For code explanation: Review "Training a Binary Classifier" section in chapter 3: Classification

In [1]:
```
import numpy as np
from numpy.core.numeric import cross
import pandas as pd
from scipy.sparse.construct import rand
from sklearn.model_selection import train_test_split
from sklearn.linear_model import SGDClassifier
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import cross_val_predict
from sklearn.metrics import precision_recall_curve
```

```
/tmp/ipykernel_398/2120357507.py:4: DeprecationWarning: Please import `rand` from th
e `scipy.sparse` namespace; the `scipy.sparse.construct` namespace is deprecated and
will be removed in SciPy 2.0.0.
  from scipy.sparse.construct import rand
```

In [2]:
```
df = pd.read_csv('employee_retention.csv')
#print(df.describe()) uncomment to see some data describtion
# df.head() # uncomment to see first few rows of the data
```

In [3]:
```
#some data cleaning


#separate features/attributes from class_label
X = df.iloc[:, 0:7]
y = df.iloc[:,7]
#print (X)
#print(y)
```

In [4]:
```
#split data into training and test sets, replace ??? with the desired percentage of
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_sta
```

In [5]:
```
# Use the schotastic gradient descent classifier and fit the data: USE random_state
model = SGDClassifier(random_state=42)
model.fit(X_train, y_train)
```

Out[5]:
```
▾        SGDClassifier

SGDClassifier(random_state=42)
```

In [6]:
```
# Test the trained model on the testing set, X_test
y_pred = model.predict(X_test)
y_pred[:10]  # show first 10 predictions
```

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

In [7]:
```
#score the predictions using X_test and y_test
from sklearn.metrics import accuracy_score
accuracy = accuracy_score(y_test, y_pred)
print("Accuracy:", accuracy)
```

```
Accuracy: 0.7646666666666667
```

In [8]:
```
# train the model using a 10-fold cross-validation training using accuracy for scor
cv_scores = cross_val_score(model, X_train, y_train, cv=10, scoring='accuracy')
print("Cross-validation accuracies:", cv_scores)
print("Mean CV Accuracy:", cv_scores.mean())
```

```
Cross-validation accuracies: [0.7525     0.78       0.73       0.76416667 0.62666667
0.65916667
 0.78666667 0.75833333 0.76       0.76146789]
Mean CV Accuracy: 0.7378967889908257
```

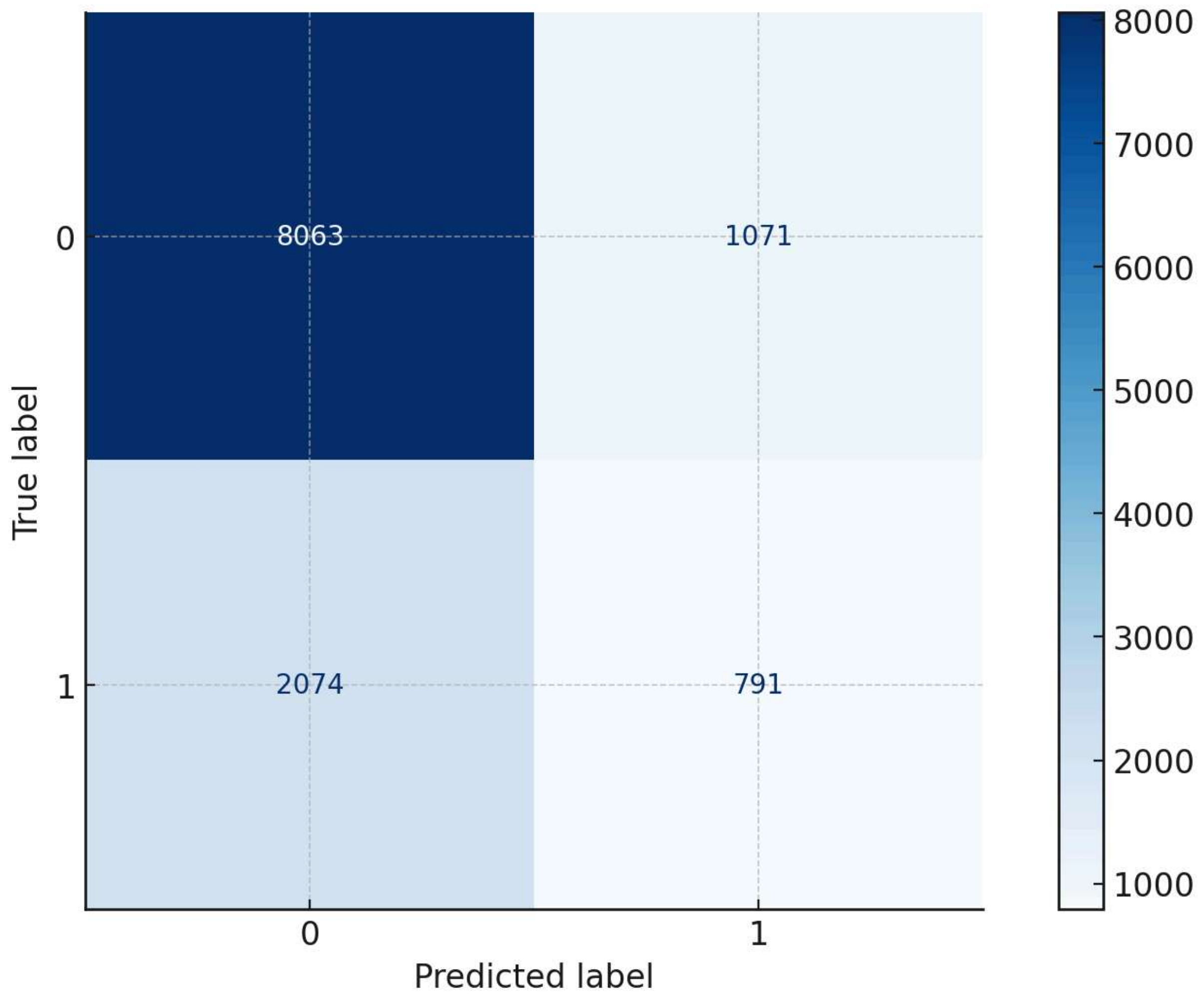
In [9]:
```
# run a prediction on the cross_val_predict() on X_train and y_train for k=10 folds
y_train_pred = cross_val_predict(model, X_train, y_train, cv=10)
```

