

## Test Case:

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PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

/usr/local/bin/python3 "/Users/peilinhe/Documents/MS Homework/Algorithm/Project_3/problem2/K-Means_test_cases.py"
peilinhe@MacBookPro_M1Max problem2 % /usr/local/bin/python3 "/Users/peilinhe/Documents/MS Homework/Algorithm/Project_3/problem2/K_Meams.py"
after 1 iteration, the loss is: 64.81358843857731
after 2 iteration, the loss is: 43.53233380751258
after 3 iteration, the loss is: 32.06386290809377
after 4 iteration, the loss is: 30.96376193434194
after 5 iteration, the loss is: 30.96376193434194
The coordinates of centroid 1: [ 0.06026253 -0.08038639]
100 points are assigned to centroid 1
The coordinates of centroid 2: [10.16808624 10.04671581]
100 points are assigned to centroid 2
peilinhe@MacBookPro_M1Max problem2 %
```

## Power Consumptions:

K = 2:

```
/usr/local/bin/python3 "/Users/peilinhe/Documents/MS Homework/Algorithm/Project_3/problem2/K_Meams.py"
peilinhe@MacBookPro_M1Max problem2 % /usr/local/bin/python3 "/Users/peilinhe/Documents/MS Homework/Algorithm/Project_3/problem2/K_Meams.py"
For K = 2:
after 1 iteration, the loss is: 95.47340048757863
after 2 iteration, the loss is: 95.43596681822214
after 3 iteration, the loss is: 95.43542246732873
after 4 iteration, the loss is: 95.43541459727292
after 5 iteration, the loss is: 95.43541430450904
after 6 iteration, the loss is: 95.43541427157619
after 7 iteration, the loss is: 95.43541426413451
after 8 iteration, the loss is: 95.43541426062137
after 9 iteration, the loss is: 95.43541426062137
The coordinates of centroid 1: [5.83699889e-01 1.15967353e-01 2.41537948e+02 2.52966457e+00
5.54954328e-01 8.30905960e-01 4.19764151e-01]
1335600 points are assigned to centroid 1
The coordinates of centroid 2: [2.04214114e+00 1.38212653e-01 2.39533433e+02 8.55419039e+00
2.18296435e+00 2.17362543e+00 1.77594020e+01]
713680 points are assigned to centroid 2
```

K = 3:

```
For K = 3:  
after 1 iteration, the loss is: 140.78088602365247  
after 2 iteration, the loss is: 91.62788423372007  
after 3 iteration, the loss is: 88.83674152223479  
after 4 iteration, the loss is: 85.32812204401154  
after 5 iteration, the loss is: 64.61017719284449  
after 6 iteration, the loss is: 60.03006634820755  
after 7 iteration, the loss is: 59.93376791518368  
after 8 iteration, the loss is: 59.925724341490074  
after 9 iteration, the loss is: 59.92465416138898  
after 10 iteration, the loss is: 59.924496613759224  
after 11 iteration, the loss is: 59.92447416930569  
after 12 iteration, the loss is: 59.924470230010336  
after 13 iteration, the loss is: 59.92446965989594  
after 14 iteration, the loss is: 59.924469606587955  
after 15 iteration, the loss is: 59.924469580809806  
after 16 iteration, the loss is: 59.924469580809806  
The coordinates of centroid 1: [5.23983963e-01 1.14194861e-01 2.41614549e+02 2.27800324e+00  
5.71411901e-02 4.81562776e-01 4.13654063e-01]  
1302528 points are assigned to centroid 1  
The coordinates of centroid 2: [3.94879772e+00 1.95691510e-01 2.37295773e+02 1.67542555e+01  
2.17326465e+01 1.72460240e+01 1.10913647e+01]  
9650 points are assigned to centroid 2  
The coordinates of centroid 3: [1.80436284e+00 1.32093834e-01 2.39814331e+02 7.53383043e+00  
1.93438044e-01 5.66251700e-01 1.78801409e+01]  
650172 points are assigned to centroid 3
```

K = 4:

```
after 36 iteration, the loss is: 56.402615037591923  
after 37 iteration, the loss is: 56.402614912449465  
after 38 iteration, the loss is: 56.40261488147329  
after 39 iteration, the loss is: 56.40261487531682  
after 40 iteration, the loss is: 56.402614872949634  
after 41 iteration, the loss is: 56.40261487240384  
after 42 iteration, the loss is: 56.40261487220266  
after 43 iteration, the loss is: 56.40261487215683  
after 44 iteration, the loss is: 56.40261487206192  
after 45 iteration, the loss is: 56.40261487206192  
The coordinates of centroid 1: [7.32492485e-01 1.30022185e-01 2.38763511e+02 3.18823634e+00  
1.13189641e-01 7.30037418e-01 3.96674532e-01]  
496291 points are assigned to centroid 1  
The coordinates of centroid 2: [3.98040364e-01 1.04584015e-01 2.43362391e+02 1.72836371e+00  
2.48142400e-02 3.51677507e-01 4.27170565e-01]  
807359 points are assigned to centroid 2  
The coordinates of centroid 3: [1.80475115e+00 1.32070966e-01 2.39814349e+02 7.53534788e+00  
1.93255423e-01 5.70439741e-01 1.78844615e+01]  
649974 points are assigned to centroid 3  
The coordinates of centroid 4: [3.96308269e+00 1.95672221e-01 2.37290025e+02 1.68111922e+01  
2.19255980e+01 1.71867839e+01 1.11753157e+01]  
95656 points are assigned to centroid 4
```

K = 5:

```
after 43 iteration, the loss is: 54.09603678114250
after 44 iteration, the loss is: 54.09602870185803
after 45 iteration, the loss is: 54.09602291654529
after 46 iteration, the loss is: 54.09601960122369
after 47 iteration, the loss is: 54.096017538648184
after 48 iteration, the loss is: 54.09601598202047
after 49 iteration, the loss is: 54.096015012406475
after 50 iteration, the loss is: 54.09601434961182
The coordinates of centroid 1: [1.52116676e+00 1.19566435e-01 2.40792157e+02 6.29993281e+00
1.05325489e-01 3.77930783e-01 1.77378328e+01]
476238 points are assigned to centroid 1
The coordinates of centroid 2: [3.97489188e-01 1.04517073e-01 2.43348885e+02 1.72610233e+00
2.48113320e-02 3.50343554e-01 4.24781249e-01]
811081 points are assigned to centroid 2
The coordinates of centroid 3: [3.98497408e+00 1.95093685e-01 2.37273058e+02 1.68965719e+01
2.25294973e+01 1.70280429e+01 1.10774601e+01]
928222 points are assigned to centroid 3
The coordinates of centroid 4: [7.37134286e-01 1.30302457e-01 2.38748430e+02 3.20828444e+00
1.13577185e-01 7.66121880e-01 3.93567687e-01]
492731 points are assigned to centroid 4
The coordinates of centroid 5: [2.59109190e+00 1.67218403e-01 2.37151148e+02 1.09638089e+01
4.62875833e-01 1.35379348e+00 1.82590926e+01]
176408 points are assigned to centroid 5
```

K = 6:

