In [36]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import confusion_matrix, accuracy_score, precision_s
```

In [10]:
```
df = pd.read_csv("Desktop/datasets/Iris.csv")
df.head()
```

Out[10]:

	Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Species
0	1	5.1	3.5	1.4	0.2	Iris-setosa
1	2	4.9	3.0	1.4	0.2	Iris-setosa
2	3	4.7	3.2	1.3	0.2	Iris-setosa
3	4	4.6	3.1	1.5	0.2	Iris-setosa
4	5	5.0	3.6	1.4	0.2	Iris-setosa

In [12]:
```
X = df.iloc[:, :-1]   # all columns except species
y = df.iloc[:, -1]    # species column
```

In [14]:
```
X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.3, random_state=42
)
```

In [16]:
```
model = GaussianNB()
model.fit(X_train, y_train)
```

Out[16]:
```
GaussianNB()
```

In [18]:
```
y_pred = model.predict(X_test)
```

In [20]:
```
cm = confusion_matrix(y_test, y_pred)
print("Confusion Matrix:\n", cm)
```

```
Confusion Matrix:
 [[19  0  0]
 [ 0 13  0]
 [ 0  0 13]]
```

In [22]:
```
TP = np.diag(cm)
FP = cm.sum(axis=0) - TP
FN = cm.sum(axis=1) - TP
TN = cm.sum() - (FP + FN + TP)
```

In [24]:
```
for i, cls in enumerate(model.classes_):
    print(f"\nClass: {cls}")
    print("TP:", TP[i])
    print("FP:", FP[i])
```

```
    print("FN:", FN[i])
    print("TN:", TN[i])
```

```
Class: Iris-setosa
TP: 19
FP: 0
FN: 0
TN: 26

Class: Iris-versicolor
TP: 13
FP: 0
FN: 0
TN: 32

Class: Iris-virginica
TP: 13
FP: 0
FN: 0
TN: 32
```

In [26]:
```
accuracy = accuracy_score(y_test, y_pred)
print("Accuracy:", accuracy)
```

```
Accuracy: 1.0
```

In [28]:
```
error_rate = 1 - accuracy
print("Error Rate:", error_rate)
```

```
Error Rate: 0.0
```

In [30]:
```
precision = precision_score(y_test, y_pred, average='macro')
print("Precision:", precision)
```

```
Precision: 1.0
```

In [32]:
```
recall = recall_score(y_test, y_pred, average='macro')
print("Recall:", recall)
```

```
Recall: 1.0
```

In [34]:
```
print("\n--- Model Performance ---")
print("Accuracy :", accuracy)
print("Error Rate :", error_rate)
print("Precision :", precision)
print("Recall :", recall)
```

