In [30]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.cluster import KMeans
from sklearn.preprocessing import StandardScaler
```

In [2]:
```
data = pd.read_csv('mall.csv')
```

In [3]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 200 entries, 0 to 199
Data columns (total 5 columns):
 #   Column                  Non-Null Count  Dtype 
---  ------                  --------------  ----- 
 0   CustomerID              200 non-null    int64 
 1   Gender                  200 non-null    object
 2   Age                     200 non-null    int64 
 3   Annual Income (k$)      200 non-null    int64 
 4   Spending Score (1-100)  200 non-null    int64 
dtypes: int64(4), object(1)
memory usage: 7.9+ KB
```

In [4]:
```
data.head()
```

Out[4]:

	CustomerID	Gender	Age	Annual Income (k$)	Spending Score (1-100)
0	1	Male	19	15	39
1	2	Male	21	15	81
2	3	Female	20	16	6
3	4	Female	23	16	77
4	5	Female	31	17	40

In [5]:
```
data['Gender'].unique()
```

Out[5]:
```
array(['Male', 'Female'], dtype=object)
```

In [6]:
```
data['Gender'].replace(to_replace = ['Male', 'Female'], value = [0, 1], i
```

In [7]:
```
data.head()
```

Out[7]:

	CustomerID	Gender	Age	Annual Income (k$)	Spending Score (1-100)
0	1	0	19	15	39
1	2	0	21	15	81
2	3	1	20	16	6
3	4	1	23	16	77
4	5	1	31	17	40

In [8]:
```
data.describe()
```

Out[8]:

	CustomerID	Gender	Age	Annual Income (k$)	Spending Score (1-100)
count	200.000000	200.000000	200.000000	200.000000	200.000000
mean	100.500000	0.560000	38.850000	60.560000	50.200000
std	57.879185	0.497633	13.969007	26.264721	25.823522
min	1.000000	0.000000	18.000000	15.000000	1.000000
25%	50.750000	0.000000	28.750000	41.500000	34.750000
50%	100.500000	1.000000	36.000000	61.500000	50.000000
75%	150.250000	1.000000	49.000000	78.000000	73.000000
max	200.000000	1.000000	70.000000	137.000000	99.000000

