Student Name: Bimal Kandel

```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import seaborn as sns
import matplotlib.pyplot as plt

import os

os.getcwd()

'C:\\Users\\bimal\\Documents'

#load the data using the right path
df =
pd.read_csv("C:/Users/bimal/OneDrive/Documents/Mall_Customers.csv")

# checking the first five rows of the dataset to understand the data.
df.head()

   CustomerID   Genre  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

# checking the statistics to understand the data
df.describe()

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

```python
# Check for missing values in each column
missing_values = df.isnull().sum()
print("Missing values per column:\n", missing_values)
```

```
Missing values per column:
 CustomerID                0
Genre                     0
Age                       0
Annual Income (k$)        0
Spending Score (1-100)    0
dtype: int64
```

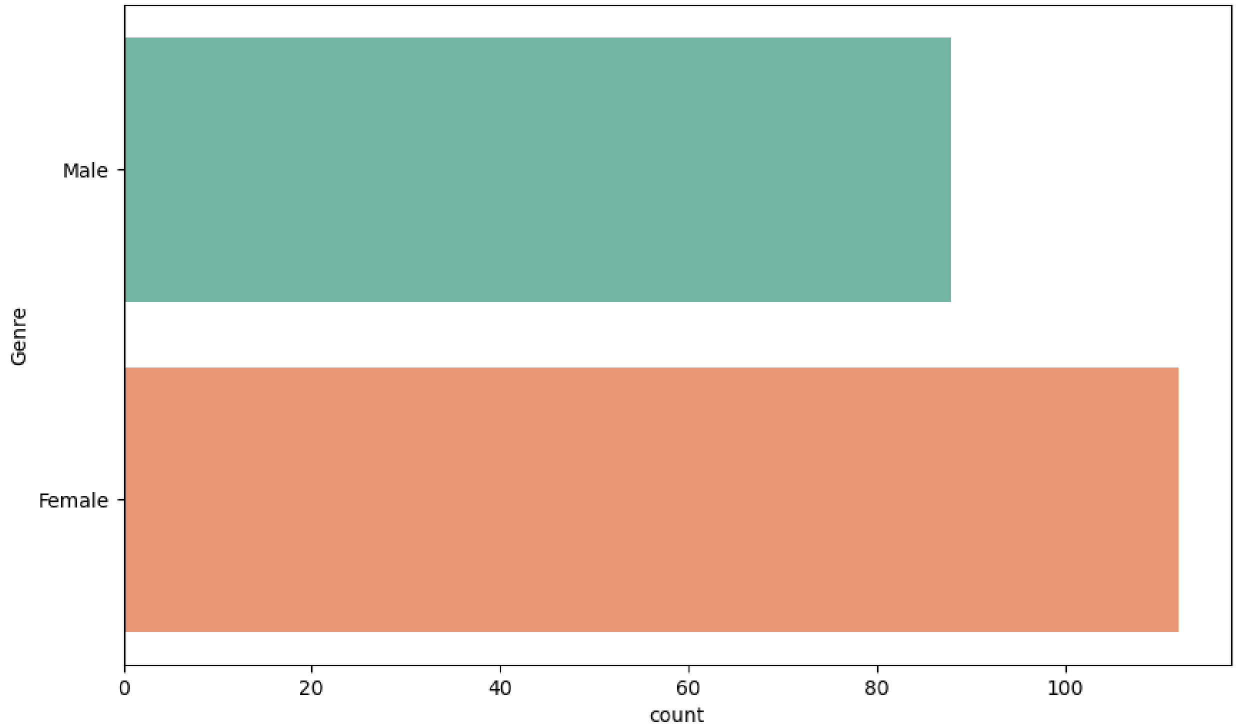
```python
## To check for the data types in the dataset.
df.info()
```

```
<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   Genre                   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
```

Data Visualisation - Univariate Analysis

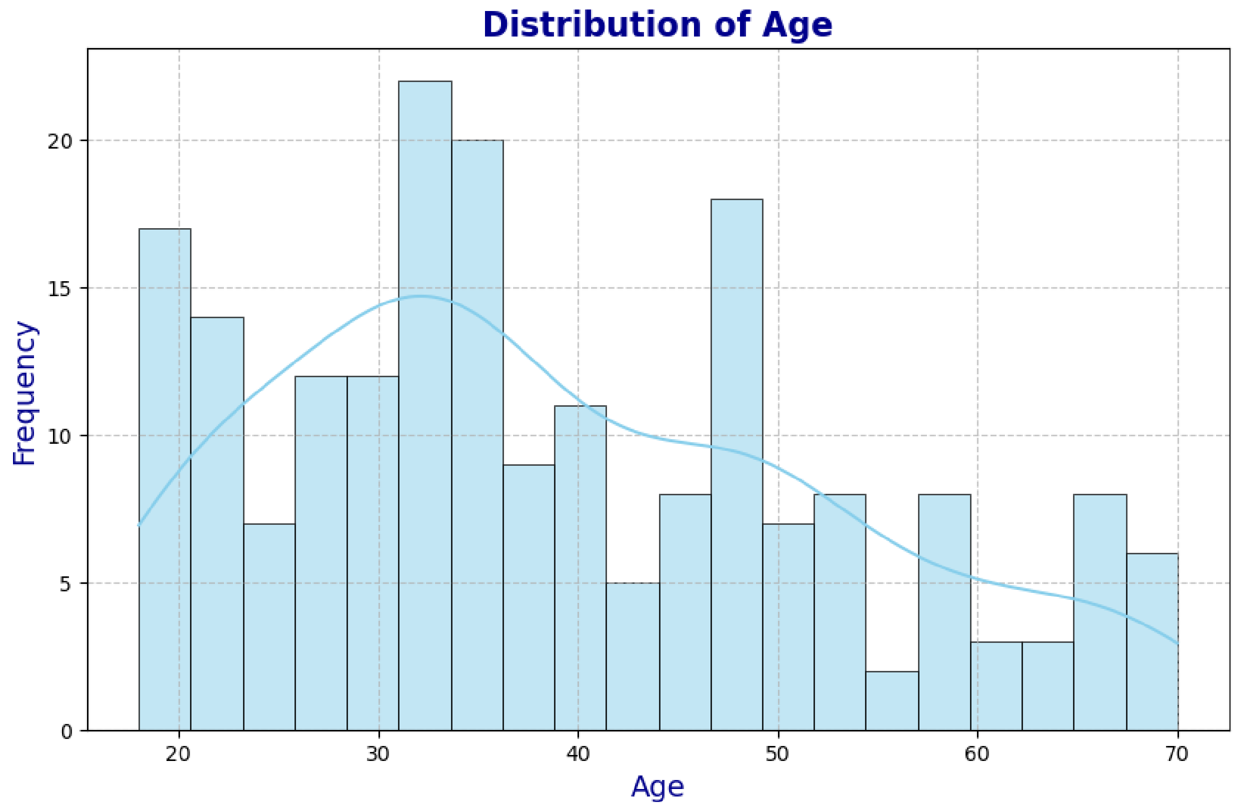
```python
import seaborn as sns
import matplotlib.pyplot as plt

