	0.320539	2.923800
3	0.908208	0.341168	2.989404

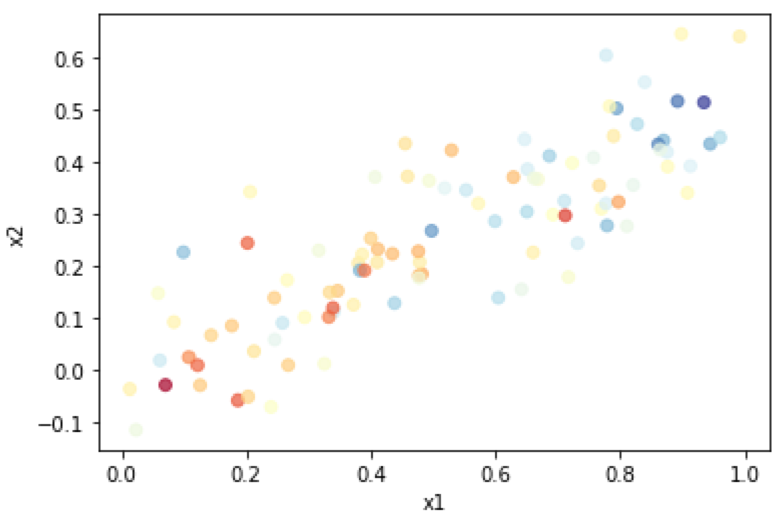
Problem 10(b)

95 0.797209 0.323573 1.691524

```
data.corr()
```

	x1	x2	y
x1	1.000000	0.835121	0.449845
x2	0.835121	1.000000	0.419917
y	0.449845	0.419917	1.000000

```
plt.scatter(data["x1"], data["x2"], c=data["y"], cmap="RdYlBu", alpha=0.7)
plt.xlabel("x1")
plt.ylabel("x2");
```



Problem 10(c)

```
X = data[["x1","x2"]]
y = data["y"]

X = sm.add_constant(X)
```

```
linear_regression_x1_x2 = sm.OLS(y, X)
linear_regression_x1_x2_results = linear_regression_x1_x2.fit()

print(linear_regression_x1_x2_results.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.209
Model:                            OLS   Adj. R-squared:                  0.193
Method:                 Least Squares   F-statistic:                     12.80
Date:                Tue, 06 Jul 2021   Prob (F-statistic):           1.16e-05
Time:                        20:34:04   Log-Likelihood:                -145.84
No. Observations:                 100   AIC:                             297.7
Df Residuals:                      97   BIC:                             305.5
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          2.1305      0.232      9.188      0.000       1.670       2.591
x1             1.4396      0.721      1.996      0.049       0.008       2.871
x2             1.0097      1.134      0.891      0.375      -1.240       3.260
==============================================================================
Omnibus:                        0.011   Durbin-Watson:                   2.081
Prob(Omnibus):                  0.995   Jarque-Bera (JB):                0.132
Skew:                          -0.005   Prob(JB):                        0.936
Kurtosis:                       2.823   Cond. No.                         14.3
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
```

Problem 10(d)

```
X = data["x1"]
y = data["y"]

X = sm.add_constant(X)

linear_regression_x1 = sm.OLS(y, X)
linear_regression_x1_results = linear_regression_x1.fit()

print(linear_regression_x1_results.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.202
Model:                            OLS   Adj. R-squared:                  0.194
Method:                 Least Squares   F-statistic:                     24.86
Date:                Tue, 06 Jul 2021   Prob (F-statistic):           2.66e-06
Time:                        20:34:04   Log-Likelihood:                -146.24
No. Observations:                 100   AIC:                             296.5
```

```
Df Residuals:                      98   BIC:                             301.7
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          2.1124      0.231      9.155      0.000       1.654       2.570
x1             1.9759      0.396      4.986      0.000       1.190       2.762
==============================================================================
Omnibus:                        0.041   Durbin-Watson:                   2.109
Prob(Omnibus):                  0.980   Jarque-Bera (JB):                0.012
Skew:                           0.003   Prob(JB):                        0.994
Kurtosis:                       2.947   Cond. No.                         4.82
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
```

Problem 10(e)

```
X = data["x2"]
y = data["y"]

X = sm.add_constant(X)

linear_regression_x2 = sm.OLS(y, X)
linear_regression_x2_results = linear_regression_x2.fit()

print(linear_regression_x2_results.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.176
Model:                            OLS   Adj. R-squared:                  0.168
Method:                 Least Squares   F-statistic:                     20.98
Date:                Tue, 06 Jul 2021   Prob (F-statistic):           1.37e-05
Time:                        20:34:04   Log-Likelihood:                -147.85
No. Observations:                 100   AIC:                             299.7
Df Residuals:                      98   BIC:                             304.9
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          2.3899      0.195     12.261      0.000       2.003       2.777
x2             2.8996      0.633      4.580      0.000       1.643       4.156
==============================================================================
Omnibus:                        0.491   Durbin-Watson:                   2.052
Prob(Omnibus):                  0.782   Jarque-Bera (JB):                0.625
Skew:                          -0.024   Prob(JB):                        0.731
Kurtosis:                       2.616   Cond. No.                         6.31
==============================================================================
```

```
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
```

Problem 10(g)

```
data_g = data.append(pd.DataFrame([[0.1, 0.8, 6]], columns=["x1", "x2", "y"]), ignor
data_g
```

	x1	x2	y
0	0.265509	0.172565	3.032974
1	0.372124	0.124859	2.763146
2	0.572853	0.320539	2.923800
3	0.908208	0.341168	2.989404
4	0.201682	0.244143	0.989147
...	...	...	...
96	0.455274	0.436354	2.496664
97	0.410084	0.206782	2.626532
98	0.810870	0.276805	3.538661
99	0.604933	0.138406	4.271852
100	0.100000	0.800000	6.000000

101 rows × 3 columns

```
X = data_g[["x1","x2"]]
y = data_g["y"]

X = sm.add_constant(X)

linear_regression_x1_x2 = sm.OLS(y, X)
linear_regression_x1_x2_results = linear_regression_x1_x2.fit()

print(linear_regression_x1_x2_results.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.219
Model:                            OLS   Adj. R-squared:                  0.203
Method:                 Least Squares   F-statistic:                     13.72
Date:                Tue, 06 Jul 2021   Prob (F-statistic):           5.56e-06
Time:                        20:34:04   Log-Likelihood:                -149.07
No. Observations:                 101   AIC:                             304.1
Df Residuals:                      98   BIC:                             312.0
```

```
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          2.2267      0.231      9.624      0.000       1.768       2.686
x1             0.5394      0.592      0.911      0.365      -0.636       1.715
x2             2.5146      0.898      2.801      0.006       0.733       4.296
==============================================================================
Omnibus:                        0.608   Durbin-Watson:                   1.992
Prob(Omnibus):                  0.738   Jarque-Bera (JB):                0.708
Skew:                          -0.024   Prob(JB):                        0.702
Kurtosis:                       2.593   Cond. No.                         11.1
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
```

```
X = data_g["x1"]
y = data_g["y"]

X = sm.add_constant(X)

linear_regression_x1 = sm.OLS(y, X)
linear_regression_x1_results = linear_regression_x1.fit()

print(linear_regression_x1_results.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.156
Model:                            OLS   Adj. R-squared:                  0.148
Method:                 Least Squares   F-statistic:                     18.33
Date:                Tue, 06 Jul 2021   Prob (F-statistic):           4.29e-05
Time:                        20:34:04   Log-Likelihood:                -152.96
No. Observations:                 101   AIC:                             309.9
Df Residuals:                      99   BIC:                             315.1
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          2.2569      0.239      9.445      0.000       1.783       2.731
x1             1.7657      0.412      4.282      0.000       0.947       2.584
==============================================================================
Omnibus:                        2.643   Durbin-Watson:                   1.957
Prob(Omnibus):                  0.267   Jarque-Bera (JB):                2.042
Skew:                           0.245   Prob(JB):                        0.360
Kurtosis:                       3.496   Cond. No.                         4.77
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
```

```
X = data_g["x2"]
```

```
y = data_g["y"]

X = sm.add_constant(X)

linear_regression_x2 = sm.OLS(y, X)
linear_regression_x2_results = linear_regression_x2.fit()

print(linear_regression_x2_results.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.212
Model:                            OLS   Adj. R-squared:                  0.204
Method:                 Least Squares   F-statistic:                     26.66
Date:                Tue, 06 Jul 2021   Prob (F-statistic):           1.25e-06
Time:                        20:34:04   Log-Likelihood:                -149.49
No. Observations:                 101   AIC:                             303.0
Df Residuals:                      99   BIC:                             308.2
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          2.3451      0.191     12.264      0.000       1.966       2.725
x2             3.1190      0.604      5.164      0.000       1.921       4.318
==============================================================================
Omnibus:                        0.837   Durbin-Watson:                   2.016
Prob(Omnibus):                  0.658   Jarque-Bera (JB):                0.862
Skew:                          -0.044   Prob(JB):                        0.650
Kurtosis:                       2.556   Cond. No.                         6.05
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
```

✓ 0s completed at 3:34 PM