

```

import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import scipy as sp
import plotly.express as px
import plotly.graph_objects as go
import plotly.io as pio
import scipy.stats as st
%matplotlib inline

from sklearn.preprocessing import LabelEncoder
from sklearn.cluster import KMeans
from mpl_toolkits.mplot3d import Axes3D
from yellowbrick.cluster import KElbowVisualizer
from termcolor import colored

from warnings import filterwarnings
filterwarnings("ignore")

from sklearn import set_config
set_config(print_changed_only = False)

print(colored("Required libraries were succesfully imported...",
              color = "green", attrs = ["bold", "dark"]))

```

Required libraries were succesfully imported...

```
df = pd.read_csv("Mall_Customers.csv")
```

```
df.head(n = 7)
```

	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
5	6	Female	22	17	76
6	7	Female	35	18	6

```
df.index = df.iloc[:, 0]
df.head(n = 7)
```

	CustomerID	Gender	Age	Annual Income (k\$)	\
CustomerID					
1	1	Male	19	15	
2	2	Male	21	15	
3	3	Female	20	16	
4	4	Female	23	16	
5	5	Female	31	17	

6	6	Female	22	17
7	7	Female	35	18

Spending Score (1-100)

CustomerID

1	39
2	81
3	6
4	77
5	40
6	76
7	6

```
dff = df.drop(["CustomerID"], axis = 1)
```

```
dff.index.name = None
```

```
print(colored("'CustomerID' variable was succesfully dropped...",
              color = "green", attrs = ["bold", "dark"]))
```

```
dff.head(n = 7)
```

```
'CustomerID' variable was succesfully dropped...
```

	Gender	Age	Annual Income (k\$)	Spending Score (1-100)
1	Male	19	15	39
2	Male	21	15	81
3	Female	20	16	6
4	Female	23	16	77
5	Female	31	17	40
6	Female	22	17	76
7	Female	35	18	6

```
dff.rename(columns = {"Annual Income (k$)": "annual_income",
                     "Spending Score (1-100)": "spending_score",
                     "Age": "age", "Gender": "gender"}, inplace =
True)
```

```
# Checking Null Values
```

```
print("There is {} null values in this
dataset".format(dff.isnull().sum().sum()))
```

```
There is 0 null values in this dataset
```

```
# Checking Duplicate Values
```

```
print("There is {} duplicated values in this
dataset".format(dff.duplicated().sum()))
```

```
There is 0 duplicated values in this dataset
```

```
dff.describe()
```

	age	annual_income	spending_score
count	200.000000	200.000000	200.000000
mean	38.850000	60.560000	50.200000
std	13.969007	26.264721	25.823522
min	18.000000	15.000000	1.000000
25%	28.750000	41.500000	34.750000
50%	36.000000	61.500000	50.000000
75%	49.000000	78.000000	73.000000
max	70.000000	137.000000	99.000000

```
dff.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 200 entries, 1 to 200
Data columns (total 4 columns):
#   Column                Non-Null Count  Dtype
---  -
0   gender                 200 non-null   object
1   age                   200 non-null   int64
2   annual_income         200 non-null   int64
3   spending_score        200 non-null   int64
dtypes: int64(3), object(1)
memory usage: 7.8+ KB
```