plt.figure(figsize=(10, 6))
sns.countplot(df['Genre'], palette="Set2")  # Specify the palette
plt.show()
```

```
C:\Users\bimal\AppData\Local\Temp\ipykernel_19080\1485131431.py:5:
FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be
removed in v0.14.0. Assign the `y` variable to `hue` and set
`legend=False` for the same effect.

  sns.countplot(df['Genre'], palette="Set2")  # Specify the palette
```



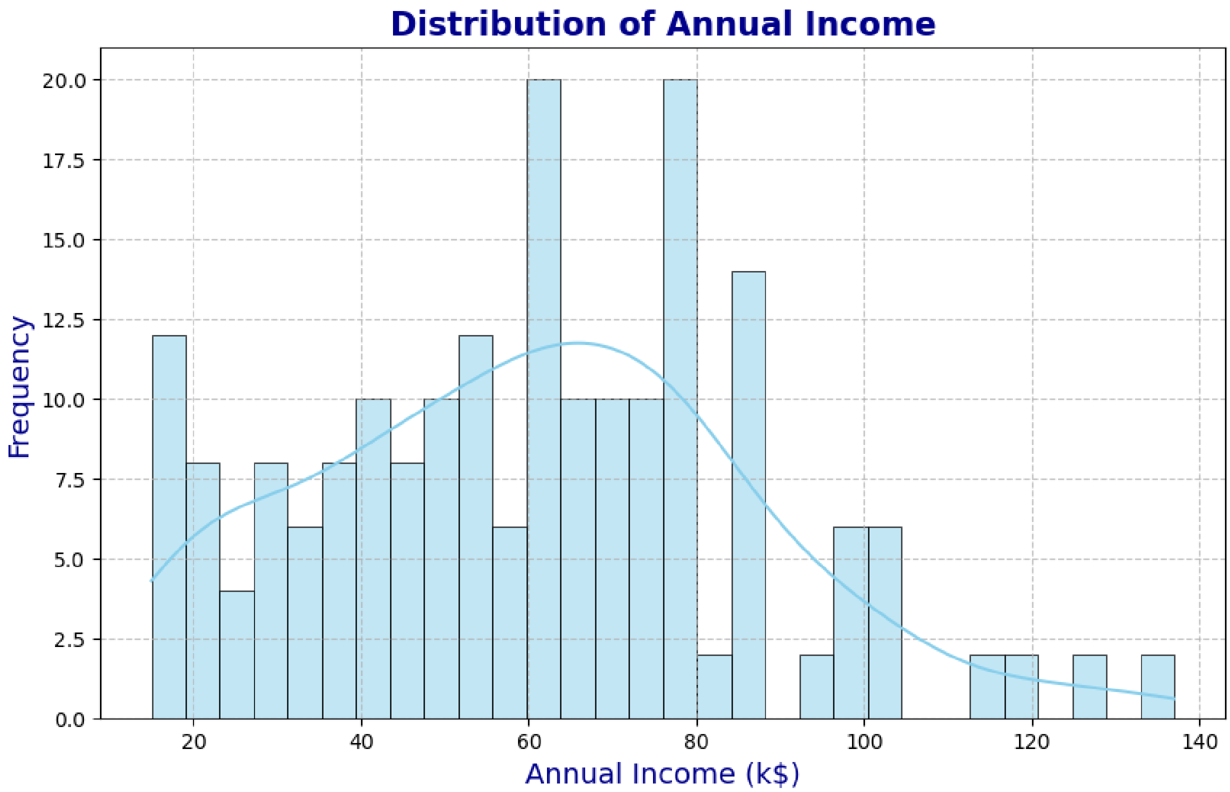
There are more female customers than the Male

```
plt.figure(figsize=(10, 6))
sns.histplot(df['Age'], bins=20, kde=True, color="skyblue",
edgecolor="black", linewidth=0.5)
plt.title("Distribution of Age", fontsize=16, fontweight='bold',
color="darkblue")
plt.xlabel("Age", fontsize=14, color="darkblue")
plt.ylabel("Frequency", fontsize=14, color="darkblue")
plt.grid(True, linestyle='--', alpha=0.7)
plt.show()
```



Age of the customers follows right skewed normal distrbution. The higher the age the frequency of spending and visiting the mall has declined.

```python
# Set the figure size for better clarity
plt.figure(figsize=(10, 6))

# Plot the distribution with both histogram and KDE (density) curve
sns.histplot(df['Annual Income (k$)'], bins=30, kde=True,
color="skyblue", edgecolor="black", linewidth=0.5)

# Add titles and labels
plt.title("Distribution of Annual Income", fontsize=16,
fontweight='bold', color="darkblue")
plt.xlabel("Annual Income (k$)", fontsize=14, color="darkblue")
plt.ylabel("Frequency", fontsize=14, color="darkblue")

# Customize grid for better readability
plt.grid(True, linestyle='--', alpha=0.7)

# Display the plot
plt.show()
```



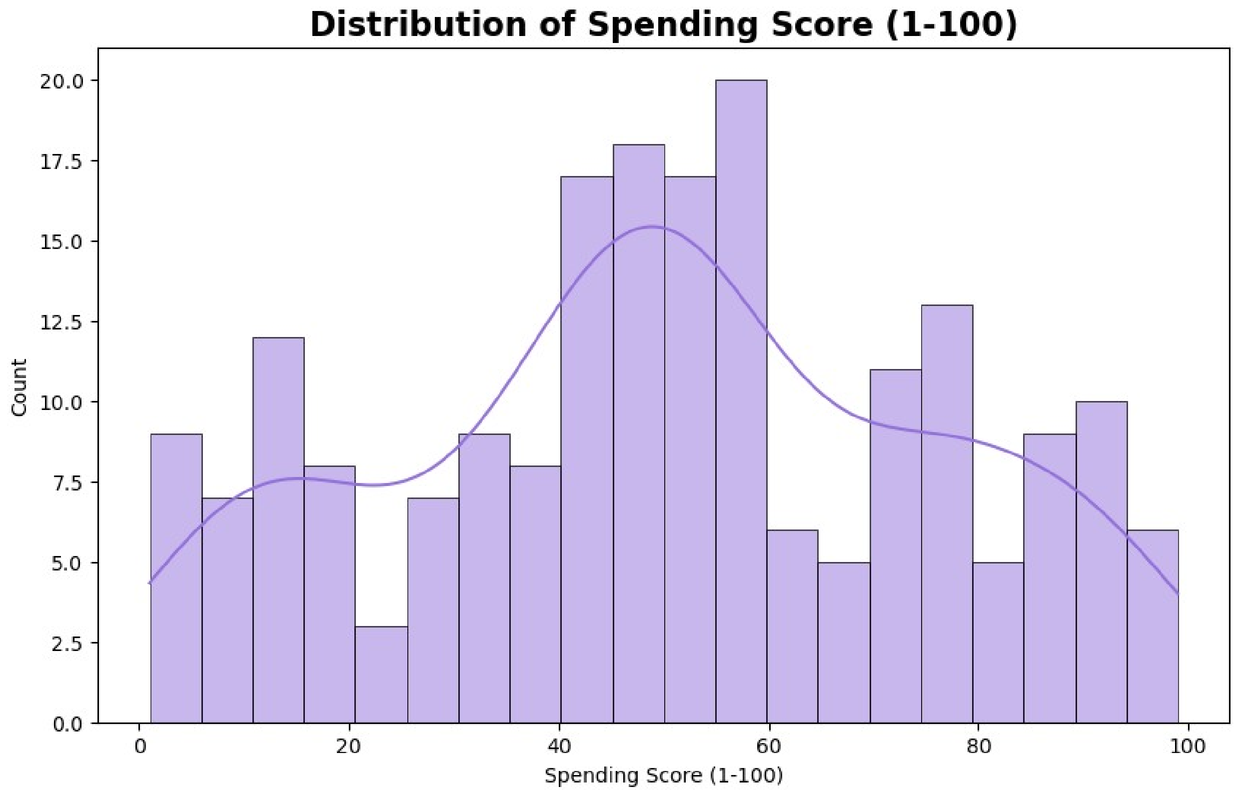
Annual income of the customers also follows right skewed normal distrbution.

```
# Set figure size
plt.figure(figsize=(10, 6))

# Plot the distribution with both histogram and KDE (density) curve
sns.histplot(df['Spending Score (1-100)'], bins=20, kde=True,
color="mediumpurple", edgecolor="black", linewidth=0.5)

# Add titles and labels
plt.title("Distribution of Spending Score (1-100)", fontsize=16,
fontweight='bold', color="darkpurple")
plt.xlabel("Spending Score (1-100)", fontsize=14, color="purple")
plt.ylabel("Frequency", fontsize=14, color="purple")

# Customize grid for better readability
plt.grid(True, linestyle='--', alpha=0.7)

# Display the plot
plt.show()
```

```
----------------------------------------------------------------------
-----
ValueError                                Traceback (most recent call
last)
Cell In[66], line 8
```

```
      5 sns.histplot(df['Spending Score (1-100)'], bins=20, kde=True,
color="mediumpurple", edgecolor="black", linewidth=0.5)
      7 # Add titles and labels
----> 8 plt.title("Distribution of Spending Score (1-100)",
fontsize=16, fontweight='bold', color="darkpurple")
      9 plt.xlabel("Spending Score (1-100)", fontsize=14,
color="purple")
     10 plt.ylabel("Frequency", fontsize=14, color="purple")

File ~\anaconda3\Lib\site-packages\matplotlib\pyplot.py:4346, in
title(label, fontdict, loc, pad, y, **kwargs)
   4336 @_copy_docstring_and_deprecators(Axes.set_title)
   4337 def title(
   4338     label: str,
   (...)
   4344     **kwargs,
   4345 ) -> Text:
-> 4346     return gca().set_title(label, fontdict=fontdict, loc=loc,
pad=pad, y=y, **kwargs)

File ~\anaconda3\Lib\site-packages\matplotlib\axes\_axes.py:206, in
Axes.set_title(self, label, fontdict, loc, pad, y, **kwargs)
    204 if fontdict is not None:
    205     title.update(fontdict)
--> 206 title._internal_update(kwargs)
    207 return title

File ~\anaconda3\Lib\site-packages\matplotlib\artist.py:1216, in
Artist._internal_update(self, kwargs)
   1209 def _internal_update(self, kwargs):
   1210     """
   1211     Update artist properties without prenormalizing them, but
generating
   1212     errors as if calling `set`.
   1213
   1214     The lack of prenormalization is to maintain
backcompatibility.
   1215     """
-> 1216     return self._update_props(
   1217         kwargs, "{cls.__name__}.set() got an unexpected
keyword argument "
   1218         "{prop_name!r}")