```
after 46 iteration, the loss is: 25.05457969834222
after 47 iteration, the loss is: 25.054579698014667
after 48 iteration, the loss is: 25.05457969788218
after 49 iteration, the loss is: 25.05457969788218
The coordinates of centroid 1: [1.79964772e+00 1.31770775e-01 2.39816154e+02 7.51313645e+00
2.03009099e-01 4.76995105e-01 1.78903892e+01]
646971 points are assigned to centroid 1
The coordinates of centroid 2: [3.99918099e-01 1.05166349e-01 2.43944907e+02 1.73267902e+00
2.29425653e-02 3.47865329e-01 4.19990160e-01]
625998 points are assigned to centroid 2
The coordinates of centroid 3: [3.67006211e-01 1.13906636e-01 2.39467516e+02 1.64200367e+00
2.63797058e-02 3.96184270e-01 4.25866225e-01]
548414 points are assigned to centroid 3
The coordinates of centroid 4: [3.71530311e+00 1.90649182e-01 2.37722580e+02 1.57888973e+01
8.52811241e-01 3.57647566e+01 1.07065922e+01]
46403 points are assigned to centroid 4
The coordinates of centroid 5: [1.80093518e+00 1.59471460e-01 2.39404626e+02 7.65674013e+00
4.04637704e-01 9.66362772e-01 3.78928175e-01]
126140 points are assigned to centroid 5
The coordinates of centroid 6: [4.00178003e+00 1.98890595e-01 2.37169936e+02 1.69665860e+01
3.70045706e+01 2.45517939e+00 1.11920367e+01]
55354 points are assigned to centroid 6
```

K = 7:

```
after 47 iteration, the loss is: 24.233158403671514
after 48 iteration, the loss is: 24.233158397274423
after 49 iteration, the loss is: 24.233158379280102
after 50 iteration, the loss is: 24.23315836860214

The coordinates of centroid 1: [3.40369831e+00 1.86057237e-01 2.37988266e+02 1.45082645e+01
1.18501192e+00 3.92232159e+01 2.53490185e+00]

21804 points are assigned to centroid 1

The coordinates of centroid 2: [1.78152657e+00 1.27982848e-01 2.39841663e+02 7.43522640e+00
2.01622946e-01 4.33767593e-01 1.75978850e+01]

628733 points are assigned to centroid 2

The coordinates of centroid 3: [ 2.36697528  0.2670678  238.97171501  9.9608824   0.26524231
0.47727404 28.22199062]

17271 points are assigned to centroid 3

The coordinates of centroid 4: [4.00423511e-01 1.04827497e-01 2.43425126e+02 1.73791277e+00
2.50284429e-02 3.55160872e-01 4.25133463e-01]

788423 points are assigned to centroid 4

The coordinates of centroid 5: [7.05856588e-01 1.28212799e-01 2.38829927e+02 3.07286441e+00
1.11157429e-01 5.25209410e-01 3.97999843e-01]

510960 points are assigned to centroid 5

The coordinates of centroid 6: [3.99212523e+00 1.98748368e-01 2.37178229e+02 1.69279738e+01
3.69697238e+01 2.33023458e+00 1.11711671e+01]

55291 points are assigned to centroid 6

The coordinates of centroid 7: [3.90812240e+00 1.95545339e-01 2.37600956e+02 1.65737742e+01
7.95805657e-01 3.16300470e+01 1.76091873e+01]

26798 points are assigned to centroid 7
```

K = 8:

```
after 50 iteration, the loss is: 20.937305667486214

The coordinates of centroid 1: [4.61956888e+00 1.84857693e-01 2.36747882e+02 1.95602843e+01
1.48566069e+00 4.32883657e+01 1.63609754e+01]

20259 points are assigned to centroid 1

The coordinates of centroid 2: [3.99483341e-01 1.05164714e-01 2.43946264e+02 1.73090069e+00
2.29417502e-02 3.48189188e-01 4.19855775e-01]

625410 points are assigned to centroid 2

The coordinates of centroid 3: [3.30211712e+00 1.96838780e-01 2.38064028e+02 1.39950716e+01
3.69775938e+01 2.17796489e+00 3.97031540e-01]

21021 points are assigned to centroid 3

The coordinates of centroid 4: [1.79672995e+00 1.31579785e-01 2.39818484e+02 7.50035133e+00
1.98131000e-01 4.36304464e-01 1.78906434e+01]

645265 points are assigned to centroid 4

The coordinates of centroid 5: [1.80174722e+00 1.57723943e-01 2.39400943e+02 7.65309597e+00
3.59676091e-01 5.31375635e-01 3.78693110e-01]

122627 points are assigned to centroid 5

The coordinates of centroid 6: [3.67626456e-01 1.14072688e-01 2.39469525e+02 1.64466795e+00
2.63024693e-02 3.99755292e-01 4.26003139e-01]

549226 points are assigned to centroid 6

The coordinates of centroid 7: [2.89219344e+00 1.95187082e-01 2.38634734e+02 1.23494569e+01
3.52177459e-01 2.81911923e+01 6.33465992e+00]

30655 points are assigned to centroid 7

The coordinates of centroid 8: [4.40308843e+00 2.00809030e-01 2.36652257e+02 1.86843324e+01
3.67690496e+01 2.58660999e+00 1.76344027e+01]

34817 points are assigned to centroid 8
```

K = 9:

```
after 50 iteration, the loss is: 19.962114515830862
The coordinates of centroid 1: [2.66560550e+00 1.90575117e-01 2.38755221e+02 1.13853055e+01
3.71680982e-01 3.02733252e+01 5.60245399e-01]
20375 points are assigned to centroid 1
The coordinates of centroid 2: [4.33012079e+00 1.91138775e-01 2.37133655e+02 1.83771241e+01
1.78127832e+00 3.83513627e+01 1.67883181e+01]
28694 points are assigned to centroid 2
The coordinates of centroid 3: [3.98078863e-01 1.04790630e-01 2.43950075e+02 1.72375267e+00
2.28105677e-02 3.48251827e-01 3.91544206e-01]
622650 points are assigned to centroid 3
The coordinates of centroid 4: [1.57618451e+00 1.10602750e-01 2.40935063e+02 6.51197146e+00
1.12042863e-01 3.91716312e-01 1.84130629e+01]
436931 points are assigned to centroid 4
The coordinates of centroid 5: [3.65330798e-01 1.13582087e-01 2.39469053e+02 1.63298922e+00
2.61774737e-02 3.99485201e-01 3.82492453e-01]
546233 points are assigned to centroid 5
The coordinates of centroid 6: [1.80422874e+00 1.57208952e-01 2.39393412e+02 7.66377768e+00
4.11364608e-01 5.33292759e-01 2.93581603e-01]
121588 points are assigned to centroid 6
The coordinates of centroid 7: [2.50337530e+00 1.56703031e-01 2.36847141e+02 1.05945182e+01
4.76159651e-01 7.79125428e-01 1.78212073e+01]
176109 points are assigned to centroid 7
The coordinates of centroid 8: [3.97876203e+00 1.98354140e-01 2.37200643e+02 1.68650873e+01
3.70712561e+01 2.13545059e+00 1.11033259e+01]
54662 points are assigned to centroid 8
The coordinates of centroid 9: [1.06176968e+00 2.61387031e-01 2.40777419e+02 4.62019126e+00
6.49650316e-02 4.46572149e-01 1.10129882e+01]
42038 points are assigned to centroid 9
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K = 10:

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after 46 iteration, the loss is: 20.93339310305178
The coordinates of centroid 1: [4.00352418e+00 1.98559695e-01 2.37173564e+02 1.69709813e+01
3.70780882e+01 2.46078360e+00 1.11784691e+01]
55130 points are assigned to centroid 1
The coordinates of centroid 2: [3.54497287e-01 1.07319411e-01 2.42935274e+02 1.55796610e+00
1.96350103e-02 3.59144920e-01 4.46908349e-01]
446040 points are assigned to centroid 2
The coordinates of centroid 3: [3.72819459e+00 1.90032694e-01 2.37721362e+02 1.58409445e+01
8.60709909e-01 3.60177040e+01 1.07197348e+01]
45696 points are assigned to centroid 3
The coordinates of centroid 4: [2.50331755e+00 1.62279797e-01 2.37074314e+02 1.05874388e+01
4.66348585e-01 7.28997450e-01 1.82341076e+01]
185906 points are assigned to centroid 4
The coordinates of centroid 5: [3.42959765e-01 1.14593771e-01 2.40250444e+02 1.53763870e+00
2.21448097e-02 4.06258955e-01 4.66242060e-01]
401313 points are assigned to centroid 5
The coordinates of centroid 6: [2.27342005e+00 1.73316382e-01 2.37921498e+02 9.71095350e+00
6.65365355e-01 1.86730710e+00 2.83536025e-01]
48925 points are assigned to centroid 6
The coordinates of centroid 7: [4.07200523e-01 9.43889269e-02 2.46288893e+02 1.73039712e+00
1.74377504e-02 3.03236195e-01 3.15579519e-01]
178234 points are assigned to centroid 7
The coordinates of centroid 8: [1.36388570e+00 1.54029699e-01 2.41236823e+02 5.77789483e+00
2.09033708e-01 4.91811236e-01 5.85123596e-01]
111250 points are assigned to centroid 8
The coordinates of centroid 9: [4.18866343e-01 1.05835776e-01 2.35950479e+02 1.87523169e+00
3.76175821e-02 3.50694626e-01 1.86740389e-01]
115026 points are assigned to centroid 9
The coordinates of centroid 10: [1.51830865e+00 1.19666654e-01 2.40918651e+02 6.28426758e+00
1.04175329e-01 3.90440922e-01 1.77496470e+01]
461760 points are assigned to centroid 10
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K = 11:

The coordinates of centroid 1: [4.05339108e-01 9.42513710e-02 2.46291066e+02 1.72272924e+00  
1.73178922e-02 2.97919491e-01 3.15209260e-01]

177793 points are assigned to centroid 1

The coordinates of centroid 2: [4.15458343e-01 1.05853323e-01 2.35957345e+02 1.86097552e+00  
3.70521881e-02 3.62288062e-01 1.86975594e-01]

114892 points are assigned to centroid 2

The coordinates of centroid 3: [1.51841958e+00 1.19784183e-01 2.40934092e+02 6.28437388e+00  
1.04090108e-01 3.90801875e-01 1.77500234e+01]

460159 points are assigned to centroid 3

The coordinates of centroid 4: [3.52640541e-01 1.07082403e-01 2.42936637e+02 1.55005703e+00  
1.92874032e-02 3.58066715e-01 4.44413447e-01]

444487 points are assigned to centroid 4

The coordinates of centroid 5: [2.26031896e+00 1.66550662e-01 2.37921189e+02 9.63590407e+00  
6.84824361e-01 5.23494875e-01 2.76226490e-01]

50245 points are assigned to centroid 5

The coordinates of centroid 6: [2.88576633e+00 1.94860034e-01 2.38660987e+02 1.23195164e+01  
2.91496912e-01 2.83086805e+01 6.31245893e+00]

30436 points are assigned to centroid 6

The coordinates of centroid 7: [2.49097186e+00 1.61228098e-01 2.37052005e+02 1.05347984e+01  
4.64070229e-01 5.67685543e-01 1.82347128e+01]

185793 points are assigned to centroid 7

The coordinates of centroid 8: [4.74552794e+00 1.88285582e-01 2.36579401e+02 2.01091438e+01  
3.91724393e+00 4.28230350e+01 1.61939134e+01]

21654 points are assigned to centroid 8

The coordinates of centroid 9: [3.41945571e-01 1.14387426e-01 2.40250629e+02 1.53314383e+00  
2.20262777e-02 4.04208922e-01 4.63148824e-01]

400340 points are assigned to centroid 9

The coordinates of centroid 10: [1.33355069e+00 1.56175941e-01 2.41334391e+02 5.65385337e+00  
1.90532577e-01 5.61660306e-01 6.14471659e-01]

109787 points are assigned to centroid 10

The coordinates of centroid 11: [3.93899262e+00 1.97767460e-01 2.37245361e+02 1.66934183e+01  
3.70854472e+01 1.55138377e+00 1.10784445e+01]

53694 points are assigned to centroid 11

K = 12:

The coordinates of centroid 1: [3.50746722e+00 1.83819194e-01 2.36586003e+02 1.49146955e+01  
1.12574502e+00 8.90505681e-01 1.73209164e+01]

42952 points are assigned to centroid 1

The coordinates of centroid 2: [2.47243069e+00 1.57246433e-01 2.39563794e+02 1.03627432e+01  
3.60736904e-01 8.32476661e-01 1.78873368e+01]

100583 points are assigned to centroid 2

The coordinates of centroid 3: [1.57973808e+00 1.13805073e-01 2.34864422e+02 6.71089782e+00  
1.30762666e-01 4.34597680e-01 1.69713878e+01]

71473 points are assigned to centroid 3

The coordinates of centroid 4: [4.00313337e+00 1.98444057e-01 2.37171732e+02 1.69685984e+01  
3.71115957e+01 2.46475495e+00 1.11533373e+01]

55029 points are assigned to centroid 4

The coordinates of centroid 5: [1.56674165e+00 1.06033397e-01 2.43287238e+02 6.40896465e+00  
1.03712010e-01 3.56501655e-01 1.84567643e+01]

164089 points are assigned to centroid 5

The coordinates of centroid 6: [4.15095176e-01 9.95372849e-02 2.45102694e+02 1.77806164e+00  
2.18997773e-02 3.21421783e-01 3.60404522e-01]

352515 points are assigned to centroid 6

The coordinates of centroid 7: [1.42353228e+00 1.26528079e-01 2.39662570e+02 5.93258762e+00  
8.98129669e-02 3.95668499e-01 1.71270184e+01]

