Assignment 4

Q1) Perform dimensionality reduction using scikit-learn's TSNE estimator on the Iris dataset, then graph the results.

```
print('''Name: Sidhanta Barik, RegNo: 2241002049
----------------------------------------------------''')

import numpy as np
import matplotlib.pyplot as plt
from sklearn import datasets
from sklearn.manifold import TSNE
from sklearn.preprocessing import StandardScaler
iris = datasets.load_iris()
X = iris.data
y = iris.target
target_names = iris.target_names
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)
tsne = TSNE(n_components=2, random_state=42, perplexity=30)
X_tsne = tsne.fit_transform(X_scaled)
plt.figure(figsize=(8, 6))
colors = ['navy', 'turquoise', 'darkorange']
lw = 2
for color, i, target_name in zip(colors, [0, 1, 2], target_names):
    plt.scatter(X_tsne[y == i, 0], X_tsne[y == i, 1],
color=color, alpha=0.8, lw=lw,
label=target_name)
plt.title('t-SNE of IRIS dataset')
plt.legend(loc='best', shadow=False, scatterpoints=1)
plt.xlabel('t-SNE component 1')
plt.ylabel('t-SNE component 2')
plt.show()
```

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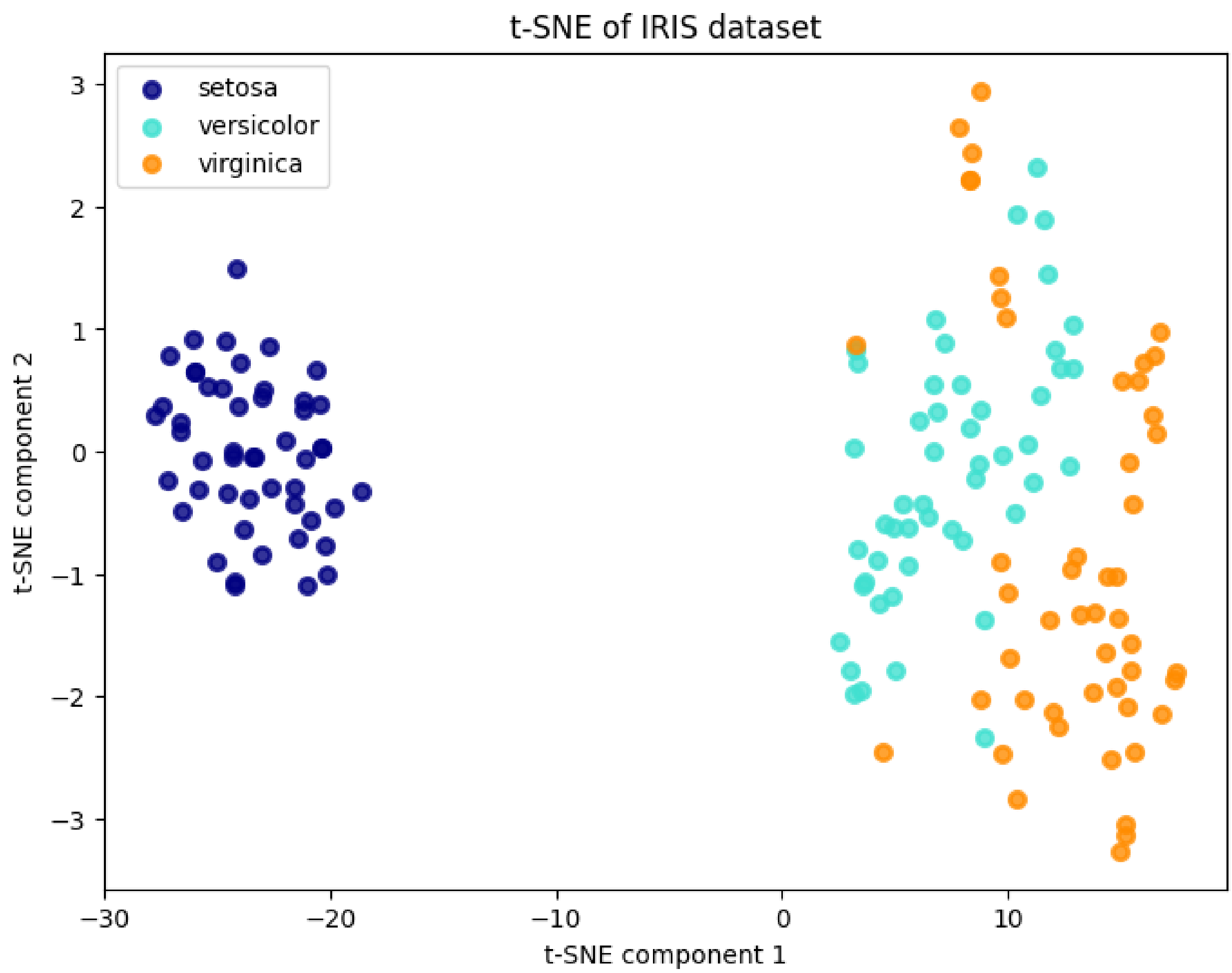
```



Q2) Create a Seaborn pairplot graph for the California Housing dataset. Try the Matplotlib features to panning and zoom in on the diagram. These are accessible via the icons in the Matplotlib window.

