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In [1]: import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.datasets import load_iris
from sklearn.preprocessing import StandardScaler
from sklearn.cluster import KMeans
from sklearn.decomposition import PCA
from sklearn.metrics import silhouette_score
```

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In [2]: iris = load_iris()
X = iris.data
y_true = iris.target
feature_names = iris.feature_names
```

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In [3]: scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)
```

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In [4]: silhouette_scores = []
K_range = range(2, 11)
for k in K_range:
    kmeans = KMeans(n_clusters=k, random_state=42, n_init=10)
    kmeans.fit(X_scaled)
    score = silhouette_score(X_scaled, kmeans.labels_)
    silhouette_scores.append(score)
    print(f"k = {k}, Silhouette Score = {score:.4f}")

best_k = K_range[np.argmax(silhouette_scores)]
print(f"\nBest number of clusters (k) = {best_k}")
```

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k = 2, Silhouette Score = 0.5818
k = 3, Silhouette Score = 0.4599
k = 4, Silhouette Score = 0.3869
k = 5, Silhouette Score = 0.3459
k = 6, Silhouette Score = 0.3171
k = 7, Silhouette Score = 0.3202
k = 8, Silhouette Score = 0.3387
k = 9, Silhouette Score = 0.3424
k = 10, Silhouette Score = 0.3518

Best number of clusters (k) = 2
```

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In [5]: kmeans_final = KMeans(n_clusters=best_k, random_state=42, n_init=10)
kmeans_final.fit(X_scaled)
labels = kmeans_final.labels_
centers = kmeans_final.cluster_centers_
```

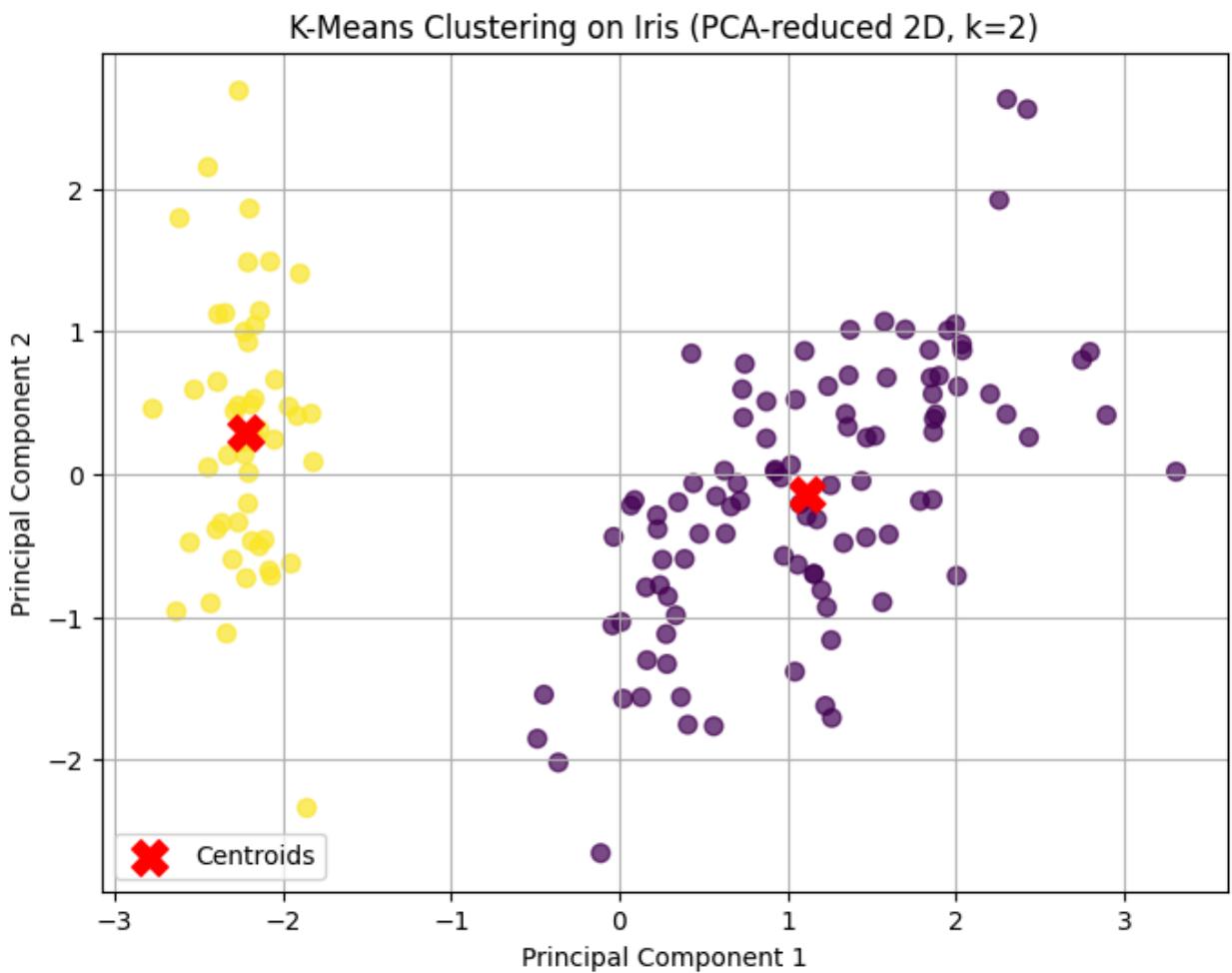
```
In [6]: pca = PCA(n_components=2)
X_pca = pca.fit_transform(X_scaled)
centers_pca = pca.transform(centers)
```

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In [7]: plt.figure(figsize=(8, 6))
scatter = plt.scatter(X_pca[:, 0], X_pca[:, 1], c=labels, cmap='viridis', s=50)
```

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plt.scatter(centers_pca[:, 0], centers_pca[:, 1], c='red', marker='X', s=200,
plt.title(f'K-Means Clustering on Iris (PCA-reduced 2D, k={best_k})')
plt.xlabel('Principal Component 1')
plt.ylabel('Principal Component 2')
plt.legend()
plt.grid(True)
plt.show()

```



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In [8]: cluster_sizes = pd.Series(labels).value_counts().sort_index()
print("\nCluster Sizes:")
print(cluster_sizes)

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Cluster Sizes:
0 100
1 50
Name: count, dtype: int64

```

In [9]: comparison = pd.crosstab(labels, y_true, rownames=['Cluster'], colnames=['True Species'])
print("\nMapping of Clusters to True Species:")
print(comparison)

```

Mapping of Clusters to True Species:

True Species	0	1	2
Cluster			
0	0	50	50
1	50	0	0

```
In [10]: iris_df = pd.DataFrame(X, columns=feature_names)
iris_df['Cluster Label'] = labels
iris_df['True Species'] = [iris.target_names[i] for i in y_true]

print("\nSample of Data with Cluster Labels:")
print(iris_df.head())
```

Sample of Data with Cluster Labels:

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	\
0	5.1	3.5	1.4	0.2	
1	4.9	3.0	1.4	0.2	
2	4.7	3.2	1.3	0.2	
3	4.6	3.1	1.5	0.2	
4	5.0	3.6	1.4	0.2	

	Cluster Label	True Species
0	1	setosa
1	1	setosa
2	1	setosa
3	1	setosa
4	1	setosa