253538 points are assigned to centroid 7

The coordinates of centroid 8: [1.82838226e+00 1.60652269e-01 2.39627032e+02 7.76752341e+00  
4.18195170e-01 1.00237829e+00 3.47088472e-01]

119834 points are assigned to centroid 8

The coordinates of centroid 9: [3.69526611e-01 1.14429606e-01 2.41362934e+02 1.63946753e+00  
2.42092532e-02 3.97285587e-01 4.85111302e-01]

653180 points are assigned to centroid 9

The coordinates of centroid 10: [4.04545533e-01 1.09439825e-01 2.36871280e+02 1.81220904e+00  
3.58777482e-02 3.72629382e-01 2.54378077e-01]

173478 points are assigned to centroid 10

The coordinates of centroid 11: [ 2.33224747 0.26837748 239.00021333 9.8102163 0.24065185  
0.53534815 28.36983704]

16875 points are assigned to centroid 11

The coordinates of centroid 12: [3.72048227e+00 1.89874754e-01 2.37721020e+02 1.58099620e+01  
8.57502077e-01 3.60112389e+01 1.06267984e+01]

45734 points are assigned to centroid 12

K = 13:

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The coordinates of centroid 1: [4.14258785e-01 9.19420086e-02 2.47386636e+02 1.74848107e+00  
1.39537520e-02 2.85275448e-01 3.04942190e-01]
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88220 points are assigned to centroid 1

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The coordinates of centroid 2: [3.77564718e-01 9.97001405e-02 2.44482238e+02 1.63040070e+00  
2.01367146e-02 3.20710048e-01 3.66495435e-01]
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221337 points are assigned to centroid 2

```
The coordinates of centroid 3: [4.28700070e-01 1.19346801e-01 2.38313432e+02 1.91247758e+00  
3.88695633e-02 4.27442762e-01 3.78713567e-01]
```

138849 points are assigned to centroid 3

```
The coordinates of centroid 4: [3.93898490e+00 1.97766459e-01 2.37245315e+02 1.66934016e+01  
3.70851290e+01 1.55135487e+00 1.10782382e+01]
```

53695 points are assigned to centroid 4

```
The coordinates of centroid 5: [1.51838788e+00 1.19781748e-01 2.40933851e+02 6.28424646e+00  
1.04094907e-01 3.90797054e-01 1.77499701e+01]
```

460157 points are assigned to centroid 5

```
The coordinates of centroid 6: [2.23886654e+00 1.66260556e-01 2.37910891e+02 9.54458653e+00  
6.64567819e-01 5.24075013e-01 2.81024601e-01]
```

51298 points are assigned to centroid 6

```
The coordinates of centroid 7: [3.47670874e-01 1.10220615e-01 2.42439973e+02 1.53750144e+00  
1.92801588e-02 3.76043545e-01 4.70577342e-01]
```

329406 points are assigned to centroid 7

```
The coordinates of centroid 8: [4.74552794e+00 1.88285582e-01 2.36579401e+02 2.01091438e+01  
3.91724393e+00 4.28230350e+01 1.61939134e+01]
```

21654 points are assigned to centroid 8

```
The coordinates of centroid 9: [2.88575917e+00 1.94856420e-01 2.38661121e+02 1.23194769e+01  
2.91496912e-01 2.83086805e+01 6.31245893e+00]
```

30436 points are assigned to centroid 9

```
The coordinates of centroid 10: [4.00355947e-01 1.02728642e-01 2.34799207e+02 1.80542529e+00  
3.45772157e-02 3.44786025e-01 1.27743168e-01]
```

63886 points are assigned to centroid 10

```
The coordinates of centroid 11: [3.29910625e-01 1.11658626e-01 2.40563206e+02 1.47770298e+00  
1.93404832e-02 3.91044638e-01 4.73482578e-01]
```

302009 points are assigned to centroid 11

```
The coordinates of centroid 12: [1.35733162e+00 1.55578738e-01 2.41537822e+02 5.74743391e+00  
1.99465621e-01 5.57245804e-01 5.92399731e-01]
```

102549 points are assigned to centroid 12

```
The coordinates of centroid 13: [2.49113883e+00 1.61237006e-01 2.37052763e+02 1.05354810e+01  
4.64092710e-01 5.67766869e-01 1.82352625e+01]
```

185784 points are assigned to centroid 13

K = 14:

The coordinates of centroid 1: [1.37851266e+00 1.54182577e-01 2.38644240e+02 5.88341528e+00  
1.96093952e-01 5.92894220e-01 3.52214087e-01]

65693 points are assigned to centroid 1

The coordinates of centroid 2: [4.61707480e+00 1.85128104e-01 2.36750590e+02 1.95500959e+01  
1.47563314e+00 4.32373248e+01 1.63728547e+01]

20335 points are assigned to centroid 2

The coordinates of centroid 3: [3.37676356e-01 1.02688089e-01 2.37443266e+02 1.51911181e+00  
2.87630199e-02 3.38745547e-01 2.25384074e-01]

88134 points are assigned to centroid 3

The coordinates of centroid 4: [3.99958572e-01 9.06368272e-02 2.47844863e+02 1.68674277e+00  
1.02148755e-02 2.85763905e-01 3.01078325e-01]

63339 points are assigned to centroid 4

The coordinates of centroid 5: [1.38654784e+00 1.49189499e-01 2.42755682e+02 5.83422055e+00  
2.19809902e-01 5.17995065e-01 3.53754508e-01]

68491 points are assigned to centroid 5

The coordinates of centroid 6: [4.40984785e+00 2.00116635e-01 2.36648439e+02 1.87074917e+01  
3.69305290e+01 2.60241034e+00 1.76322209e+01]

34518 points are assigned to centroid 6

The coordinates of centroid 7: [2.88613044e+00 1.94899287e-01 2.38653061e+02 1.23231483e+01  
3.53902237e-01 2.83443911e+01 6.19002486e+00]

30175 points are assigned to centroid 7

The coordinates of centroid 8: [3.44312420e-01 1.12661008e-01 2.41533616e+02 1.53185694e+00  
2.05524230e-02 3.96151698e-01 4.58690856e-01]

293688 points are assigned to centroid 8

The coordinates of centroid 9: [3.73315923e-01 9.57605451e-02 2.45109204e+02 1.60298473e+00  
1.92559226e-02 3.02824585e-01 3.21729588e-01]

156731 points are assigned to centroid 9

20977 points are assigned to centroid 10

The coordinates of centroid 11: [3.01327061e+00 1.76524389e-01 2.37938973e+02 1.27342966e+01  
6.88755453e-01 6.49181405e-01 1.81679598e+01]

106585 points are assigned to centroid 11

The coordinates of centroid 12: [3.47122821e-01 1.17056468e-01 2.39851010e+02 1.55875936e+00  
2.35017358e-02 4.19363238e-01 4.37799196e-01]

218920 points are assigned to centroid 12

The coordinates of centroid 13: [2.55620320e+00 1.70426497e-01 2.38149604e+02 1.08776862e+01  
6.67672213e-01 5.07572695e-01 2.15363085e-01]

32155 points are assigned to centroid 13

The coordinates of centroid 14: [1.61678893e+00 1.12599705e-01 2.42160019e+02 6.64964569e+00  
1.11827768e-01 3.83272408e-01 1.87240703e+01]

284500 points are assigned to centroid 14

K = 15:

```
The coordinates of centroid 1: [2.88409340e+00 1.94673890e-01 2.38661272e+02 1.23124424e+01  
2.89751021e-01 2.83269332e+01 6.29350547e+00]  
30364 points are assigned to centroid 1  
  
The coordinates of centroid 2: [1.47869511e+00 1.28517859e-01 2.37892996e+02 6.21525143e+00  
1.08486500e-01 4.22972747e-01 1.68810918e+01]  
244777 points are assigned to centroid 2  
  
The coordinates of centroid 3: [3.43258710e-01 1.08801666e-01 2.42423774e+02 1.51752712e+00  
1.85677285e-02 3.66770738e-01 4.63529642e-01]  
327019 points are assigned to centroid 3  
  
The coordinates of centroid 4: [3.73500876e-01 1.02624707e-01 2.34740754e+02 1.69337367e+00  
3.34292233e-02 3.38855272e-01 1.14935688e-01]  
60486 points are assigned to centroid 4  
  
The coordinates of centroid 5: [1.38400668e+00 1.54039156e-01 2.38514632e+02 5.90934810e+00  
1.65613746e-01 5.83821644e-01 4.19306598e-01]  
65532 points are assigned to centroid 5  
  
The coordinates of centroid 6: [3.97933205e-01 9.14360627e-02 2.47389891e+02 1.68185891e+00  
1.21839711e-02 2.83065880e-01 3.04873588e-01]  
87492 points are assigned to centroid 6  
  
The coordinates of centroid 7: [4.74474461e+00 1.88333410e-01 2.36581700e+02 2.01058183e+01  
3.91201034e+00 4.28117935e+01 1.61972962e+01]  
21673 points are assigned to centroid 7  
  
The coordinates of centroid 8: [1.36334963e+00 1.52527242e-01 2.42673248e+02 5.74841215e+00  
1.94329317e-01 5.30892323e-01 5.60027997e-01]  
72866 points are assigned to centroid 8  
  
The coordinates of centroid 9: [2.93008372e+00 1.77866615e-01 2.37953962e+02 1.23801850e+01  
6.51939258e-01 6.23889578e-01 1.85714106e+01]  
119324 points are assigned to centroid 9  
  
The coordinates of centroid 10: [3.93975469e+00 1.97738944e-01 2.37243905e+02 1.66956447e+01  
3.71122302e+01 1.55285099e+00 1.10756533e+01]  
53613 points are assigned to centroid 10  
  
The coordinates of centroid 11: [2.55543187e+00 1.71780262e-01 2.38253709e+02 1.08927667e+01  
9.80939184e-01 5.08822171e-01 2.56997691e-01]  
32475 points are assigned to centroid 11  
  
The coordinates of centroid 12: [3.42605236e-01 1.09662338e-01 2.38344285e+02 1.54248985e+00  
2.76452590e-02 3.75642577e-01 3.30301886e-01]  
129751 points are assigned to centroid 12  
  
The coordinates of centroid 13: [3.65305702e-01 9.88815521e-02 2.44465211e+02 1.57973482e+00  
1.87736605e-02 3.19011175e-01 3.63288075e-01]  
219776 points are assigned to centroid 13  
  
The coordinates of centroid 14: [3.49123519e-01 1.16519907e-01 2.40578205e+02 1.56350043e+00  
2.23032660e-02 4.17815402e-01 4.96591957e-01]  
301346 points are assigned to centroid 14  
  
The coordinates of centroid 15: [1.59550268e+00 1.15286556e-01 2.42266478e+02 6.56356467e+00  
1.09779126e-01 3.83300446e-01 1.84483143e+01]  
282786 points are assigned to centroid 15
```

K = 16:

```
The coordinates of centroid 1: [1.49179090e+00 1.07527080e-01 2.39728748e+02 6.19061046e+00  
9.63272516e-02 3.93500534e-01 1.80032766e+01]  
156259 points are assigned to centroid 1  
  
The coordinates of centroid 2: [1.63759481e+00 1.03444341e-01 2.45142833e+02 6.64841848e+00  
1.17888627e-01 3.64744748e-01 1.87701363e+01]  
54789 points are assigned to centroid 2  
  
The coordinates of centroid 3: [4.03400078e-01 1.09252939e-01 2.36867569e+02 1.80635025e+00  
3.58497010e-02 3.72291591e-01 2.34316841e-01]  
172749 points are assigned to centroid 3  
  
The coordinates of centroid 4: [3.57053213e+00 1.84442577e-01 2.36449135e+02 1.51891115e+01  
1.12248864e+00 8.64931586e-01 1.72946398e+01]  
38077 points are assigned to centroid 4  
  
The coordinates of centroid 5: [1.60067760e+00 1.10414114e-01 2.33035653e+02 6.85191371e+00  
1.39383667e-01 4.62989214e-01 1.67614484e+01]  
32450 points are assigned to centroid 5  
  
The coordinates of centroid 6: [1.82957193e+00 1.60213632e-01 2.39623368e+02 7.77077417e+00  
4.18373691e-01 1.00429347e+00 2.95131829e-01]  
119018 points are assigned to centroid 6  
  
The coordinates of centroid 7: [4.00296101e+00 1.98443839e-01 2.37172049e+02 1.69679385e+01  
3.71087794e+01 2.46471529e+00 1.11544933e+01]  
55038 points are assigned to centroid 7  
  
The coordinates of centroid 8: [2.57507828e+00 1.57919784e-01 2.39513127e+02 1.07971044e+01  
4.21731802e-01 8.86686090e-01 1.78998694e+01]  
89583 points are assigned to centroid 8  
  
The coordinates of centroid 9: [1.56536930e+00 1.13057135e-01 2.37250021e+02 6.57701880e+00  
1.26547133e-01 4.29930198e-01 1.75504561e+01]  
89682 points are assigned to centroid 9  
  
The coordinates of centroid 10: [9.71063117e-01 2.54287344e-01 2.42339904e+02 4.24168251e+00  
3.66832073e-02 3.91411214e-01 1.05347122e+01]  
21563 points are assigned to centroid 10  
  
The coordinates of centroid 11: [ 2.33532334 0.26891321 239.01510543 9.8220178 0.24162236  
0.53598949 28.40571053]  
16741 points are assigned to centroid 11  
  
The coordinates of centroid 12: [3.72053429e+00 1.89791350e-01 2.37720338e+02 1.58101065e+01  
8.57677247e-01 3.60188349e+01 1.06246144e+01]  
45713 points are assigned to centroid 12  
  
The coordinates of centroid 13: [1.54137473e+00 1.03815722e-01 2.42077308e+02 6.33329741e+00  
9.92759667e-02 3.55979364e-01 1.83551896e+01]  
135491 points are assigned to centroid 13  
  
The coordinates of centroid 14: [1.15963381e+00 2.68267001e-01 2.39195622e+02 5.03327389e+00  
9.45105788e-02 5.17711697e-01 1.14212733e+01]  
20749 points are assigned to centroid 14  
  
The coordinates of centroid 15: [3.67481713e-01 1.13971473e-01 2.41363507e+02 1.62898335e+00  
2.41576664e-02 3.97224530e-01 4.47310686e-01]  
649980 points are assigned to centroid 15  
  
The coordinates of centroid 16: [4.14362922e-01 9.93963938e-02 2.45105256e+02 1.77417515e+00  
2.18954007e-02 3.21609685e-01 3.44569406e-01]  
351398 points are assigned to centroid 16
```

K = 17:

```
The coordinates of centroid 1: [2.50294998e+00 1.70729839e-01 2.38070857e+02 1.06555521e+01  
6.45793458e-01 5.12155406e-01 2.41908299e-01]  
35005 points are assigned to centroid 1  
The coordinates of centroid 2: [1.56873102e+00 1.15090819e-01 2.43370812e+02 6.42652015e+00  
1.07194943e-01 3.63146083e-01 1.81030221e+01]  
167993 points are assigned to centroid 2  
The coordinates of centroid 3: [4.41396227e+00 2.00118906e-01 2.36643456e+02 1.87248836e+01  
3.69372487e+01 2.66257775e+00 1.76313612e+01]  
34565 points are assigned to centroid 3  
The coordinates of centroid 4: [1.41313827e+00 1.43080791e-01 2.36394168e+02 6.00568927e+00  
1.06635904e-01 4.17561550e-01 1.57406975e+01]  
105321 points are assigned to centroid 4  
The coordinates of centroid 5: [3.90013515e+00 1.95212579e-01 2.37617728e+02 1.65355204e+01  
6.54535845e-01 3.17071615e+01 1.76175771e+01]  
26489 points are assigned to centroid 5  
The coordinates of centroid 6: [1.61302183e+00 1.21085420e-01 2.39677014e+02 6.71010403e+00  
1.16731258e-01 4.29256986e-01 1.85050789e+01]  
269645 points are assigned to centroid 6  
The coordinates of centroid 7: [3.47626663e-01 1.12994133e-01 2.41685153e+02 1.54629380e+00  
2.04254624e-02 3.94392700e-01 4.91617901e-01]  
391668 points are assigned to centroid 7  
The coordinates of centroid 8: [2.67768519e+00 1.89192684e-01 2.38750928e+02 1.14356586e+01  
3.94463322e-01 3.05225365e+01 3.85018989e-01]  
20012 points are assigned to centroid 8  
The coordinates of centroid 9: [1.31506909e+00 1.55184569e-01 2.38817854e+02 5.62154707e+00  
1.81053875e-01 6.17562704e-01 4.65273872e-01]  
71128 points are assigned to centroid 9  
The coordinates of centroid 10: [3.57710585e-01 1.01558301e-01 2.43905651e+02 1.55637638e+00  
1.86382929e-02 3.29769457e-01 3.94595170e-01]  
291443 points are assigned to centroid 10  
The coordinates of centroid 11: [5.94635049e+00 1.76049029e-01 2.35474677e+02 2.53190291e+01  
3.31286408e+00 6.90769417e+01 1.20356796e+01]  
4120 points are assigned to centroid 11  
The coordinates of centroid 12: [3.66284562e-01 1.01875940e-01 2.35326278e+02 1.65729274e+00  
3.20567960e-02 3.35978483e-01 1.25864722e-01]  
82541 points are assigned to centroid 12  
The coordinates of centroid 13: [3.36757262e-01 1.13582460e-01 2.39431737e+02 1.51527867e+00  
2.33325834e-02 3.98367865e-01 4.22125867e-01]  
244465 points are assigned to centroid 13  
The coordinates of centroid 14: [1.39072135e+00 1.50856896e-01 2.42851408e+02 5.85603310e+00  
2.20831597e-01 5.16935532e-01 5.02708495e-01]  
67196 points are assigned to centroid 14  
The coordinates of centroid 15: [3.02611268e+00 1.75269556e-01 2.37906663e+02 1.27897222e+01  
6.99295524e-01 6.04215322e-01 1.80099665e+01]  
104049 points are assigned to centroid 15  
The coordinates of centroid 16: [3.30323108e+00 1.96712944e-01 2.38067020e+02 1.39974923e+01  
3.70171633e+01 2.17702026e+00 3.97806913e-01]  
20975 points are assigned to centroid 16  
The coordinates of centroid 17: [3.90795846e-01 9.16662317e-02 2.47005012e+02 1.65564283e+00  
1.33315582e-02 2.85297120e-01 3.03767807e-01]  
112665 points are assigned to centroid 17
```

K = 18:

The coordinates of centroid 1: [1.37851266e+00 1.54182577e-01 2.38644240e+02 5.88341528e+00  
1.96093952e-01 5.92894220e-01 3.52214087e-01]

65693 points are assigned to centroid 1

The coordinates of centroid 2: [4.61707480e+00 1.85128104e-01 2.36750590e+02 1.95500959e+01  
1.47563314e+00 4.32373248e+01 1.63728547e+01]

20335 points are assigned to centroid 2

The coordinates of centroid 3: [3.37676356e-01 1.02688089e-01 2.37443266e+02 1.51911181e+00  
2.87630199e-02 3.38745547e-01 2.25384074e-01]

88134 points are assigned to centroid 3

The coordinates of centroid 4: [3.99958572e-01 9.06368272e-02 2.47844863e+02 1.68674277e+00  
1.02148755e-02 2.85763905e-01 3.01078325e-01]

63339 points are assigned to centroid 4

The coordinates of centroid 5: [1.38654784e+00 1.49189499e-01 2.42755682e+02 5.83422055e+00  
2.19809902e-01 5.17995065e-01 3.53754508e-01]

68491 points are assigned to centroid 5

The coordinates of centroid 6: [4.40984785e+00 2.00116635e-01 2.36648439e+02 1.87074917e+01  
3.69305290e+01 2.60241034e+00 1.76322209e+01]

34518 points are assigned to centroid 6

The coordinates of centroid 7: [2.88613044e+00 1.94899287e-01 2.38653061e+02 1.23231483e+01  
3.53902237e-01 2.83443911e+01 6.19002486e+00]

30175 points are assigned to centroid 7

The coordinates of centroid 8: [3.44312420e-01 1.12661008e-01 2.41533616e+02 1.53185694e+00  
2.05524230e-02 3.96151698e-01 4.58690856e-01]

293688 points are assigned to centroid 8

The coordinates of centroid 9: [3.73315923e-01 9.57605451e-02 2.45109204e+02 1.60298473e+00  
1.92559226e-02 3.02824585e-01 3.21729588e-01]

156731 points are assigned to centroid 9

The coordinates of centroid 10: [3.30356476e+00 1.96701721e-01 2.38066661e+02 1.39989322e+01  
3.70171140e+01 2.18343900e+00 3.97387615e-01]

