```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, classification_report, confusion_matrix, roc_auc_score
from sklearn.preprocessing import StandardScaler, OneHotEncoder
from sklearn.compose import ColumnTransformer
from sklearn.decomposition import PCA
import matplotlib.pyplot as plt
import seaborn as sns
```

```
heart_data = pd.read_csv('heart_disease_data.csv')
```

```
heart_data.shape
```

```
(303, 14)
```

```
heart_data.head()
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1	1
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2	1
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2	1
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2	1
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2	1

Next steps: Generate code with heart_data | View recommended plots | New interactive sheet

```
heart_data.tail()
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
298	57	0	0	140	241	0	1	123	1	0.2	1	0	3	0
299	45	1	3	110	264	0	1	132	0	1.2	1	0	3	0
300	68	1	0	144	193	1	1	141	0	3.4	1	2	3	0
301	57	1	0	130	131	0	1	115	1	1.2	1	1	3	0
302	57	0	1	130	236	0	0	174	0	0.0	1	1	2	0

```
if heart_data.isnull().sum().any():
    print("Missing values detected.")
else:
    print("No missing values detected.\n")
```

```
heart_data.isnull().sum()
```

```
No missing values detected.
```

	0
age	0
sex	0
cp	0
trestbps	0
chol	0
fbs	0
restecg	0
thalach	0
exang	0
oldpeak	0
slope	0
ca	0
thal	0
target	0

dtype: int64

```
heart_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    int64  
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    int64  
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        303 non-null    int64  
 12  thal      303 non-null    int64  
 13  target    303 non-null    int64  
dtypes: float64(1), int64(13)
memory usage: 33.3 KB
```

```
heart_data.describe()
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope
count	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000
mean	54.366337	0.683168	0.966997	131.623762	246.264026	0.148515	0.528053	149.646865	0.326733	1.039604	1.399340
std	9.082101	0.466011	1.032052	17.538143	51.830751	0.356198	0.525860	22.905161	0.469794	1.161075	0.616226
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	71.000000	0.000000	0.000000	0.000000
25%	47.500000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000	133.500000	0.000000	0.000000	1.000000
50%	55.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000	153.000000	0.000000	0.800000	1.000000
75%	61.000000	1.000000	2.000000	140.000000	274.500000	0.000000	1.000000	166.000000	1.000000	1.600000	2.000000
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000	202.000000	1.000000	6.200000	2.000000

```
heart_data['target'].value_counts()
```

target	count
1	165
0	138

dtype: int64

```
heart_data['age_group'] = pd.cut(heart_data['age'], bins=[0, 30, 45, 60, np.inf], labels=['young', 'middle-aged', 'elderly', 'senior'])
heart_data['age_chol_interaction'] = heart_data['age'] * heart_data['chol']


X = heart_data.drop(columns=['target', 'age'], axis=1)
Y = heart_data['target']


numerical_cols = X.select_dtypes(include=np.number).columns.tolist()
categorical_cols = X.select_dtypes(exclude=np.number).columns.tolist()


X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.2, stratify=Y, random_state=2)


numeric_transformer = StandardScaler()
categorical_transformer = OneHotEncoder(handle_unknown='ignore')


preprocessor = ColumnTransformer(
    transformers=[
        ('num', numeric_transformer, numerical_cols),
        ('cat', categorical_transformer, categorical_cols)
    ])


X_train_scaled = preprocessor.fit_transform(X_train)
X_test_scaled = preprocessor.transform(X_test)


pca = PCA(n_components=10)
X_train_pca = pca.fit_transform(X_train_scaled)
X_test_pca = pca.transform(X_test_scaled)


param_grid = {'C': [0.001, 0.01, 0.1, 1, 10, 100]}
grid_search = GridSearchCV(LogisticRegression(max_iter=1000), param_grid, cv=5, scoring='accuracy')
grid_search.fit(X_train_pca, Y_train)
best_model = grid_search.best_estimator_


train_predictions = best_model.predict(X_train_pca)
train_accuracy = accuracy_score(Y_train, train_predictions)
print("Training data accuracy:", train_accuracy)
```

