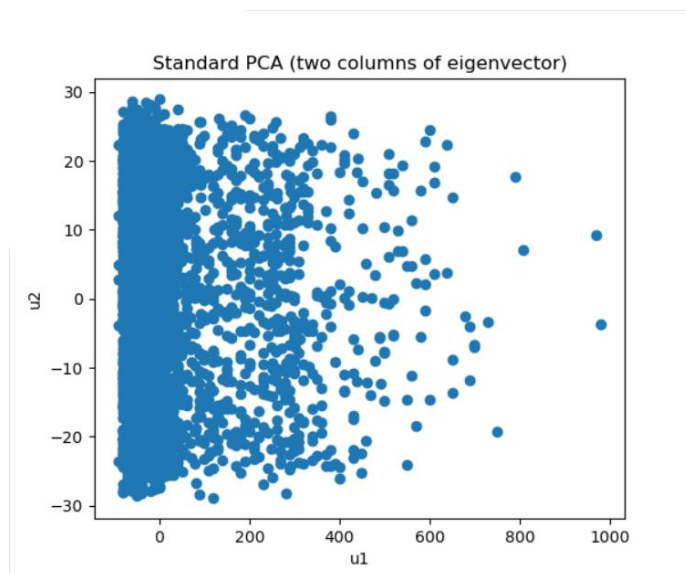
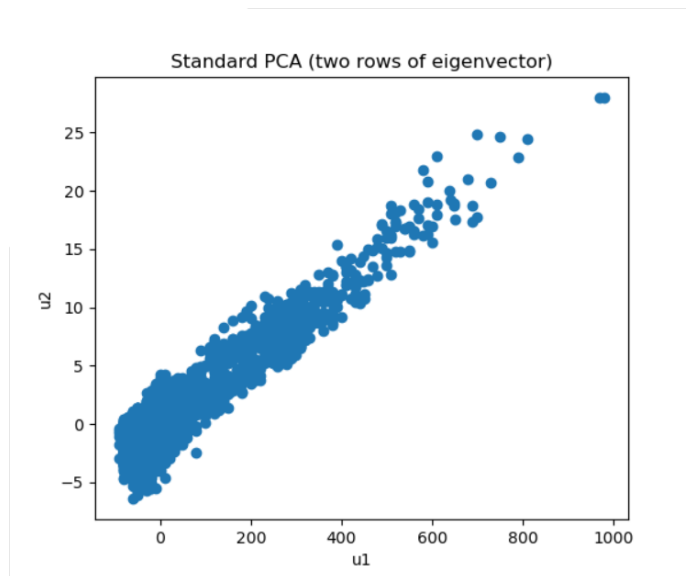


Part1:

10k data set seems too big to repeatedly run to collect result, so I choose 5k.

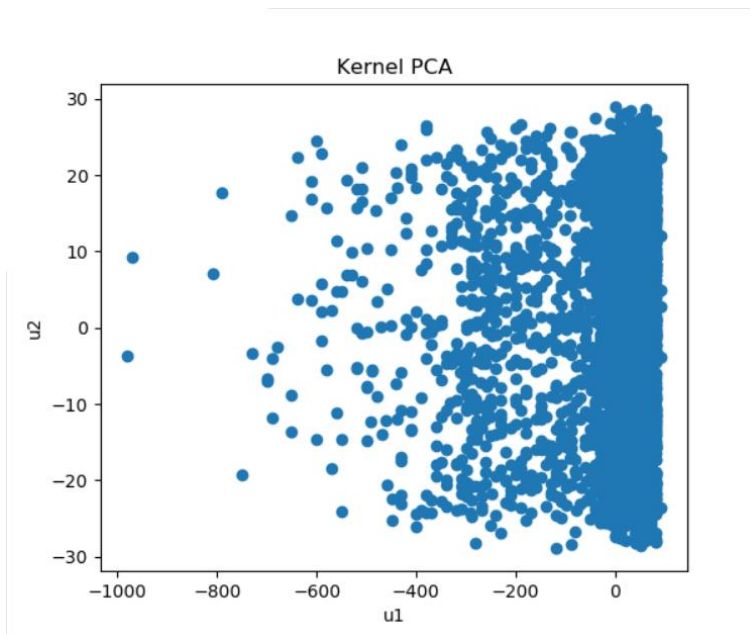
Use the code from previous homework to generate two graphs for standard PCA. (One used rows of eigenvector as normal, the other one used columns). We can see that their reduced dimensions are identical to each other, the graph of standard PCA (first two columns eigenvector) are like the graph of Kernel PCA (flipped). And the eigenvalues of standard PCA are much smaller than Kernel PCA.



