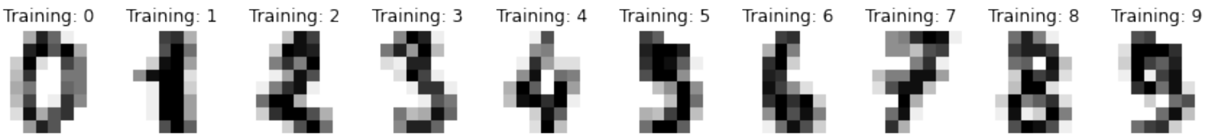
** Homework 5 **

In [1]:
```
%matplotlib inline
#Modified by Mehul Motani from SKLearn

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn import datasets, metrics
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn import svm, linear_model
from sklearn.naive_bayes import GaussianNB
from sklearn.preprocessing import StandardScaler
import time
```

In [2]:
```
#plot the digits to find the hardest recognition one
digits = datasets.load_digits()

#digits.data flattened image
#digits.image 8x8 image
#digits.target label

print("digits.data.shape,digits.target.shape,digits.images.shape")
print(digits.data.shape,digits.target.shape,digits.images.shape)
_, axes = plt.subplots(nrows=1, ncols=10, figsize=(15, 3))
for ax, image, label in zip(axes, digits.images, digits.target):
    ax.set_axis_off()
    ax.imshow(image, cmap=plt.cm.gray_r, interpolation="nearest")
    ax.set_title("Training: %i" % label)
```

```
digits.data.shape,digits.target.shape,digits.images.shape
(1797, 64) (1797,) (1797, 8, 8)
```



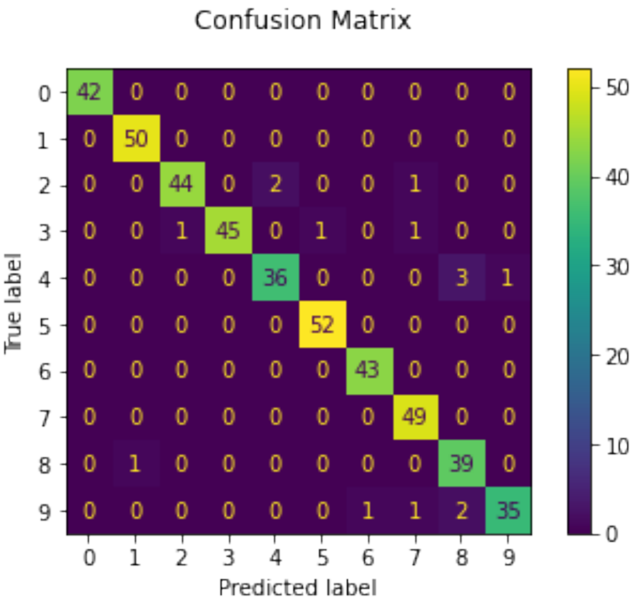
** SVM, Naïve Bayes and Logistic Regression classifiers **

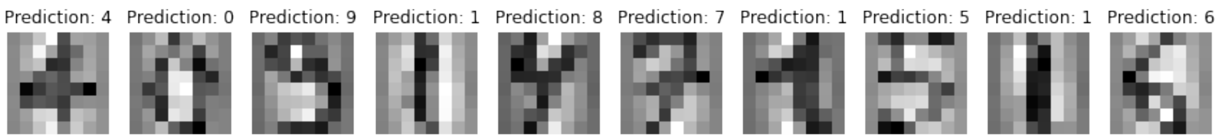
SVM needs standard normalization

In [3]:

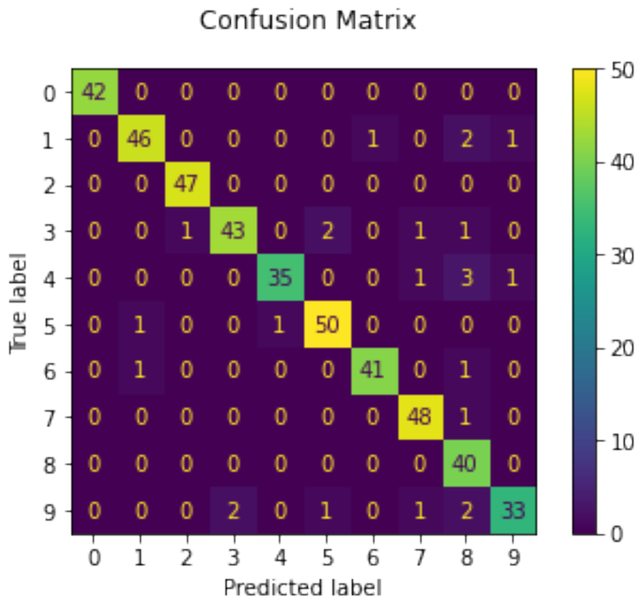
```
svc = svm.SVC()
lr = linear_model.LogisticRegression(max_iter=5000)
gnb = GaussianNB()

# Split the data into 75% training and 25% test sets
x_train, x_test, y_train, y_test = train_test_split(
    digits.data, digits.target, test_size=0.25, random_state=2, shuffle=T

# Normalize the data set
sc = StandardScaler()
sc.fit(x_train)
X_train = sc.transform(x_train)
X_test = sc.transform(x_test)

# Classify
for clf in [svc, lr, gnb]:
  y_pred=clf.fit(X_train, y_train).predict(X_test)
  print(metrics.accuracy_score(y_pred,y_test),clf)
  disp = metrics.ConfusionMatrixDisplay.from_predictions(y_test, y_pred)
  disp.figure_.suptitle("Confusion Matrix")
  print(f"Confusion matrix:\n{disp.confusion_matrix}")
  plt.show()
  _, axes = plt.subplots(nrows=1, ncols=10, figsize=(15, 3))
  for ax, image, prediction in zip(axes, X_test, y_pred):
    ax.set_axis_off()
    image = image.reshape(8, 8)
    ax.imshow(image, cmap=plt.cm.gray_r, interpolation="nearest")
    ax.set_title(f"Prediction: {prediction}")
  plt.show()
  print(
    f"Classification report for classifier {clf}:\n"
    f"{metrics.classification_report(y_test, y_pred)}\n"
  )
```

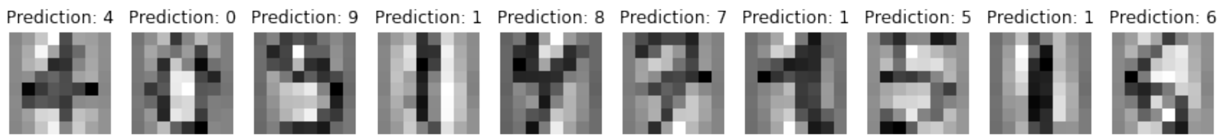
```
0.9666666666666667 SVC()
Confusion matrix:
[[42  0  0  0  0  0  0  0  0  0]
 [ 0 50  0  0  0  0  0  0  0  0]
 [ 0  0 44  0  2  0  0  1  0  0]
 [ 0  0  1 45  0  1  0  1  0  0]
 [ 0  0  0  0 36  0  0  0  3  1]
 [ 0  0  0  0  0 52  0  0  0  0]
 [ 0  0  0  0  0  0 43  0  0  0]
 [ 0  0  0  0  0  0  0 49  0  0]
 [ 0  1  0  0  0  0  0  0 39  0]
 [ 0  0  0  0  0  0  1  1  2 35]]
```



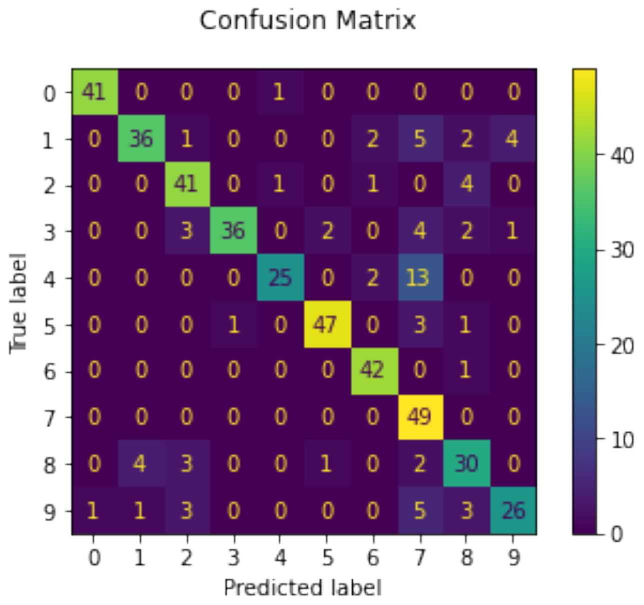


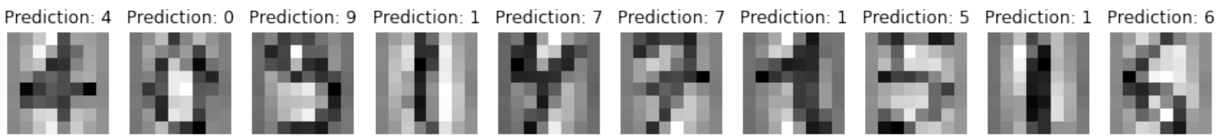

```
Classification report for classifier SVC():
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        42
           1       0.98      1.00      0.99        50
           2       0.98      0.94      0.96        47
           3       1.00      0.94      0.97        48
           4       0.95      0.90      0.92        40
           5       0.98      1.00      0.99        52
           6       0.98      1.00      0.99        43
           7       0.94      1.00      0.97        49
           8       0.89      0.97      0.93        40
           9       0.97      0.90      0.93        39

    accuracy                           0.97       450
   macro avg       0.97      0.96      0.96       450
weighted avg       0.97      0.97      0.97       450


0.9444444444444444 LogisticRegression(max_iter=5000)
Confusion matrix:
[[42  0  0  0  0  0  0  0  0  0]
 [ 0 46  0  0  0  0  1  0  2  1]
 [ 0  0 47  0  0  0  0  0  0  0]
 [ 0  0  1 43  0  2  0  1  1  0]
 [ 0  0  0  0 35  0  0  1  3  1]
 [ 0  1  0  0  1 50  0  0  0  0]
 [ 0  1  0  0  0  0 41  0  1  0]
 [ 0  0  0  0  0  0  0 48  1  0]
 [ 0  0  0  0  0  0  0  0 40  0]
 [ 0  0  0  2  0  1  0  1  2 33]]
```






```
Classification report for classifier LogisticRegression(max_iter=5000):
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        42
           1       0.96      0.92      0.94        50
           2       0.98      1.00      0.99        47
           3       0.96      0.90      0.92        48
           4       0.97      0.88      0.92        40
           5       0.94      0.96      0.95        52
           6       0.98      0.95      0.96        43
           7       0.94      0.98      0.96        49
           8       0.80      1.00      0.89        40
           9       0.94      0.85      0.89        39

    accuracy                           0.94       450
   macro avg       0.95      0.94      0.94       450
weighted avg       0.95      0.94      0.94       450


0.8288888888888889 GaussianNB()
Confusion matrix:
[[41  0  0  0  1  0  0  0  0  0]
 [ 0 36  1  0  0  0  2  5  2  4]
 [ 0  0 41  0  1  0  1  0  4  0]
 [ 0  0  3 36  0  2  0  4  2  1]
 [ 0  0  0  0 25  0  2 13  0  0]
 [ 0  0  0  1  0 47  0  3  1  0]
 [ 0  0  0  0  0  0 42  0  1  0]
 [ 0  0  0  0  0  0  0 49  0  0]
 [ 0  4  3  0  0  1  0  2 30  0]
 [ 1  1  3  0  0  0  0  5  3 26]]
```






```
Classification report for classifier GaussianNB():
              precision    recall  f1-score   support

           0       0.98      0.98      0.98        42
           1       0.88      0.72      0.79        50
           2       0.80      0.87      0.84        47
           3       0.97      0.75      0.85        48
           4       0.93      0.62      0.75        40
           5       0.94      0.90      0.92        52
           6       0.89      0.98      0.93        43
           7       0.60      1.00      0.75        49
           8       0.70      0.75      0.72        40
           9       0.84      0.67      0.74        39

    accuracy                           0.83       450
   macro avg       0.85      0.82      0.83       450
weighted avg       0.85      0.83      0.83       450
```

In [4]:
```
monte=100
Accuracy=np.zeros([monte,3])
for i in range(1,monte):
    k=0
    # Split the data into 75% training and 25% test sets
    x_train, x_test, y_train, y_test = train_test_split(
    digits.data, digits.target, test_size=0.25, random_state=2, shuffle=T

    # Normalize the data set
    sc = StandardScaler()
    sc.fit(x_train)
    X_train = sc.transform(x_train)
    X_test = sc.transform(x_test)
    for clf in [svc, lr, gnb]:
      y_pred=clf.fit(X_train, y_train).predict(X_test)
      Accuracy[i,k]=metrics.accuracy_score(y_pred,y_test)
      k+=1

avg_SVC=np.mean(Accuracy[:,0])
avg_LoR=np.mean(Accuracy[:,1])
avg_GNB=np.mean(Accuracy[:,2])
print("cycle%d"%monte+"times with average accuracy in SVC:%f"%avg_SVC+
      " LogisticRegression:%f"%avg_LoR+" Gaussion:%f"%avg_GNB)
```

```
cycle100times with average accuracy in SVC:0.957000 LogisticRegression:0.
935000 Gaussion:0.820600
```