20977 points are assigned to centroid 10

The coordinates of centroid 11: [3.01327061e+00 1.76524389e-01 2.37938973e+02 1.27342966e+01  
6.88755453e-01 6.49181405e-01 1.81679598e+01]

106585 points are assigned to centroid 11

The coordinates of centroid 12: [3.47122821e-01 1.17056468e-01 2.39851010e+02 1.55875936e+00  
2.35017358e-02 4.19363238e-01 4.37799196e-01]

218920 points are assigned to centroid 12

The coordinates of centroid 13: [2.55620320e+00 1.70426497e-01 2.38149604e+02 1.08776862e+01  
6.67672213e-01 5.07572695e-01 2.15363085e-01]

32155 points are assigned to centroid 13

The coordinates of centroid 14: [1.61678893e+00 1.12599705e-01 2.42160019e+02 6.64964569e+00  
1.11827768e-01 3.83272408e-01 1.87240703e+01]

284500 points are assigned to centroid 14

The coordinates of centroid 15: [1.06285113e+00 2.62533244e-01 2.40800464e+02 4.62302731e+00  
6.44496128e-02 4.44026183e-01 1.10324646e+01]

41707 points are assigned to centroid 15

The coordinates of centroid 16: [3.48939803e-01 1.05643728e-01 2.43176670e+02 1.53082599e+00  
1.79382932e-02 3.49468531e-01 4.28013236e-01]

258999 points are assigned to centroid 16

The coordinates of centroid 17: [1.55652627e+00 1.12067974e-01 2.37545654e+02 6.53025436e+00  
1.18591594e-01 4.24753938e-01 1.76611461e+01]

219965 points are assigned to centroid 17

The coordinates of centroid 18: [4.02614272e-01 1.05810359e-01 2.34199980e+02 1.82532907e+00  
3.92174540e-02 3.57532456e-01 1.13144609e-01]

44368 points are assigned to centroid 18

K = 19:

The coordinates of centroid 1: [3.94027940e+00 1.97655260e-01 2.37243348e+02 1.66972426e+01  
3.71273033e+01 1.55370111e+00 1.10757584e+01]

53565 points are assigned to centroid 1

The coordinates of centroid 2: [2.88299046e+00 1.94516453e-01 2.38662030e+02 1.23078649e+01  
2.89844549e-01 2.83454569e+01 6.26842470e+00]

30299 points are assigned to centroid 2

The coordinates of centroid 3: [2.64869596e+00 1.73563742e-01 2.37910724e+02 1.13182764e+01  
1.20108696e+00 5.05201863e-01 2.21622671e-01]

25760 points are assigned to centroid 3

The coordinates of centroid 4: [3.96997988e-01 1.06226145e-01 2.33949073e+02 1.80483408e+00  
3.90052848e-02 3.63226655e-01 1.16908550e-01]

37277 points are assigned to centroid 4

The coordinates of centroid 5: [1.49538978e+00 1.53219061e-01 2.38152223e+02 6.37484904e+00  
1.72335395e-01 5.51164060e-01 3.18661331e-01]

54980 points are assigned to centroid 5

The coordinates of centroid 6: [ 2.34205017 0.26876567 238.99102113 9.85263841 0.25605005  
0.54515406 28.36270806]

16942 points are assigned to centroid 6

The coordinates of centroid 7: [3.97068544e-01 9.04431959e-02 2.47713826e+02 1.67553672e+00  
1.05618623e-02 2.82813623e-01 2.99310246e-01]

69590 points are assigned to centroid 7

The coordinates of centroid 8: [8.78209424e-01 1.70206830e-01 2.41257993e+02 3.78969852e+00  
1.06809063e-01 7.64137563e-01 5.04297334e-01]

82493 points are assigned to centroid 8

The coordinates of centroid 9: [1.63626648e+00 1.46251987e-01 2.42957605e+02 6.84916897e+00  
2.35557917e-01 4.23549416e-01 2.92263549e-01]

47050 points are assigned to centroid 9

The coordinates of centroid 10: [1.55478558e+00 1.11887561e-01 2.37545122e+02 6.52281968e+00  
1.18985054e-01 4.26894034e-01 1.76003789e+01]

216918 points are assigned to centroid 10

The coordinates of centroid 11: [1.59859610e+00 1.07227683e-01 2.42218551e+02 6.57012538e+00  
1.12364634e-01 3.81999942e-01 1.83695094e+01]

276288 points are assigned to centroid 11

The coordinates of centroid 12: [3.39291637e-01 1.06366158e-01 2.43012477e+02 1.49409691e+00  
1.67306782e-02 3.54583650e-01 4.34445204e-01]

266098 points are assigned to centroid 12

The coordinates of centroid 13: [2.99504935e-01 1.02304022e-01 2.41326495e+02 1.33719413e+00  
1.39598972e-02 3.33703972e-01 4.42390951e-01]

270704 points are assigned to centroid 13

The coordinates of centroid 14: [3.02147809e+00 1.69333320e-01 2.37937555e+02 1.27686172e+01  
7.17801720e-01 6.32816052e-01 1.75839182e+01]

101170 points are assigned to centroid 14

The coordinates of centroid 15: [3.29910325e-01 1.15804279e-01 2.39567882e+02 1.48875354e+00  
2.11942014e-02 4.13738096e-01 4.23551022e-01]

186183 points are assigned to centroid 15

The coordinates of centroid 16: [3.79772388e-01 9.78064949e-02 2.44936829e+02 1.63308769e+00  
2.02192164e-02 3.11940299e-01 3.31215019e-01]

171520 points are assigned to centroid 16

The coordinates of centroid 17: [3.43658929e-01 1.01839202e-01 2.37087544e+02 1.54589543e+00  
2.92750695e-02 3.32192473e-01 1.90793130e-01]

79180 points are assigned to centroid 17

The coordinates of centroid 18: [1.05840651e+00 2.62426472e-01 2.40806805e+02 4.60431426e+00  
6.18041026e-02 4.43739028e-01 1.10214270e+01]

41583 points are assigned to centroid 18

The coordinates of centroid 19: [4.74441993e+00 1.88292066e-01 2.36581339e+02 2.01044834e+01  
3.91074723e+00 4.28083948e+01 1.61973247e+01]

21680 points are assigned to centroid 19

K = 20:

The coordinates of centroid 1: [4.40998047e+00 2.00019009e-01 2.36648052e+02 1.87079223e+01  
3.69345987e+01 2.60289771e+00 1.76293248e+01]

34510 points are assigned to centroid 1

The coordinates of centroid 2: [3.76819208e-01 9.60125335e-02 2.45259804e+02 1.61625497e+00  
1.93993568e-02 3.03888824e-01 3.20326972e-01]

145211 points are assigned to centroid 2

The coordinates of centroid 3: [3.34932218e-01 1.13727124e-01 2.39828651e+02 1.50273280e+00  
2.19056711e-02 4.02720103e-01 4.17077770e-01]