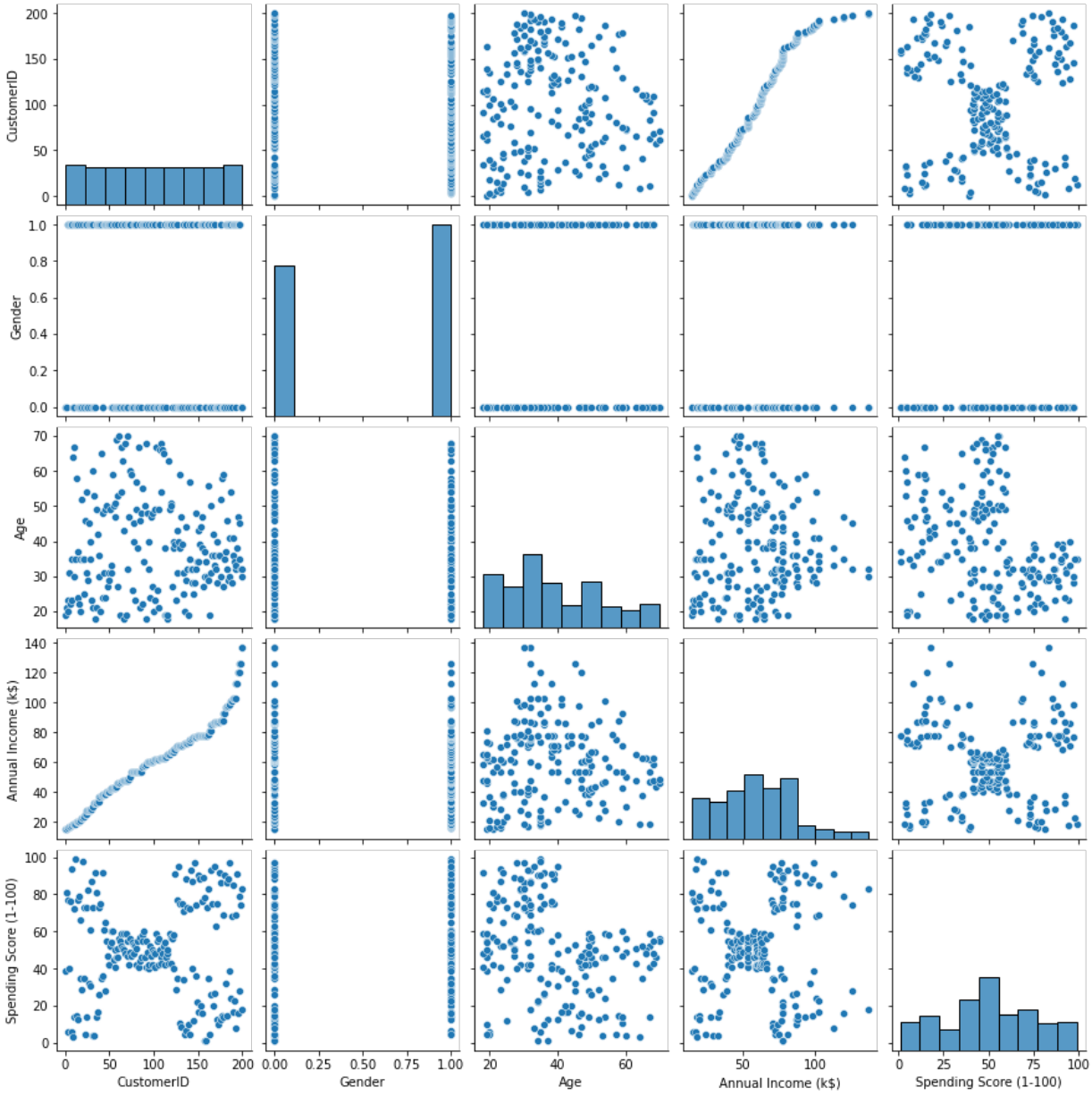
In [9]:
```
data.corr()
```

Out[9]:

	CustomerID	Gender	Age	Annual Income (k$)	Spending Score (1-100)
CustomerID	1.000000	-0.057400	-0.026763	0.977548	0.013835
Gender	-0.057400	1.000000	-0.060867	-0.056410	0.058109
Age	-0.026763	-0.060867	1.000000	-0.012398	-0.327227
Annual Income (k$)	0.977548	-0.056410	-0.012398	1.000000	0.009903
Spending Score (1-100)	0.013835	0.058109	-0.327227	0.009903	1.000000

In [10]:
```
sns.pairplot(data)
```

Out[10]:
```
<seaborn.axisgrid.PairGrid at 0x1211b3700>
```



In [11]:
```
sns.heatmap(data.corr())
```

Out[11]:
```
<AxesSubplot:>
```

In [12]:
```
data.isna().any()
```

Out[12]:
```
CustomerID                False
Gender                    False
Age                       False
Annual Income (k$)        False
Spending Score (1-100)    False
dtype: bool
```

In [13]:
```
data['Spending Score (1-100)'].unique()
```

Out[13]:
```
array([39, 81,  6, 77, 40, 76, 94,  3, 72, 14, 99, 15, 13, 79, 35, 66, 29
,
       98, 73,  5, 82, 32, 61, 31, 87,  4, 92, 17, 26, 75, 36, 28, 65, 55
,
       47, 42, 52, 60, 54, 45, 41, 50, 46, 51, 56, 59, 48, 49, 53, 44, 57
,
       58, 43, 91, 95, 11,  9, 34, 71, 88,  7, 10, 93, 12, 97, 74, 22, 90
,
       20, 16, 89,  1, 78, 83, 27, 63, 86, 69, 24, 68, 85, 23,  8, 18])
```

In [16]:
```
X = data.iloc[:,:-1]
X
```

Out[16]:

	CustomerID	Gender	Age	Annual Income (k$)
0	1	0	19	15
1	2	0	21	15
2	3	1	20	16
3	4	1	23	16
4	5	1	31	17
...	...	...	...	...
195	196	1	35	120
196	197	1	45	126
197	198	0	32	126
198	199	0	32	137
199	200	0	30	137

200 rows × 4 columns

In [17]:
```
y = data.iloc[:,-1]
y
```

Out[17]:
```
0      39
1      81
2       6
3      77
4      40
       ..
195    79
196    28
197    74
198    18
199    83
Name: Spending Score (1-100), Length: 200, dtype: int64
```