eigenvalues are: [13418.08779379 216.72711786 179.14040571] for standard PCA.

We need 3 dimensions in this case.

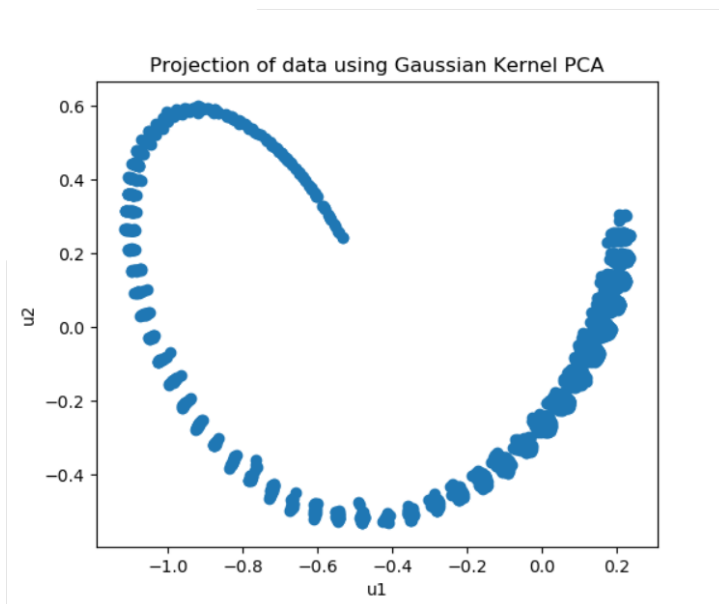
Kernel PCA



[67077020.881136715, 1083418.8621756586, 895522.888120825]

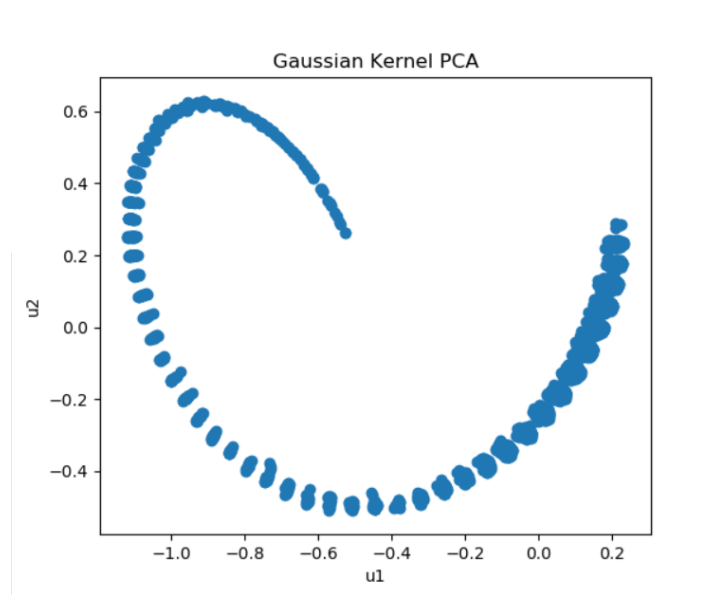
We need 3 dimensions in this case.

