A8: Apply Principal Component Analysis (PCA) using sci-kit-learn to reduce the dimensionality of a dataset and visualize the reduced features.

Load Iris Dataset

In [1]:
```
from sklearn.datasets import load_iris
from sklearn.preprocessing import StandardScaler
```

In [2]:
```
# Step 1: Load a sample dataset (Iris dataset)
iris = load_iris()
X = iris.data        # features
y = iris.target      # target labels
```

In [3]:
```
X
```

Out[3]:
```
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```

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       [6.2, 3.4, 5.4, 2.3],
       [5.9, 3. , 5.1, 1.8]])
```

Standardize the Data

PCA is effected by scale so you need to scale the features in your data before applying PCA. Use StandardScaler to help you standardize the dataset's features onto unit scale (mean = 0 and variance = 1) which is a requirement for the optimal performance of many machine learning algorithms.

In [4]:
```
X = StandardScaler().fit_transform(X)
```

In [5]:
```
X
```

Out[5]:
```
array([[-9.00681170e-01,  1.01900435e+00, -1.34022653e+00,
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        -1.31544430e+00],
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        -1.31544430e+00],
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        -1.18381211e+00],
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        -1.31544430e+00],
```

```
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        -1.31544430e+00],
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```

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         1.05393502e+00],
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         1.58046376e+00],
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         1.44883158e+00],
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[ 1.89829664e-01, -1.31979479e-01,  5.92245988e-01,
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  1.44883158e+00],
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  9.22302838e-01],
```

```
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       [ 4.32165405e-01,  7.88807586e-01,  9.33270550e-01,
         1.44883158e+00],
       [ 6.86617933e-02, -1.31979479e-01,  7.62758269e-01,
         7.90670654e-01]])
```

In [6]:
```
y
```

Out[6]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
       2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
       2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2])
```

	sepal length	sepal width	petal length	petal width
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

Standardization →

	sepal length	sepal width	petal length	petal width
0	-0.900681	1.032057	-1.341272	-1.312977
1	-1.143017	-0.124958	-1.341272	-1.312977
2	-1.385353	0.337848	-1.398138	-1.312977
3	-1.506521	0.106445	-1.284407	-1.312977
4	-1.021849	1.263460	-1.341272	-1.312977

The array x (visualized by a pandas dataframe) before and after standardization

PCA Projection to 2D

The original data has 4 columns (sepal length, sepal width, petal length, and petal width). In this section, the code projects the original data which is 4 dimensional into 2 dimensions

In [7]:
```
from sklearn.decomposition import PCA
import pandas as pd
pca = PCA(n_components=2) # creating an instance of PCA
```