In [18]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.30,
```

In [31]:
```
scaler = StandardScaler()
scaler.fit(X)
```

Out[31]:
```
▾ StandardScaler
StandardScaler()
```

In [34]:
```
scaler.mean_
```

Out[34]:
```
array([100.5 ,   0.56,  38.85,  60.56])
```

In [35]:
```
scaled_X = scaler.transform(X)
scaled_X
```

Out[35]:
```
array([[-1.7234121 , -1.12815215, -1.42456879, -1.73899919],
       [-1.70609137, -1.12815215, -1.28103541, -1.73899919],
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       [-1.6541292 ,  0.88640526, -0.56336851, -1.66266033],
       [-1.63680847,  0.88640526, -1.20926872, -1.66266033],
       [-1.61948775,  0.88640526, -0.27630176, -1.62449091],
       [-1.60216702,  0.88640526, -1.13750203, -1.62449091],
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       [-1.53288413,  0.88640526, -0.27630176, -1.58632148],
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       [-1.48092195, -1.12815215, -0.13276838, -1.54815205],
       [-1.46360123, -1.12815215, -1.20926872, -1.54815205],
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```

```
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       [ 1.55020485,  0.88640526, -0.20453507,  1.61991057],
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       [ 1.5848463 ,  0.88640526, -0.49160182,  1.61991057],
       [ 1.60216702, -1.12815215, -0.41983513,  2.00160487],
       [ 1.61948775,  0.88640526, -0.06100169,  2.00160487],
       [ 1.63680847,  0.88640526,  0.58489852,  2.26879087],
       [ 1.6541292 ,  0.88640526, -0.27630176,  2.26879087],
       [ 1.67144992,  0.88640526,  0.44136514,  2.49780745],
       [ 1.68877065, -1.12815215, -0.49160182,  2.49780745],
       [ 1.70609137, -1.12815215, -0.49160182,  2.91767117],
       [ 1.7234121 , -1.12815215, -0.6351352 ,  2.91767117]])
```

In [45]:
```
kmeans = KMeans(n_clusters=6, random_state=0).fit(X_train)
```

In [46]:
```
y_train.unique()
# 73 unique values
```

Out[46]:
```
array([57, 52, 95, 91, 59, 75, 48, 50, 56, 26, 28, 83, 49, 20, 44, 92, 51
,
       55,  4, 13, 42, 82, 60, 66, 16, 41, 39, 87, 77, 73, 74, 17, 85, 24
,
       68, 65, 34, 90, 69, 36, 35, 27, 15, 99,  5, 46,  6, 11, 89, 22, 14
,
       43, 12, 97, 40, 71, 47, 31, 88, 32,  8, 29, 61,  1, 58, 93, 76, 86
,
       45, 72,  3, 79, 78])
```

In [47]:
```
kmeans.labels_
```

Out[47]:
```
array([2, 3, 3, 5, 0, 1, 5, 2, 3, 1, 2, 1, 0, 5, 2, 5, 3, 5, 2, 1, 3, 3,
       1, 5, 1, 4, 1, 2, 4, 0, 1, 4, 3, 3, 0, 4, 4, 4, 5, 0, 1, 0, 0, 0,
       1, 2, 3, 0, 0, 1, 2, 2, 3, 5, 5, 5, 5, 4, 2, 4, 4, 3, 3, 5, 4, 2,
       5, 5, 5, 3, 1, 3, 1, 2, 5, 5, 4, 2, 1, 3, 5, 4, 2, 5, 0, 3, 2, 0,
       0, 2, 3, 0, 3, 5, 5, 5, 3, 4, 4, 1, 1, 4, 1, 5, 3, 5, 1, 3, 3, 5,
       2, 5, 4, 3, 0, 0, 4, 1, 2, 3, 3, 1, 2, 2, 4, 2, 5, 1, 4, 3, 4, 0,
       5, 5, 2, 2, 1, 4, 2, 4], dtype=int32)
```

In [48]:
```
kmeans.cluster_centers_
```

Out[48]:
```
array([[189.05882353,   0.70588235,  37.70588235, 106.52941176],
       [ 49.04545455,   0.54545455,  44.5       ,  40.31818182],
       [122.91666667,   0.58333333,  33.16666667,  68.25      ],
       [ 89.5       ,   0.53846154,  48.42307692,  56.92307692],
       [ 17.54545455,   0.54545455,  33.09090909,  22.5       ],
       [158.        ,   0.44827586,  37.4137931 ,  80.62068966]])
```