212639 points are assigned to centroid 3

The coordinates of centroid 4: [3.78816024e-01 1.28587351e-01 2.41590365e+02 1.70369213e+00  
2.46273068e-02 4.53149012e-01 1.29998687e+00]

152270 points are assigned to centroid 4

The coordinates of centroid 5: [3.00885270e+00 1.69396204e-01 2.38137277e+02 1.27059918e+01  
6.94231032e-01 6.30490880e-01 1.76104530e+01]

102306 points are assigned to centroid 5

The coordinates of centroid 6: [1.58587243e+00 1.15051181e-01 2.35013871e+02 6.73509733e+00  
1.34848940e-01 4.36144484e-01 1.69534075e+01]

76493 points are assigned to centroid 6

The coordinates of centroid 7: [1.36443227e+00 1.54661348e-01 2.38705822e+02 5.82581038e+00  
1.91654039e-01 5.95017381e-01 4.08384586e-01]

67314 points are assigned to centroid 7

The coordinates of centroid 8: [1.49162371e+00 1.28051385e-01 2.39697012e+02 6.21755585e+00  
1.01943711e-01 4.15857674e-01 1.72697565e+01]

281832 points are assigned to centroid 8

The coordinates of centroid 9: [3.39577580e-01 1.03303354e-01 2.37431251e+02 1.52823797e+00  
2.89344572e-02 3.42673178e-01 2.32665058e-01]

87439 points are assigned to centroid 9

The coordinates of centroid 10: [4.00736094e-01 9.05215098e-02 2.47955752e+02 1.68960132e+00  
9.76161118e-03 2.86991369e-01 3.09169064e-01]

58392 points are assigned to centroid 10

The coordinates of centroid 11: [4.04906892e-01 1.05853536e-01 2.34200648e+02 1.83520180e+00  
3.93704328e-02 3.57459247e-01 1.17863969e-01]

44475 points are assigned to centroid 11

The coordinates of centroid 12: [2.54567815e+00 1.70880680e-01 2.38103066e+02 1.08359801e+01  
6.69614345e-01 5.08843036e-01 2.43367723e-01]

32568 points are assigned to centroid 12

The coordinates of centroid 13: [3.30351892e+00 1.96715225e-01 2.38066802e+02 1.39987892e+01  
3.70162551e+01 2.18338259e+00 3.97368672e-01]

20978 points are assigned to centroid 13

The coordinates of centroid 14: [2.88510191e+00 1.94801525e-01 2.38652488e+02 1.23189454e+01  
3.53937987e-01 2.83435583e+01 6.17496269e+00]

30155 points are assigned to centroid 14

The coordinates of centroid 15: [4.61665870e+00 1.85117763e-01 2.36751044e+02 1.95483731e+01  
1.47498280e+00 4.32308070e+01 1.63734886e+01]

20346 points are assigned to centroid 15

The coordinates of centroid 16: [1.61803251e+00 1.09089075e-01 2.43289375e+02 6.62535943e+00  
1.16776267e-01 3.75520134e-01 1.84377941e+01]

168947 points are assigned to centroid 16

The coordinates of centroid 17: [1.40706530e+00 1.48706214e-01 2.42802854e+02 5.91754463e+00  
2.23092566e-01 5.09829028e-01 3.74602696e-01]

66385 points are assigned to centroid 17

The coordinates of centroid 18: [3.49667201e-01 1.08083866e-01 2.41602632e+02 1.54973677e+00  
2.03544424e-02 3.78647876e-01 0.00000000e+00]

184628 points are assigned to centroid 18

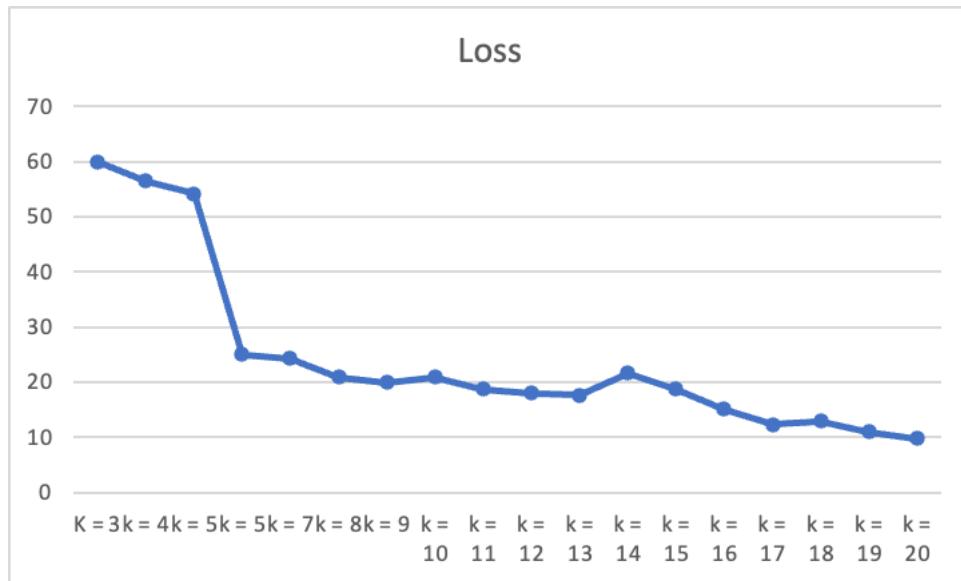
The coordinates of centroid 19: [2.33732231e+00 2.68423233e-01 2.38995867e+02 9.83246042e+00  
2.29212028e-01 5.46401459e-01 2.83380215e+01]

16993 points are assigned to centroid 19

The coordinates of centroid 20: [3.44603800e-01 1.02321908e-01 2.43334072e+02 1.50646824e+00  
1.73798589e-02 3.32405593e-01 4.06798724e-01]

245399 points are assigned to centroid 20

Slot:



Using the elbow method, the loss rate dropped from K=3 to 5 slightly while decreased significantly after or equals to K =5 then meltly again. So, the elbow point equals K=6, and this value of K fits the data best.

Additions:

#### Stopping criteria:

I used two stopping criteria: 1. The change status of clusters. 2. Max iteration times.

If clusters did not change after one iteration (the loss does not change), the clusters well be assigned so we can stop calculation. But sometimes it takes too many iterations to make clusters unchanged. Therefore, we should set a maximum of iteration in order to avoid wasting time and memory on tiny loss convergence rate. Generally, when K increases, the loss needs more and more iterations to converge completely. Limited by the computing power, I set my number of iterations for 50 maximums, which makes me unable to calculate the final convergence value of losses for that K. Thus, the results may not perform very well about clustering the data.

#### Centroid initialization method:

In my algorithm, I randomly select K points for all data as the initial clusters. the initial clusters could be different for the same input and parameters. For each time running the code, different initial clusters can require different time to produce the different results. Because if the algorithm selects lucky initial clusters which are close to the results, the less time will be required. Moreover, for the same K, the final clusters' coordinates may not be unique depends on the initial clusters, which means the final loss can be different after each time of running program. For this problem, we can run the program for many times (eg.50) and pick clustering that gave the lowest loss.