File ~\anaconda3\Lib\site-packages\matplotlib\artist.py:1192, in
Artist._update_props(self, props, errfmt)
   1189             if not callable(func):
   1190                 raise AttributeError(
   1191                     errfmt.format(cls=type(self),
prop_name=k))
-> 1192             ret.append(func(v))
```

```
   1193 if ret:
   1194     self.pchanged()

File ~\anaconda3\Lib\site-packages\matplotlib\text.py:996, in
Text.set_color(self, color)
    993 # "auto" is only supported by axisartist, but we can just let
it error
    994 # out at draw time for simplicity.
    995 if not cbook._str_equal(color, "auto"):
--> 996     mpl.colors._check_color_like(color=color)
    997 self._color = color
    998 self.stale = True

File ~\anaconda3\Lib\site-packages\matplotlib\colors.py:246, in
_check_color_like(**kwargs)
    244 for k, v in kwargs.items():
    245     if not is_color_like(v):
--> 246         raise ValueError(
    247             f"{v!r} is not a valid value for {k}: supported
inputs are "
    248             f"(r, g, b) and (r, g, b, a) 0-1 float tuples; "
    249             f"'#rrggbb', '#rrggbbaa', '#rgb', '#rgba' strings;
"
    250             f"named color strings; "
    251             f"string reprs of 0-1 floats for grayscale values;
"
    252             f"'C0', 'C1', ... strings for colors of the color
cycle; "
    253             f"and pairs combining one of the above with an
alpha value")

ValueError: 'darkpurple' is not a valid value for color: supported
inputs are (r, g, b) and (r, g, b, a) 0-1 float tuples; '#rrggbb',
'#rrggbbaa', '#rgb', '#rgba' strings; named color strings; string
reprs of 0-1 floats for grayscale values; 'C0', 'C1', ... strings for
colors of the color cycle; and pairs combining one of the above with
an alpha value
```



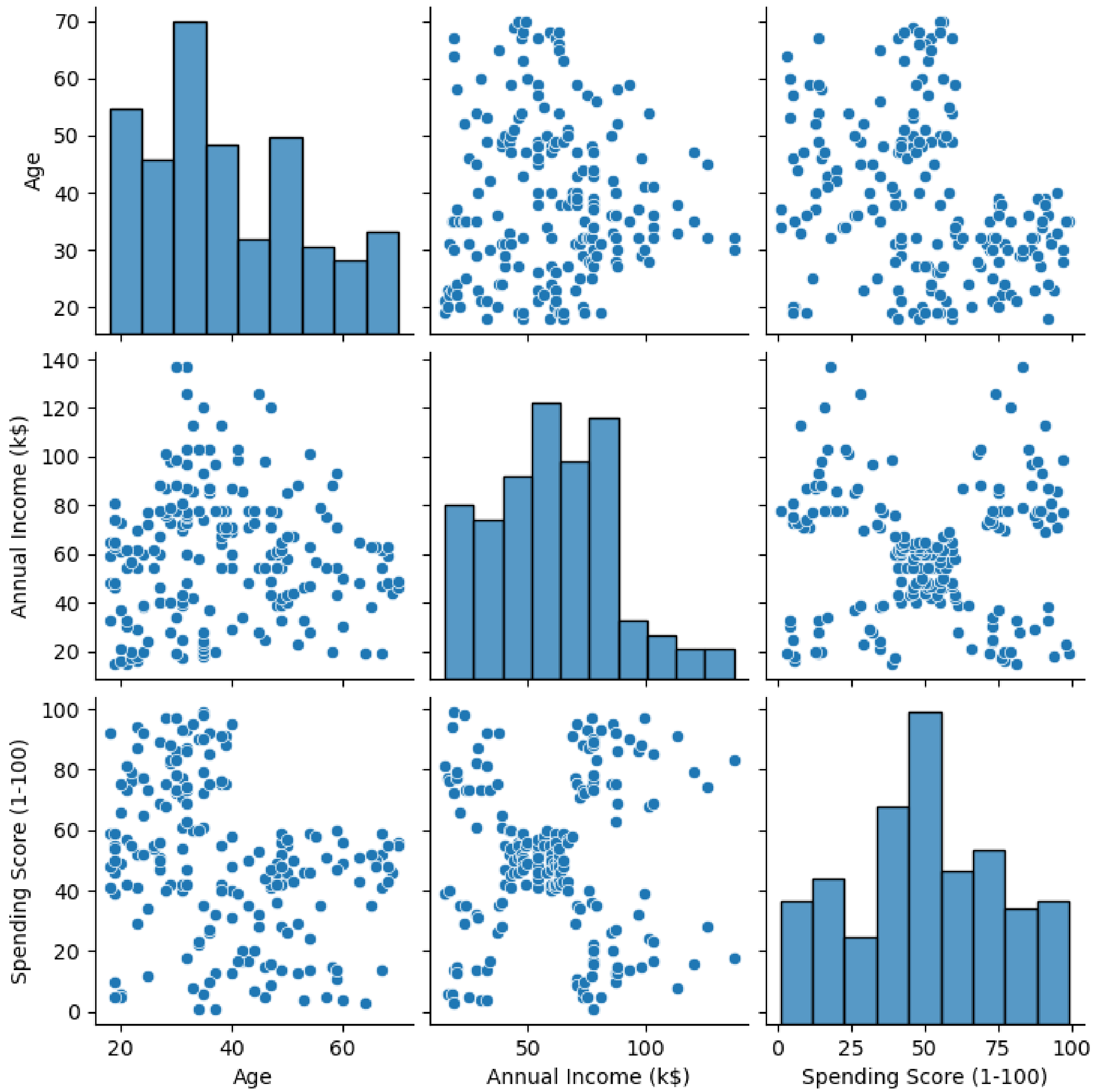
Spending score of the customers roughly follws normal distribution.This indicates that many customers tend to have a moderate spending score, and few customers have extremely high or low scores.

Data Visualisation - Bivariate Analysis

Time to check for the relationship between different features by using a pairplot.

```
sns.pairplot(df[[ 'Genre', 'Age', 'Annual Income (k$)','Spending Score (1-100)']])
```

```
<seaborn.axisgrid.PairGrid at 0x2c5111ef620>
```



Observations:

Most of the customers are in the 20-40 age group. Spending score is high for the customers in the age group of 20-40. Spending score is high for customers with very low and very high income.

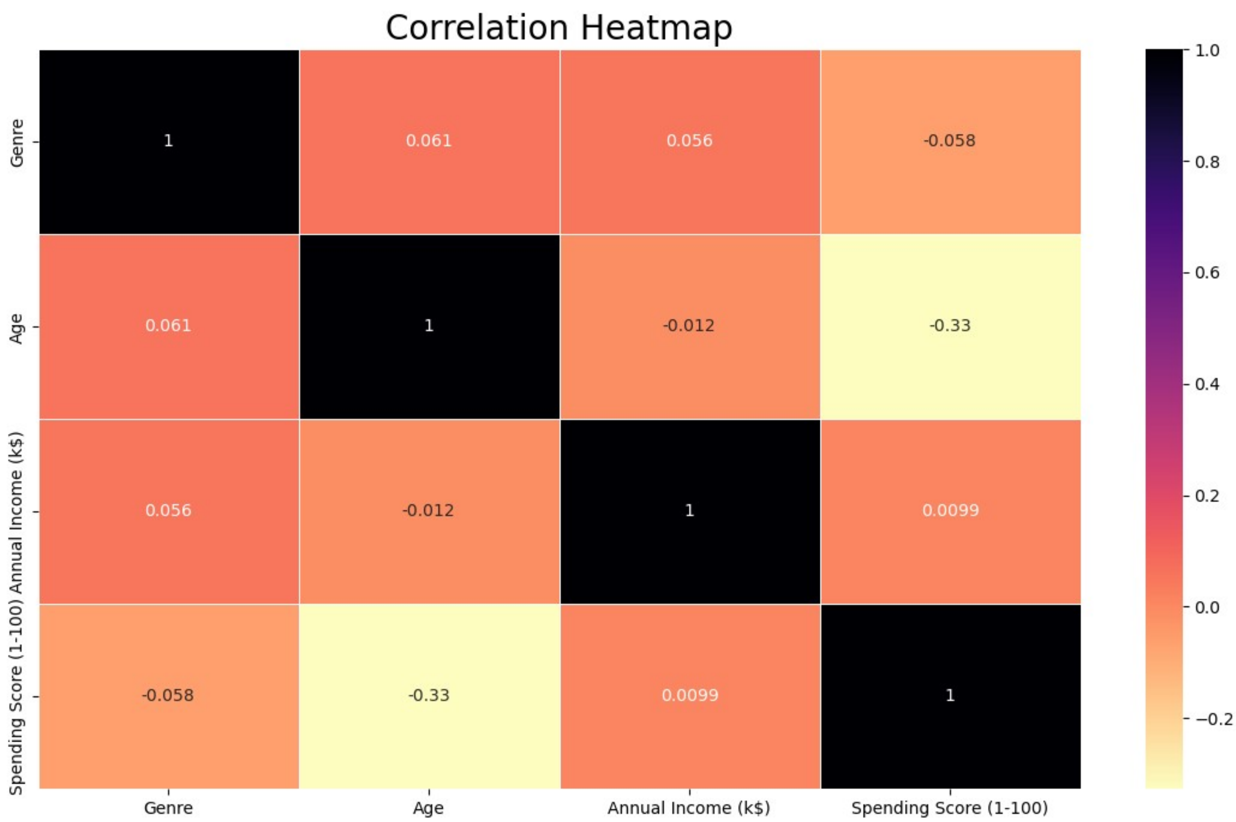
Checking Corelation between features using the Heatmap

```
# Error only for documentation
plt.rcParams['figure.figsize'] = (14, 8)
sns.heatmap(df[[ 'Genre', 'Age', 'Annual Income (k$)','Spending Score
(1-100)']].corr(), cmap = 'magma_r', annot = True, linewidths=.5)
```

```
plt.title('Heatmap', fontsize = 20)
plt.show()
```

```
---------------------------------------------------------------------------
-----
ValueError                                Traceback (most recent call
last)
Cell In[80], line 2
      1 plt.rcParams['figure.figsize'] = (14, 8)
----> 2 sns.heatmap(df[[ 'Genre', 'Age', 'Annual Income
(k$)','Spending Score (1-100)']].corr(), cmap = 'magma_r', annot =
True, linewidths=.5)
      3 plt.title('Heatmap', fontsize = 20)
      4 plt.show()

File ~\anaconda3\Lib\site-packages\pandas\core\frame.py:11049, in
DataFrame.corr(self, method, min_periods, numeric_only)
  11047 cols = data.columns
  11048 idx = cols.copy()
> 11049 mat = data.to_numpy(dtype=float, na_value=np.nan, copy=False)
  11051 if method == "pearson":
  11052     correl = libalgos.nancorr(mat, minp=min_periods)

File ~\anaconda3\Lib\site-packages\pandas\core\frame.py:1993, in
DataFrame.to_numpy(self, dtype, copy, na_value)
   1991 if dtype is not None:
   1992     dtype = np.dtype(dtype)
-> 1993 result = self._mgr.as_array(dtype=dtype, copy=copy,
na_value=na_value)
   1994 if result.dtype is not dtype:
   1995     result = np.asarray(result, dtype=dtype)

File ~\anaconda3\Lib\site-packages\pandas\core\internals\
managers.py:1694, in BlockManager.as_array(self, dtype, copy,
na_value)
   1692         arr.flags.writeable = False
   1693 else:
-> 1694     arr = self._interleave(dtype=dtype, na_value=na_value)
   1695     # The underlying data was copied within _interleave, so no
need
   1696     # to further copy if copy=True or setting na_value
   1698 if na_value is lib.no_default:

File ~\anaconda3\Lib\site-packages\pandas\core\internals\
managers.py:1753, in BlockManager._interleave(self, dtype, na_value)
   1751     else:
   1752         arr = blk.get_values(dtype)
-> 1753     result[rl.indexer] = arr
   1754     itemmask[rl.indexer] = 1
   1756 if not itemmask.all():
```

```
ValueError: could not convert string to float: 'Male'

from sklearn.preprocessing import LabelEncoder

# Encode the 'Genre' column as numeric
le = LabelEncoder()
df['Genre'] = le.fit_transform(df['Genre'])

# Select relevant columns (including the encoded 'Genre')
numeric_cols = df[['Genre', 'Age', 'Annual Income (k$)', 'Spending
Score (1-100)']]

# Calculate the correlation matrix
plt.rcParams['figure.figsize'] = (14, 8)
sns.heatmap(numeric_cols.corr(), cmap='magma_r', annot=True,
linewidths=0.5)

# Add a title and show the plot
plt.title('Correlation Heatmap', fontsize=20)
plt.show()
```



It Can be seen that there is not much corelation in this data between the diffrent features

```python
from sklearn.preprocessing import StandardScaler

# Select the numeric columns for clustering
features = ['Age', 'Annual Income (k$)', 'Spending Score (1-100)']

# Create a new DataFrame with the selected features
X = df[features]

# Initialize the StandardScaler
scaler = StandardScaler()

# Fit and transform the data to standardize it
X_scaled = scaler.fit_transform(X)

# Convert the scaled data back to a DataFrame
X_scaled_df = pd.DataFrame(X_scaled, columns=features)

# Show the first few rows of the standardized data
print(X_scaled_df.head())
```

```
        Age  Annual Income (k$)  Spending Score (1-100)
0 -1.424569           -1.738999               -0.434801
1 -1.281035           -1.738999                1.195704
2 -1.352802           -1.700830               -1.715913
3 -1.137502           -1.700830                1.040418
4 -0.563369           -1.662660               -0.395980
```

K-Means clustering based on annual income Elbow method to find the optimal number of Clusters¶

```python
# using Elbow method to find the optimal number of Clusters
data=df.iloc[:,[3,4]].values
from sklearn.cluster import KMeans
wcss=[] # within cluster sum of square
for i in range(1,11):
    kmeans=KMeans(n_clusters=i, init='k-means++',random_state=0)
    kmeans.fit(data)
    wcss.append(kmeans.inertia_) #inertia_ = to find the wcss value

plt.plot(range(1,11),wcss)
plt.title('The Elbow Method')
plt.xlabel('Number of Clusters')
plt.ylabel('WCSS')
plt.show()
```

```
C:\Users\bimal\anaconda3\Lib\site-packages\sklearn\cluster\
_kmeans.py:1429: UserWarning: KMeans is known to have a memory leak on
Windows with MKL, when there are less chunks than available threads.
You can avoid it by setting the environment variable
OMP_NUM_THREADS=1.
```

```
  warnings.warn(
C:\Users\bimal\anaconda3\Lib\site-packages\sklearn\cluster\
_kmeans.py:1429: UserWarning: KMeans is known to have a memory leak on
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```
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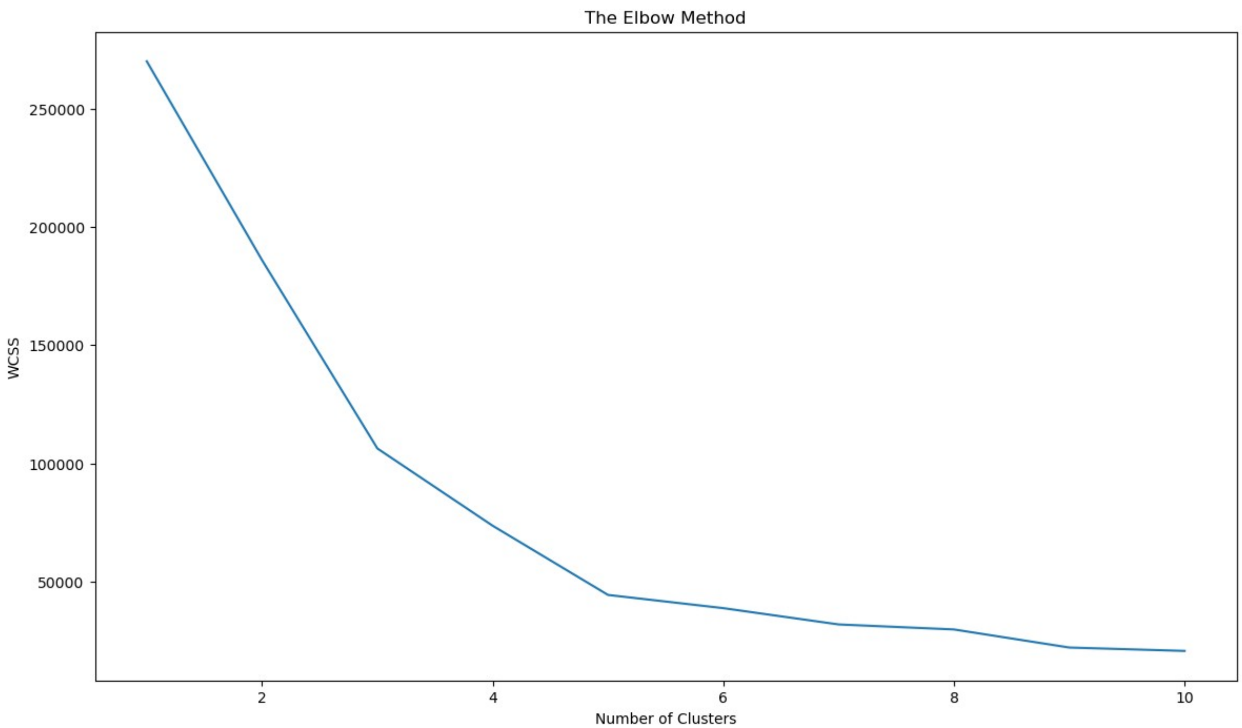
```



From the above figure, we can see that last most significant slope occurs at k = 5 , hence we will have 5 clusters in this case.

```
kmeans=KMeans(n_clusters=5,init='k-means++',random_state=0)
y_kmeans=kmeans.fit_predict(data)

#plotting the the clusters
fig,ax = plt.subplots(figsize=(14,6))
ax.scatter(data[y_kmeans==0,0],data[y_kmeans==0,1],s=100,c='red',label
='Cluster 1')
ax.scatter(data[y_kmeans==1,0],data[y_kmeans==1,1],s=100,c='blue',labe
l='Cluster 2')
ax.scatter(data[y_kmeans==2,0],data[y_kmeans==2,1],s=100,c='green',lab
el='Cluster 3')
ax.scatter(data[y_kmeans==3,0],data[y_kmeans==3,1],s=100,c='cyan',labe
l='Cluster 4')
ax.scatter(data[y_kmeans==4,0],data[y_kmeans==4,1],s=100,c='magenta',l
abel='Cluster 5')

ax.scatter(kmeans.cluster_centers_[:,0],kmeans.cluster_centers_[:,1],s
```

```
=400,c='yellow',label='Centroid')
plt.title('Cluster Segmentation of Customers')
plt.xlabel('Annual Income(K$)')
plt.ylabel('Spending Score(1-100)')
plt.legend()
plt.show()

C:\Users\bimal\anaconda3\Lib\site-packages\sklearn\cluster\
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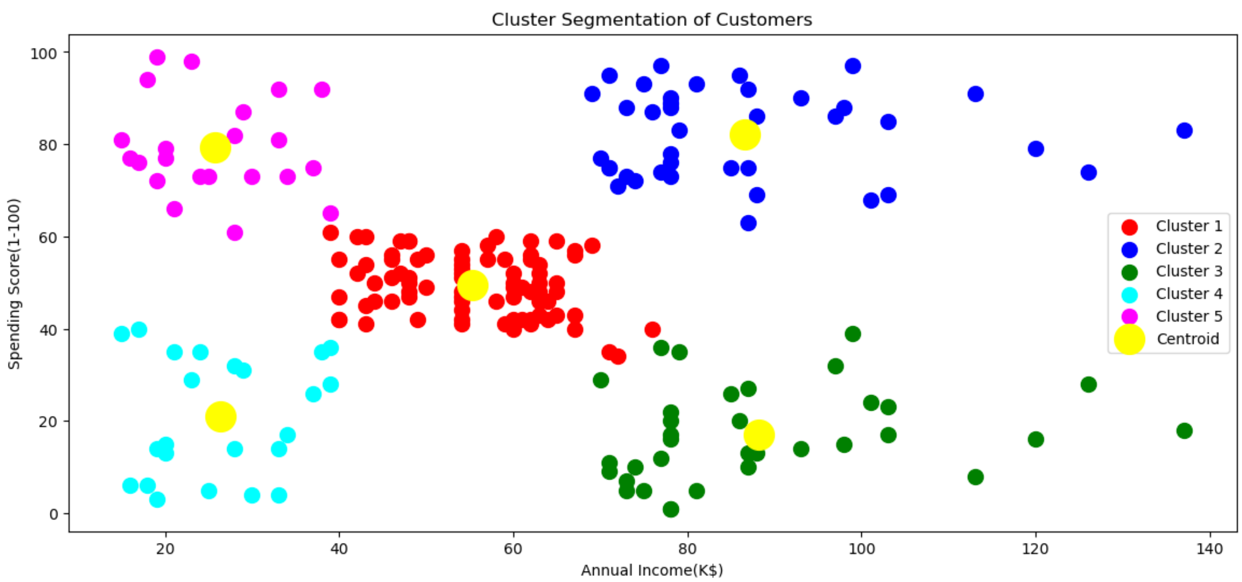
  warnings.warn(
```



k-means clustering based on Age

```
data = df.iloc[:,[2,4]].values
from sklearn.cluster import KMeans
wcss=[]  # within cluster sum of square
for i in range(1,11):
    kmeans=KMeans(n_clusters=i, init='k-means++',random_state=0)
    kmeans.fit(data)
    wcss.append(kmeans.inertia_)  # inertia_ = to find the wcss value

plt.plot(range(1,11),wcss)
plt.title('The Elbow Method')
plt.xlabel('Number of Clusters')
plt.ylabel('WCSS')
plt.show()

C:\Users\bimal\anaconda3\Lib\site-packages\sklearn\cluster\
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```

```
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```

```
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_kmeans.py:1429: UserWarning: KMeans is known to have a memory leak on
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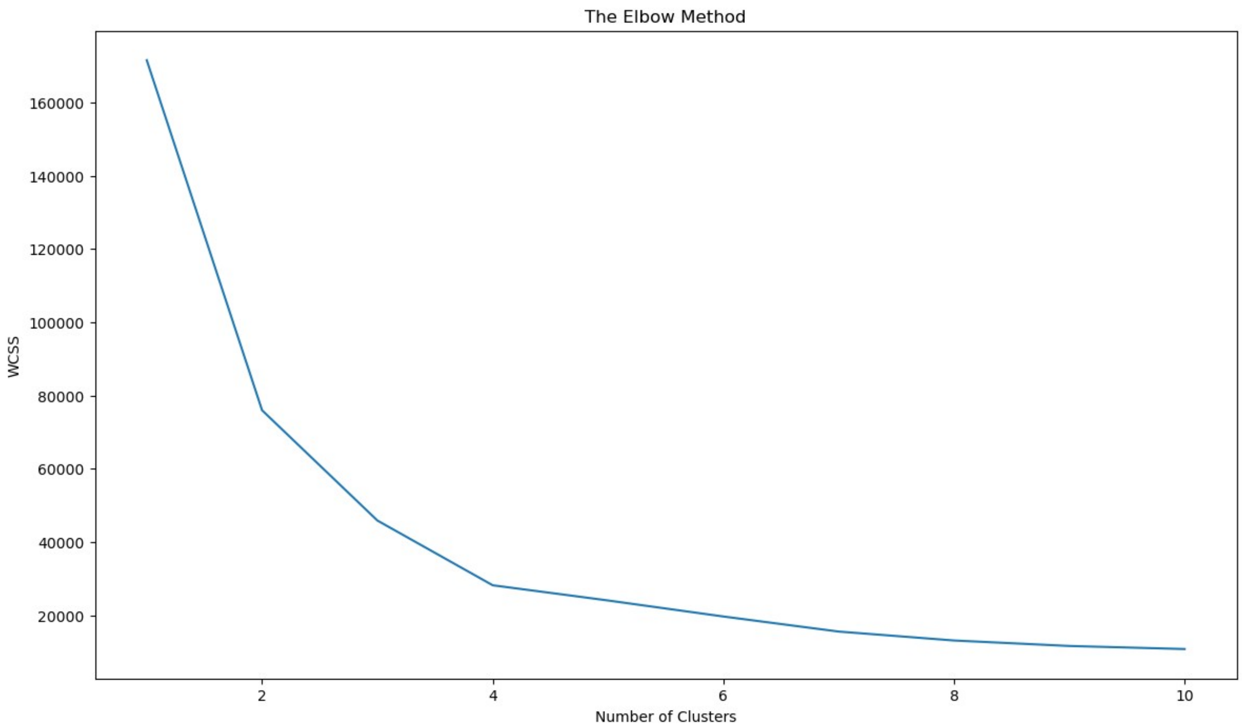
  warnings.warn(
```



k-means clustering based on Spending score (1-100)

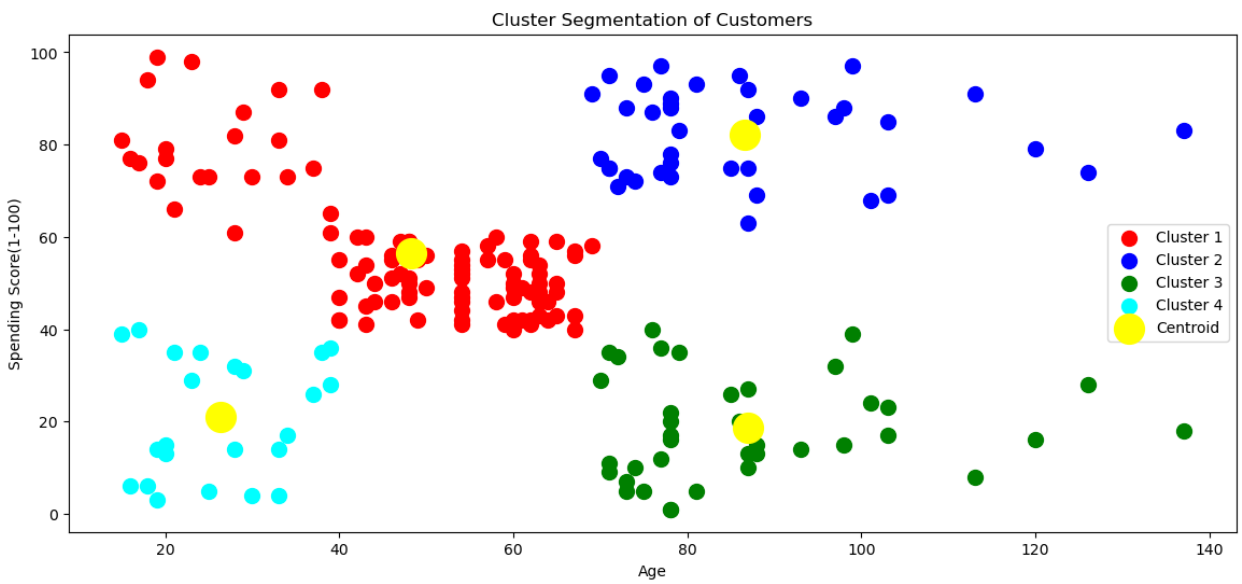
```
kmeans=KMeans(n_clusters=4,init='k-means++',random_state=0)
y_kmeans=kmeans.fit_predict(data)

#Plotting the clusters
fig,ax = plt.subplots(figsize=(14,6))
ax.scatter(data[y_kmeans==0,0],data[y_kmeans==0,1],s=100,c='red',label
='Cluster 1')
ax.scatter(data[y_kmeans==1,0],data[y_kmeans==1,1],s=100,c='blue',labe
l='Cluster 2')
ax.scatter(data[y_kmeans==2,0],data[y_kmeans==2,1],s=100,c='green',lab
el='Cluster 3')
ax.scatter(data[y_kmeans==3,0],data[y_kmeans==3,1],s=100,c='cyan',labe
l='Cluster 4')

ax.scatter(kmeans.cluster_centers_[:,0],kmeans.cluster_centers_[:,1],s
```

```
=400,c='yellow',label='Centroid')
plt.title('Cluster Segmentation of Customers')
plt.xlabel('Age')
plt.ylabel('Spending Score(1-100)')
plt.legend()
plt.show()
```

```
C:\Users\bimal\anaconda3\Lib\site-packages\sklearn\cluster\
_kmeans.py:1429: UserWarning: KMeans is known to have a memory leak on
Windows with MKL, when there are less chunks than available threads.
You can avoid it by setting the environment variable
OMP_NUM_THREADS=1.
  warnings.warn(
```



Results

We have been able to create distinct clusters based on various features by using k-means clustering. To boost profits, mall management can focus on clusters with average spending scores. They should also continue to have positive relationships with premium customers who have high spending scores.In order to improve the clients with poor spending scores, they should also focus on developing fresh, creative concepts.