In [49]:
```
predicted = kmeans.predict(X_test)
predicted
```

Out[49]:
```
array([1, 4, 4, 0, 1, 4, 5, 1, 1, 4, 3, 4, 3, 5, 2, 1, 3, 3, 2, 0, 5, 2,
       1, 3, 3, 2, 2, 4, 1, 5, 5, 1, 3, 3, 4, 0, 2, 5, 1, 5, 0, 4, 4, 2,
       1, 3, 2, 0, 1, 2, 4, 1, 3, 5, 4, 1, 5, 3, 3, 1], dtype=int32)
```

In [50]:
```
mean_distance = np.array(kmeans.fit_transform(X_test))
mean_distance
```

Out[50]:
```
array([[ 45.84848234, 111.2227309 ,  51.60406153,   9.46003105,
        154.10163043,  58.52773588],
       [ 95.19672613, 171.05513586,  17.4158692 ,  64.16768803,
        214.10000584, 122.73454524],
       [ 79.65812367, 154.03672955,   3.80515002,  44.72965669,
        197.39886651, 104.01112464],
       [133.39071682,  64.91424731, 213.29122306, 167.47646756,
         18.68990369, 111.61111648],
       [ 42.58423026, 117.38996958,  39.72588367,  14.35242793,
        160.18056218,  68.82088382],
       [ 80.97787764, 155.34344781,   3.1589819 ,  46.059659  ,
        198.75817593, 105.31789736],
       [ 74.81588512,  15.9358217 , 156.1691791 , 112.29700436,
         50.60941118,  59.26861391],
       [ 46.07331115, 115.1569895 ,  44.81419976,   5.32608557,
        158.30449299,  63.34569982],
       [ 25.9566947 ,  99.68562153,  57.10790226,  15.94105353,
        142.89091119,  51.73573984],
       [ 98.36200147, 174.35868322,  21.1221645 ,  67.7872937 ,
        217.308105  , 126.26359676],
       [ 26.80329582,  69.22982446,  90.25415503,  42.82367555,
        112.52249775,  16.8723942 ],
       [100.31658221, 168.29558805,  35.74184056,  59.81945492,
        211.54033303, 115.27376684],
       [ 16.78541033,  92.41726253,  65.4724815 ,  25.75348884,
        134.83068086,  47.43555872],
       [ 54.48317783,  22.53573838, 135.26324642,  90.40805931,
         66.80428504,  37.20148402],
       [ 35.2242814 ,  42.14202669, 116.65967241,  73.05899799,
         85.057701  ,  29.35124985],
       [ 43.61670169, 107.35093451,  55.67446303,  11.47789996,
```

```
 150.30240351,  54.49057846],
[ 47.54383942,  64.90794499, 105.26939647,  58.07854326,
 106.68792106,  16.75072467],
[ 13.51850583,  89.93101121,  68.46760183,  29.75932102,
 132.37376062,  46.68701839],
[ 21.00991829,  57.28354876, 102.44988612,  60.70001802,
 100.0840272 ,  31.54571653],
[102.92594425,  28.24479766, 183.82141469, 138.19412863,
  21.59427007,  80.95254196],
[ 70.65467666,  15.54890977, 147.78524678, 101.07728324,
  58.67548466,  41.94417778],
[ 48.03557709,  36.54816815, 123.07238724,  76.13716036,
  80.70509587,  17.14233077],
[ 32.39470121, 108.99852149,  50.83285519,  24.77886574,
 151.35822574,  64.65323907],
[  4.05174859,  80.68933384,  77.91648841,  37.71594076,
 123.16985224,  40.07884791],
[ 46.20335486,  71.50616918,  99.19078838,  52.21103511,
 113.09426378,  20.94463382],
[ 35.12477758,  44.40153002, 112.48990695,  66.47738102,
  89.05510934,  14.18531425],
[ 52.24700948,  29.59645947, 129.02898576,  82.38320331,
  74.3088992 ,  23.98191467],
[ 99.67656027, 175.58123076,  21.69437331,  68.71948186,
 218.60995517, 127.31330522],
[ 47.68035934, 123.30245686,  34.29255264,  20.84147757,
 166.0656873 ,  75.48115632],
[ 87.21477321,  10.58495736, 167.15904353, 121.24197783,
  38.5397522 ,  63.37726474],
[ 71.40786605,   7.61251688, 151.7288563 , 106.63426835,
  53.28989116,  50.83883139],
[ 56.03942065, 132.42989725,  28.28979498,  31.67794481,
 174.85082928,  85.86112177],
[ 27.41198035,  91.61354333,  67.25185871,  19.70069003,
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[  4.44409721,  77.09230273,  82.94965843,  43.67627717,
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[100.77739495,  30.54870113, 176.99947034, 129.67311667,
  40.71010317,  70.08076804],
[ 42.25024655,  37.64843899, 119.68282737,  73.33905636,
  82.05067032,  17.36887118],
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[ 55.72925623, 124.91832042,  37.43633485,  14.92036151,
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[ 93.20452421,  21.39340286, 170.48600871, 123.50755923,
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[109.45508972,  34.23376131, 190.02143519, 144.01993677,
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[ 92.96280618, 168.75761385,  15.03260346,  61.72614671,
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  72.15478155,  40.26441531],
```

```
       [ 35.3282229 , 110.9444802 ,  46.70987583,  16.66184826,
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       [ 42.9000777 ,  99.38284768,  66.68692401,  21.79144758,
        142.17880468,  45.92429991],
       [ 13.28219359,  63.52555287,  94.06015363,  50.776394  ,
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       [134.06621498,  65.58509708, 214.1509884 , 168.46028371,
         19.03450814, 112.70817287],
       [ 47.28724282, 114.37714908,  47.51293683,   7.86556975,
        157.40016677,  61.9739348 ],
       [ 48.31235177,  57.10950768, 111.27209518,  63.86894541,
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       [ 79.87333723, 150.05891405,  23.08995092,  39.86373273,
        193.25840861,  97.69500524],
       [ 52.25657853, 127.2104393 ,  29.94404504,  20.89239545,
        170.00238969,  78.30619071],
       [ 28.7995949 ,  66.33417777,  93.52172208,  46.06644318,
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       [ 76.18890995,   4.30068224, 156.53321   , 111.22608591,
         48.42326404,  54.80084152],
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       [ 45.68460718,  83.09657828,  88.32220842,  42.19884107,
        124.66680593,  30.60964575],
       [ 46.42646515, 121.24147751,  35.66014348,  16.59419138,
        164.24923896,  72.54807468]])
```

