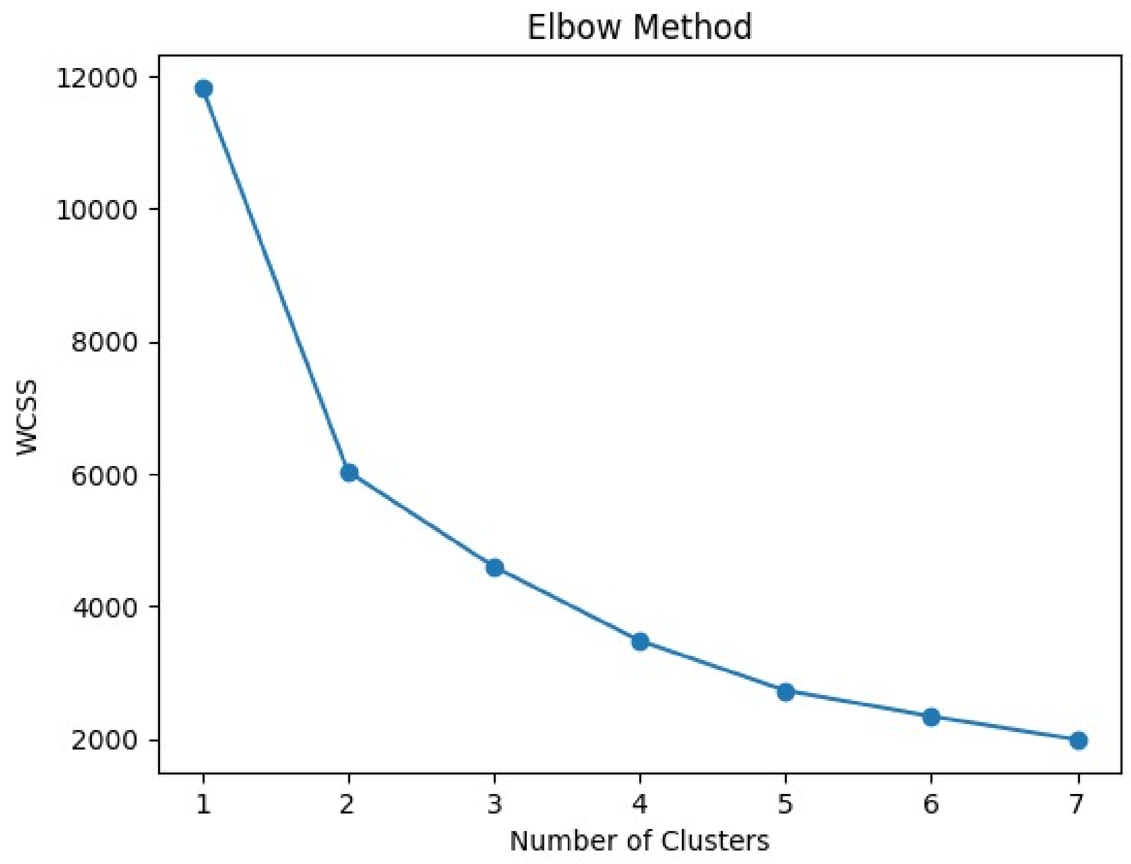
Question 1:

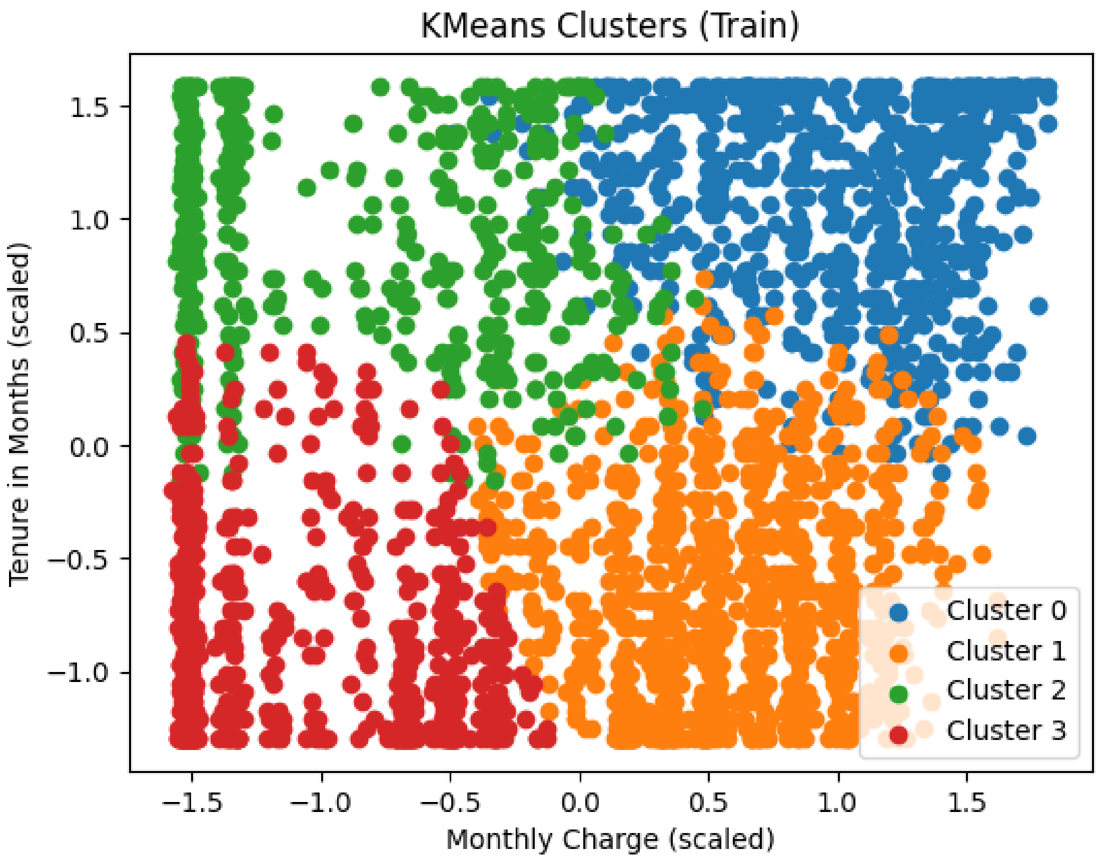
```python
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.cluster import KMeans
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.metrics import silhouette_score

df = pd.read_csv("train-telecom-churn.csv")
features = ['Monthly Charge', 'Tenure in Months', 'Total Charges',
'Total Long Distance Charges']
X = df[features].dropna()

X_train, X_test = train_test_split(X, test_size=0.3,
random_state=1172)

scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

wcss = []
for i in range(1, 8):
    km = KMeans(n_clusters=i, random_state=1172, n_init=10)
    km.fit(X_train_scaled)
    wcss.append(km.inertia_)

plt.plot(range(1, 8), wcss, marker='o')
plt.title('Elbow Method')
plt.xlabel('Number of Clusters')
plt.ylabel('WCSS')
plt.show()
```



```
kmeans = KMeans(n_clusters=4, random_state=1172, n_init=10)
train_clusters = kmeans.fit_predict(X_train_scaled)
test_clusters = kmeans.predict(X_test_scaled)

from sklearn.metrics import adjusted_rand_score

print("Train Silhouette Score:", silhouette_score(X_train_scaled,
train_clusters))
print("Test Silhouette Score:", silhouette_score(X_test_scaled,
test_clusters))

y_train = df.loc[X_train.index, 'Churn']
y_test = df.loc[X_test.index, 'Churn']
print("ARI (Train):", adjusted_rand_score(y_train, train_clusters))
print("ARI (Test):", adjusted_rand_score(y_test, test_clusters))
```

```
Train Silhouette Score: 0.38068897406884156
Test Silhouette Score: 0.39463176266835714
ARI (Train): 0.021627061737314972
ARI (Test): 0.03008545532241815
```

```
plt.figure()
for c in range(4):
    plt.scatter(X_train_scaled[train_clusters == c, 0],
                X_train_scaled[train_clusters == c, 1],
label=f'Cluster {c}')
plt.xlabel('Monthly Charge (scaled)')
plt.ylabel('Tenure in Months (scaled)')
plt.title('KMeans Clusters (Train)')
plt.legend()
plt.show()
```



Question 2:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import LabelEncoder, OrdinalEncoder
from sklearn.metrics import silhouette_score, adjusted_rand_score
from scipy.cluster.hierarchy import linkage, dendrogram
from sklearn.cluster import AgglomerativeClustering

data = pd.read_csv('adult.csv')
features = ['workclass', 'education', 'marital.status', 'occupation',
'relationship', 'race', 'native.country']
```

```python
X = data[features].copy()

X.replace("?", np.nan, inplace=True)
for col in X.columns:
    X[col].fillna(X[col].mode()[0], inplace=True)

le_dict = {}
for col in X.columns:
    le = LabelEncoder()
    X[col] = le.fit_transform(X[col])
    le_dict[col] = le

encoder = OrdinalEncoder()
X_encoded = encoder.fit_transform(X)

y_true = data['income']
```

```
/tmp/ipython-input-2457081726.py:7: FutureWarning: A value is trying
to be set on a copy of a DataFrame or Series through chained
assignment using an inplace method.
The behavior will change in pandas 3.0. This inplace method will never
work because the intermediate object on which we are setting values
always behaves as a copy.

For example, when doing 'df[col].method(value, inplace=True)', try
using 'df.method({col: value}, inplace=True)' or df[col] =
df[col].method(value) instead, to perform the operation inplace on the
original object.