Data Visualization and Exploratory Data Analysis

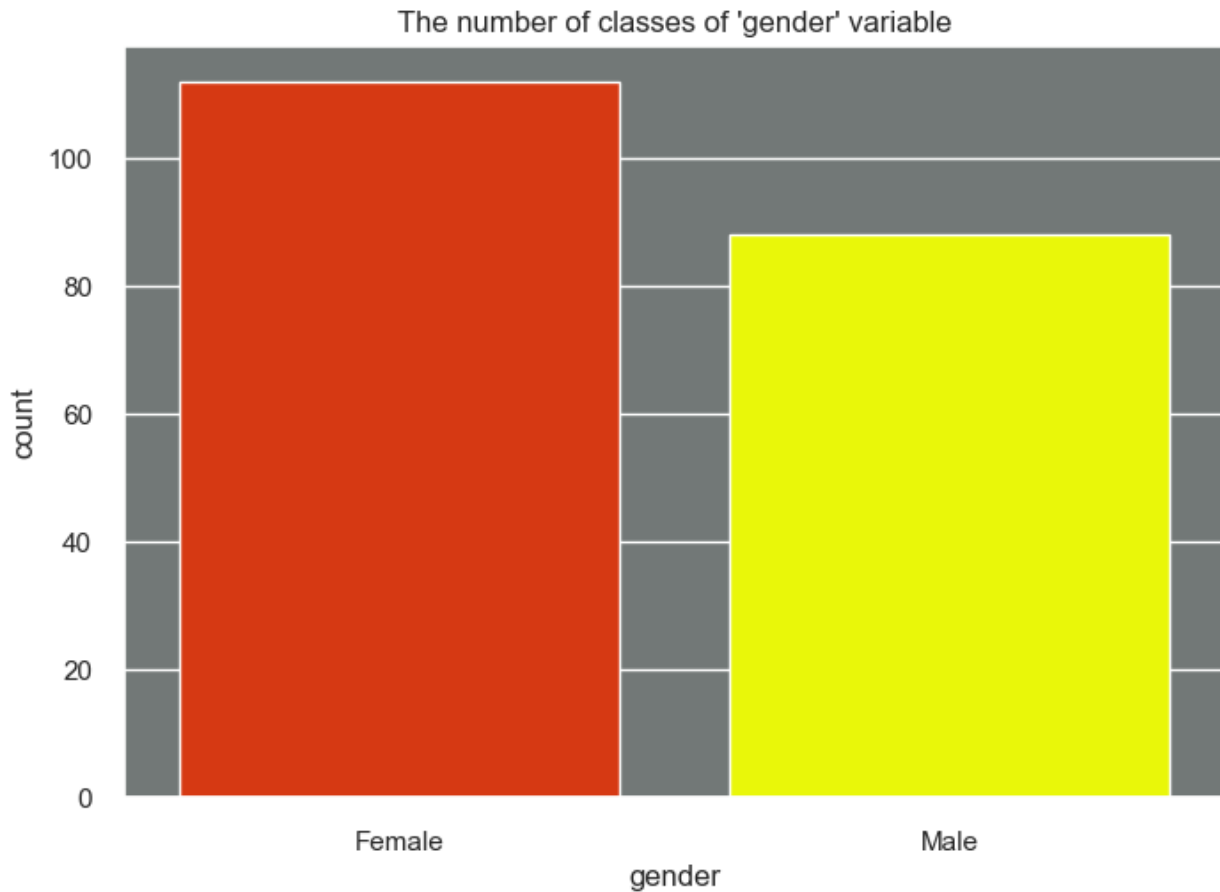
```
sns.set(rc={"axes.facecolor": "#727877", "figure.facecolor": "#ffffff"})

plt.figure(figsize = [10, 7], clear = False)

<Figure size 1000x700 with 0 Axes>

<Figure size 1000x700 with 0 Axes>

sns.barplot(x = dff["gender"].value_counts().index,
            y = dff["gender"].value_counts(), palette = ["#D63913",
            "#E9F709"],
            saturation = 1).set(title = "The number of classes of
'gender' variable");
```

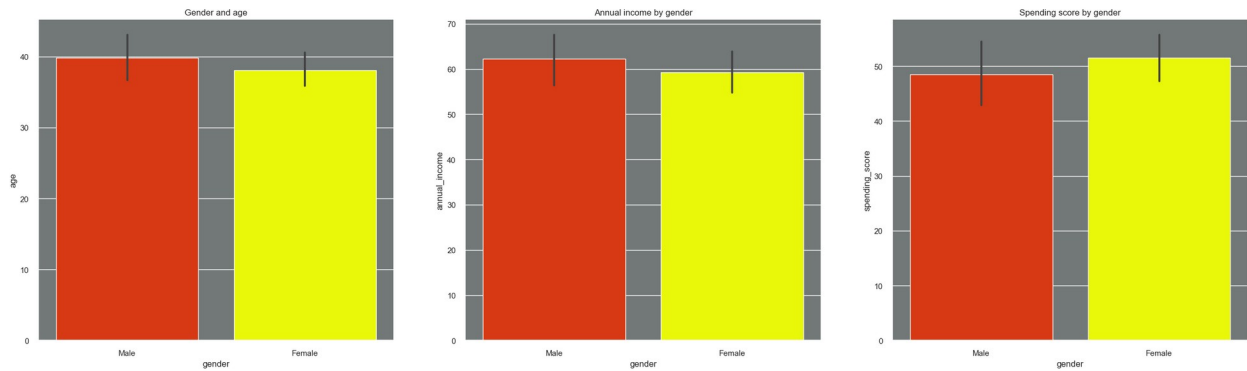


```
fig, axes = plt.subplots(1, 3, figsize = (30, 8))

sns.barplot(ax = axes[0], x = "gender", y = "age", data = dff,
saturation = 1, palette = ["#D63913", "#E9F709"])
axes[0].set_title("Gender and age")

sns.barplot(ax = axes[1], x = "gender", y = "annual_income", data =
dff, saturation = 1, palette = ["#D63913", "#E9F709"])
axes[1].set_title("Annual income by gender")

sns.barplot(ax = axes[2], x = "gender", y = "spending_score", data =
dff, saturation = 1, palette = ["#D63913", "#E9F709"])
axes[2].set_title("Spending score by gender");
```