In [54]:
```
np.shape(mean_distance)
```

Out[54]:
```
(60, 6)
```

In [55]:
```
mean_distance.mean(0)
```

Out[55]:
```
array([ 59.34643335,  85.2969965 ,  87.03255465,  60.83440601,
       121.61945562,  62.168689  ])
```

In [56]:
```
mean_distance.mean()
```

Out[56]:
```
79.38308918904679
```

In [57]:
```
sse = {}
for k in range(1, 30):
    kmeans = KMeans(n_clusters=k, max_iter=2000).fit(data)
    elbow_prediction = kmeans.labels_
    print(elbow_prediction)
    sse[k] = kmeans.inertia_
print(sse)
```

```
[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0
```

```
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0]
[0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1
1
 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1
 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1
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1
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2
 2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
2
 2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0]
[0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  2  0  2  2  0  2  2  2  2  2  2  2  2  2  2  2
2
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2
 2  2  2  2  2  2  2  2  2  2  2  2  1  2  1  2  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3
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3
 1  3  1  3  1  3  1  3  1  3  1  3  1  3  1]
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0
 4  0  4  0  4  0  4  0  4  0  0  0  0  0  4  4  2  0  0  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
2
 2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
2
 2  2  2  2  2  2  2  2  2  2  2  2  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3
1
 3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1  3  1
3
 1  3  1  3  1  3  1  3  1  3  1  3  1  3  1]
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3
 1  3  1  3  1  3  1  3  1  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4  4