```
Training data accuracy: 0.8388429752066116
```

```
test_predictions = best_model.predict(X_test_pca)
test_accuracy = accuracy_score(Y_test, test_predictions)
print("Test data accuracy:", test_accuracy)
```

```
Test data accuracy: 0.819672131147541
```

```
print("Classification Report:")
print(classification_report(Y_test, test_predictions))
```

```
Classification Report:
                precision    recall  f1-score   support

             0       0.84      0.75      0.79        28
             1       0.81      0.88      0.84        33

      accuracy                           0.82        61
     macro avg       0.82      0.81      0.82        61
  weighted avg       0.82      0.82      0.82        61
```

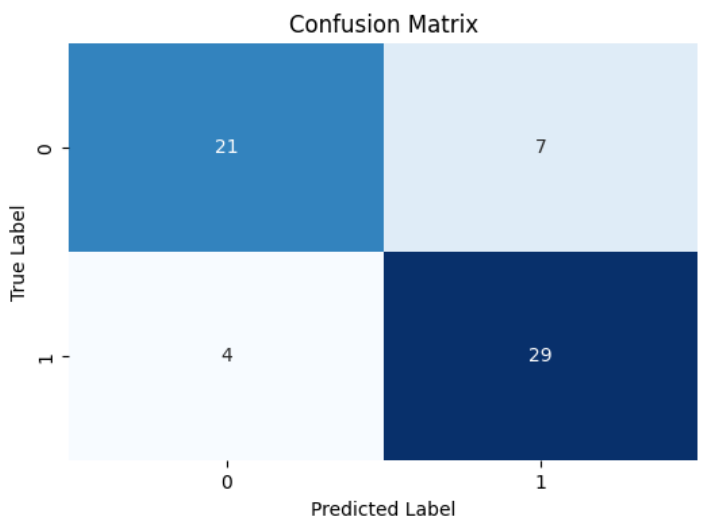
```
print("Confusion Matrix:")
print(confusion_matrix(Y_test, test_predictions))
```

```
Confusion Matrix:
[[21  7]
 [ 4 29]]
```

```
roc_auc = roc_auc_score(Y_test, best_model.predict_proba(X_test_pca)[:, 1])
print("ROC-AUC Score:", roc_auc)
```

```
ROC-AUC Score: 0.9069264069264069
```

```
plt.figure(figsize=(6, 4))
sns.heatmap(confusion_matrix(Y_test, test_predictions), annot=True, fmt='d', cmap='Blues', cbar=False)
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```




```
def predict_heart_disease(input_data, model, preprocessor, pca):
    try:
        input_data_dict = {
            'age': [input_data[0]],
            'sex': [input_data[1]],
            'cp': [input_data[2]],
            'trestbps': [input_data[3]],
            'chol': [input_data[4]],
            'fbs': [input_data[5]],
            'restecg': [input_data[6]],
            'thalach': [input_data[7]],
            'exang': [input_data[8]],
            'oldpeak': [input_data[9]],
            'slope': [input_data[10]],
            'ca': [input_data[11]],
            'thal': [input_data[12]],
            'age_group': [input_data[13]],
            'age_chol_interaction': [input_data[14]]
        }
        input_data_df = pd.DataFrame(input_data_dict)
        input_data_transformed = preprocessor.transform(input_data_df)
        input_data_pca = pca.transform(input_data_transformed)
        prediction = model.predict(input_data_pca)
        if prediction[0] == 0:
            return 'The Person does not have a Heart Disease'
        else:
            return 'The Person has Heart Disease'
    except Exception as e:
        return f"An error occurred: {e}"
```

```
input_data = [41, 0, 1, 130, 204, 0, 0, 172, 0, 1.4, 2, 0, 2, 'middle-aged', 8416]
```

```
prediction_result = predict_heart_disease(input_data, best_model, preprocessor, pca)
```

```
print("Prediction Result:", prediction_result)
```

```
Prediction Result: The Person has Heart Disease
```