In [10]:
```
# generate the confusion matrix - Check Confusion Matrices section in chapter 3
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay

cm = confusion_matrix(y_train, y_train_pred)
disp = ConfusionMatrixDisplay(confusion_matrix=cm)
disp.plot(cmap="Blues")

print("Confusion Matrix:\n", cm)
```

```
Confusion Matrix:
 [[8063 1071]
 [2074  791]]
```



```
In [11]: # Calculate the precision using y_train and y_train_pred
         from sklearn.metrics import precision_score
         precision = precision_score(y_train, y_train_pred)
         print("Precision:", precision)
```

```
Precision: 0.424812030075188
```

```
In [12]: # Calculate the recall using y_train and y_train_pred
         from sklearn.metrics import recall_score
         recall = recall_score(y_train, y_train_pred)
         print("Recall:", recall)
```

```
Recall: 0.27609075043630016
```

```
In [13]: # Calculate the F1 score using y_train and y_train_pred
         from sklearn.metrics import f1_score
         f1 = f1_score(y_train, y_train_pred)
         print("F1 Score:", f1)
```

```
F1 Score: 0.3346731542204358
```

```
In [14]: # Calculate the y_scores
         y_scores = cross_val_predict(model, X_train, y_train, cv=10, method="decision_funct
```