4
```

```
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2
 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2
5
 2 5 2 5 2 5 2 5 2 5 2 5 2 5 2]
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5
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0
 0 0 0 0 0 0 0 0 0 0 0 0 0 6 0 6 0 6 2 6 2 6 0 6 2 6 2 6 2 6 2 6 2 6 2 6
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1
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3
 3 3 3 3 3 3 3 3 3 3 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
7
 7 7 7 7 7 7 7 7 7 7 7 7 7 0 6 0 6 0 6 0 6 0 6 0 6 0 6 0 6 0 6 0 6 0 6 0
0
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2
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0
 0 8 0 0 8 0 0 6 0 6 8 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6
6
 6 6 6 6 6 6 6 6 6 6 6 6 6 4 2 4 2 4 2 4 2 4 2 4 2 4 2 4 2 4 2 4 2 4 2 4
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7
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5
 5 7 5 5 7 5 5 5 5 5 7 5 5 7 7 5 5 7 2 7 7 7 2 7 2 7 7 2 2 7 2 7 2 2 2 2
2
 7 2 7 7 7 2 2 2 2 7 2 2 6 8 6 2 6 8 6 8 6 8 6 8 6 8 6 8 6 8 6 8 6 8 6 8
6
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3
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  6  6 10  6  6 10 10 10 10 10  6 10 10  6 10 10 10  6 10 10  6  6 10 10
 10 10 10  6 10 10  6  5  5  5  5  5  0  5  5  0  0  5  5  0  5  5  0  0
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  0  0  0  7  8  7  8  7  8  7  8  7  8  7  8  7  8  7  8  7  8  7  8  7
```

```
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In [58]:
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plt.plot(list(sse.keys()), list(sse.values()))
plt.xlabel("Number of clusters")
plt.ylabel("SSE")
plt.show()
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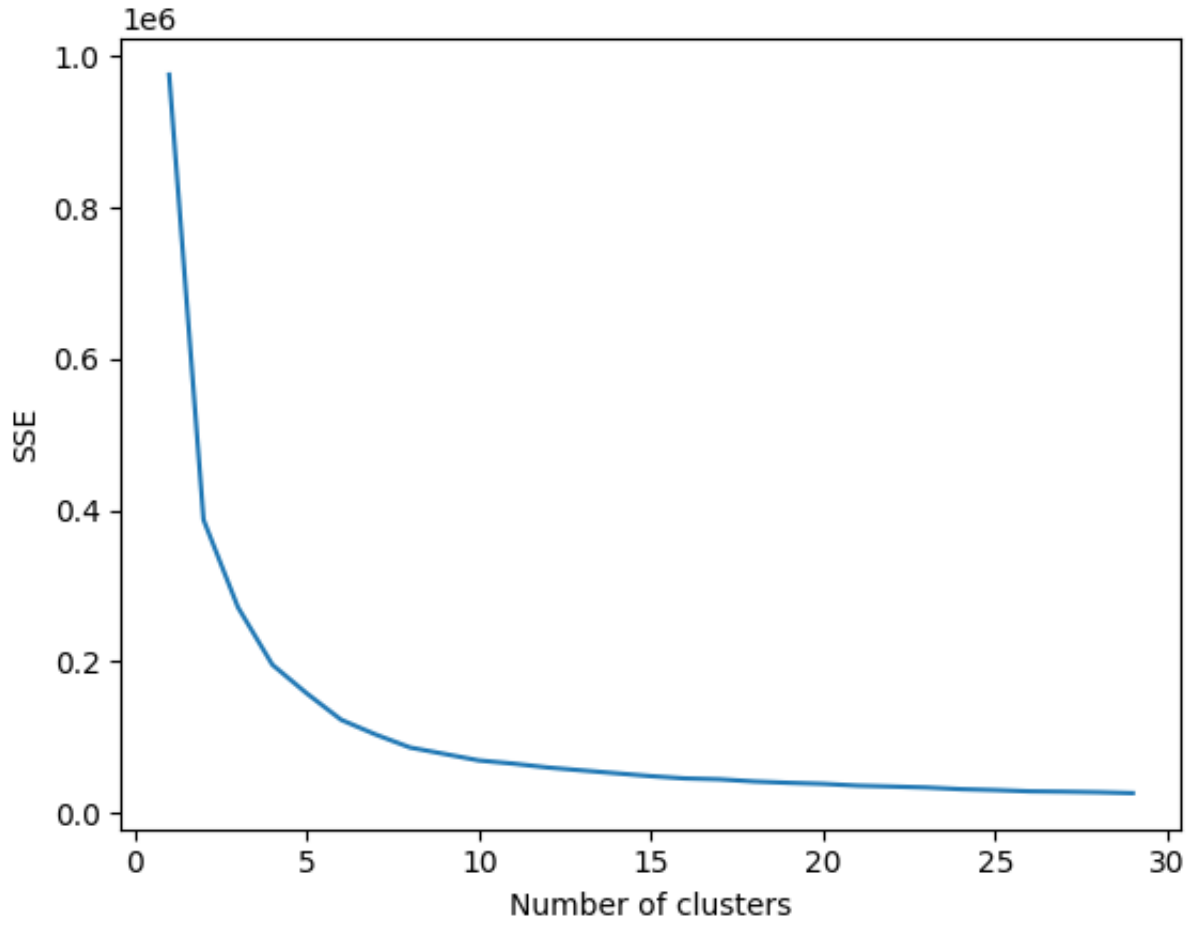

In [ ]:
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