  X[col].fillna(X[col].mode()[0], inplace=True)
```

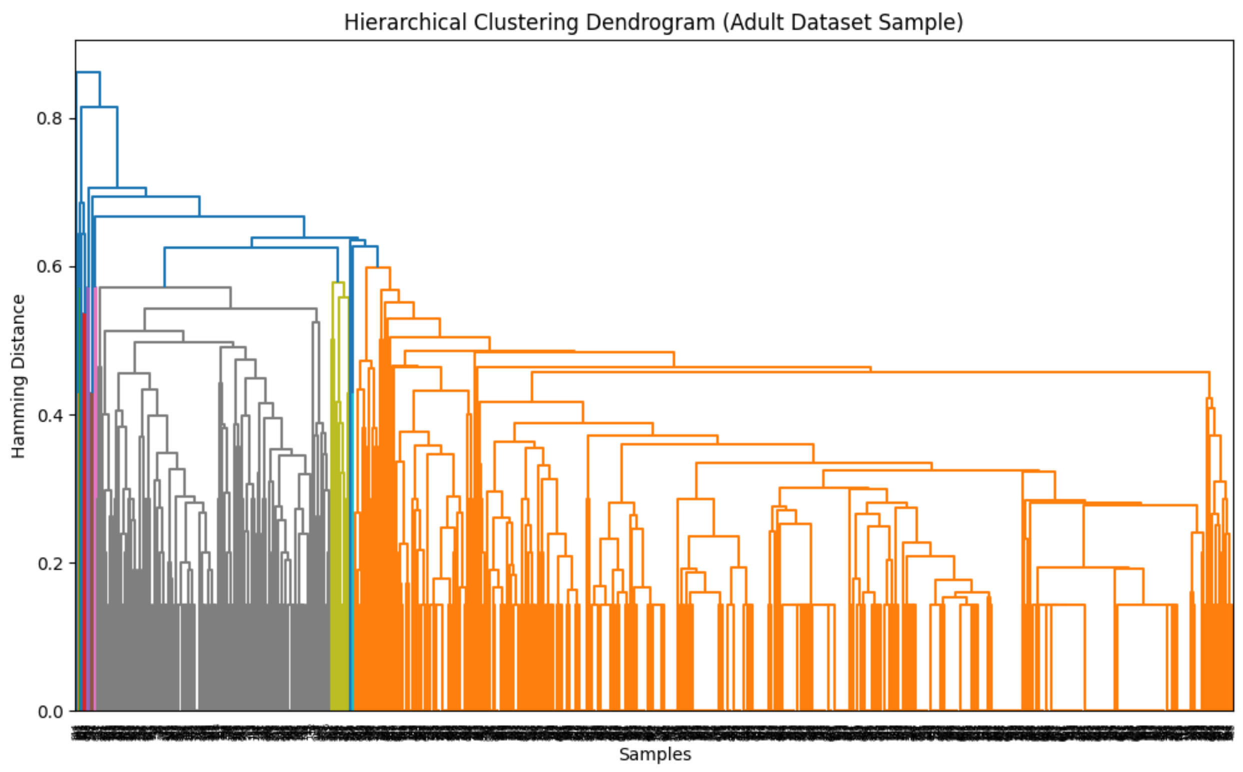
```python
# trying different k values using a sample (full data too slow for
silhouette)
sil_scores = []
sample_idx = np.random.RandomState(1172).choice(len(X_encoded), 3000,
replace=False)
X_sil = X_encoded[sample_idx]

for k in range(2, 6):
    agg_temp = AgglomerativeClustering(n_clusters=k, metric='hamming',
linkage='average')
    labels_temp = agg_temp.fit_predict(X_sil)
    sil_scores.append(silhouette_score(X_sil, labels_temp,
metric='hamming'))
    print(f"k={k}, Silhouette Score: {sil_scores[-1]:.4f}")
```

```
k=2, Silhouette Score: 0.3647
k=3, Silhouette Score: 0.3159
k=4, Silhouette Score: 0.2770
k=5, Silhouette Score: 0.2499
```

```
agg = AgglomerativeClustering(n_clusters=2, metric='hamming',
linkage='average')
clusters = agg.fit_predict(X_encoded)

print("\nCluster Distribution:\n")
print(pd.Series(clusters).value_counts().sort_index())
```

```
Cluster Distribution:

0    32536
1       25
Name: count, dtype: int64
```

```
sample_size = 1000
X_sample = X_encoded[:sample_size]

linked = linkage(X_sample, method='average', metric='hamming')

plt.figure(figsize=(12, 7))
dendrogram(linked)
plt.title("Hierarchical Clustering Dendrogram (Adult Dataset Sample)")
plt.xlabel("Samples")
plt.ylabel("Hamming Distance")
plt.show()
```



```python
le_target = LabelEncoder()
y_encoded = le_target.fit_transform(data['income'])

sil_score = silhouette_score(X_encoded, clusters, metric='hamming')
ari_score = adjusted_rand_score(y_encoded, clusters)

print("Silhouette Score:", sil_score)
print("ARI Score:", ari_score)
```

```
Silhouette Score: 0.3216980347356974
ARI Score: 0.00034387125636205 09
```