```
print('''Name: Sidhanta Barik, RegNo: 2241002049
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import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.datasets import fetch_california_housing
import pandas as pd

california = fetch_california_housing()
data = pd.DataFrame(california.data, columns=california.feature_names)
data['MedHouseVal'] = california.target
pair_grid = sns.pairplot(data[['MedInc', 'HouseAge', 'AveRooms',
'AveBedrms','MedHouseVal']], diag_kind='kde', plot_kws={'alpha': 0.6,
```

```
's': 15})
plt.show()

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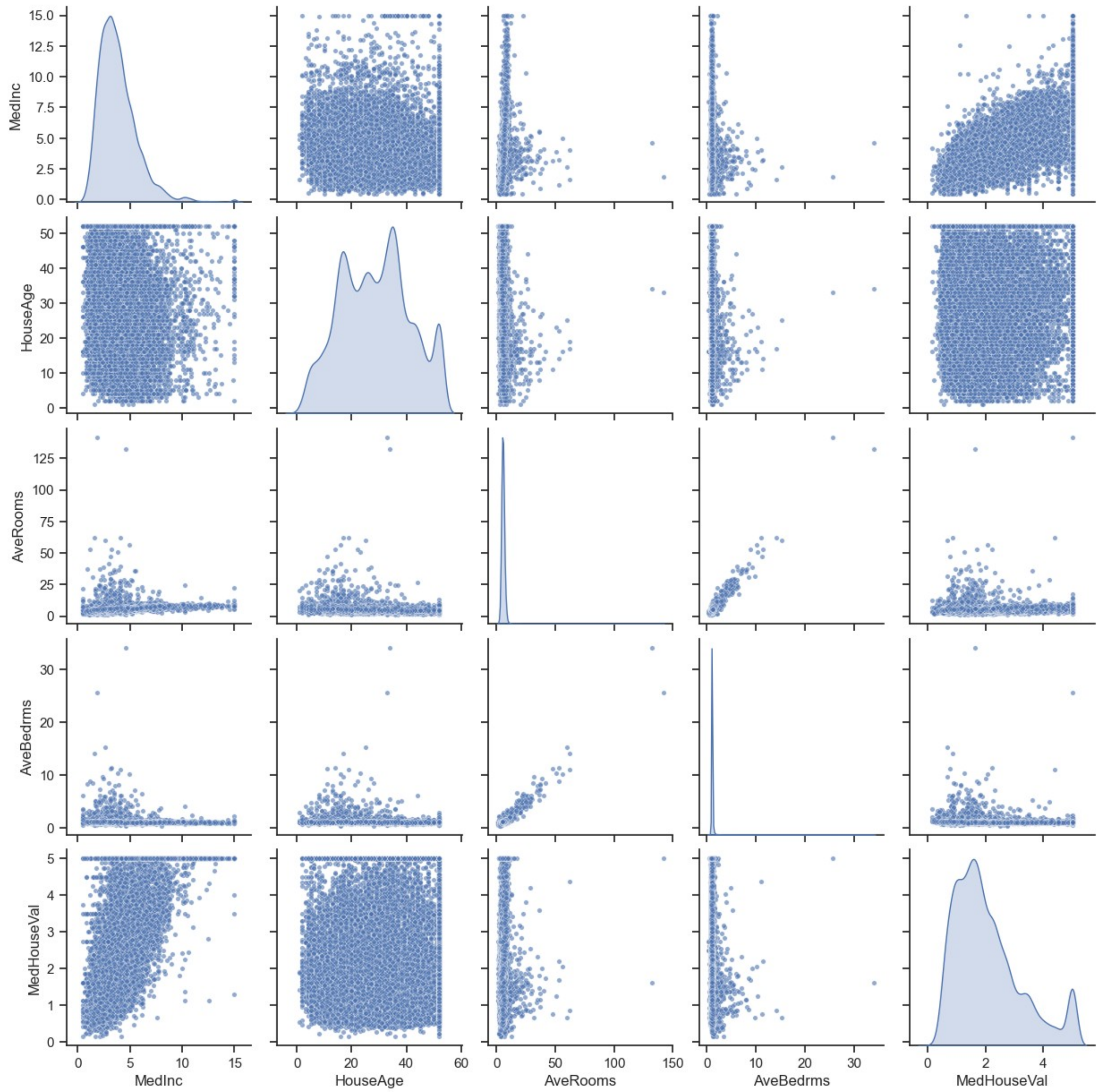
```



Q3) Go to NOAA's Climate at a Glance page and download the available time series data for the average annual temperatures of New York City from 1895 to today (1895-2025). Implement simple linear regression using average annual temperature data. Also, show how does the temperature trend compare to the average January high temperatures?

```
print('''Name: Sidhanta Barik, RegNo: 2241002049
-----------------------------------------------------''')

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.linear_model import LinearRegression
from scipy import stats

def load_noaa_data(filename):
    df = pd.read_csv(filename, comment='#')
    df = df[df['Value'] != -99] # Remove missing values
    df['Year'] = df['Date'].astype(str).str[:4].astype(int)
    return df[['Year', 'Value']]

annual_df =
load_noaa_data('AnnualAvg.csv').rename(columns={'Value':'Annual_Avg'})
jan_df = load_noaa_data('JanMax.csv').rename(columns={'Value':
'Jan_High'})
df = pd.merge(annual_df, jan_df, on='Year')

def calculate_trend(df, col_name):
    X = df[['Year']].values
    y = df[col_name].values
    model = LinearRegression().fit(X, y)
    trend = model.predict(X)
    rate = model.coef_[0] * 100 # Change per century
    r2 = model.score(X, y)
    return trend, rate, r2

df['Annual_Trend'], annual_rate, annual_r2 = calculate_trend(df,
'Annual_Avg')
df['Jan_Trend'], jan_rate, jan_r2 = calculate_trend(df, 'Jan_High')
plt.figure(figsize=(12, 6))
plt.scatter(df['Year'], df['Annual_Avg'], alpha=0.5, label='Annual Avg
(°F)')
plt.plot(df['Year'], df['Annual_Trend'], 'b-',label=f'Annual Trend:
{annual_rate:.2f}°F/century (R²={annual_r2:.2f})')
plt.scatter(df['Year'], df['Jan_High'], alpha=0.5, color='red',
label='Jan High(°F)')
plt.plot(df['Year'], df['Jan_Trend'], 'r-',label=f'Jan Trend:
{jan_rate:.2f}°F/century (R²={jan_r2:.2f})')
plt.title('NYC Temperature Trends (1895-2023)', fontsize=14)
plt.xlabel('Year', fontsize=12)
plt.ylabel('Temperature (°F)', fontsize=12)
plt.legend(fontsize=10)
plt.grid(True, alpha=0.3)
plt.show()

print("Temperature Trend Analysis Results:")
```

```
print(f"Annual average warming rate: {annual_rate:.2f}°F per century")
print(f"January high warming rate: {jan_rate:.2f}°F per century")
print(f"Difference: {jan_rate - annual_rate:.2f}°F/century (January
warms␣faster)")
print(f"\nKey Insights:")
print("- January temperatures are warming faster than annual
averages")
print("- Urban heat island effect may amplify winter warming")
print("- Recent years (2010+) show accelerated warming in both
series")
```

```
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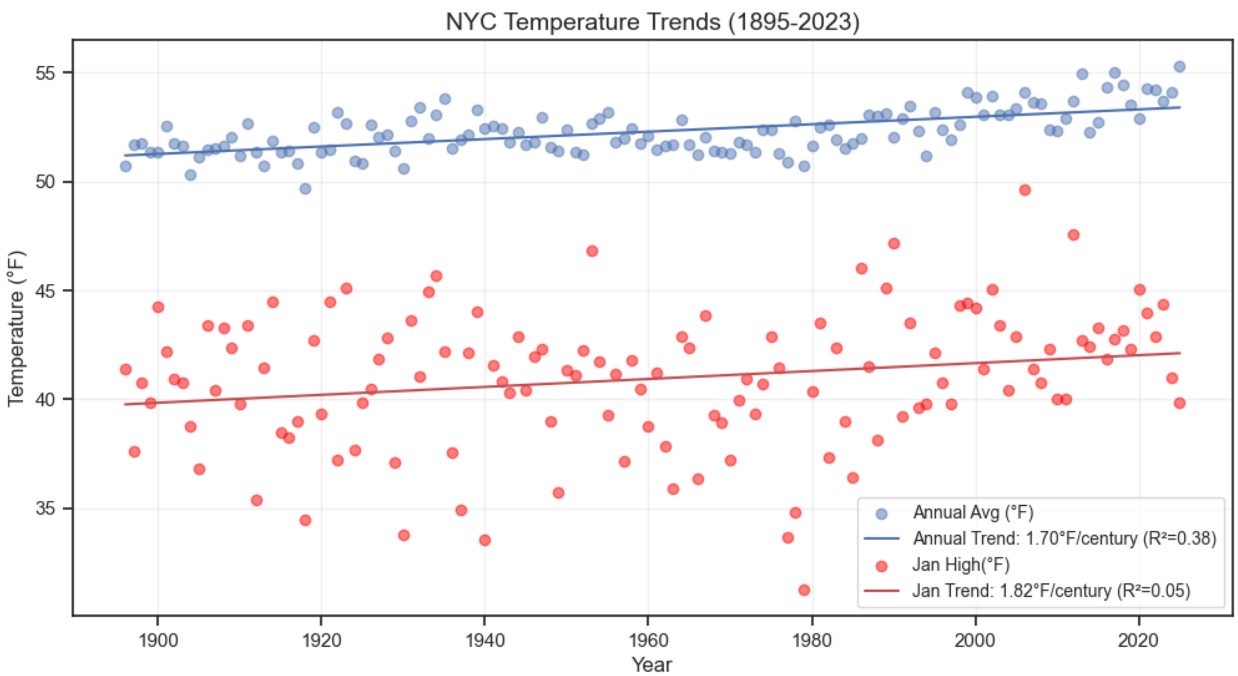
```