```
--- Model Performance ---
Accuracy : 1.0
Error Rate : 0.0
Precision : 1.0
Recall : 1.0
```

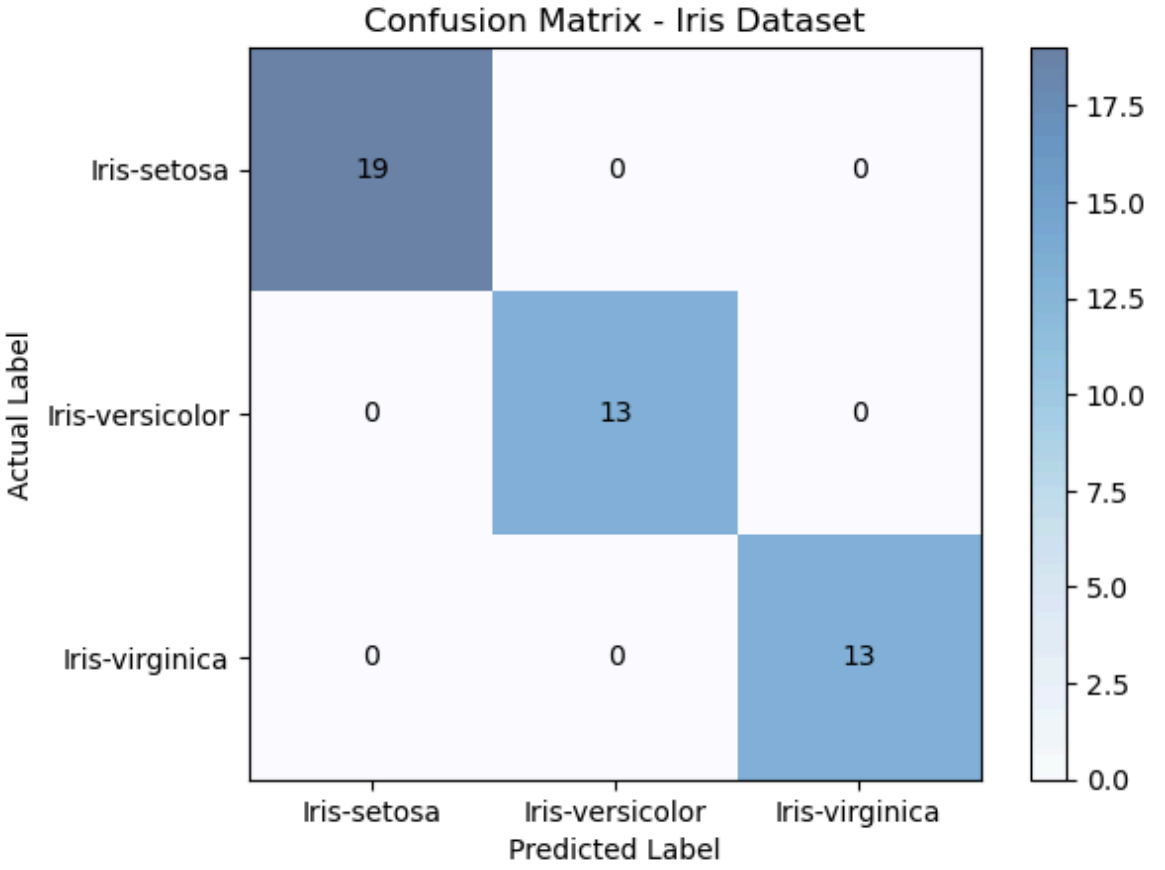
In [42]:
```
plt.figure()
plt.imshow(cm, cmap="Blues", alpha=0.6)  # lighter color
plt.title("Confusion Matrix - Iris Dataset")
plt.xlabel("Predicted Label")
plt.ylabel("Actual Label")
plt.colorbar()

classes = model.classes_
plt.xticks(range(len(classes)), classes)
```

```
plt.yticks(range(len(classes)), classes)

for i in range(len(classes)):
    for j in range(len(classes)):
        plt.text(j, i, cm[i, j], ha="center", va="center")

plt.show()
```



In [ ]:
```
### part 2
```

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import confusion_matrix, accuracy_score, precision_s
```

In [17]:
```
df = pd.read_csv("Desktop/datasets/email.csv", encoding="latin-1")
df.head()
```

Out[17]:

	Email No.	the	to	ect	and	for	of	a	you	hou	...	expectations	mx	moved	c
0	Email 1	0	0	1	0	0	0	2	0	0	...	0	0	0	
1	Email 2	8	13	24	6	6	2	102	1	27	...	0	0	0	
2	Email 3	0	0	1	0	0	0	8	0	0	...	0	0	0	
3	Email 4	0	5	22	0	5	1	51	2	10	...	0	0	0	
4	Email 5	7	6	17	1	5	2	57	0	9	...	0	0	1	

5 rows × 1024 columns

In [19]:
```
print(df.head())
print(df.columns)
```

```
  Email No.  the  to  ect  and  for  of    a  you  hou  ...  expectations
mx  \
0   Email 1    0   0    1    0    0   0    2    0    0  ...             0
0
1   Email 2    8  13   24    6    6   2  102    1   27  ...             0
0
2   Email 3    0   0    1    0    0   0    8    0    0  ...             0
0
3   Email 4    0   5   22    0    5   1   51    2   10  ...             0
0
4   Email 5    7   6   17    1    5   2   57    0    9  ...             0
0

   moved  cernosek  matter  devon  calls  worldwide  records  removed
0      0         0       0      0      0          0        0        0
1      0         0       0      0      0          0        0        0
2      0         0       0      0      0          0        0        0
3      0         0       0      0      0          0        0        0
4      1         0       0      0      0          0        0        0

[5 rows x 1024 columns]
Index(['Email No.', 'the', 'to', 'ect', 'and', 'for', 'of', 'a', 'you', 'h
ou',
       ...
       'expectations', 'mx', 'moved', 'cernosek', 'matter', 'devon', 'call
s',
       'worldwide', 'records', 'removed'],
      dtype='object', length=1024)
```

In [29]:
```
df.columns = df.columns.str.strip()
```

In [31]:
```
print(df.columns[:5])
```

```
Index(['the', 'to', 'ect', 'and', 'for'], dtype='object')
```