Spread value: 15000



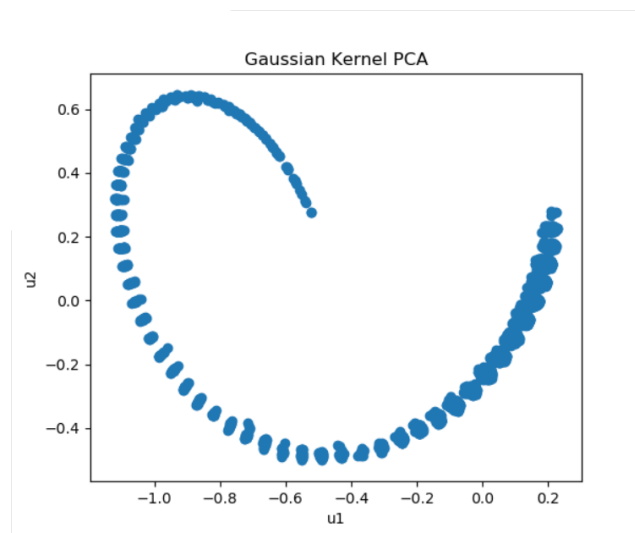
We need 15 dimensions in this case.

Spread value: 17500



We need 14 dimensions

Spread value: 19000



We can see that as the spread value increases, the number of dimensions decrease very slightly, almost none, so I stopped at spread value 19000 because we are not getting much improvement if we increase the value of spread upon the current value.

Part2:

```
Training data: weight vector is [ 21.37717131  1.93972058 -0.10605521  14.6182821 -17.87746171
-13.40594356  24.40732926  5.63963499 -3.10468924 -0.28634313
 0.80209705  0.0522942  7.64488575  0.26228429  2.82343488
-1.64295361  8.12688066 -4.7502904 -17.5311978 -0.61631137
-11.89083519  0.20284244 -1.29638408  1.9383389  0.16269223
 6.48900229 -0.0318524 ]
```

```
Training data: L2 norm weight is 49.66073
```

```
Training result: SSE is 120658752.67174, MSE is 10439.97055, R Square is 0.16336
```

```
Testing result: SSE is 52652327.69044, MSE is 10677.85843, R Square is 0.16706
```

```
Training data: weight vector is [ 1.19484552e+02  1.91457289e+00 -1.83172553e+00  1.44833523e+01
-1.44675068e+01 -1.21446763e+01  2.47387060e+01  4.26005529e+00
-4.06306636e+00 -5.40637108e-01 -1.06724973e+00  1.62558793e-01
 6.18033854e+00  2.89176025e-01  3.09383175e+00 -1.76789396e+00
 8.67428331e+00 -4.80759871e+00 -1.71484344e+01 -4.97711808e-01
-1.05135198e+01  7.78890336e-02 -1.22622163e+00  1.73184982e+00
 1.49920891e-01  6.47988101e+00 -7.83892685e-02]
```

```
Training data: L2 norm weight is 126.88174
```

```
Training result: SSE is 119679825.10167, MSE is 10319.50466, R Square is 0.16046
```

```
Testing result: SSE is 53697610.46063, MSE is 10958.48753, R Square is 0.17228
```

```
Training data: weight vector is [ 1.11528030e+02  2.05206336e+00 -3.44724132e-01  1.52203364e+01
-1.76788782e+01 -1.34812163e+01  2.48119231e+01  5.07177426e+00
-3.34847414e+00 -1.17426774e+00  1.58763299e+00  3.58888077e-02
 7.33682798e+00  3.00969220e-01 -1.91383597e-01 -8.98287198e-01
 9.74164436e+00 -4.86724515e+00 -1.63502802e+01 -5.21252314e-01
-1.18820132e+01  8.54767872e-02 -1.37297053e+00  1.90261203e+00
 1.37771012e-01  6.50275997e+00 -2.10828147e-03]
```

```
Training data: L2 norm weight is 120.22978
```

```
Training result: SSE is 121351734.29787, MSE is 10511.41242, R Square is 0.16427
```

```
Testing result: SSE is 51993877.20778, MSE is 10509.88348, R Square is 0.16433
```

I have repeatedly test it three times, from the output above, we can see that the R square has a small difference, all set around at 0.16.