```
Temperature Trend Analysis Results:
Annual average warming rate: 1.70°F per century
January high warming rate: 1.82°F per century
Difference: 0.12°F/century (January warms␣faster)

Key Insights:
- January temperatures are warming faster than annual averages
- Urban heat island effect may amplify winter warming
- Recent years (2010+) show accelerated warming in both series
```

Q4) Load the Iris dataset from the scikit-learn library and perform classification on it with the k-nearest neighbors algorithm. Use a KNeighborsClassifier with the default k value. What is the prediction accuracy?

```
print('''Name: Sidhanta Barik, RegNo: 2241002049
----------------------------------------------------''')

from sklearn.datasets import load_iris
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score

iris = load_iris()
X, y = iris.data, iris.target
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)
knn = KNeighborsClassifier()
knn.fit(X_train, y_train)
y_pred = knn.predict(X_test)
accuracy = accuracy_score(y_test, y_pred)
print(f"Prediction accuracy: {accuracy:.2f} ({accuracy*100:.1f}%)")
```

```
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Prediction accuracy: 1.00 (100.0%)
```

Q5) You are given a dataset of 2D points with their corresponding class labels. The dataset is as follows:

- Point_ID x y Class
- A 2.0 3.0 0
- B 1.0 1.0 0
- C 4.0 4.0 1
- D 5.0 2.0 1

A new point P with coordinates (3.0, 3.0) needs to be classified using the KNN algorithm. Use the Euclidean distance to calculate the distance between points.

```
print('''Name: Sidhanta Barik, RegNo: 2241002049
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import numpy as np
from sklearn.neighbors import KNeighborsClassifier
X = np.array([
    [2.0, 3.0], # Point A
    [1.0, 1.0], # Point B
    [4.0, 4.0], # Point C
    [5.0, 2.0] # Point D
```

```
])
y = [0, 0, 1, 1]
new_point = np.array([[3.0, 3.0]])
knn = KNeighborsClassifier(n_neighbors=3, metric='euclidean')
knn.fit(X, y)
prediction = knn.predict(new_point)
print(f"The new point P is classified as class: {prediction[0]}")
```

```
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The new point P is classified as class: 1
```

Q6) A teacher wants to classify students as ”Pass” or ”Fail” based on their performance in three exams. The dataset includes three features:

- Exam 1 Score Exam 2 Score Exam 3 Score Class (Pass/Fail)
- 85 90 88 Pass
- 70 75 80 Pass
- 60 65 70 Fail
- 50 55 58 Fail
- 95 92 96 Pass
- 45 50 48 Fail

A new student has the following scores:

- Exam 1 Score: 72
- Exam 2 Score: 78
- Exam 3 Score: 75

Classify this student using the K-Nearest Neighbors (KNN) algorithm with k = 3.

```
print('''Name: Sidhanta Barik, RegNo: 2241002049
----------------------------------------------------''')

import numpy as np
from sklearn.neighbors import KNeighborsClassifier
X = np.array([
    [85, 90, 88],
    [70, 75, 80],
    [60, 65, 70],
    [50, 55, 58],
    [95, 92, 96],
    [45, 50, 48]
])
y = ['Pass', 'Pass', 'Fail', 'Fail', 'Pass', 'Fail']
new_student = np.array([[72, 78, 75]])
knn = KNeighborsClassifier(n_neighbors=3)
```

```
knn.fit(X, y)
prediction = knn.predict(new_student)
print(f"The new student is classified as: {prediction[0]}")
```

```
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-----------------------------------------------------
The new student is classified as: Pass
```

Q7) Using scikit-learn's KFold class and the cross val score function, determine the optimal value for k to classify the Iris dataset using a KNeighborsClassifier.

```
print('''Name: Sidhanta Barik, RegNo: 2241002049
-----------------------------------------------------''')

import numpy as np
from sklearn.datasets import load_iris
from sklearn.model_selection import KFold, cross_val_score
from sklearn.neighbors import KNeighborsClassifier
import matplotlib.pyplot as plt

iris = load_iris()
X = iris.data
y = iris.target
kf = KFold(n_splits=5, shuffle=True, random_state=0)
k_values = range(1, 21)
mean_scores = []

for k in k_values:
    knn = KNeighborsClassifier(n_neighbors=k)
    scores = cross_val_score(knn, X, y, cv=kf)
    mean_scores.append(scores.mean())

plt.figure(figsize=(10, 6))
plt.plot(k_values, mean_scores, marker='o', linestyle='-')
plt.title("KNN Cross-Validation Accuracy vs k (Iris Dataset)")
plt.xlabel("Number of Neighbors (k)")
plt.ylabel("Cross-Validation Accuracy")
plt.grid(True)
plt.xticks(k_values)
plt.show()

optimal_k = k_values[np.argmax(mean_scores)]
print(f"Optimal number of neighbors (k): {optimal_k}")
```