In [33]:
```
df = df.iloc[:, 1:]
```

In [39]:
```
X = df.iloc[:, :-1]
y = df.iloc[:, -1]
```

In [41]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(
    X, y,
    test_size=0.2,
    random_state=42
)
```

In [43]:
```
from sklearn.naive_bayes import MultinomialNB

model = MultinomialNB()
model.fit(X_train, y_train)
```

Out[43]:

▾ MultinomialNB

```
MultinomialNB()
```

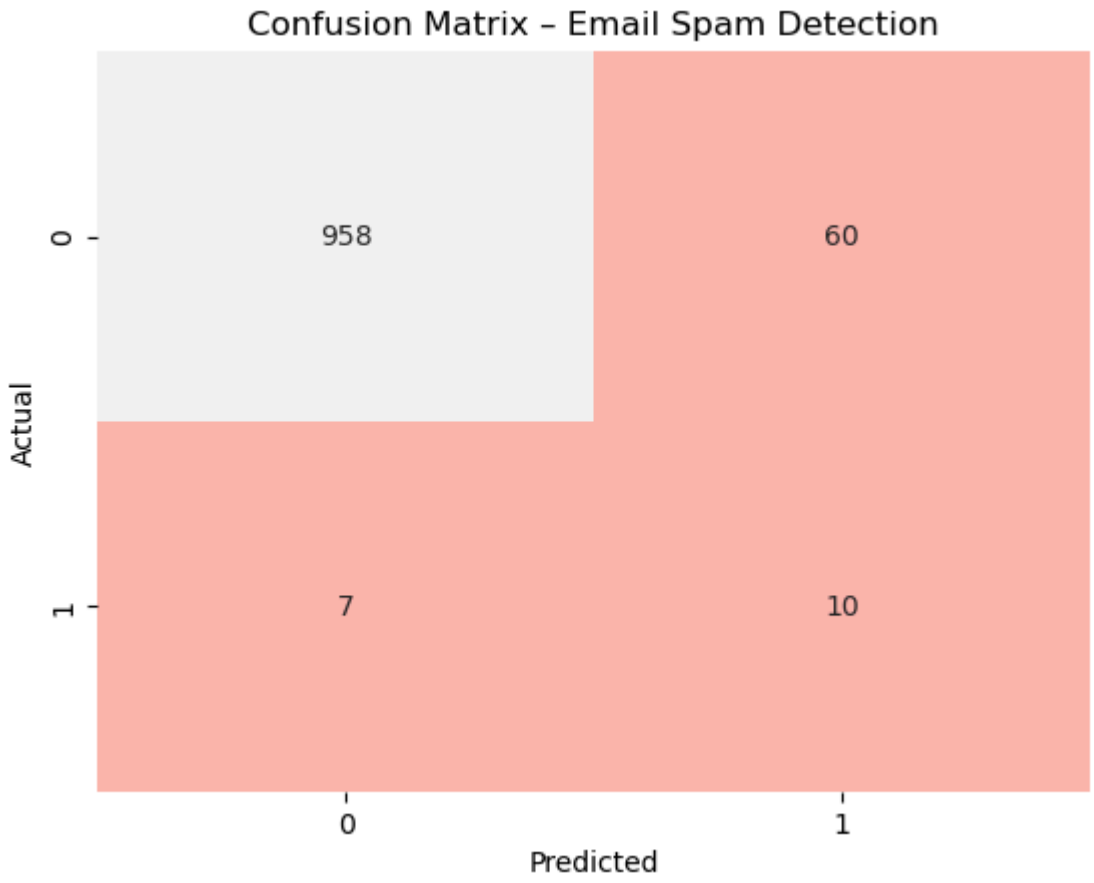
In [45]:
```
y_pred = model.predict(X_test)
```

In [47]:
```
from sklearn.metrics import confusion_matrix
import seaborn as sns
import matplotlib.pyplot as plt

cm = confusion_matrix(y_test, y_pred)

sns.heatmap(
    cm,
    annot=True,
    fmt='d',
    cmap='Pastel1',
    cbar=False
)

plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.title("Confusion Matrix – Email Spam Detection")
plt.show()
```



In [49]:
```
tn, fp, fn, tp = cm.ravel()

print("TP:", tp)
print("FP:", fp)
print("TN:", tn)
print("FN:", fn)

accuracy = (tp + tn) / (tp + tn + fp + fn)
precision = tp / (tp + fp)
recall = tp / (tp + fn)

print("\nAccuracy:", accuracy)
print("Precision:", precision)
print("Recall:", recall)
```

```
TP: 10
FP: 60
TN: 958
FN: 7

Accuracy: 0.9352657004830918
Precision: 0.14285714285714285
Recall: 0.5882352941176471
```

In [ ]: