Unsupervised_Learning_Assignment_1_20176062

March 19, 2019

```
In [1]: import numpy as np
        import pandas as pd
        import matplotlib.pyplot as plt
        from sklearn.linear_model import LogisticRegression
        %matplotlib inline
```

```
In [4]: df = pd.read_csv('secom.data', sep=" ", header=None)
        print(data)
```

```
          0        1          2          3       4      5         6       7    \
0     3030.93  2564.00  2187.7333  1411.1265  1.3602  100.0   97.6133  0.1242
1     3095.78  2465.14  2230.4222  1463.6606  0.8294  100.0  102.3433  0.1247
2     2932.61  2559.94  2186.4111  1698.0172  1.5102  100.0   95.4878  0.1241
3     2988.72  2479.90  2199.0333   909.7926  1.3204  100.0  104.2367  0.1217
4     3032.24  2502.87  2233.3667  1326.5200  1.5334  100.0  100.3967  0.1235
5     2946.25  2432.84  2233.3667  1326.5200  1.5334  100.0  100.3967  0.1235
6     3030.27  2430.12  2230.4222  1463.6606  0.8294  100.0  102.3433  0.1247
7     3058.88  2690.15  2248.9000  1004.4692  0.7884  100.0  106.2400  0.1185
8     2967.68  2600.47  2248.9000  1004.4692  0.7884  100.0  106.2400  0.1185
9     3016.11  2428.37  2248.9000  1004.4692  0.7884  100.0  106.2400  0.1185
10    2994.05  2548.21  2195.1222  1046.1468  1.3204  100.0  103.3400  0.1223
11    2928.84  2479.40  2196.2111  1605.7578  0.9959  100.0   97.9156  0.1257
12    2920.07  2507.40  2195.1222  1046.1468  1.3204  100.0  103.3400  0.1223
13    3051.44  2529.27  2184.4333   877.6266  1.4668  100.0  107.8711  0.1240
14    2963.97  2629.48  2224.6222   947.7739  1.2924  100.0  104.8489  0.1197
15    2988.31  2546.26  2224.6222   947.7739  1.2924  100.0  104.8489  0.1197
16    3028.02  2560.87  2270.2556  1258.4558  1.3950  100.0  104.8078  0.1207
17    3032.73  2517.79  2270.2556  1258.4558  1.3950  100.0  104.8078  0.1207
18    3040.34  2501.16  2207.3889   962.5317  1.2043  100.0  104.0311  0.1210
19    2988.30  2519.05  2208.8556  1157.7224  1.5509  100.0  107.8022  0.1233
20    2987.32  2528.81        NaN        NaN     NaN    NaN       NaN  0.1195
21        NaN  2481.85  2207.3889   962.5317  1.2043  100.0  104.0311  0.1210
22    3002.27  2497.45  2207.3889   962.5317  1.2043  100.0  104.0311  0.1210
23    2884.74  2514.54  2160.3667   899.9488  1.4022  100.0  105.4978  0.1240
24    3010.41  2632.80  2203.9000  1116.4129  1.2639  100.0  102.2733  0.1199
25    2979.74  2446.56  2257.1667  1437.9565  1.4918  100.0  106.3400  0.1203
26    3067.35  2456.33  2257.1667  1437.9565  1.4918  100.0  106.3400  0.1203
```

27	2988.99	2607.63	2223.0333	1533.9934	1.3548	100.0	109.7067	0.1211
28	2972.78	2431.57	2190.4889	1059.4390	0.8614	100.0	102.1178	0.1216
29	2981.85	2529.11	2180.3778	1208.7411	1.2998	100.0	100.2789	0.1209
...	...	...	...	...	...	...	...	...
1537	3006.22	2525.20	2192.7889	1268.5852	1.9935	100.0	104.5867	0.1268
1538	3128.11	2367.16	2223.5333	1352.1869	0.8714	100.0	97.2189	0.1196
1539	2908.94	2560.99	2187.3444	2882.8558	1.5876	100.0	85.4189	0.1235
1540	2996.04	2555.92	2190.7666	3530.2362	0.8017	100.0	83.8767	0.1249
1541	3246.31	2499.79	2216.8111	1190.4067	2.5148	100.0	114.5533	0.1230
1542	2965.57	2487.91	2210.3556	910.7177	1.6941	100.0	119.8822	0.1268
1543	3109.18	2447.97	2210.3556	910.7177	1.6941	100.0	119.8822	0.1268
1544	3108.98	2537.73	2210.3556	910.7177	1.6941	100.0	119.8822	0.1268
1545	3100.19	2490.60	2212.8445	1068.5644	1.7835	100.0	113.8833	0.1249
1546	3093.24	2488.18	2212.8445	1068.5644	1.7835	100.0	113.8833	0.1249
1547	3008.77	2542.36	2167.4222	2837.8788	1.4892	100.0	83.8222	0.1255
1548	3027.01	2464.98	2212.6334	1081.5662	1.0096	100.0	113.4278	0.1253
1549	3183.63	2498.00	2195.4444	2914.1792	1.5978	100.0	85.1011	0.1235
1550	3072.20	2406.47	2195.4444	2914.1792	1.5978	100.0	85.1011	0.1235
1551	2958.43	2489.06	2192.7556	867.3027	1.7393	100.0	123.4244	0.1251
1552	2939.35	2521.98	2195.1000	1526.4440	0.8279	100.0	96.3100	0.1203
1553	3020.79	2500.19	2210.3556	910.7177	1.6941	100.0	119.8822	0.1268
1554	3031.78	2528.55	2182.5555	1261.0898	1.2110	100.0	112.2922	0.1252
1555	2902.96	2515.03	2181.1889	1338.8895	2.1195	100.0	108.1400	0.1263
1556	3025.21	2503.30	2179.7333	3085.3781	1.4843	100.0	82.2467	0.1248
1557	3072.10	2534.87	2177.4333	2945.8855	1.3321	100.0	83.1700	0.1253
1558	3012.30	2466.84	2217.4111	1032.2836	1.4802	100.0	101.3511	0.1195
1559	3076.33	2456.13	2217.4111	1032.2836	1.4802	100.0	101.3511	0.1195
1560	2770.40	2549.42	2204.2889	2637.9989	1.5549	100.0	86.1089	0.1234
1561	2951.14	2326.59	2212.6334	1081.5662	1.0096	100.0	113.4278	0.1253
1562	2899.41	2464.36	2179.7333	3085.3781	1.4843	100.0	82.2467	0.1248
1563	3052.31	2522.55	2198.5667	1124.6595	0.8763	100.0	98.4689	0.1205
1564	2978.81	2379.78	2206.3000	1110.4967	0.8236	100.0	99.4122	0.1208
1565	2894.92	2532.01	2177.0333	1183.7287	1.5726	100.0	98.7978	0.1213
1566	2944.92	2450.76	2195.4444	2914.1792	1.5978	100.0	85.1011	0.1235

	8	9	...	580	581	582	583	584	\
0	1.5005	0.0162	...	NaN	NaN	0.5005	0.0118	0.0035	
1	1.4966	-0.0005	...	0.0060	208.2045	0.5019	0.0223	0.0055	
2	1.4436	0.0041	...	0.0148	82.8602	0.4958	0.0157	0.0039	
3	1.4882	-0.0124	...	0.0044	73.8432	0.4990	0.0103	0.0025	
4	1.5031	-0.0031	...	NaN	NaN	0.4800	0.4766	0.1045	
5	1.5287	0.0167	...	0.0052	44.0077	0.4949	0.0189	0.0044	
6	1.5816	-0.0270	...	NaN	NaN	0.5010	0.0143	0.0042	
7	1.5153	0.0157	...	0.0063	95.0310	0.4984	0.0106	0.0034	
8	1.5358	0.0111	...	0.0045	111.6525	0.4993	0.0172	0.0046	
9	1.5381	0.0159	...	0.0073	90.2294	0.4967	0.0152	0.0038	
10	1.5144	-0.0190	...	0.0071	57.8122	0.4925	0.0158	0.0041	
11	1.4690	0.0170	...	0.0081	75.5077	0.4987	0.0427	0.0092	

12	1.5310	-0.0259	...	0.0034	52.2039	0.4950	0.0153	0.0041
13	1.5236	-0.0209	...	NaN	NaN	0.5034	0.0151	0.0038
14	1.4474	0.0144	...	0.0084	142.9080	0.5077	0.0094	0.0026
15	1.5465	0.0250	...	0.0045	100.2745	0.5058	0.0078	0.0021
16	1.4368	0.0150	...	0.0042	82.0989	0.5005	0.0108	0.0034
17	1.5537	0.0220	...	NaN	NaN	0.5015	0.0105	0.0027
18	1.5481	-0.0367	...	NaN	NaN	0.4948	0.0117	0.0034
19	1.5362	-0.0259	...	0.0032	47.1586	0.5036	0.0169	0.0039
20	1.6343	-0.0263	...	NaN	NaN	0.5011	0.0117	0.0033
21	1.5559	0.0002	...	0.0023	34.4153	0.4947	0.0137	0.0041
22	1.5465	0.0195	...	0.0075	114.5979	0.4977	0.0114	0.0037
23	1.5585	-0.0317	...	0.0077	216.8869	0.4982	0.0099	0.0027
24	1.4227	0.0194	...	0.0101	125.0600	0.5032	0.0159	0.0039
25	1.5136	0.0018	...	NaN	NaN	0.5012	0.0336	0.0072
26	1.4860	-0.0019	...	NaN	NaN	0.5006	0.0083	0.0022
27	1.5582	-0.0101	...	0.0116	216.9552	0.5069	0.0158	0.0040
28	1.5438	0.0065	...	0.0053	127.5067	0.5036	0.0137	0.0036
29	1.4200	-0.0016	...	0.0062	146.8715	0.5019	0.0139	0.0034
...	...	...	...	...	...	...	...	...
1537	1.4522	-0.0039	...	NaN	NaN	0.4942	0.0175	0.0045
1538	1.3907	0.0074	...	0.0038	47.3376	0.4977	0.0144	0.0037
1539	1.4167	0.0041	...	NaN	NaN	0.4987	0.0118	0.0028
1540	1.4158	-0.0029	...	0.0046	67.6676	0.5011	0.0163	0.0035
1541	1.3966	-0.0057	...	0.0019	23.5979	0.5021	0.0103	0.0030
1542	1.3109	0.0174	...	0.0087	121.9426	0.4992	0.0136	0.0037
1543	1.3502	0.0201	...	0.0055	50.8827	0.4975	0.0109	0.0038
1544	1.2901	0.0202	...	0.0039	72.9676	0.4986	0.0192	0.0046
1545	1.4294	-0.0014	...	0.0070	402.6874	0.4951	0.0165	0.0051
1546	1.3482	0.0060	...	0.0047	105.7142	0.5022	0.0249	0.0049
1547	1.2895	0.0023	...	0.0022	36.2975	0.5012	0.0160	0.0044
1548	1.4410	0.0035	...	0.0071	88.5812	0.4944	0.0171	0.0040
1549	1.4129	-0.0081	...	NaN	NaN	0.5037	0.0117	0.0030
1550	1.3148	-0.0024	...	0.0022	27.5514	0.5034	0.0178	0.0043
1551	1.4386	-0.0179	...	0.0044	30.7574	0.4972	0.0157	0.0040
1552	1.4366	0.0083	...	0.0074	247.6285	0.5031	0.0111	0.0028
1553	1.3405	0.0201	...	0.0077	134.3983	0.4985	0.0126	0.0036
1554	1.3485	0.0151	...	0.0098	117.0945	0.5025	0.0138	0.0039
1555	1.3255	-0.0052	...	0.0051	184.8703	0.5002	0.0130	0.0035
1556	1.3687	-0.0070	...	0.0016	46.1076	0.5019	0.0158	0.0043
1557	1.4359	-0.0114	...	0.0023	26.7330	0.5010	0.0132	0.0035
1558	1.3832	0.0042	...	0.0054	176.6783	0.4993	0.0130	0.0037
1559	1.3120	-0.0043	...	0.0057	117.4564	0.4960	0.0157	0.0036
1560	1.2811	0.0037	...	0.0042	127.3154	0.5009	0.0155	0.0036
1561	1.4492	-0.0134	...	0.0051	46.4573	0.4965	0.0118	0.0032
1562	1.3424	-0.0045	...	0.0047	203.1720	0.4988	0.0143	0.0039
1563	1.4333	-0.0061	...	NaN	NaN	0.4975	0.0131	0.0036
1564	NaN	NaN	...	0.0025	43.5231	0.4987	0.0153	0.0041
1565	1.4622	-0.0072	...	0.0075	93.4941	0.5004	0.0178	0.0038

```
1566     NaN     NaN    ...     0.0045  137.7844  0.4987  0.0181  0.0040

          585     586     587     588       589
0      2.3630     NaN     NaN     NaN       NaN
1      4.4447  0.0096  0.0201  0.0060  208.2045
2      3.1745  0.0584  0.0484  0.0148   82.8602
3      2.0544  0.0202  0.0149  0.0044   73.8432
4     99.3032  0.0202  0.0149  0.0044   73.8432
5      3.8276  0.0342  0.0151  0.0052   44.0077
6      2.8515  0.0342  0.0151  0.0052   44.0077
7      2.1261  0.0204  0.0194  0.0063   95.0310
8      3.4456  0.0111  0.0124  0.0045  111.6525
9      3.0687  0.0212  0.0191  0.0073   90.2294
10     3.2115  0.0355  0.0205  0.0071   57.8122
11     8.5646  0.0370  0.0279  0.0081   75.5077
12     3.0926  0.0188  0.0098  0.0034   52.2039
13     3.0063  0.0188  0.0098  0.0034   52.2039
14     1.8483  0.0202  0.0289  0.0084  142.9080
15     1.5352  0.0174  0.0174  0.0045  100.2745
16     2.1574  0.0184  0.0151  0.0042   82.0989
17     2.0979  0.0184  0.0151  0.0042   82.0989
18     2.3737  0.0184  0.0151  0.0042   82.0989
19     3.3514  0.0229  0.0108  0.0032   47.1586
20     2.3308  0.0229  0.0108  0.0032   47.1586
21     2.7729  0.0175  0.0060  0.0023   34.4153
22     2.2849  0.0250  0.0286  0.0075  114.5979
23     1.9771  0.0098  0.0213  0.0077  216.8869
24     3.1576  0.0288  0.0361  0.0101  125.0600
25     6.7053  0.0288  0.0361  0.0101  125.0600
26     1.6593  0.0288  0.0361  0.0101  125.0600
27     3.1232  0.0183  0.0397  0.0116  216.9552
28     2.7205  0.0130  0.0165  0.0053  127.5067
29     2.7747  0.0121  0.0178  0.0062  146.8715
...       ...     ...     ...     ...       ...
1537   3.5322  0.0199  0.0097  0.0037   48.7045
1538   2.9002  0.0237  0.0112  0.0038   47.3376
1539   2.3583  0.0237  0.0112  0.0038   47.3376
1540   3.2608  0.0181  0.0123  0.0046   67.6676
1541   2.0418  0.0266  0.0063  0.0019   23.5979
1542   2.7204  0.0216  0.0263  0.0087  121.9426
1543   2.1905  0.0273  0.0139  0.0055   50.8827
1544   3.8442  0.0172  0.0126  0.0039   72.9676
1545   3.3383  0.0063  0.0252  0.0070  402.6874
1546   4.9623  0.0134  0.0142  0.0047  105.7142
1547   3.2008  0.0222  0.0080  0.0022   36.2975
1548   3.4656  0.0253  0.0224  0.0071   88.5812
1549   2.3203  0.0253  0.0224  0.0071   88.5812
1550   3.5459  0.0236  0.0065  0.0022   27.5514
```

```
1551   3.1578  0.0400  0.0123  0.0044   30.7574
1552   2.2144  0.0085  0.0212  0.0074  247.6285
1553   2.5295  0.0174  0.0234  0.0077  134.3983
1554   2.7512  0.0235  0.0275  0.0098  117.0945
1555   2.5982  0.0086  0.0160  0.0051  184.8703
1556   3.1428  0.0120  0.0055  0.0016   46.1076
1557   2.6249  0.0277  0.0074  0.0023   26.7330
1558   2.5976  0.0097  0.0172  0.0054  176.6783
1559   3.1743  0.0150  0.0176  0.0057  117.4564
1560   3.0997  0.0105  0.0133  0.0042  127.3154
1561   2.3817  0.0320  0.0148  0.0051   46.4573
1562   2.8669  0.0068  0.0138  0.0047  203.1720
1563   2.6238  0.0068  0.0138  0.0047  203.1720
1564   3.0590  0.0197  0.0086  0.0025   43.5231
1565   3.5662  0.0262  0.0245  0.0075   93.4941
1566   3.6275  0.0117  0.0162  0.0045  137.7844

[1567 rows x 590 columns]
```

Count number of NAs for each column

```
In [5]: nas = [df[x].isna().sum() for x in df.columns]
        print(nas)
```

```
[6, 7, 14, 14, 14, 14, 14, 9, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 10, 0, 2, 2, 2, 2, 2, 2, 2, 2, 2,
```

Read lables for the data

```
In [7]: lables = pd.read_csv('secom_labels.data', sep=" ", header=None)
        print(lables)
```

```
      0                    1
0    -1  19/07/2008 11:55:00
1    -1  19/07/2008 12:32:00
2     1  19/07/2008 13:17:00
3    -1  19/07/2008 14:43:00
4    -1  19/07/2008 15:22:00
5    -1  19/07/2008 17:53:00
6    -1  19/07/2008 19:44:00
7    -1  19/07/2008 19:45:00
8    -1  19/07/2008 20:24:00
9    -1  19/07/2008 21:35:00
10    1  19/07/2008 21:57:00
11    1  19/07/2008 22:52:00
12   -1  20/07/2008 03:35:00
13   -1  21/07/2008 08:21:00
14    1  21/07/2008 11:53:00
```

```
15   -1  22/07/2008 00:03:00
16   -1  22/07/2008 02:59:00
17   -1  22/07/2008 08:41:00
18   -1  22/07/2008 11:47:00
19   -1  22/07/2008 14:00:00
20   -1  22/07/2008 15:30:00
21   -1  23/07/2008 05:15:00
22   -1  23/07/2008 19:22:00
23    1  25/07/2008 15:23:00
24   -1  27/07/2008 04:18:00
25   -1  27/07/2008 09:37:00
26   -1  27/07/2008 11:10:00
27   -1  27/07/2008 15:46:00
28   -1  27/07/2008 16:06:00
29   -1  27/07/2008 16:49:00
...  ..                  ...
1537 -1  15/10/2008 18:16:00
1538 -1  15/10/2008 19:15:00
1539 -1  15/10/2008 19:24:00
1540 -1  15/10/2008 21:44:00
1541 -1  15/10/2008 22:45:00
1542 -1  15/10/2008 22:54:00
1543 -1  15/10/2008 23:00:00
1544 -1  15/10/2008 23:45:00
1545 -1  16/10/2008 02:16:00
1546 -1  16/10/2008 02:16:00
1547 -1  16/10/2008 02:17:00
1548 -1  16/10/2008 02:22:00
1549 -1  16/10/2008 02:55:00
1550 -1  16/10/2008 03:56:00
1551 -1  16/10/2008 04:02:00
1552 -1  16/10/2008 04:02:00
1553 -1  16/10/2008 04:04:00
1554 -1  16/10/2008 04:47:00
1555 -1  16/10/2008 04:50:00
1556 -1  16/10/2008 04:54:00
1557 -1  16/10/2008 05:08:00
1558 -1  16/10/2008 05:13:00
1559 -1  16/10/2008 05:44:00
1560 -1  16/10/2008 05:58:00
1561 -1  16/10/2008 15:02:00
1562 -1  16/10/2008 15:13:00
1563 -1  16/10/2008 20:49:00
1564 -1  17/10/2008 05:26:00
1565 -1  17/10/2008 06:01:00
1566 -1  17/10/2008 06:07:00

[1567 rows x 2 columns]
```

Replace -1 with 0

```
In [8]: lables = lables.replace(-1,0)
        print(lables)
```

```
      0                    1
0     0  19/07/2008 11:55:00
1     0  19/07/2008 12:32:00
2     1  19/07/2008 13:17:00
3     0  19/07/2008 14:43:00
4     0  19/07/2008 15:22:00
5     0  19/07/2008 17:53:00
6     0  19/07/2008 19:44:00
7     0  19/07/2008 19:45:00
8     0  19/07/2008 20:24:00
9     0  19/07/2008 21:35:00
10    1  19/07/2008 21:57:00
11    1  19/07/2008 22:52:00
12    0  20/07/2008 03:35:00
13    0  21/07/2008 08:21:00
14    1  21/07/2008 11:53:00
15    0  22/07/2008 00:03:00
16    0  22/07/2008 02:59:00
17    0  22/07/2008 08:41:00
18    0  22/07/2008 11:47:00
19    0  22/07/2008 14:00:00
20    0  22/07/2008 15:30:00
21    0  23/07/2008 05:15:00
22    0  23/07/2008 19:22:00
23    1  25/07/2008 15:23:00
24    0  27/07/2008 04:18:00
25    0  27/07/2008 09:37:00
26    0  27/07/2008 11:10:00
27    0  27/07/2008 15:46:00
28    0  27/07/2008 16:06:00
29    0  27/07/2008 16:49:00
...  ..                  ...
1537  0  15/10/2008 18:16:00
1538  0  15/10/2008 19:15:00
1539  0  15/10/2008 19:24:00
1540  0  15/10/2008 21:44:00
1541  0  15/10/2008 22:45:00
1542  0  15/10/2008 22:54:00
1543  0  15/10/2008 23:00:00
1544  0  15/10/2008 23:45:00
1545  0  16/10/2008 02:16:00
```

```
1546  0  16/10/2008 02:16:00
1547  0  16/10/2008 02:17:00
1548  0  16/10/2008 02:22:00
1549  0  16/10/2008 02:55:00
1550  0  16/10/2008 03:56:00
1551  0  16/10/2008 04:02:00
1552  0  16/10/2008 04:02:00
1553  0  16/10/2008 04:04:00
1554  0  16/10/2008 04:47:00
1555  0  16/10/2008 04:50:00
1556  0  16/10/2008 04:54:00
1557  0  16/10/2008 05:08:00
1558  0  16/10/2008 05:13:00
1559  0  16/10/2008 05:44:00
1560  0  16/10/2008 05:58:00
1561  0  16/10/2008 15:02:00
1562  0  16/10/2008 15:13:00
1563  0  16/10/2008 20:49:00
1564  0  17/10/2008 05:26:00
1565  0  17/10/2008 06:01:00
1566  0  17/10/2008 06:07:00

[1567 rows x 2 columns]
```

Substitute NAs with mean of that particular column

```
In [9]: df = df.apply(lambda x: x.fillna(x.mean()), axis=0)
        print(df)
```

```
              0       1            2            3         4      5    \
0     3030.930000  2564.00  2187.733300  1411.126500  1.360200  100.0
1     3095.780000  2465.14  2230.422200  1463.660600  0.829400  100.0
2     2932.610000  2559.94  2186.411100  1698.017200  1.510200  100.0
3     2988.720000  2479.90  2199.033300   909.792600  1.320400  100.0
4     3032.240000  2502.87  2233.366700  1326.520000  1.533400  100.0
5     2946.250000  2432.84  2233.366700  1326.520000  1.533400  100.0
6     3030.270000  2430.12  2230.422200  1463.660600  0.829400  100.0
7     3058.880000  2690.15  2248.900000  1004.469200  0.788400  100.0
8     2967.680000  2600.47  2248.900000  1004.469200  0.788400  100.0
9     3016.110000  2428.37  2248.900000  1004.469200  0.788400  100.0
10    2994.050000  2548.21  2195.122200  1046.146800  1.320400  100.0
11    2928.840000  2479.40  2196.211100  1605.757800  0.995900  100.0
12    2920.070000  2507.40  2195.122200  1046.146800  1.320400  100.0
13    3051.440000  2529.27  2184.433300   877.626600  1.466800  100.0
14    2963.970000  2629.48  2224.622200   947.773900  1.292400  100.0
15    2988.310000  2546.26  2224.622200   947.773900  1.292400  100.0
16    3028.020000  2560.87  2270.255600  1258.455800  1.395000  100.0
```

```
17    3032.730000  2517.79  2270.255600  1258.455800  1.395000  100.0
18    3040.340000  2501.16  2207.388900   962.531700  1.204300  100.0
19    2988.300000  2519.05  2208.855600  1157.722400  1.550900  100.0
20    2987.320000  2528.81  2200.547318  1396.376627  4.197013  100.0
21    3014.452896  2481.85  2207.388900   962.531700  1.204300  100.0
22    3002.270000  2497.45  2207.388900   962.531700  1.204300  100.0
23    2884.740000  2514.54  2160.366700   899.948800  1.402200  100.0
24    3010.410000  2632.80  2203.900000  1116.412900  1.263900  100.0
25    2979.740000  2446.56  2257.166700  1437.956500  1.491800  100.0
26    3067.350000  2456.33  2257.166700  1437.956500  1.491800  100.0
27    2988.990000  2607.63  2223.033300  1533.993400  1.354800  100.0
28    2972.780000  2431.57  2190.488900  1059.439000  0.861400  100.0
29    2981.850000  2529.11  2180.377800  1208.741100  1.299800  100.0
...           ...      ...          ...          ...       ...    ...
1537  3006.220000  2525.20  2192.788900  1268.585200  1.993500  100.0
1538  3128.110000  2367.16  2223.533300  1352.186900  0.871400  100.0
1539  2908.940000  2560.99  2187.344400  2882.855800  1.587600  100.0
1540  2996.040000  2555.92  2190.766600  3530.236200  0.801700  100.0
1541  3246.310000  2499.79  2216.811100  1190.406700  2.514800  100.0
1542  2965.570000  2487.91  2210.355600   910.717700  1.694100  100.0
1543  3109.180000  2447.97  2210.355600   910.717700  1.694100  100.0
1544  3108.980000  2537.73  2210.355600   910.717700  1.694100  100.0
1545  3100.190000  2490.60  2212.844500  1068.564400  1.783500  100.0
1546  3093.240000  2488.18  2212.844500  1068.564400  1.783500  100.0
1547  3008.770000  2542.36  2167.422200  2837.878800  1.489200  100.0
1548  3027.010000  2464.98  2212.633400  1081.566200  1.009600  100.0
1549  3183.630000  2498.00  2195.444400  2914.179200  1.597800  100.0
1550  3072.200000  2406.47  2195.444400  2914.179200  1.597800  100.0
1551  2958.430000  2489.06  2192.755600   867.302700  1.739300  100.0
1552  2939.350000  2521.98  2195.100000  1526.444000  0.827900  100.0
1553  3020.790000  2500.19  2210.355600   910.717700  1.694100  100.0
1554  3031.780000  2528.55  2182.555500  1261.089800  1.211000  100.0
1555  2902.960000  2515.03  2181.188900  1338.889500  2.119500  100.0
1556  3025.210000  2503.30  2179.733300  3085.378100  1.484300  100.0
1557  3072.100000  2534.87  2177.433300  2945.885500  1.332100  100.0
1558  3012.300000  2466.84  2217.411100  1032.283600  1.480200  100.0
1559  3076.330000  2456.13  2217.411100  1032.283600  1.480200  100.0
1560  2770.400000  2549.42  2204.288900  2637.998900  1.554900  100.0
1561  2951.140000  2326.59  2212.633400  1081.566200  1.009600  100.0
1562  2899.410000  2464.36  2179.733300  3085.378100  1.484300  100.0
1563  3052.310000  2522.55  2198.566700  1124.659500  0.876300  100.0
1564  2978.810000  2379.78  2206.300000  1110.496700  0.823600  100.0
1565  2894.920000  2532.01  2177.033300  1183.728700  1.572600  100.0
1566  2944.920000  2450.76  2195.444400  2914.179200  1.597800  100.0

             6       7         8         9       ...          580  \
0     97.613300  0.1242  1.500500  0.016200     ...     0.005396
1     102.343300  0.1247  1.496600 -0.000500     ...     0.006000
```

2	95.487800	0.1241	1.443600	0.004100	...	0.014800
3	104.236700	0.1217	1.488200	-0.012400	...	0.004400
4	100.396700	0.1235	1.503100	-0.003100	...	0.005396
5	100.396700	0.1235	1.528700	0.016700	...	0.005200
6	102.343300	0.1247	1.581600	-0.027000	...	0.005396
7	106.240000	0.1185	1.515300	0.015700	...	0.006300
8	106.240000	0.1185	1.535800	0.011100	...	0.004500
9	106.240000	0.1185	1.538100	0.015900	...	0.007300
10	103.340000	0.1223	1.514400	-0.019000	...	0.007100
11	97.915600	0.1257	1.469000	0.017000	...	0.008100
12	103.340000	0.1223	1.531000	-0.025900	...	0.003400
13	107.871100	0.1240	1.523600	-0.020900	...	0.005396
14	104.848900	0.1197	1.447400	0.014400	...	0.008400
15	104.848900	0.1197	1.546500	0.025000	...	0.004500
16	104.807800	0.1207	1.436800	0.015000	...	0.004200
17	104.807800	0.1207	1.553700	0.022000	...	0.005396
18	104.031100	0.1210	1.548100	-0.036700	...	0.005396
19	107.802200	0.1233	1.536200	-0.025900	...	0.003200
20	101.112908	0.1195	1.634300	-0.026300	...	0.005396
21	104.031100	0.1210	1.555900	0.000200	...	0.002300
22	104.031100	0.1210	1.546500	0.019500	...	0.007500
23	105.497800	0.1240	1.558500	-0.031700	...	0.007700
24	102.273300	0.1199	1.422700	0.019400	...	0.010100
25	106.340000	0.1203	1.513600	0.001800	...	0.005396
26	106.340000	0.1203	1.486000	-0.001900	...	0.005396
27	109.706700	0.1211	1.558200	-0.010100	...	0.011600
28	102.117800	0.1216	1.543800	0.006500	...	0.005300
29	100.278900	0.1209	1.420000	-0.001600	...	0.006200
...	...	...	...	...	...	...
1537	104.586700	0.1268	1.452200	-0.003900	...	0.005396
1538	97.218900	0.1196	1.390700	0.007400	...	0.003800
1539	85.418900	0.1235	1.416700	0.004100	...	0.005396
1540	83.876700	0.1249	1.415800	-0.002900	...	0.004600
1541	114.553300	0.1230	1.396600	-0.005700	...	0.001900
1542	119.882200	0.1268	1.310900	0.017400	...	0.008700
1543	119.882200	0.1268	1.350200	0.020100	...	0.005500
1544	119.882200	0.1268	1.290100	0.020200	...	0.003900
1545	113.883300	0.1249	1.429400	-0.001400	...	0.007000
1546	113.883300	0.1249	1.348200	0.006000	...	0.004700
1547	83.822200	0.1255	1.289500	0.002300	...	0.002200
1548	113.427800	0.1253	1.441000	0.003500	...	0.007100
1549	85.101100	0.1235	1.412900	-0.008100	...	0.005396
1550	85.101100	0.1235	1.314800	-0.002400	...	0.002200
1551	123.424400	0.1251	1.438600	-0.017900	...	0.004400
1552	96.310000	0.1203	1.436600	0.008300	...	0.007400
1553	119.882200	0.1268	1.340500	0.020100	...	0.007700
1554	112.292200	0.1252	1.348500	0.015100	...	0.009800
1555	108.140000	0.1263	1.325500	-0.005200	...	0.005100

1556	82.246700	0.1248	1.368700	-0.007000	...	0.001600
1557	83.170000	0.1253	1.435900	-0.011400	...	0.002300
1558	101.351100	0.1195	1.383200	0.004200	...	0.005400
1559	101.351100	0.1195	1.312000	-0.004300	...	0.005700
1560	86.108900	0.1234	1.281100	0.003700	...	0.004200
1561	113.427800	0.1253	1.449200	-0.013400	...	0.005100
1562	82.246700	0.1248	1.342400	-0.004500	...	0.004700
1563	98.468900	0.1205	1.433300	-0.006100	...	0.005396
1564	99.412200	0.1208	1.462862	-0.000841	...	0.002500
1565	98.797800	0.1213	1.462200	-0.007200	...	0.007500
1566	85.101100	0.1235	1.462862	-0.000841	...	0.004500

	581	582	583	584	585	586	587	\
0	97.934373	0.5005	0.0118	0.0035	2.3630	0.021458	0.016475	
1	208.204500	0.5019	0.0223	0.0055	4.4447	0.009600	0.020100	
2	82.860200	0.4958	0.0157	0.0039	3.1745	0.058400	0.048400	
3	73.843200	0.4990	0.0103	0.0025	2.0544	0.020200	0.014900	
4	97.934373	0.4800	0.4766	0.1045	99.3032	0.020200	0.014900	
5	44.007700	0.4949	0.0189	0.0044	3.8276	0.034200	0.015100	
6	97.934373	0.5010	0.0143	0.0042	2.8515	0.034200	0.015100	
7	95.031000	0.4984	0.0106	0.0034	2.1261	0.020400	0.019400	
8	111.652500	0.4993	0.0172	0.0046	3.4456	0.011100	0.012400	
9	90.229400	0.4967	0.0152	0.0038	3.0687	0.021200	0.019100	
10	57.812200	0.4925	0.0158	0.0041	3.2115	0.035500	0.020500	
11	75.507700	0.4987	0.0427	0.0092	8.5646	0.037000	0.027900	
12	52.203900	0.4950	0.0153	0.0041	3.0926	0.018800	0.009800	
13	97.934373	0.5034	0.0151	0.0038	3.0063	0.018800	0.009800	
14	142.908000	0.5077	0.0094	0.0026	1.8483	0.020200	0.028900	
15	100.274500	0.5058	0.0078	0.0021	1.5352	0.017400	0.017400	
16	82.098900	0.5005	0.0108	0.0034	2.1574	0.018400	0.015100	
17	97.934373	0.5015	0.0105	0.0027	2.0979	0.018400	0.015100	
18	97.934373	0.4948	0.0117	0.0034	2.3737	0.018400	0.015100	
19	47.158600	0.5036	0.0169	0.0039	3.3514	0.022900	0.010800	
20	97.934373	0.5011	0.0117	0.0033	2.3308	0.022900	0.010800	
21	34.415300	0.4947	0.0137	0.0041	2.7729	0.017500	0.006000	
22	114.597900	0.4977	0.0114	0.0037	2.2849	0.025000	0.028600	
23	216.886900	0.4982	0.0099	0.0027	1.9771	0.009800	0.021300	
24	125.060000	0.5032	0.0159	0.0039	3.1576	0.028800	0.036100	
25	97.934373	0.5012	0.0336	0.0072	6.7053	0.028800	0.036100	
26	97.934373	0.5006	0.0083	0.0022	1.6593	0.028800	0.036100	
27	216.955200	0.5069	0.0158	0.0040	3.1232	0.018300	0.039700	
28	127.506700	0.5036	0.0137	0.0036	2.7205	0.013000	0.016500	
29	146.871500	0.5019	0.0139	0.0034	2.7747	0.012100	0.017800	
...	...	...	...	...	...	...	...	
1537	97.934373	0.4942	0.0175	0.0045	3.5322	0.019900	0.009700	
1538	47.337600	0.4977	0.0144	0.0037	2.9002	0.023700	0.011200	
1539	97.934373	0.4987	0.0118	0.0028	2.3583	0.023700	0.011200	
1540	67.667600	0.5011	0.0163	0.0035	3.2608	0.018100	0.012300	

1541	23.597900	0.5021	0.0103	0.0030	2.0418	0.026600	0.006300
1542	121.942600	0.4992	0.0136	0.0037	2.7204	0.021600	0.026300
1543	50.882700	0.4975	0.0109	0.0038	2.1905	0.027300	0.013900
1544	72.967600	0.4986	0.0192	0.0046	3.8442	0.017200	0.012600
1545	402.687400	0.4951	0.0165	0.0051	3.3383	0.006300	0.025200
1546	105.714200	0.5022	0.0249	0.0049	4.9623	0.013400	0.014200
1547	36.297500	0.5012	0.0160	0.0044	3.2008	0.022200	0.008000
1548	88.581200	0.4944	0.0171	0.0040	3.4656	0.025300	0.022400
1549	97.934373	0.5037	0.0117	0.0030	2.3203	0.025300	0.022400
1550	27.551400	0.5034	0.0178	0.0043	3.5459	0.023600	0.006500
1551	30.757400	0.4972	0.0157	0.0040	3.1578	0.040000	0.012300
1552	247.628500	0.5031	0.0111	0.0028	2.2144	0.008500	0.021200
1553	134.398300	0.4985	0.0126	0.0036	2.5295	0.017400	0.023400
1554	117.094500	0.5025	0.0138	0.0039	2.7512	0.023500	0.027500
1555	184.870300	0.5002	0.0130	0.0035	2.5982	0.008600	0.016000
1556	46.107600	0.5019	0.0158	0.0043	3.1428	0.012000	0.005500
1557	26.733000	0.5010	0.0132	0.0035	2.6249	0.027700	0.007400
1558	176.678300	0.4993	0.0130	0.0037	2.5976	0.009700	0.017200
1559	117.456400	0.4960	0.0157	0.0036	3.1743	0.015000	0.017600
1560	127.315400	0.5009	0.0155	0.0036	3.0997	0.010500	0.013300
1561	46.457300	0.4965	0.0118	0.0032	2.3817	0.032000	0.014800
1562	203.172000	0.4988	0.0143	0.0039	2.8669	0.006800	0.013800
1563	97.934373	0.4975	0.0131	0.0036	2.6238	0.006800	0.013800
1564	43.523100	0.4987	0.0153	0.0041	3.0590	0.019700	0.008600
1565	93.494100	0.5004	0.0178	0.0038	3.5662	0.026200	0.024500
1566	137.784400	0.4987	0.0181	0.0040	3.6275	0.011700	0.016200

	588	589
0	0.005283	99.670066
1	0.006000	208.204500
2	0.014800	82.860200
3	0.004400	73.843200
4	0.004400	73.843200
5	0.005200	44.007700
6	0.005200	44.007700
7	0.006300	95.031000
8	0.004500	111.652500
9	0.007300	90.229400
10	0.007100	57.812200
11	0.008100	75.507700
12	0.003400	52.203900
13	0.003400	52.203900
14	0.008400	142.908000
15	0.004500	100.274500
16	0.004200	82.098900
17	0.004200	82.098900
18	0.004200	82.098900
19	0.003200	47.158600

```
20    0.003200   47.158600
21    0.002300   34.415300
22    0.007500  114.597900
23    0.007700  216.886900
24    0.010100  125.060000
25    0.010100  125.060000
26    0.010100  125.060000
27    0.011600  216.955200
28    0.005300  127.506700
29    0.006200  146.871500
...        ...         ...
1537  0.003700   48.704500
1538  0.003800   47.337600
1539  0.003800   47.337600
1540  0.004600   67.667600
1541  0.001900   23.597900
1542  0.008700  121.942600
1543  0.005500   50.882700
1544  0.003900   72.967600
1545  0.007000  402.687400
1546  0.004700  105.714200
1547  0.002200   36.297500
1548  0.007100   88.581200
1549  0.007100   88.581200
1550  0.002200   27.551400
1551  0.004400   30.757400
1552  0.007400  247.628500
1553  0.007700  134.398300
1554  0.009800  117.094500
1555  0.005100  184.870300
1556  0.001600   46.107600
1557  0.002300   26.733000
1558  0.005400  176.678300
1559  0.005700  117.456400
1560  0.004200  127.315400
1561  0.005100   46.457300
1562  0.004700  203.172000
1563  0.004700  203.172000
1564  0.002500   43.523100
1565  0.007500   93.494100
1566  0.004500  137.784400

[1567 rows x 590 columns]
```

```
In [28]: sum([df[x].isna().sum() for x in df.columns])
```

```
Out[28]: 0
```

Convert dataframe to numpy array

```
In [10]: data = df.values
         print(data)
```

```
[[3.03093000e+03 2.56400000e+03 2.18773330e+03 ... 1.64749042e-02
  5.28333333e-03 9.96700663e+01]
 [3.09578000e+03 2.46514000e+03 2.23042220e+03 ... 2.01000000e-02
  6.00000000e-03 2.08204500e+02]
 [2.93261000e+03 2.55994000e+03 2.18641110e+03 ... 4.84000000e-02
  1.48000000e-02 8.28602000e+01]
 ...
 [2.97881000e+03 2.37978000e+03 2.20630000e+03 ... 8.60000000e-03
  2.50000000e-03 4.35231000e+01]
 [2.89492000e+03 2.53201000e+03 2.17703330e+03 ... 2.45000000e-02
  7.50000000e-03 9.34941000e+01]
 [2.94492000e+03 2.45076000e+03 2.19544440e+03 ... 1.62000000e-02
  4.50000000e-03 1.37784400e+02]]
```

Mean for each column

```
In [11]: mean_data = np.mean(data.T, axis=1)
         print(mean_data)
```

```
[ 3.01445290e+03  2.49585023e+03  2.20054732e+03  1.39637663e+03
  4.19701314e+00  1.00000000e+02  1.01112908e+02  1.21821502e-01
  1.46286166e+00 -8.41022364e-04  1.45750799e-04  9.64352780e-01
  1.99956809e+02  0.00000000e+00  9.00537052e+00  4.13086035e+02
  9.90760281e+00  9.71443926e-01  1.90047354e+02  1.24810340e+01
  1.40505424e+00 -5.61839361e+03  2.69937843e+03 -3.80629973e+03
 -2.98598136e+02  1.20384473e+00  1.93847681e+00  6.63862799e+00
  6.94995323e+01  2.36619744e+00  1.84158914e-01  3.67318939e+00
  8.53374687e+01  8.96027854e+00  5.05826386e+01  6.45557870e+01
  4.94173705e+01  6.62212736e+01  8.68365766e+01  1.18679554e+02
  6.79049093e+01  3.35306617e+00  7.00000000e+01  3.55538904e+02
  1.00311650e+01  1.36743060e+02  7.33672811e+02  1.17795811e+00
  1.39972231e+02  1.00000000e+00  6.32254197e+02  1.57420991e+02
  0.00000000e+00  4.59297121e+00  4.83852271e+00  2.85617210e+03
  9.28849328e-01  9.49215035e-01  4.59331177e+00  2.96024147e+00
  3.55159094e+02  1.04231429e+01  1.16502329e+02  1.39899270e+01
  2.05421090e+01  2.71318156e+01  7.06668523e+02  1.67154436e+01
  1.47437578e+02  1.00000000e+00  6.19101687e+02  1.04329033e+02
  1.50361552e+02  4.68020404e+02  2.68770019e-03 -6.90304601e-03
 -2.93904731e-02 -7.04141283e-03 -1.36425794e-02  3.45832793e-03
 -1.85307842e-02 -2.11533377e-02  6.05489307e-03  7.45206660e+00
  1.33107910e-01  1.12783186e-01  2.40187154e+00  9.82420294e-01
  1.80781502e+03  1.88703232e-01  8.82753687e+03  2.43984625e-03
  5.06900958e-04 -5.40511182e-04 -2.91479821e-05  6.00256246e-05
```

```
 1.71266496e-02  0.00000000e+00 -1.81426650e-02  1.54010250e-03
-2.12684177e-05 -7.23894939e-06  1.11460602e-03 -9.78907348e-03
-1.46325879e-05 -4.97885971e-04  5.39525945e-04 -1.76591928e-03
-1.07885971e-02  9.79992532e-01  1.01318253e+02  2.31818898e+02
 4.57537676e-01  9.45424186e-01  1.22527122e-04  7.47383792e+02
 9.87129930e-01  5.86259079e+01  5.98411666e-01  9.70777090e-01
 6.31086305e+00  1.57964249e+01  3.89838960e+00  1.58296598e+01
 1.57947047e+01  1.18495571e+00  2.75072850e+00  6.48477599e-01
 3.19218228e+00 -5.54228306e-01  7.44976444e-01  9.97808344e-01
 2.31854464e+00  1.00404309e+03  3.93919785e+01  1.17960948e+02
 1.38194747e+02  1.22692949e+02  5.76030246e+01  4.16766964e+02
 2.60779039e+01  0.00000000e+00  6.64156471e+00  4.16944801e-03
 1.20008115e-01  6.36214058e-02  5.50100319e-02  1.74109904e-02
 8.47130792e+00  0.00000000e+00  6.81426790e+00  1.40474028e+01
 1.19673318e+00  1.19264706e-02  7.69797091e+00  5.07171484e-01
 5.80885769e-02  4.71043478e-02  1.03965074e+03  8.82680511e+02
 5.55346326e+02  4.06685048e+03  4.79715463e+03  1.40204473e-01
 1.27942492e-01  2.52025559e-01  2.78888179e+00  1.23578275e+00
 1.24396805e-01  4.00453674e-01  6.84330332e-01  1.20064112e-01
 3.20112516e-01  5.76191954e-01  3.20112771e-01  7.78043614e-01
 2.44717752e-01  3.94759898e-01  0.00000000e+00  0.00000000e+00
 1.90132567e+01  5.46770115e-01  1.07805428e+01  2.66611704e+01
 1.44815453e-01  7.36574074e+00  0.00000000e+00  1.79362898e+01
 4.32114183e+01  0.00000000e+00  0.00000000e+00  0.00000000e+00
 0.00000000e+00  0.00000000e+00  0.00000000e+00  2.87084453e-01
 8.68848718e+00  2.00927098e+01  5.57358744e-01  1.15320564e+01
 1.76001923e+01  7.83935897e+00  1.01704633e+01  3.00731427e+01
 3.22181689e+01  9.05012172e+00  1.28122998e-03  2.03761755e+01
 7.32643165e+01  2.95643818e-02  8.88657809e-02  5.67549579e-02
 5.14320804e-02  6.03461439e-02  8.32684381e-02  8.10755671e-02
 8.34835386e-02  7.16353856e-02  3.77146539e+00  3.25401929e-03
 9.21283186e-03  6.07175495e-02  8.82118698e-03  1.22846571e+02
 5.93704485e-02  1.04105659e+03  0.00000000e+00  1.91250479e-02
 1.78444089e-02  0.00000000e+00  0.00000000e+00  0.00000000e+00
 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
 0.00000000e+00  0.00000000e+00  4.79137380e-03  4.57488818e-03
 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
 5.75500911e-03  1.72972332e+00  4.14874189e+00  5.33735915e-02
 2.51712189e-02  1.06522017e-03  1.09650967e+02  4.28481174e-03
 4.64511487e+00  3.32162022e-02  1.39432036e-02  4.03848117e-01
 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
 0.00000000e+00  0.00000000e+00  0.00000000e+00  7.05869147e-02
 1.95046767e+01  3.77786568e+00  2.92602905e+01  4.60565981e+01
 4.12981474e+01  2.01812462e+01  1.36292426e+02  8.69321275e+00
 0.00000000e+00  2.21074449e+00  1.11745828e-03  4.10568690e-02
 1.80335463e-02  1.50940575e-02  5.76984026e-03  2.80398428e+00
 0.00000000e+00  2.11979533e+00  4.26001784e+00  3.67529284e-01
```

```
3.92365729e-03  2.57859597e+00  1.23426975e-01  1.99262285e-02
1.44869565e-02  3.35551157e+02  4.01814750e+02  2.52999118e+02
1.87922837e+03  2.34282698e+03  6.38044728e-02  6.02668371e-02
1.18386198e-01  9.10145942e-01  4.03342300e-01  4.03438339e-02
1.32076486e-01  2.64916794e-01  4.86231162e-02  1.28920945e-01
2.18414240e-01  1.28921264e-01  3.04751788e-01  9.73443167e-02
1.60050830e-01  0.00000000e+00  0.00000000e+00  0.00000000e+00
5.97697701e+00  1.72629119e-01  3.18877050e+00  7.91603608e+00
4.31049170e-02  2.26372739e+00  0.00000000e+00  5.39341980e+00
1.33321717e+01  0.00000000e+00  0.00000000e+00  0.00000000e+00
0.00000000e+00  0.00000000e+00  0.00000000e+00  8.32318618e-02
2.59348455e+00  6.21586579e+00  1.68363869e-01  3.42692511e+00
9.73638641e+00  2.32748160e+00  3.03757994e+00  9.32895772e+00
1.46735066e+01  2.73209366e+00  2.86483024e-04  6.19850826e+00
2.32171463e+01  7.95837581e+00  5.77021164e+00  8.91396541e-03
2.47057032e-02  2.52522359e-02  2.32020739e-02  2.75842515e-02
2.33557356e-02  4.03305250e-02  4.19209981e-02  3.45430979e-02
1.29862861e+00  9.98842444e-04  2.44292035e-03  1.98399489e-02
2.94486280e-03  3.99364063e+01  1.83829156e-02  3.33319601e+02
0.00000000e+00  5.19853035e-03  4.81399361e-03  3.77328635e-03
3.17162076e-03  0.00000000e+00  0.00000000e+00  0.00000000e+00
0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
1.60083067e-03  1.57073482e-03  0.00000000e+00  0.00000000e+00
0.00000000e+00  0.00000000e+00  1.82568306e-03  5.41039891e-01
1.28544827e+00  1.14269953e-02  8.28079132e-03  3.39246969e-04
3.51550911e+01  1.33835354e-03  1.43186752e+00  1.09559948e-02
4.53280153e-03  1.33989534e-01  0.00000000e+00  0.00000000e+00
0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
0.00000000e+00  2.42075048e-02  6.73061495e+00  1.23199731e+00
5.34093188e+00  4.58043030e+00  4.92934410e+00  2.61608635e+00
3.09113164e+01  2.56126897e+01  0.00000000e+00  6.63061590e+00
3.40434852e+00  8.19090550e+00  3.20259235e+02  3.09061299e+02
1.82126134e+00  4.17452351e+00  0.00000000e+00  7.76604459e+01
3.31546854e+00  6.79631247e+00  1.23385761e+00  4.05850083e+00
4.22074746e+00  4.17184365e+00  1.84216001e+01  2.23583049e+01
9.93676327e+01  2.05519304e+02  1.47339455e+01  9.37066556e+00
7.51326633e+00  4.01678550e+00  5.47010519e+01  7.06439420e+01
1.15266165e+01  8.02080971e-01  1.34525868e+00  6.33941060e-01
8.95042784e-01  6.47089911e-01  1.17500319e+00  2.81895338e-01
3.32270115e-01  0.00000000e+00  0.00000000e+00  0.00000000e+00
5.34681558e+00  5.46097126e+00  7.88374157e+00  3.63663346e+00
1.23256854e+01  5.26366571e+00  0.00000000e+00  2.83838014e+00
2.91974136e+01  0.00000000e+00  0.00000000e+00  0.00000000e+00
0.00000000e+00  0.00000000e+00  0.00000000e+00  6.25209066e+00
2.24173047e+02  5.66229270e+00  5.36775176e+00  9.63879680e+00
1.37888406e+02  3.94268471e+01  3.76370497e+01  4.26257335e+00
2.01321546e+01  6.25792146e+00  1.28122998e-01  3.28339423e+00
```

```
 7.55381309e+01  0.00000000e+00  3.18418448e+02  2.06564196e+02
 2.15288948e+02  2.01111728e+02  3.02506186e+02  2.39455326e+02
 3.52616477e+02  2.72169707e+02  5.13540452e+01  2.44267312e+00
 8.17094292e+00  2.53004639e+00  9.56441991e-01  6.80782572e+00
 2.98658964e+01  1.18210299e+01  0.00000000e+00  2.63195864e+02
 2.40981377e+02  0.00000000e+00  0.00000000e+00  0.00000000e+00
 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
 0.00000000e+00  0.00000000e+00  5.57635084e+01  2.75979457e+02
 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
 6.78897814e-01  1.73890219e+00  1.80627286e+00  1.17284399e+01
 2.69599930e+00  1.16100797e+01  1.47288659e+01  4.53896426e-01
 5.68778162e+00  5.56039734e+00  1.44345750e+00  6.39571704e+00
 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
 0.00000000e+00  0.00000000e+00  0.00000000e+00  0.00000000e+00
 0.00000000e+00  0.00000000e+00  0.00000000e+00  3.03423489e+00
 1.94282809e+00  9.61162809e+00  1.11208435e-01  8.47086262e-03
 2.50920128e-03  7.61140313e+00  1.03963030e+00  4.03546477e+02
 7.56798715e+01  6.63256465e-01  1.70133129e+01  1.23071155e+00
 2.76687988e-01  7.70387353e+00  5.03657460e-01  5.77465372e+01
 4.21690451e+00  1.62307001e+00  9.95008940e-01  3.25708174e-01
 7.24434227e-02  3.22849559e+01  2.62729683e+02  6.79640726e-01
 6.44498454e+00  1.45609505e-01  2.61086963e+00  6.00863988e-02
 2.45241692e+00  2.11176740e+01  5.30523623e+02  2.10183631e+00
 2.84501650e+01  3.45636439e-01  9.16231500e+00  1.04729164e-01
 5.56374652e+00  1.66423629e+01  2.16145631e-02  1.68294498e-02
 5.39595469e-03  9.79343730e+01  5.00096169e-01  1.53177522e-02
 3.84655172e-03  3.06782637e+00  2.14584291e-02  1.64749042e-02
 5.28333333e-03  9.96700663e+01]
```

Subtract means from each column

In [12]:
```
diff_data = data - mean_data
print(diff_data)
```

```
[[ 1.64771044e+01  6.81497692e+01 -1.28140177e+01 ... -2.42861287e-17
  -1.73472348e-17 -1.56319402e-13]
 [ 8.13271044e+01 -3.07102308e+01  2.98748823e+01 ...  3.62509579e-03
   7.16666667e-04  1.08534434e+02]
 [-8.18428956e+01  6.40897692e+01 -1.41362177e+01 ...  3.19250958e-02
   9.51666667e-03 -1.68098663e+01]
 ...
 [-3.56428956e+01 -1.16070231e+02  5.75268229e+00 ... -7.87490421e-03
  -2.78333333e-03 -5.61469663e+01]
 [-1.19532896e+02  3.61597692e+01 -2.35140177e+01 ...  8.02509579e-03
   2.21666667e-03 -6.17596635e+00]
 [-6.95328956e+01 -4.50902308e+01 -5.10291771e+00 ... -2.74904215e-04
  -7.83333333e-04  3.81143337e+01]]
```

Calculate covariance matrix

```
In [13]: cov_mat = np.cov(diff_data.T)
         print(cov_mat)
```

```
[[ 5.39940056e+03 -8.47962623e+02  1.02671010e+01 ... -1.67440688e-02
  -5.93197815e-03  2.87879850e+01]
 [-8.47962623e+02  6.43649877e+03  1.35942679e+01 ...  1.21967287e-02
   2.32652705e-03  3.37335304e+02]
 [ 1.02671010e+01  1.35942679e+01  8.63239193e+02 ... -7.59126039e-03
  -2.59521865e-03 -9.07023669e+01]
 ...
 [-1.67440688e-02  1.21967287e-02 -7.59126039e-03 ...  7.75231441e-05
   2.45865358e-05  3.22979001e-01]
 [-5.93197815e-03  2.32652705e-03 -2.59521865e-03 ...  2.45865358e-05
   8.21484994e-06  1.04706789e-01]
 [ 2.87879850e+01  3.37335304e+02 -9.07023669e+01 ...  3.22979001e-01
   1.04706789e-01  8.81006310e+03]]
```

Comput Eigen values and Eigen vectors

```
In [14]: eig_val_cov, eig_vec_cov = np.linalg.eig(cov_mat)
         print(eig_val_cov, eig_vec_cov)
```

```
[ 5.34151979e+07+0.00000000e+00j  2.17466719e+07+0.00000000e+00j
  8.24837662e+06+0.00000000e+00j  2.07388086e+06+0.00000000e+00j
  1.31540439e+06+0.00000000e+00j  4.67693557e+05+0.00000000e+00j
  2.90863555e+05+0.00000000e+00j  2.83668601e+05+0.00000000e+00j
  2.37155830e+05+0.00000000e+00j  2.08513836e+05+0.00000000e+00j
  1.96098849e+05+0.00000000e+00j  1.86856549e+05+0.00000000e+00j
  1.52422354e+05+0.00000000e+00j  1.13215032e+05+0.00000000e+00j
  1.08493848e+05+0.00000000e+00j  1.02849533e+05+0.00000000e+00j
  1.00166164e+05+0.00000000e+00j  8.33473762e+04+0.00000000e+00j
  8.15850591e+04+0.00000000e+00j  7.76560524e+04+0.00000000e+00j
  6.66060410e+04+0.00000000e+00j  6.52620058e+04+0.00000000e+00j
  5.96776503e+04+0.00000000e+00j  5.16269933e+04+0.00000000e+00j
  5.03324580e+04+0.00000000e+00j  4.54661746e+04+0.00000000e+00j
  4.41914029e+04+0.00000000e+00j  4.15532551e+04+0.00000000e+00j
  3.55294040e+04+0.00000000e+00j  3.31436743e+04+0.00000000e+00j
  2.67385181e+04+0.00000000e+00j  1.47123429e+04+0.00000000e+00j
  1.44089194e+04+0.00000000e+00j  1.09321187e+04+0.00000000e+00j
  1.04841308e+04+0.00000000e+00j  9.48876548e+03+0.00000000e+00j
  8.34665462e+03+0.00000000e+00j  7.22765535e+03+0.00000000e+00j
  5.34196392e+03+0.00000000e+00j  4.95614671e+03+0.00000000e+00j
  4.23060022e+03+0.00000000e+00j  4.10673182e+03+0.00000000e+00j
  3.41199406e+03+0.00000000e+00j  3.24193522e+03+0.00000000e+00j
  2.74523635e+03+0.00000000e+00j  2.35027999e+03+0.00000000e+00j
  2.16835314e+03+0.00000000e+00j  1.86414157e+03+0.00000000e+00j
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 0.00000000e+00+0.00000000e+00j  0.00000000e+00+0.00000000e+00j
 0.00000000e+00+0.00000000e+00j  0.00000000e+00+0.00000000e+00j] [[-6.39070760e-04+0.j -1.20314
  0.00000000e+00+0.j  0.00000000e+00+0.j  0.00000000e+00+0.j]
 [ 2.35722934e-05+0.j -6.60163227e-04+0.j  1.71369126e-03+0.j ...
  0.00000000e+00+0.j  0.00000000e+00+0.j  0.00000000e+00+0.j]
 [ 2.36801459e-04+0.j  1.58026311e-04+0.j  3.28185512e-04+0.j ...
  0.00000000e+00+0.j  0.00000000e+00+0.j  0.00000000e+00+0.j]
 ...
 [ 2.61329351e-08+0.j -6.06233975e-09+0.j  1.09328336e-09+0.j ...
  0.00000000e+00+0.j  0.00000000e+00+0.j  0.00000000e+00+0.j]
 [ 5.62597732e-09+0.j  5.96647587e-09+0.j  8.83024927e-09+0.j ...
  0.00000000e+00+0.j  0.00000000e+00+0.j  0.00000000e+00+0.j]
 [ 3.89298443e-04+0.j -2.32070657e-04+0.j  7.13534990e-04+0.j ...
  0.00000000e+00+0.j  0.00000000e+00+0.j  0.00000000e+00+0.j]]
```
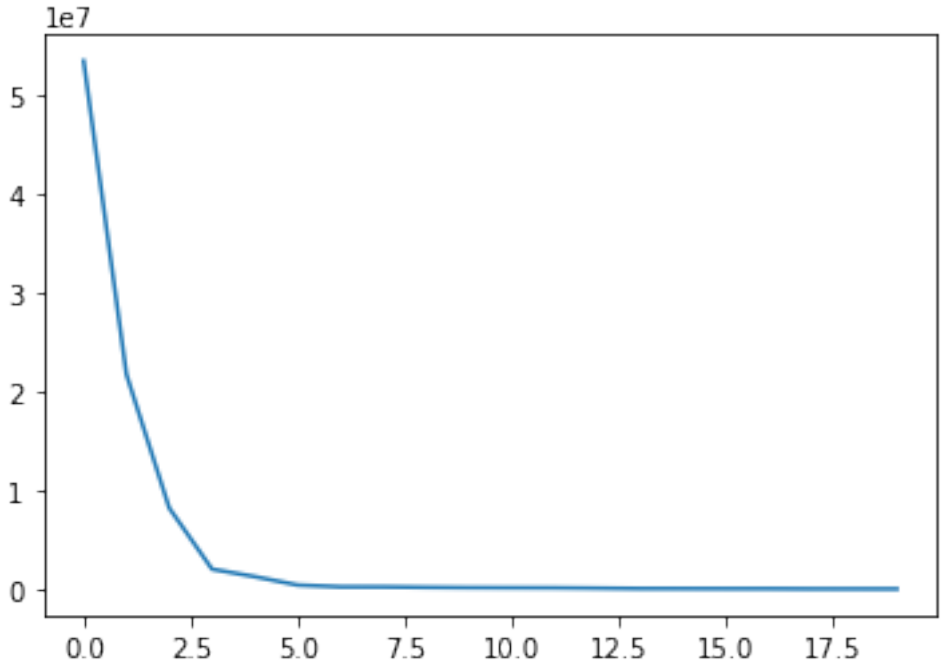

```
In [15]: plt.plot(eig_val_cov[:20])
```

```
/anaconda3/lib/python3.6/site-packages/numpy/core/numeric.py:492: ComplexWarning: Casting comple
```

```
  return array(a, dtype, copy=False, order=order)
```

```
Out[15]: [<matplotlib.lines.Line2D at 0x109949d68>]
```




```
In [37]: eig_vec_cov.shape
```

```
Out[37]: (590, 590)
```

```
In [38]: eig_val_cov.shape
```

```
Out[38]: (590,)
```

Get indexes of the sorted eigen values

```
In [39]: idx = np.argsort(eig_val_cov)[::-1]
```

```
In [40]: P = eig_vec_cov.T.dot(diff_data.T)
```

```
In [41]: len(P)
```

```
Out[41]: 590
```

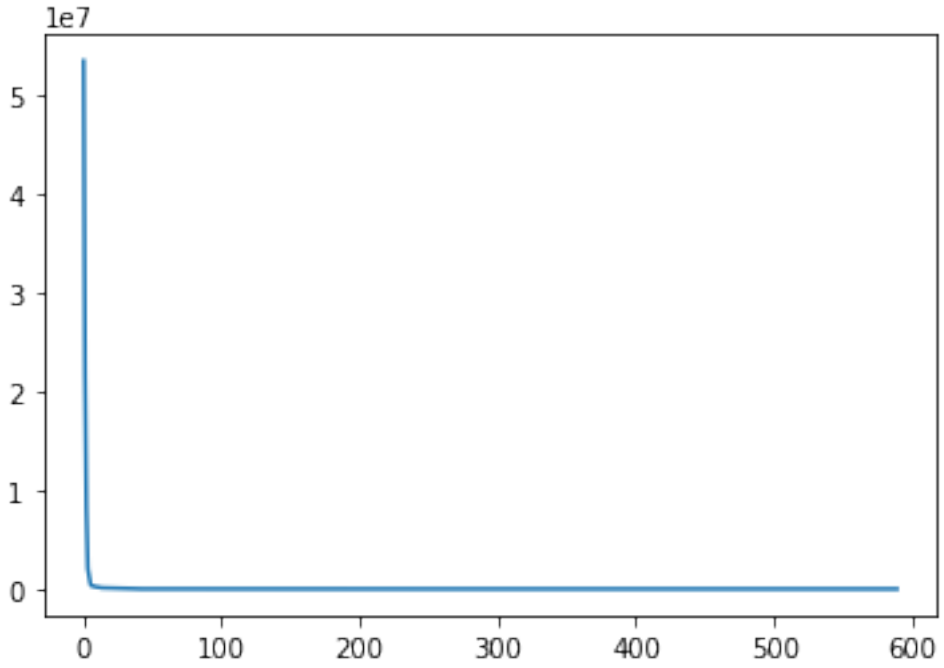
```
In [42]: np.var(P[0,:])
```

```
Out[42]: 53381110.302403666
```

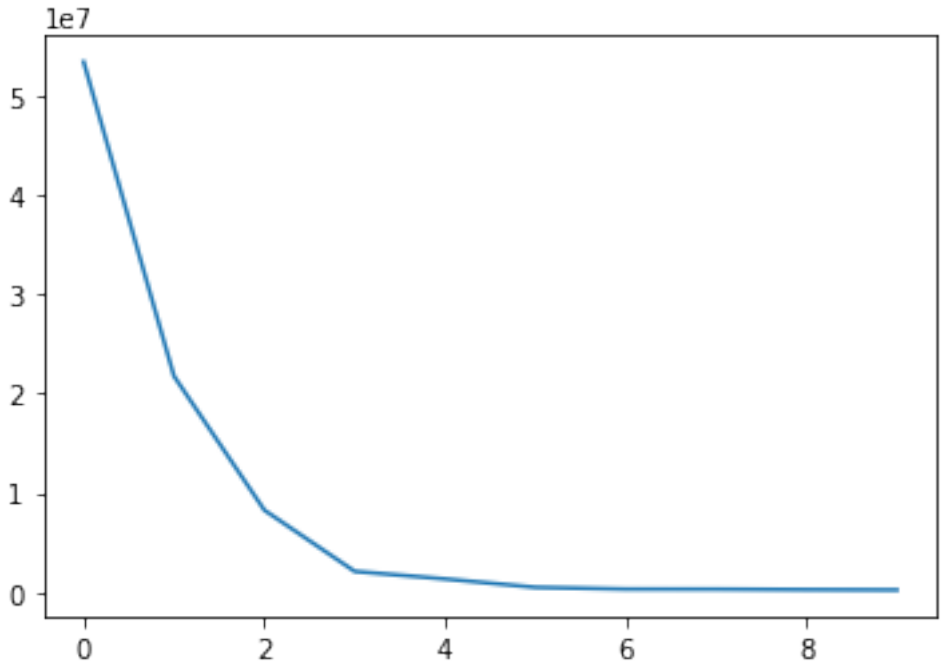
```
In [43]: variances = np.array([np.var(P[x,:]) for x in range(P.shape[0])])

In [44]: variances[:10]

Out[44]: array([53381110.30240367, 21732794.00299704,  8243112.81400466,
                 2072557.38714381,  1314564.94654084,   467395.09304467,
                  290677.93732237,   283487.5741031 ,   237004.48591036,
                  208380.77019583])
```

Plot the variances

```
In [45]: plt.plot(variances)
         plt.show()
```




```
In [46]: plt.plot(variances[:10])
         plt.show()
```



5 is the saturation point