```
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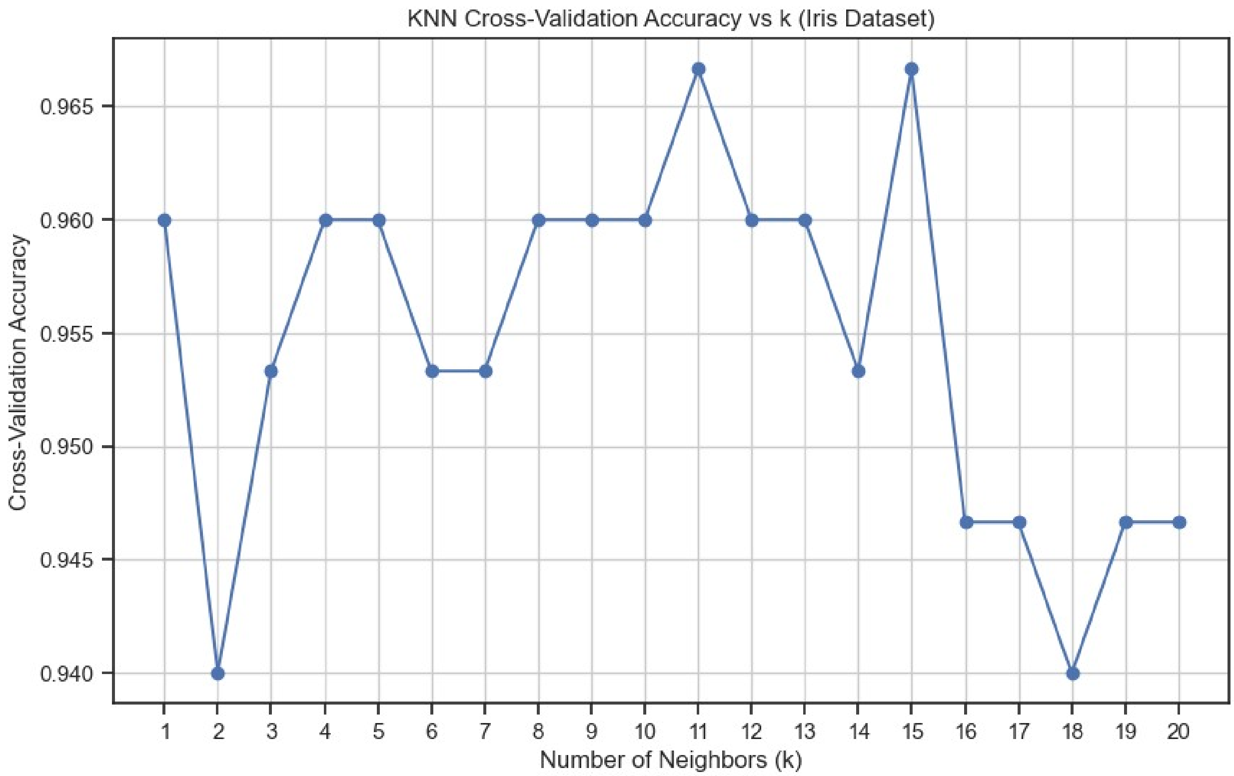
```




```
Optimal number of neighbors (k): 11
```

Q8) Write a Python script to perform K-Means clustering on the following dataset:

```
_Dataset: {(1, 1), (2, 2), (3, 3), (8, 8), (9, 9), (10, 10)}_.
```

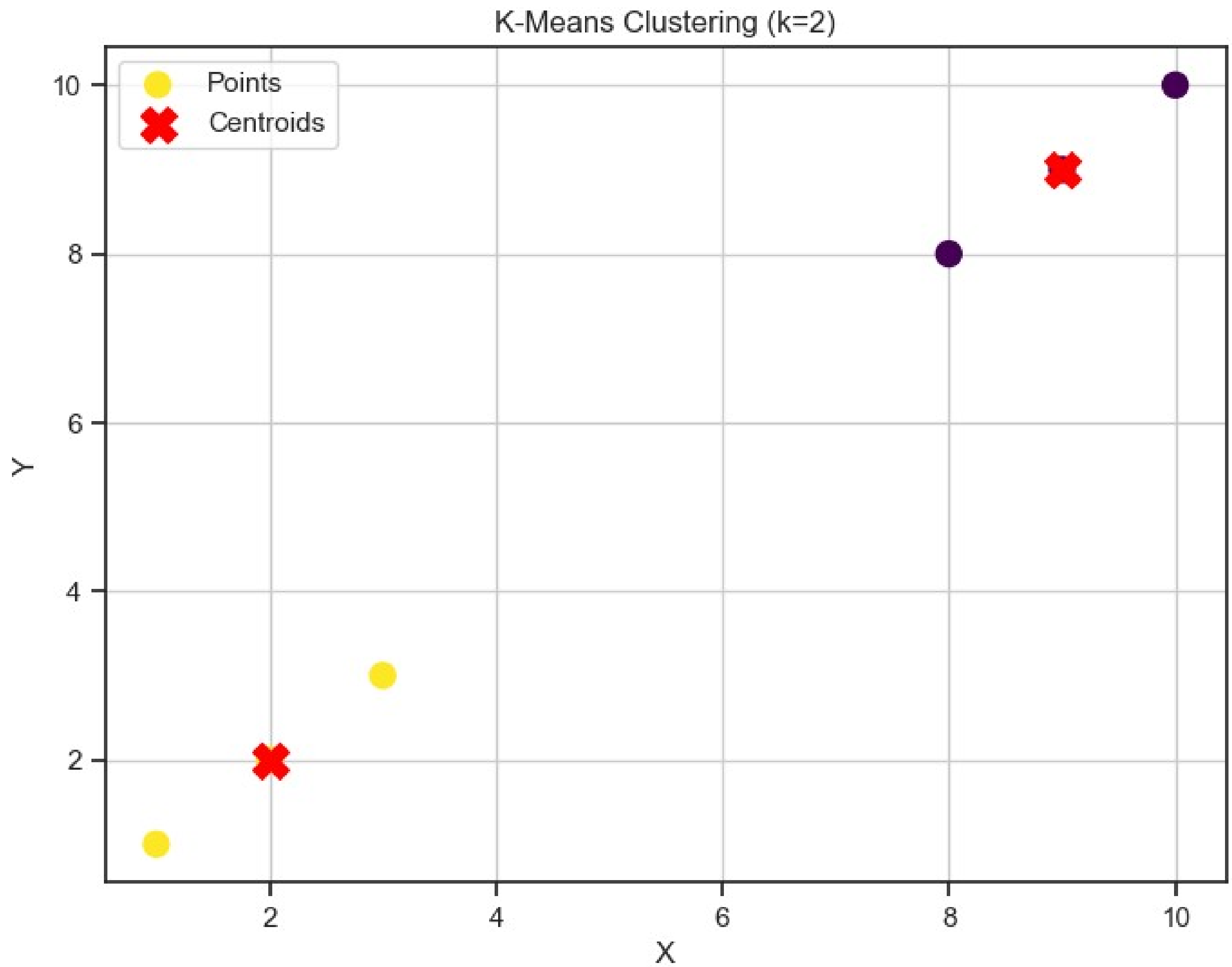
Use k=2 and visualize the clusters.

```
print('''Name: Sidhanta Barik, RegNo: 2241002049
----------------------------------------------------''')

import numpy as np
import matplotlib.pyplot as plt
from sklearn.cluster import KMeans

X = np.array([(1, 1), (2, 2), (3, 3), (8, 8), (9, 9), (10, 10)])
kmeans = KMeans(n_clusters=2, random_state=0)
kmeans.fit(X)
labels = kmeans.labels_
centroids = kmeans.cluster_centers_
plt.figure(figsize=(8, 6))
plt.scatter(X[:, 0], X[:, 1], c=labels, cmap='viridis', marker='o',
s=100,label='Points')
```

```
plt.scatter(centroids[:, 0], centroids[:, 1], c='red', marker='X',
s=200,label='Centroids')
plt.title("K-Means Clustering (k=2)")
plt.xlabel("X")
plt.ylabel("Y")
plt.legend()
plt.grid(True)
plt.show()
```



Q9) Write a Python script to perform K-Means clustering on the following dataset: Mall Customer Segmentation. Use k = 5 (also, determine optimal k via the Elbow Method) and visualize the clusters to identify customer segments.

Expected Output:

- Scatter plot showing clusters (e.g., “High Income-Low Spenders,” “Moderate Income-Moderate Spenders”).
- Insights for targeted marketing strategies.

```python
print('''Name: Sidhanta Barik, RegNo: 2241002049
----------------------------------------------------''')

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

df = pd.read_csv('Mall_Customers.csv')
X = df[['Annual Income (k$)', 'Spending Score (1-100)']]
inertia = []
k_range = range(1, 11)
for k in k_range:
    kmeans = KMeans(n_clusters=k, random_state=42)
    kmeans.fit(X)
    inertia.append(kmeans.inertia_)

plt.figure(figsize=(8, 5))
plt.plot(k_range, inertia, 'bo-')
plt.xlabel('Number of Clusters (k)')
plt.ylabel('Inertia')
plt.title('Elbow Method For Optimal k')
plt.grid(True)
plt.show()

kmeans = KMeans(n_clusters=5, random_state=42)
clusters = kmeans.fit_predict(X)
df['Cluster'] = clusters

plt.figure(figsize=(10, 6))
sns.scatterplot(data=df, x='Annual Income (k$)', y='Spending Score (1-
100)', hue='Cluster', palette='Set2', s=100)
plt.scatter(kmeans.cluster_centers_[:, 0], kmeans.cluster_centers_[:,
1], s=300, c='black', marker='X', label='Centroids')
plt.title('Customer Segments (k=5)')
plt.legend()
plt.grid(True)
plt.show()
```

