```python
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.preprocessing import StandardScaler
from sklearn.cluster import KMeans

import warnings
warnings.filterwarnings('ignore')
```

Loading Data

```python
original_df= pd.read_csv('online_retail_II.csv')
df= original_df.copy()
df
```

	Invoice	StockCode	Description	Quantity	InvoiceDate	Price	Customer ID	Country
0	489434	85048	15CM CHRISTMAS GLASS BALL 20 LIGHTS	12	2009-12-01 07:45:00	6.95	13085.0	United Kingdom
1	489434	79323P	PINK CHERRY LIGHTS	12	2009-12-01 07:45:00	6.75	13085.0	United Kingdom
2	489434	79323W	WHITE CHERRY LIGHTS	12	2009-12-01 07:45:00	6.75	13085.0	United Kingdom
3	489434	22041	RECORD FRAME 7" SINGLE SIZE	48	2009-12-01 07:45:00	2.10	13085.0	United Kingdom
4	489434	21232	STRAWBERRY CERAMIC TRINKET BOX	24	2009-12-01 07:45:00	1.25	13085.0	United Kingdom
...	...	...	...	...	...	...	...	...
1067366	581587	22899	CHILDREN'S APRON DOLLY GIRL	6	2011-12-09 12:50:00	2.10	12680.0	France
1067367	581587	23254	CHILDRENS CUTLERY DOLLY GIRL	4	2011-12-09 12:50:00	4.15	12680.0	France
1067368	581587	23255	CHILDRENS CUTLERY CIRCUS PARADE	4	2011-12-09 12:50:00	4.15	12680.0	France
1067369	581587	22138	BAKING SET 9 PIECE RETROSPOT	3	2011-12-09 12:50:00	4.95	12680.0	France
1067370	581587	POST	POSTAGE	1	2011-12-09 12:50:00	18.00	12680.0	France

1067371 rows × 8 columns

Data Cleaning

```python
df.shape
```

```
(1067371, 8)
```

```python
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1067371 entries, 0 to 1067370
Data columns (total 8 columns):
 #   Column       Non-Null Count    Dtype
---  ------       --------------    -----
 0   Invoice      1067371 non-null  object
 1   StockCode    1067371 non-null  object
 2   Description  1062989 non-null  object
 3   Quantity     1067371 non-null  int64
 4   InvoiceDate  1067371 non-null  object
 5   Price        1067371 non-null  float64
 6   Customer ID  824364 non-null   float64
 7   Country      1067371 non-null  object
dtypes: float64(2), int64(1), object(5)
memory usage: 65.1+ MB
```

```python
df['Price'].describe()
```

```
count    1.067371e+06
mean     4.649388e+00
std      1.235531e+02
min     -5.359436e+04
25%      1.250000e+00
50%      2.100000e+00
75%      4.150000e+00
max      3.897000e+04
Name: Price, dtype: float64
```

```python
df.isnull().sum()
```

```
Invoice             0
StockCode           0
Description      4382
Quantity            0
InvoiceDate         0
Price               0
Customer ID    243007
Country             0
dtype: int64
```

```python
df.dropna(subset=['Customer ID'], inplace=True)
df.shape
```

```
(824364, 8)
```

```python
for col in df.columns:
    print(f"-------Value counts for column: {col}------\n")
    print(df[col].value_counts())
```

```
-------Value counts for column: Invoice------

Invoice
576339     542
579196     533
580727     529
578270     442
573576     435
          ...
502263       1
C514528      1
546102       1
C546106      1
C494927      1
Name: count, Length: 44876, dtype: int64
-------Value counts for column: StockCode------

StockCode
85123A    5322
22423     3777
85099B    3446
84879     2794
20725     2755
          ...
21766        1
37477C       1
20939        1
72751C       1
90011E       1
Name: count, Length: 4646, dtype: int64
-------Value counts for column: Description------

Description
WHITE HANGING HEART T-LIGHT HOLDER    5315
REGENCY CAKESTAND 3 TIER              3777
ASSORTED COLOUR BIRD ORNAMENT         2794
JUMBO BAG RED RETROSPOT               2776
LUNCH BAG  BLACK SKULL.               2161
                                      ...
SET 12 COLOURING PENCILS DOILEY          1
SPOTTY COCKEREL DOORSTOP                 1
S/3 ROSE GARDEN SCENT SQU CANDLE         1
RUSSIAN FOLKART STACKING TINS            1
BLUE BAROQUE FLOCK CANDLE HOLDER         1
Name: count, Length: 5299, dtype: int64
-------Value counts for column: Quantity------

Quantity
 1        153683
 12       119842
 2        117920
 6         80249
 4         62209
           ...
 1968          1
 1960          1
 9360          1
 6336          1
-80995         1
Name: count, Length: 643, dtype: int64
-------Value counts for column: InvoiceDate------

InvoiceDate
2011-11-14 15:27:00    543
2011-11-28 15:54:00    534
2011-12-05 17:17:00    530
2011-11-23 13:39:00    444
2011-10-31 14:09:00    436
                      ...
2011-02-11 11:44:00      1
2010-10-04 11:52:00      1
2011-10-19 11:45:00      1
2010-10-04 11:08:00      1
2010-05-04 16:28:00      1
Name: count, Length: 41439, dtype: int64
-------Value counts for column: Price------

Price
1.25      99565
1.65      72549
2.95      64509
0.85      62315
0.42      42600
          ...
75.19         1
280.91        1
129.95        1
1.77          1
224.69        1
Name: count, Length: 1022, dtype: int64
-------Value counts for column: Customer ID------

Customer ID
17841.0    13097
14911.0    11613
12748.0     7307
14606.0     6709
14096.0     5128
           ...
14580.0        1
16154.0        1
16443.0        1
15233.0        1
17948.0        1
Name: count, Length: 5942, dtype: int64
-------Value counts for column: Country------

Country
United Kingdom          741301
Germany                  17624
EIRE                     16195
France                   14202
Netherlands               5140
Spain                     3811
Belgium                   3123
Switzerland               3064
Portugal                  2504
Australia                 1913
Channel Islands           1664
Italy                     1534
Norway                    1455
Sweden                    1345
Cyprus                    1176
Finland                   1049
Austria                    938
Denmark                    817
Greece                     663
Japan                      582
USA                        535
Poland                     535
Unspecified                524
United Arab Emirates       386
Singapore                  346
Israel                     324
Malta                      299
Iceland                    253
Canada                     228
Lithuania                  189
RSA                        123
Brazil                      94
Thailand                    76
Korea                       63
European Community          61
Bahrain                     59
West Indies                 54
Lebanon                     45
Czech Republic              30
Nigeria                     30
Saudi Arabia                10
Name: count, dtype: int64
```

```python
df['Invoice']= df['Invoice'].astype(str)
df['Invoice']= df['Invoice'].replace(r'[a-zA-Z]+', '', regex=True)
df['Invoice'] = df['Invoice'].astype(int)
df['Invoice'].value_counts()
```

```
Invoice
576339    542
579196    533
580727    529
578270    442
573576    435
         ...
502263      1
514528      1
546102      1
546106      1
494927      1
Name: count, Length: 44876, dtype: int64
```

```python
df = df[df['Quantity'] > 0]
df['Quantity'].value_counts()
```

```
Quantity
1        153683
12       119842
2        117920
6         80249
4         62209
          ...
174           1
2304          1
985           1
327           1
80995         1
Name: count, Length: 438, dtype: int64
```

```python
df.dtypes
```

```
Invoice          int32
StockCode       object
Description     object
Quantity         int64
InvoiceDate     object
Price          float64
Customer ID    float64
Country         object
dtype: object
```

```python
df['InvoiceDate'] = pd.to_datetime(df['InvoiceDate'])
df['Customer ID']= df['Customer ID'].astype(int)
```

```python
df.dtypes
```

```
Invoice                 int32
StockCode              object
Description            object
Quantity                int64
InvoiceDate    datetime64[ns]
Price                 float64
Customer ID             int32
Country                object
dtype: object
```

```python
df.columns = df.columns.str.strip().str.lower().str.replace(' ', '_')
```

```python
df.columns
```

```
Index(['invoice', 'stockcode', 'description', 'quantity', 'invoicedate',
       'price', 'customer_id', 'country'],
      dtype='object')
```

```python
df['total_price']= df['quantity'] * df['price']
df.drop('description', axis=1, inplace=True)
df.to_csv('cleaned_df.csv', index=False)
df
```

	invoice	stockcode	quantity	invoicedate	price	customer_id	country	total_price
0	489434	85048	12	2009-12-01 07:45:00	6.95	13085	United Kingdom	83.40
1	489434	79323P	12	2009-12-01 07:45:00	6.75	13085	United Kingdom	81.00
2	489434	79323W	12	2009-12-01 07:45:00	6.75	13085	United Kingdom	81.00
3	489434	22041	48	2009-12-01 07:45:00	2.10	13085	United Kingdom	100.80
4	489434	21232	24	2009-12-01 07:45:00	1.25	13085	United Kingdom	30.00
...	...	...	...	...	...	...	...	...
1067366	581587	22899	6	2011-12-09 12:50:00	2.10	12680	France	12.60
1067367	581587	23254	4	2011-12-09 12:50:00	4.15	12680	France	16.60
1067368	581587	23255	4	2011-12-09 12:50:00	4.15	12680	France	16.60
1067369	581587	22138	3	2011-12-09 12:50:00	4.95	12680	France	14.85
1067370	581587	POST	1	2011-12-09 12:50:00	18.00	12680	France	18.00

805620 rows × 8 columns

RFM Feature Engineering

```python
snapshot_date = df['invoicedate'].max() + pd.Timedelta(days=1)
```

```python
rfm_data = df.groupby('customer_id').agg({
    'invoicedate': lambda date: (snapshot_date - date.max()).days,
    'invoice': 'nunique',
    'total_price': 'sum'
})

rfm_data.rename(columns={'invoicedate': 'recency',
                         'invoice': 'frequency',
                         'total_price': 'monetary'}, inplace=True)
```

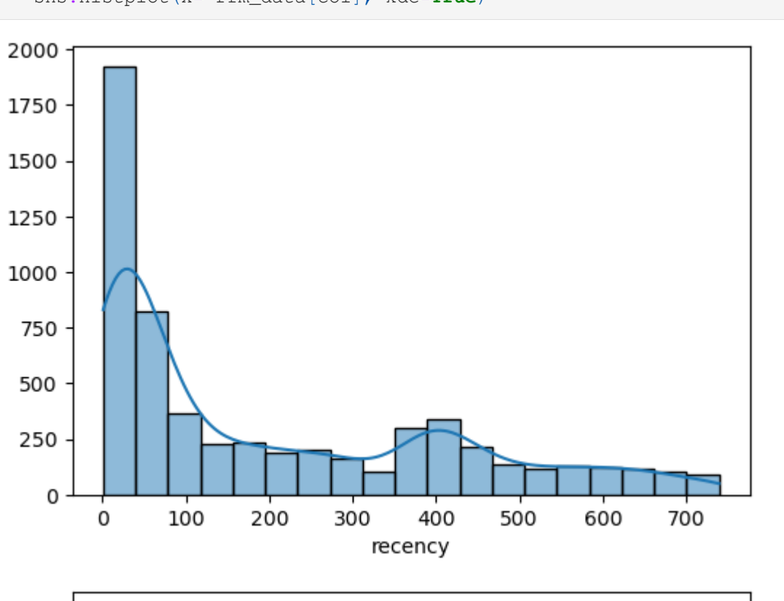
```python
rfm_data
```

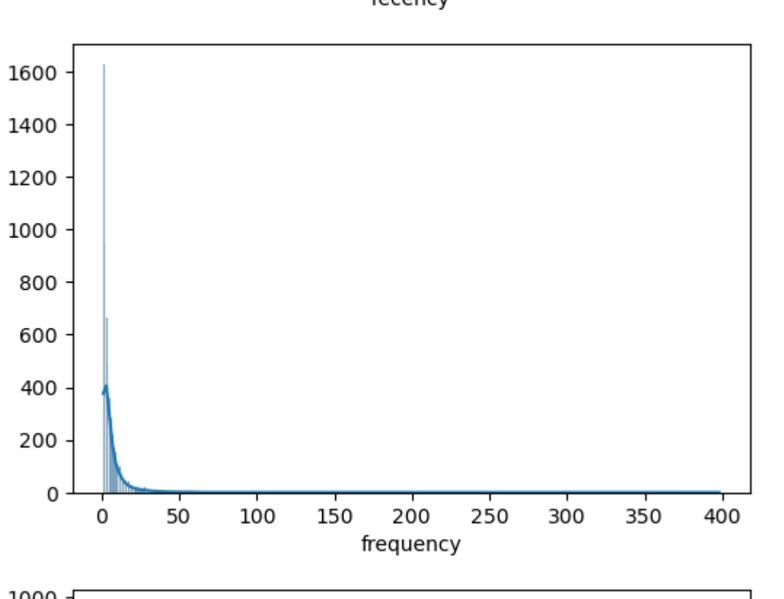
customer_id	recency	frequency	monetary
12346	326	12	77556.46
12347	2	8	5633.32
12348	75	5	2019.40
12349	19	4	4428.69
12350	310	1	334.40
...	...	...	...
18283	4	22	2736.65
18284	432	1	461.68
18285	661	1	427.00
18286	477	2	1296.43
18287	43	7	4182.99

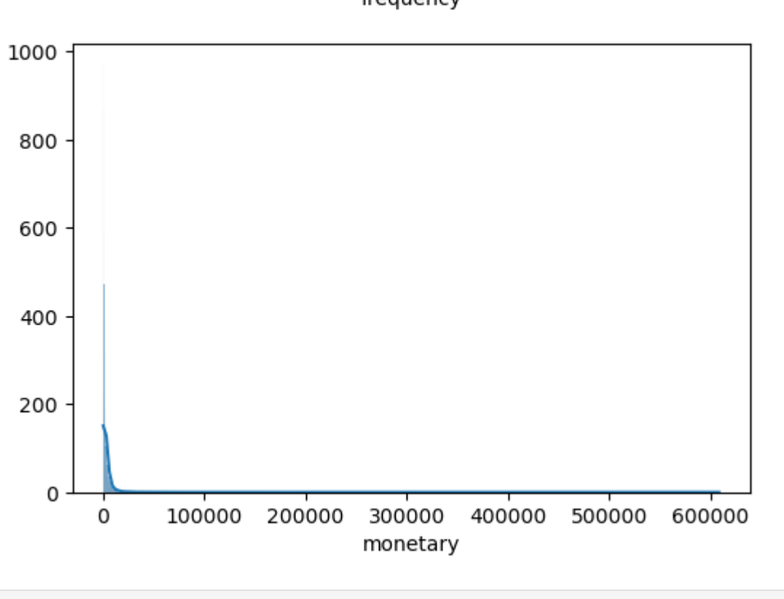
5881 rows × 3 columns

EDA

```python
rfm_cols= ['recency', 'frequency', 'monetary']
for col in rfm_cols:
    plt.figure(figsize=(6,4))
    sns.histplot(x= rfm_data[col], kde=True)
```





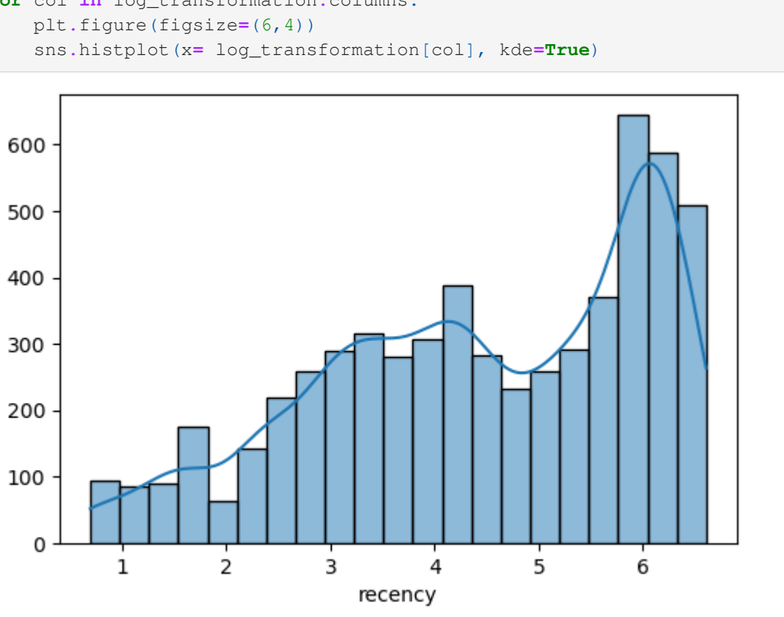


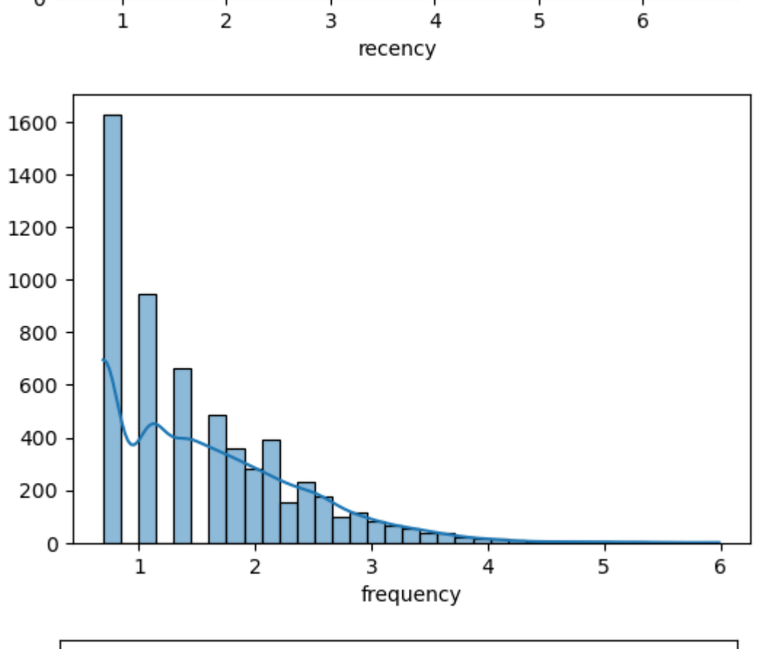

```python
log_transformation= np.log1p(rfm_data)
log_transformation
```

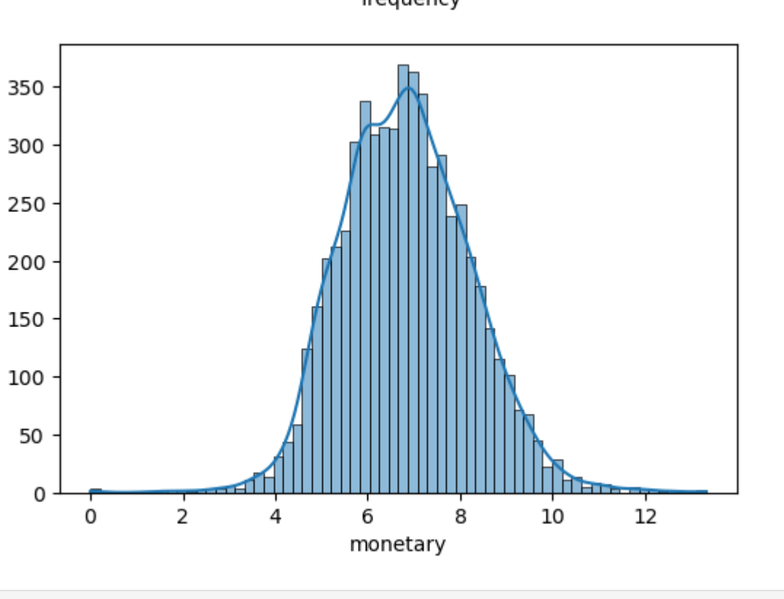
customer_id	recency	frequency	monetary
12346	5.789960	2.564949	11.258774
12347	1.098612	2.197225	8.636632
12348	4.330733	1.791759	7.611051
12349	2.995732	1.609438	8.396085
12350	5.739793	0.693147	5.815324
...	...	...	...
18283	1.609438	3.135494	7.914855
18284	6.070738	0.693147	6.137036
18285	6.495266	0.693147	6.059123
18286	6.169611	1.098612	7.168141
18287	3.784190	2.079442	8.339021

5881 rows × 3 columns

```python
for col in log_transformation.columns:
    plt.figure(figsize=(6,4))
    sns.histplot(x= log_transformation[col], kde=True)
```







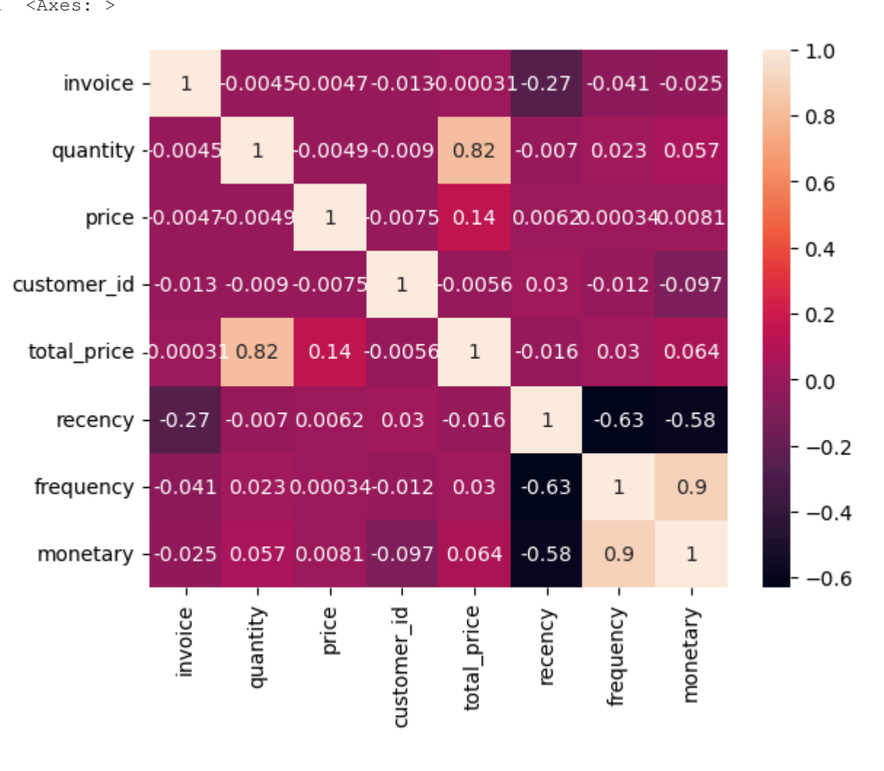

```python
merged_df= pd.merge(df, log_transformation, on='customer_id')
merged_df
```

	invoice	stockcode	quantity	invoicedate	price	customer_id	country	total_price	recency	frequency	monetary
0	489434	85048	12	2009-12-01 07:45:00	6.95	13085	United Kingdom	83.40	5.068904	2.197225	7.797406
1	489434	79323P	12	2009-12-01 07:45:00	6.75	13085	United Kingdom	81.00	5.068904	2.197225	7.797406
2	489434	79323W	12	2009-12-01 07:45:00	6.75	13085	United Kingdom	81.00	5.068904	2.197225	7.797406
3	489434	22041	48	2009-12-01 07:45:00	2.10	13085	United Kingdom	100.80	5.068904	2.197225	7.797406
4	489434	21232	24	2009-12-01 07:45:00	1.25	13085	United Kingdom	30.00	5.068904	2.197225	7.797406
...	...	...	...	...	...	...	...	...	...	...	...
805615	581587	22899	6	2011-12-09 12:50:00	2.10	12680	France	12.60	0.693147	1.609438	6.781977
805616	581587	23254	4	2011-12-09 12:50:00	4.15	12680	France	16.60	0.693147	1.609438	6.781977
805617	581587	23255	4	2011-12-09 12:50:00	4.15	12680	France	16.60	0.693147	1.609438	6.781977
805618	581587	22138	3	2011-12-09 12:50:00	4.95	12680	France	14.85	0.693147	1.609438	6.781977
805619	581587	POST	1	2011-12-09 12:50:00	18.00	12680	France	18.00	0.693147	1.609438	6.781977

805620 rows × 11 columns

```python
sns.heatmap(merged_df.corr(numeric_only= True), annot=True)
```

```
<Axes: >
```



Customer Segmentation with K-Means Clustering

```python
scaler= StandardScaler()
df_scaled= scaler.fit_transform(log_transformation)
df_scaled
```

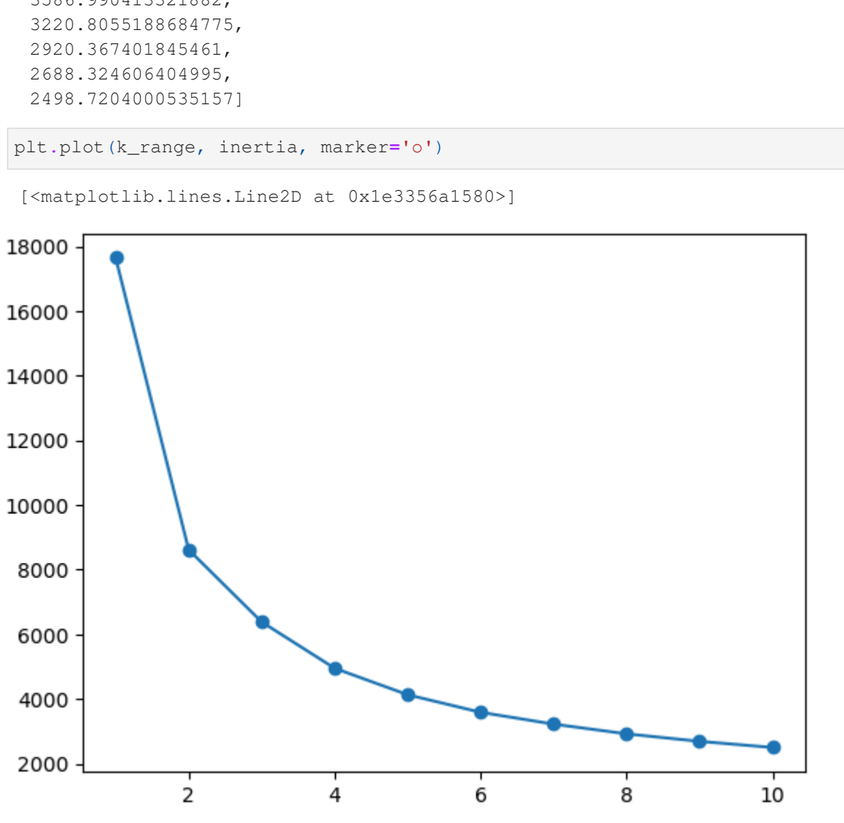
```
array([[ 0.85632068,  1.25493788,  3.17038719],
       [-2.15192393,  0.80063464,  1.2919986 ],
       [-0.07938295,  0.29970536,  0.55731714],
       ...,
       [ 1.3085854 , -1.05756818, -0.55441609],
       [ 1.09976495, -0.5566389 ,  0.24003565],
       [-0.42984452,  0.65512034,  1.07880297]])
```

```python
inertia= []
k_range= range(1,11)

for k in k_range:
    kmeans= KMeans(n_clusters=k)
    kmeans.fit(df_scaled)
    inertia.append(kmeans.inertia_)

inertia
```

```
[17643.0,
 8614.946158654508,
 6382.423057117466,
 4949.228804709554,
 4129.989857438568,
 3586.990413321882,
 3220.8055188684775,
 2920.367401845461,
 2688.324606404995,
 2498.7204000535157]
```

```python
plt.plot(k_range, inertia, marker='o')
```

```
[<matplotlib.lines.Line2D at 0x1e3356a1580>]
```



```python
kmeans_final= KMeans(n_clusters=4)
kmeans_final
```

```
KMeans
KMeans(n_clusters=4)
```

```python
cluster_labels= kmeans_final.fit_predict(df_scaled)
cluster_labels
```

```
array([1, 1, 0, ..., 3, 0, 1])
```

```python
rfm_data['cluster']= cluster_labels
rfm_data['cluster'].value_counts()
```

```
cluster
3    1972
0    1467
2    1252
1    1190
Name: count, dtype: int64
```

```python
# Calculate the mean RFM values and count for each cluster
cluster_summary = rfm_data.groupby('cluster').agg({
    'recency': 'mean',
    'frequency': 'mean',
    'monetary': 'mean',
    'cluster': 'size'  # Get the number of customers in each cluster
}).rename(columns={'cluster': 'Size'})


cluster_summary.sort_values(by='monetary', ascending=False, inplace=True)


cluster_summary
```

cluster	recency	frequency	monetary	Size
1	27.505042	19.329412	11001.208703	1190
0	228.783913	5.075665	1995.093748	1467
2	28.376997	3.045527	868.233196	1252
3	395.987830	1.376268	323.610716	1972

```python
label_map = {
    0: 'Champions',
    1: 'Lost Customers',
    2: 'At-Risk Loyalists',
    3: 'New/Promising'
}

rfm_data['Segment'] = rfm_data['cluster'].map(label_map)

rfm_data.to_csv('rfm_data.csv')
rfm_data
```

customer_id	recency	frequency	monetary	cluster	Segment
12346	326	12	77556.46	1	Lost Customers
12347	2	8	5633.32	1	Lost Customers
12348	75	5	2019.40	0	Champions
12349	19	4	4428.69	2	At-Risk Loyalists
12350	310	1	334.40	3	New/Promising
...	...	...	...	...	...
18283	4	22	2736.65	1	Lost Customers
18284	432	1	461.68	3	New/Promising
18285	661	1	427.00	3	New/Promising
18286	477	2	1296.43	0	Champions
18287	43	7	4182.99	1	Lost Customers

5881 rows × 5 columns

```python
plt.figure(figsize=(8, 6))

sns.scatterplot(
    data=rfm_data,
    x='recency',
    y='frequency',
    hue='cluster',
    size='monetary',
    sizes=(20, 200),
    palette='viridis',
    alpha=0.6
)

plt.title('Customer Segments by RFM', fontsize=16)
plt.xlabel('Recency (Days)', fontsize=12)
plt.ylabel('Frequency (Purchases)', fontsize=12)
plt.legend(title='Cluster')
plt.show()
```


Customer Segments by RFM
Frequency (# of Purchases)
Recency (Days)
Cluster
0
1
2
3
Centroids