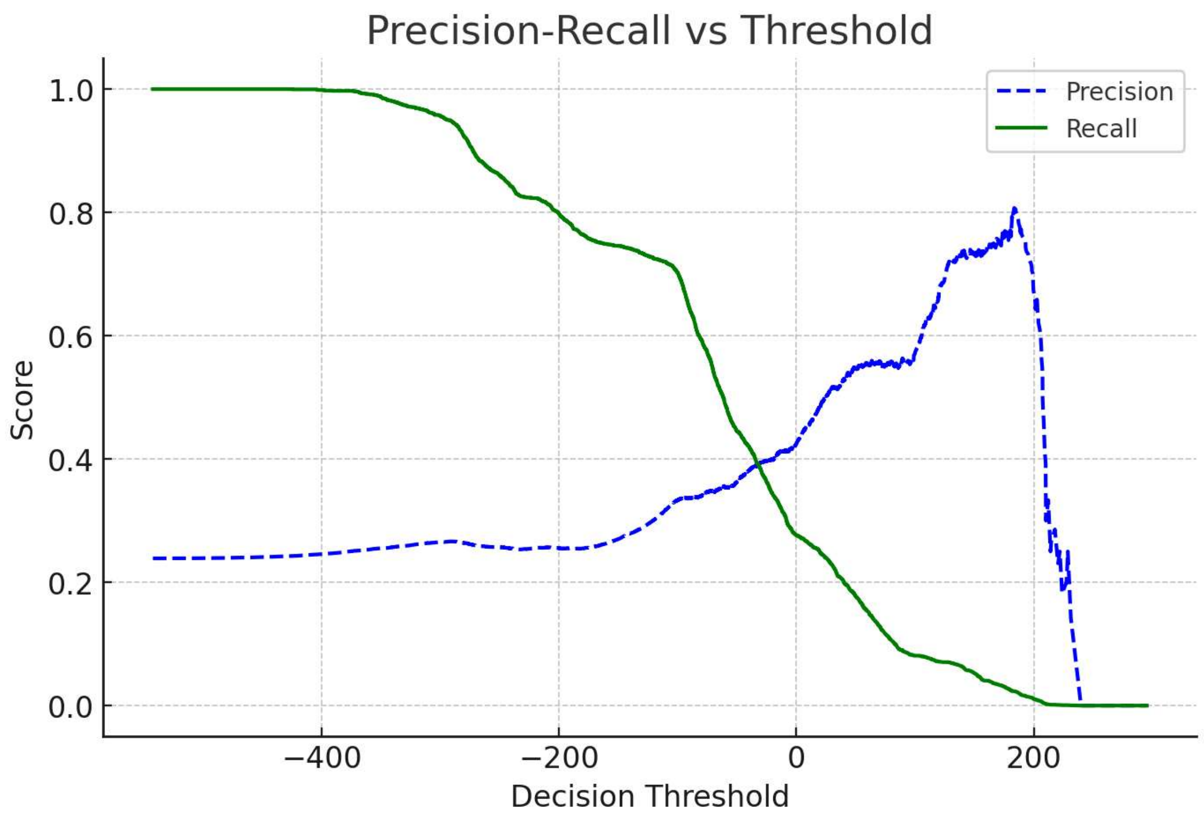
```
In [15]: # calculate the precisions, reecalls, and thresholds
         from sklearn.metrics import precision_recall_curve
```

```
import matplotlib.pyplot as plt

# Generate precision, recall, and threshold values
precisions, recalls, thresholds = precision_recall_curve(y_train, y_scores)

def plot_precision_recall_vs_threshold(precisions, recalls, thresholds):
    plt.figure(figsize=(8,5))
    plt.plot(thresholds, precisions[:-1], "b--", label="Precision")
    plt.plot(thresholds, recalls[:-1], "g-", label="Recall")
    plt.title("Precision-Recall vs Threshold")
    plt.xlabel("Decision Threshold")
    plt.ylabel("Score")
    plt.legend(loc="best")
    plt.grid(True)
    plt.show()

plot_precision_recall_vs_threshold(precisions, recalls, thresholds)
```