```python
principalComponents = pca.fit_transform(X) #fitting the pca instance to the dataset
principalDf = pd.DataFrame(data = principalComponents
             , columns = ['principal component 1', 'principal component 2'])
```

In [8]:
```python
principalDf
```

Out[8]:

	principal component 1	principal component 2
0	-2.264703	0.480027
1	-2.080961	-0.674134
2	-2.364229	-0.341908
3	-2.299384	-0.597395
4	-2.389842	0.646835
...	...	...
145	1.870503	0.386966
146	1.564580	-0.896687
147	1.521170	0.269069
148	1.372788	1.011254
149	0.960656	-0.024332

150 rows × 2 columns

	sepal length	sepal width	petal length	petal width
0	-0.900681	1.032057	-1.341272	-1.312977
1	-1.143017	-0.124958	-1.341272	-1.312977
2	-1.385353	0.337848	-1.398138	-1.312977
3	-1.506521	0.106445	-1.284407	-1.312977
4	-1.021849	1.263460	-1.341272	-1.312977

PCA
(2 components)

	principal component 1	princial component 2
0	-2.264542	0.505704
1	-2.086426	-0.655405
2	-2.367950	-0.318477
3	-2.304197	-0.575368
4	-2.388777	0.674767

PCA and Keeping the Top 2 Principal Components

In [13]:
```
# Combine PCA results with target column
finalDf = pd.concat([principalDf, pd.Series(y, name='target')], axis=1)
finalDf
```

Out[13]:

	principal component 1	principal component 2	target
0	-2.264703	0.480027	0
1	-2.080961	-0.674134	0
2	-2.364229	-0.341908	0
3	-2.299384	-0.597395	0
4	-2.389842	0.646835	0
...	...	...	...
145	1.870503	0.386966	2
146	1.564580	-0.896687	2
147	1.521170	0.269069	2
148	1.372788	1.011254	2
149	0.960656	-0.024332	2

150 rows × 3 columns

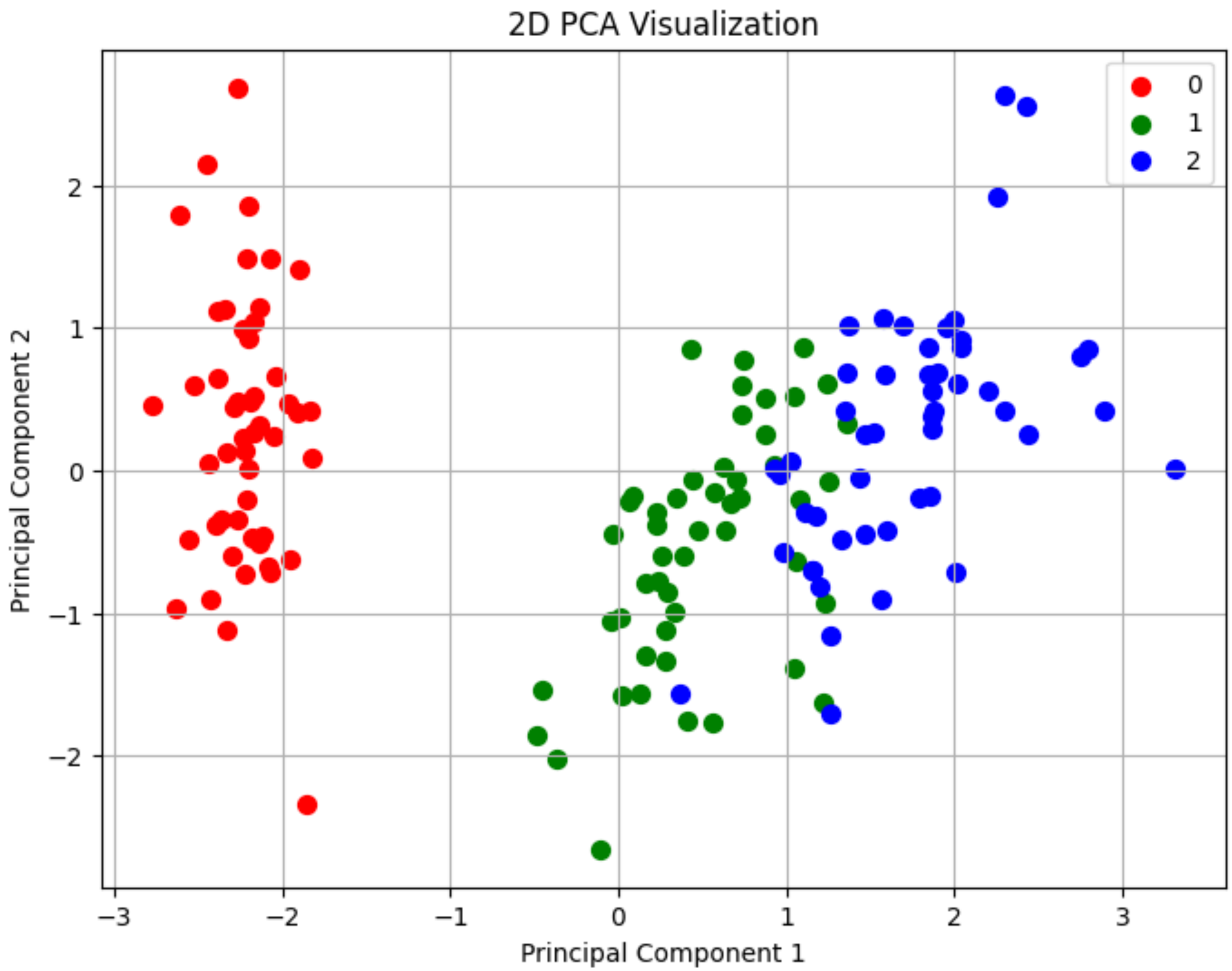
In [16]:
```
# Plot the 2D PCA projection
import matplotlib.pyplot as plt

plt.figure(figsize=(8,6))
targets = list(set(y))  # unique target classes
colors = ['r', 'g', 'b', 'c', 'm', 'y', 'k']  # add more if needed

for target, color in zip(targets, colors):
    indicesToKeep = finalDf['target'] == target
    plt.scatter(finalDf.loc[indicesToKeep, 'principal component 1'],
```

```
                finalDf.loc[indicesToKeep, 'principal component 2'],
                c=color,
                s=50,
                label=target)

plt.xlabel('Principal Component 1')
plt.ylabel('Principal Component 2')
plt.title('2D PCA Visualization')
plt.legend()
plt.grid()
plt.show()
```


2D PCA Visualization
Principal Component 1
Principal Component 2
0
1
2
−3
−2
−1
0
1
2
3
−2
−1
0
1
2