The graphs above visualize the relationship between 'gender' variable and 'age', 'annual_income' and 'spending_score' variables.

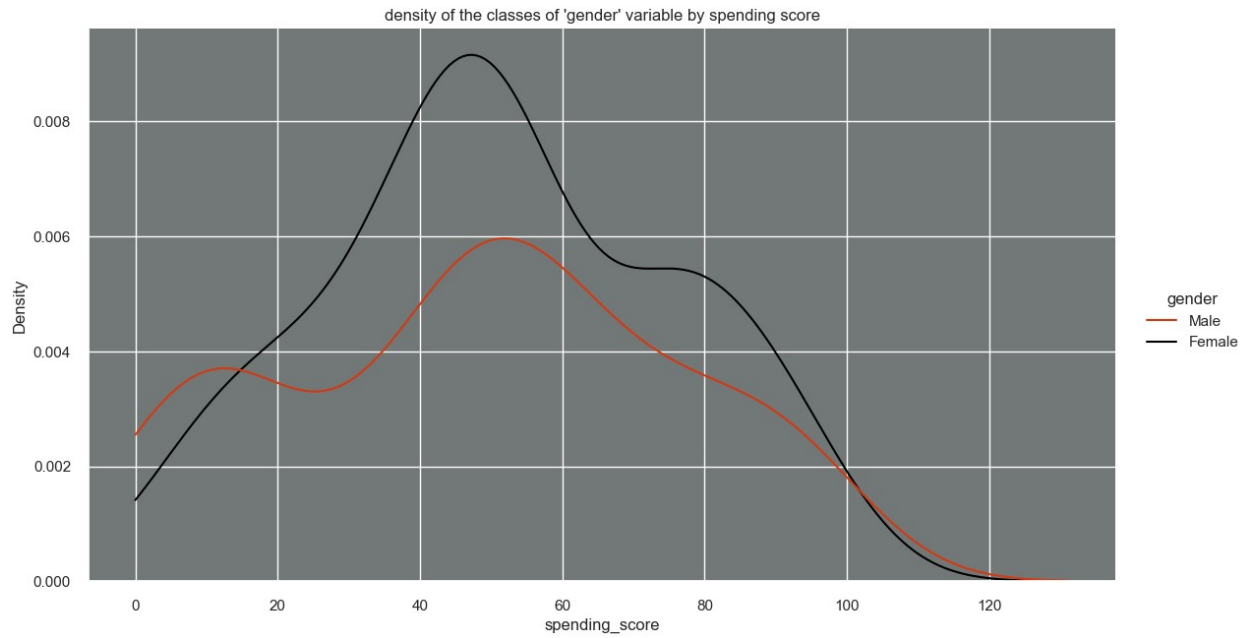
There are no significant differences between the genders (male and female) in the mentioned parameters

```
sns.set(rc={"axes.facecolor": "#727877", "figure.facecolor": "#ffffff"})

sns.displot(data = dff, x = "age", hue = "gender", kind = "kde",
height = 6.5, aspect = 1.8, clip = (0, None),
palette = ["#D63913", "#000000"]).set(title = "density of the
classes of 'gender' variable by age");
```

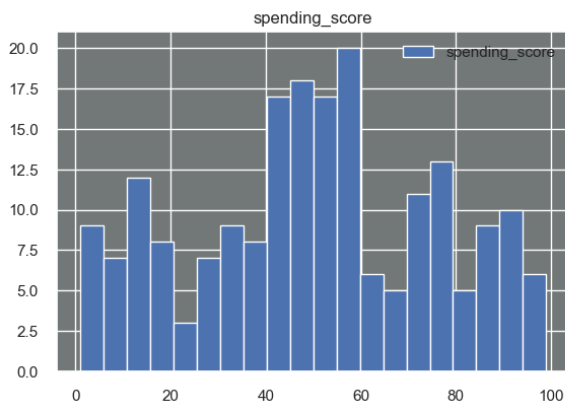
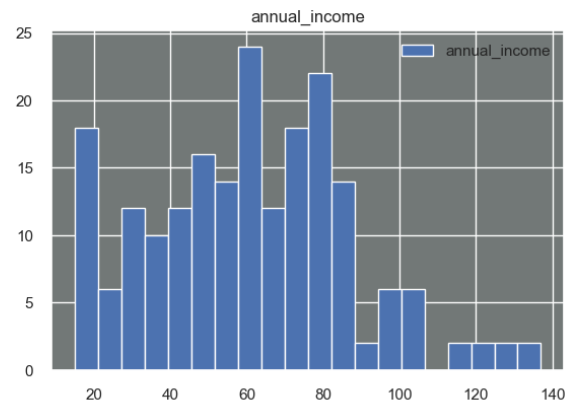
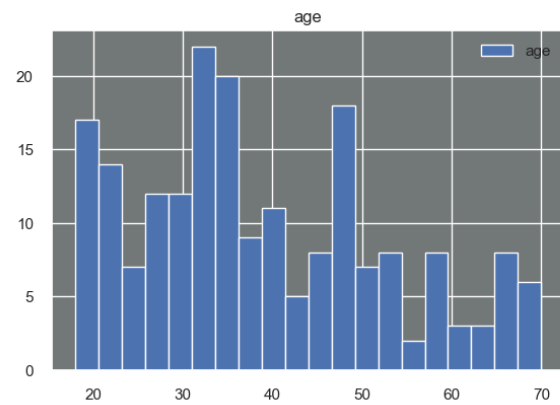


```
sns.displot(data = dff, x = "spending_score", hue = "gender", kind =
"kde", height = 6.5, aspect = 1.8,
clip = (0, None), palette = ["#D63913",
"#000000"]).set(title = "density of the classes of 'gender' variable
by spending score");
```



Histogram

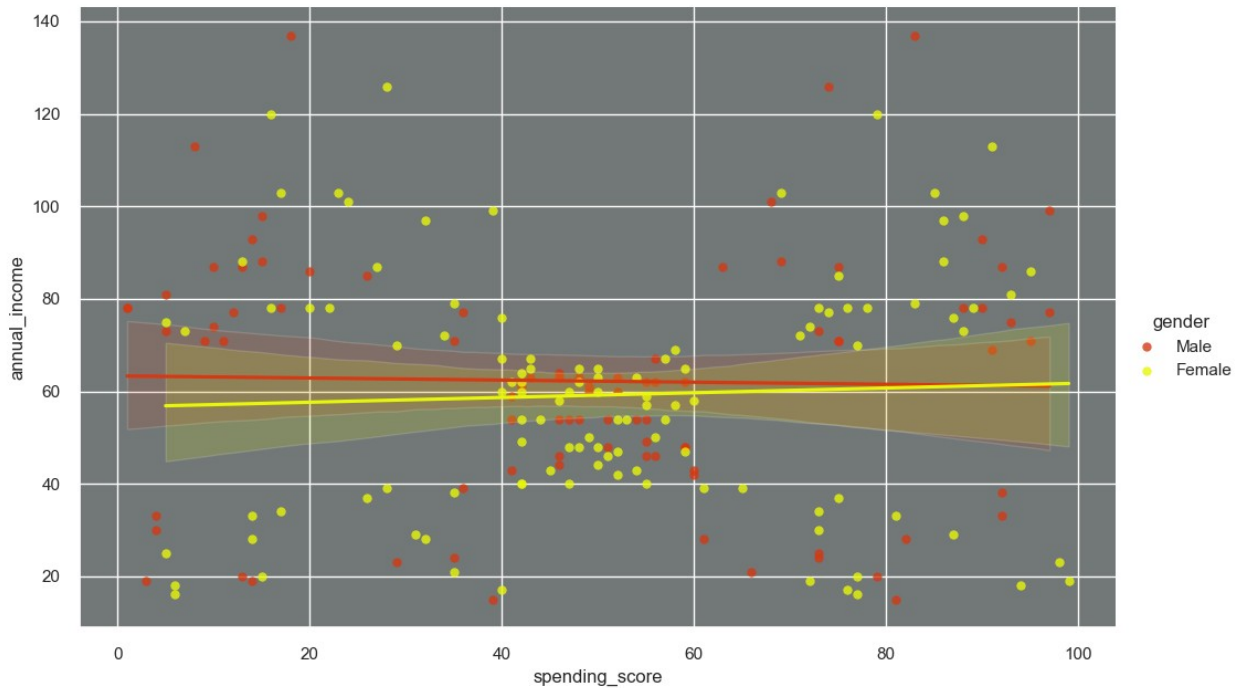
```
dff.hist(figsize = (15, 10), bins = 20, backend = None, legend = True);
```



```
# Lmplot
```

```
sns.set(rc={"axes.facecolor": "#727877", "figure.facecolor": "#ffffff"})

sns.lmplot(x = "spending_score", y = "annual_income", hue = "gender",
data = dff, height = 6.5, aspect = 1.6,
palette = ["#D63913", "#E9F709"]);
```



```
# The graph above shows the relationship between the annual income
# and annual expenditure of women and men separately.
```

```
# Visualization with plotly express...
```

```
px.scatter(dff, x = "age", y = "spending_score", color =
"annual_income", template = "plotly_dark", opacity = 1)
```

```
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```

```

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```



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```

```
fig = px.histogram(dff, x = "age", y = "spending_score", marginal =
"violin", color = "gender", template = "plotly_dark",
                    text_auto = True, width = None, height = None,
nbins = 100, hover_data = dff.columns)
fig.show()
```

```
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fig.show()
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{"text":"Density heatmap of relationship between 'annual_income' and
'spending_score' variables by 'age' variable"},"xaxis":
{"anchor":"y","domain":[0,1],"title":{"text":"age"},"yaxis":
{"anchor":"x","domain":[0,1],"title":{"text":"annual_income"}}}}

# Pearson correlation coefficient between variables...

list = (dff[["age","annual_income"]].corr(),
        dff[["age","spending_score"]].corr(),

```

```

        dff[["annual_income", "spending_score"]].corr()
for corr in list:
    print(corr, "\n\n")

```

	age	annual_income
age	1.000000	-0.012398
annual_income	-0.012398	1.000000

	age	spending_score
age	1.000000	-0.327227
spending_score	-0.327227	1.000000

	annual_income	spending_score
annual_income	1.000000	0.009903
spending_score	0.009903	1.000000

Here we see that there is not correlation between variables.

```

print("Pearson correlation coefficient between 'age' and
'annual_income' variables: \n",
      st.pearsonr(dff["age"], dff["annual_income"])[0])

```

Pearson correlation coefficient between 'age' and 'annual_income' variables:
-0.012398042736060148

```

print("Pearson correlation coefficient between 'age' and
'spending_score' variables: \n",
      st.pearsonr(dff["age"], dff["spending_score"])[0])

```

Pearson correlation coefficient between 'age' and 'spending_score' variables:
-0.3272268460390901

```

print("Pearson correlation coefficient between 'annual_income' and
'spending_score' variables: \n",
      st.pearsonr(dff["annual_income"], dff["spending_score"])[0])

```

Pearson correlation coefficient between 'annual_income' and 'spending_score' variables:
0.009902848094037624

```

print(colored("For 'annual_income' variable:", color = "blue", attrs =
["bold", "dark"]))
test_statistic, pvalue = st.shapiro(dff["annual_income"])
print("Test statistic = %.11f, p-value = %.11f" % (test_statistic,
pvalue))

```



```

print("_____")

print(colored("\nFor 'spending_score' variable:", color = "blue",
attrs = ["bold", "dark"]))
test_statistic, pvalue = st.shapiro(dff["spending_score"])
print("Test statistic = %.11f, p-value = %.11f" % (test_statistic,
pvalue))

For 'annual_income' variable:
Test statistic = 0.97839051485, p-value = 0.00353734032

_____

For 'spending_score' variable:
Test statistic = 0.96946030855, p-value = 0.00024227305

st.spearmanr(dff["annual_income"], dff["spending_score"])

SignificanceResult(statistic=0.007839641317528493,
pvalue=0.9122697727000879)

# Encode 'gender' variable...

# 1 = Male
# 0 = Female

lbe = LabelEncoder()
lbe.fit_transform(dff["gender"])
dff["gender"] = lbe.fit_transform(dff["gender"])

kmeans = KMeans(n_clusters = 2, random_state = 11)
k_fit = kmeans.fit(dff)

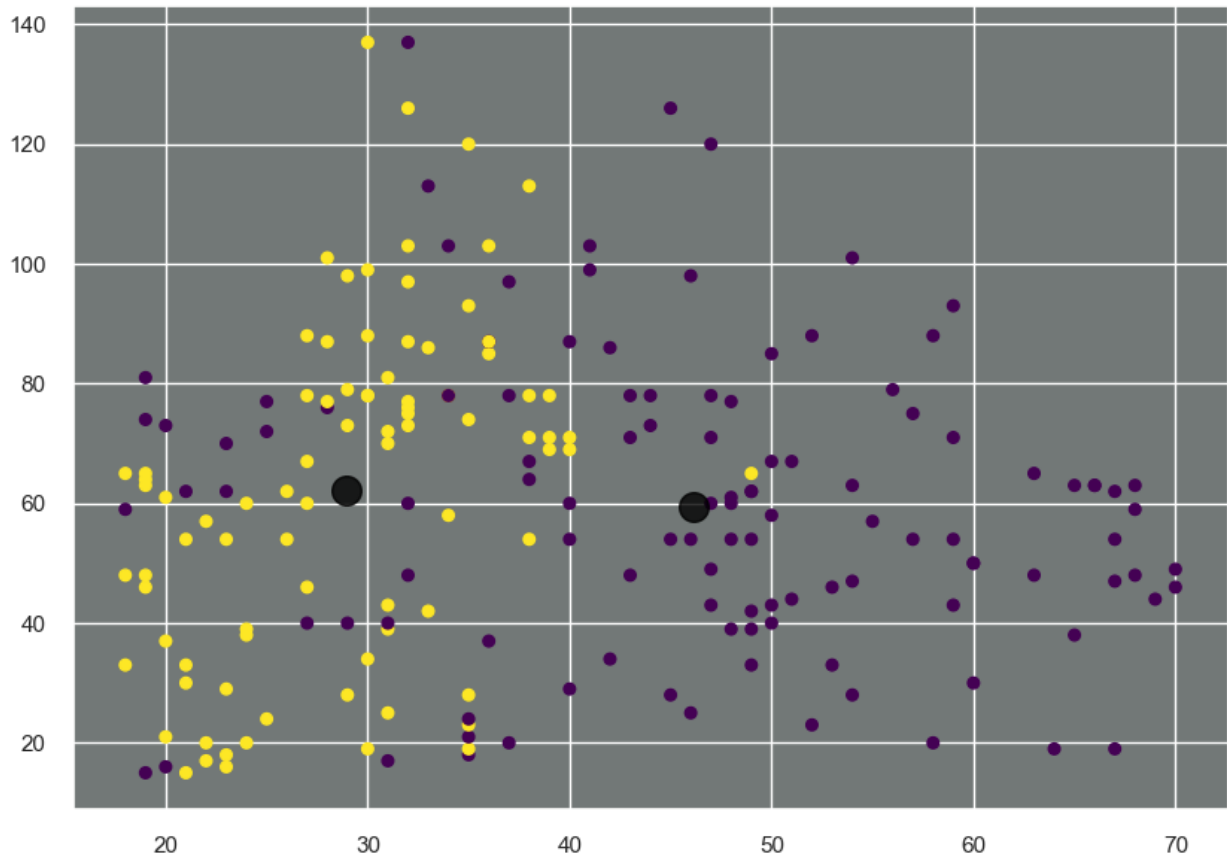
plt.figure(figsize = [10, 7], clear = False)

clusters = k_fit.labels_
centers = k_fit.cluster_centers_

plt.scatter(dff.iloc[:, 1],
            dff.iloc[:, 2],
            c = clusters,
            s = 30,
            cmap = "viridis")

plt.scatter(centers[:, 1],
            centers[:, 2],
            c = "black",
            s = 200,
            alpha = 0.8);

```



```
kmeans = KMeans(n_clusters = 3, random_state = 11)
k_fit = kmeans.fit(dff)
clusters = k_fit.labels_
centers = k_fit.cluster_centers_

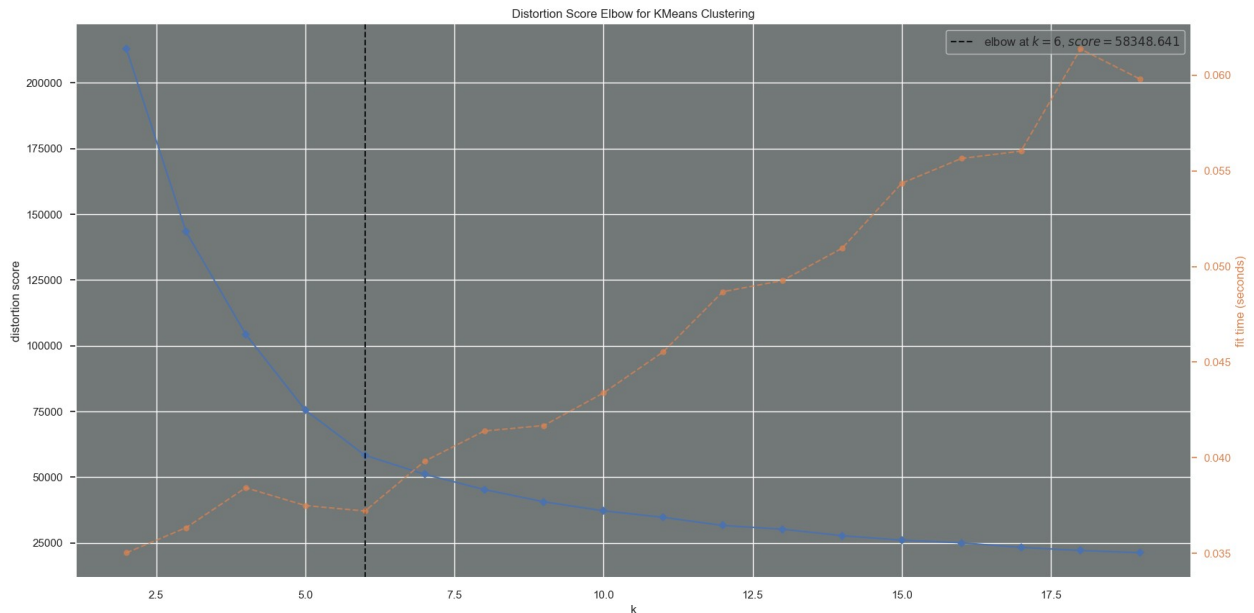
plt.rcParams["figure.figsize"] = (20, 10)
fig = plt.figure()
ax = Axes3D(fig)
ax.scatter(dff.iloc[:, 1], dff.iloc[:, 2], dff.iloc[:, 3]);

fig = plt.figure()
ax = Axes3D(fig)
ax.scatter(dff.iloc[:, 1], dff.iloc[:, 2], dff.iloc[:, 3], c =
clusters)
ax.scatter(centers[:, 1], centers[:, 2], centers[:, 3],
          marker = '*',
          c = "#8F931F",
          s = 1000);

<Figure size 2000x1000 with 0 Axes>
<Figure size 2000x1000 with 0 Axes>
```



```
kmeans = KMeans(random_state = 11)
visualizer = KElbowVisualizer(kmeans, k = (2, 20), locate_elbow =
True)
visualizer.fit(dff)
visualizer.poof();
```



```
kmeans = KMeans(n_clusters = 6, random_state = 11)
k_fit = kmeans.fit(dff)
clusters = k_fit.labels_
data = pd.DataFrame({"Customer ID": dff.index, "Clusters":
(k_fit.labels_ + 1)})

data.head(n = 7)
```

	Customer ID	Clusters
0	1	6
1	2	2
2	3	6
3	4	2
4	5	6
5	6	2
6	7	6