```
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----------------------------------------------------
```
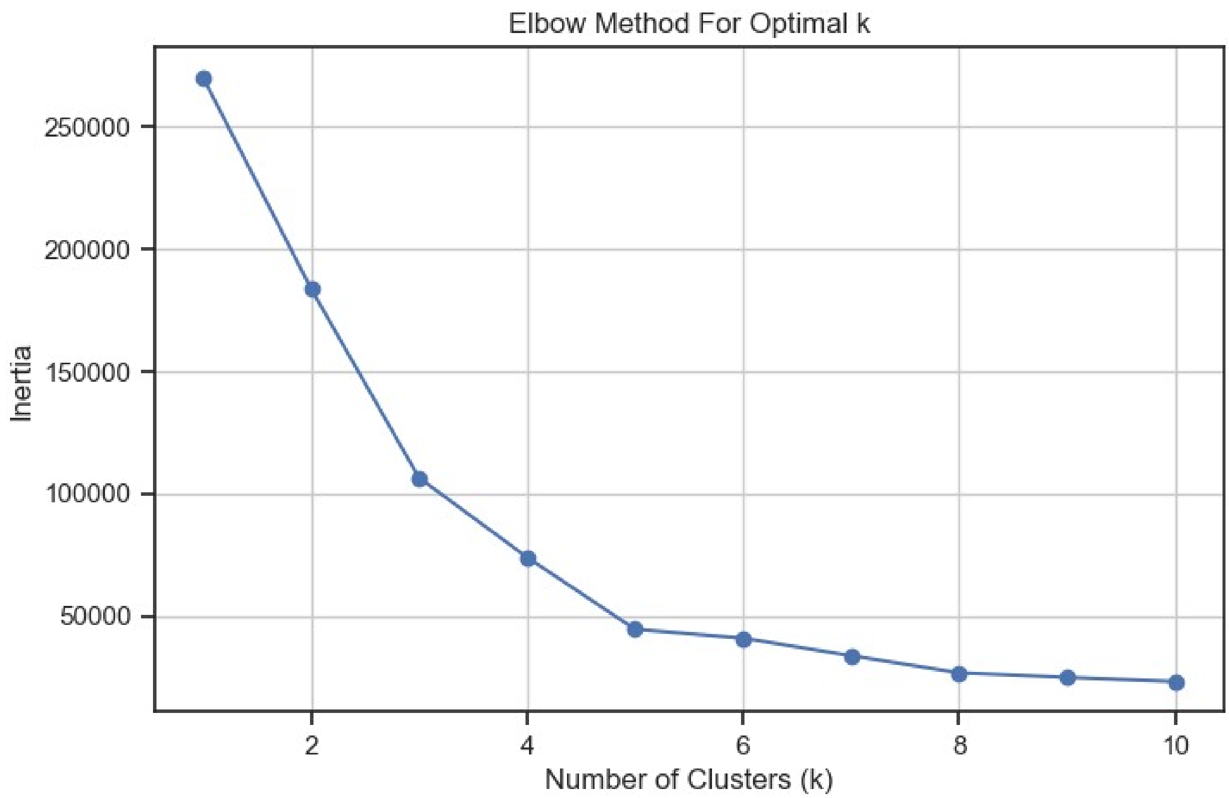
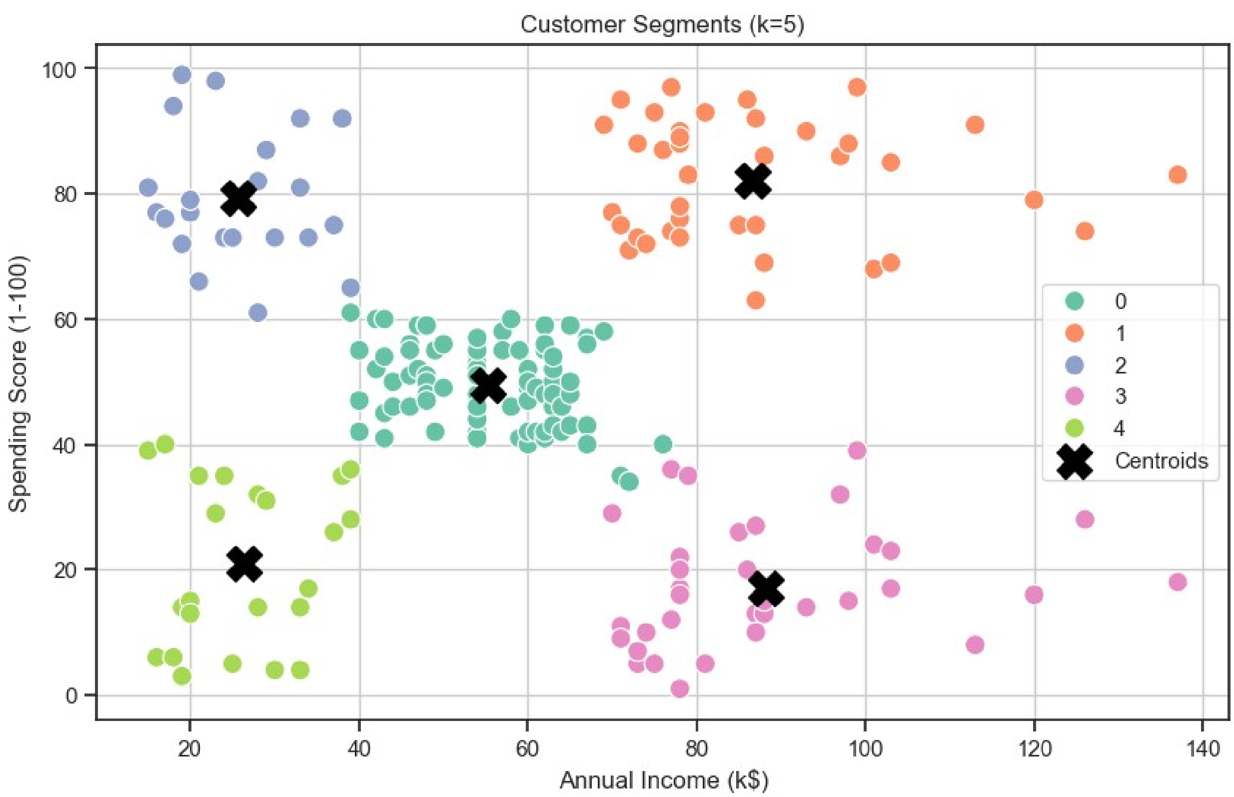


Elbow Method For Optimal k
Inertia
250000
200000
150000
100000
50000
2
4
6
8
10
Number of Clusters (k)


Customer Segments (k=5)
Spending Score (1-100)
100
80
60
40
20
0
20
40
60
80
100
120
140
Annual Income (k$)
0
1
2
3
4
Centroids

Q10) Perform the following tasks using the pandas Series object:

```
(a) Create a Series from the list [7, 11, 13, 17].

(b) Create a Series with five elements where each element is 100.0.

(c) Create a Series with 20 elements that are all random numbers in
the range 0 to 100. Use the describe method to produce the Series’
basic descriptive statistics.

(d) Create a Series called temperatures with the following floating-
point values: 98.6, 98.9, 100.2, and 97.9. Use the index keyword
argument to specify the custom indices ’Julie’, ’Charlie’, ’Sam’, and
’Andrea’.

(e) Form a dictionary from the names and values in Part (d), then use
it to initialize a Series.

print('''Name: Sidhanta Barik, RegNo: 2241002049
----------------------------------------------------''')

import pandas as pd
import numpy as np

# (a) Create a Series from the list [7, 11, 13, 17]
series_a = pd.Series([7, 11, 13, 17])
print("(a) Series from list:\n", series_a, "\n")

# (b) Create a Series with five elements where each element is 100.0
series_b = pd.Series([100.0] * 5)
print("(b) Series of five 100.0s:\n", series_b, "\n")

# (c) Create a Series with 20 elements that are random numbers from 0
to 100
series_c = pd.Series(np.random.randint(0, 101, size=20))
print("(c) Series of 20 random numbers:\n", series_c, "\n")
print("Descriptive statistics:\n", series_c.describe(), "\n")

# (d) Create a Series called temperatures with custom indices
temperatures = pd.Series([98.6, 98.9, 100.2, 97.9], index=['Julie',
'Charlie', 'Sam', 'Andrea'])
print("(d) Temperatures Series with custom indices:\n", temperatures,
"\n")

# (e) Form a dictionary from (d) and use it to initialize a Series
temp_dict = {'Julie': 98.6, 'Charlie': 98.9, 'Sam': 100.2, 'Andrea':
97.9}
series_e = pd.Series(temp_dict)
print("(e) Series from dictionary:\n", series_e)
```

```python
print("Verification that (d) and (e) are equivalent:")
print("Are the two Series equal?", temperatures.equals(series_e))
```

```
Name: Sidhanta Barik, RegNo: 2241002049
----------------------------------------------------
(a) Series from list:
 0     7
1    11
2    13
3    17
dtype: int64

(b) Series of five 100.0s:
 0    100.0
1    100.0
2    100.0
3    100.0
4    100.0
dtype: float64

(c) Series of 20 random numbers:
 0     34
1     29
2     42
3     10
4     87
5     94
6     92
7      6
8     15
9     64
10    37
11    90
12    22
13    63
14    44
15    90
16    81
17    44
18    93
19    95
dtype: int32

Descriptive statistics:
 count    20.000000
mean     56.600000
std      31.743047
min       6.000000
25%      32.750000
50%      53.500000
```

```
75%      90.000000
max      95.000000
dtype: float64

(d) Temperatures Series with custom indices:
 Julie       98.6
Charlie     98.9
Sam        100.2
Andrea      97.9
dtype: float64

(e) Series from dictionary:
 Julie       98.6
Charlie     98.9
Sam        100.2
Andrea      97.9
dtype: float64
Verification that (d) and (e) are equivalent:
Are the two Series equal? True
```