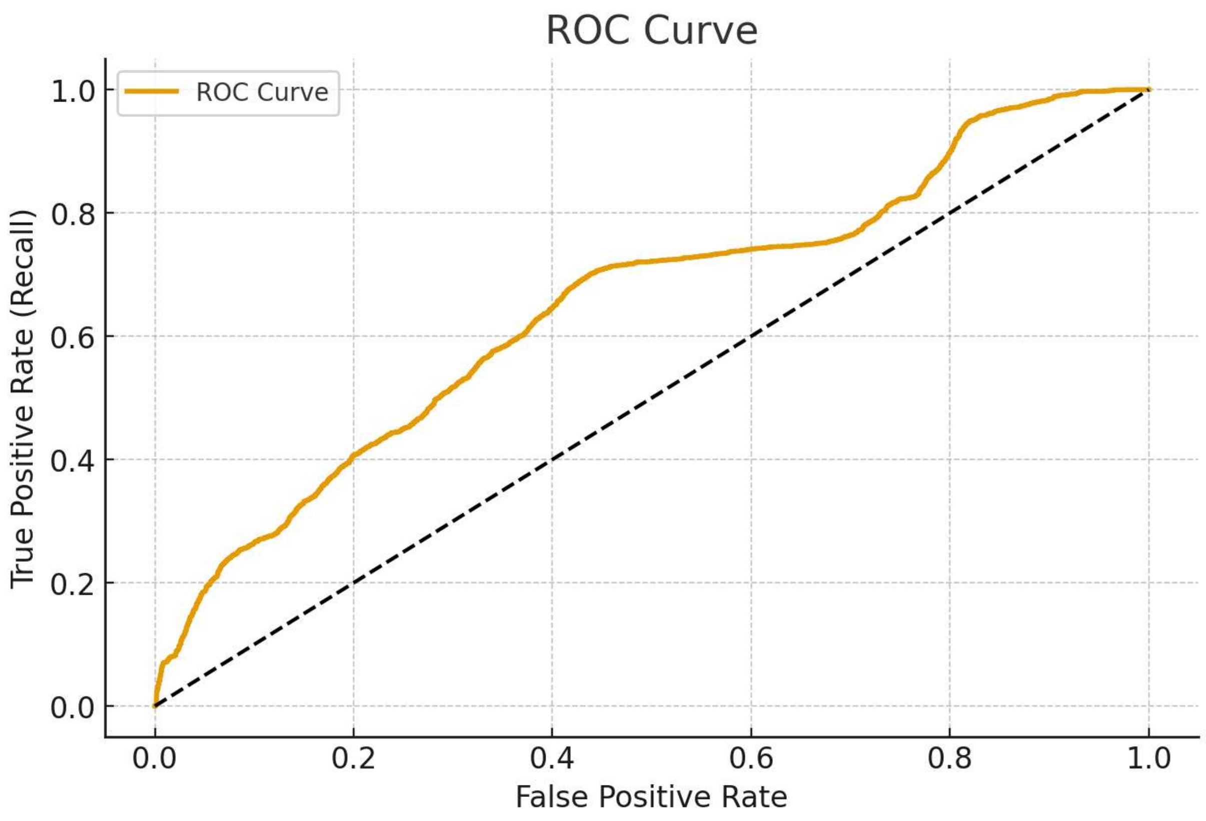


In [16]:
```
# In employee retention, recall (identifying employees likely to leave) is more cri
# Missing an at-risk employee (false negative) is more costly than mistakenly flagg
```

In [17]:
```
#generate the ROC curve
from sklearn.metrics import roc_curve

fpr, tpr, thresholds = roc_curve(y_train, y_scores)

plt.figure(figsize=(8,5))
plt.plot(fpr, tpr, linewidth=2, label="ROC Curve")
plt.plot([0, 1], [0, 1], "k--")
plt.title("ROC Curve")
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate (Recall)")
plt.legend(loc="best")
plt.grid(True)
plt.show()
```



In [18]:
```
# Calulate the area under the curve
from sklearn.metrics import roc_auc_score

auc = roc_auc_score(y_train, y_scores)
print("Area Under the Curve (AUC):", auc)
```

```
Area Under the Curve (AUC): 0.6493905363272678
```

In [19]:
```
from matplotlib.backends.backend_pdf import PdfPages
from sklearn.metrics import precision_recall_curve

# Recompute precision, recall, and thresholds using the same y_train and y_scores
precisions, recalls, thresholds = precision_recall_curve(y_train, y_scores)

with PdfPages("employee_retention_results.pdf") as pdf:
    # --- Confusion Matrix ---
    disp.plot(cmap="Blues")
    plt.title("Confusion Matrix")
    pdf.savefig()
    plt.close()

    # --- Precision-Recall Curve ---
    plt.figure(figsize=(8,5))
    n = len(thresholds)
    plt.plot(thresholds, precisions[:n], "b--", label="Precision")
    plt.plot(thresholds, recalls[:n], "g-", label="Recall")
    plt.title("Precision-Recall vs Threshold")
    plt.xlabel("Decision Threshold")
    plt.ylabel("Score")
    plt.legend(loc="best")
    plt.grid(True)
    pdf.savefig()
    plt.close()

    # --- ROC Curve ---
    plt.figure(figsize=(8,5))
    plt.plot(fpr, tpr, linewidth=2, label="ROC Curve")
    plt.plot([0,1], [0,1], "k--")
    plt.title("ROC Curve")
    plt.xlabel("False Positive Rate")
    plt.ylabel("True Positive Rate")
    plt.legend()
    pdf.savefig()
    plt.close()

print("✅ PDF report 'employee_retention_results.pdf' generated successfully.")
```

```
✅ PDF report 'employee_retention_results.pdf' generated successfully.
```