In [22]:
```
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#21CS10052
```

In [1]:
```
import pandas as pd
```

In [3]:
```
df = pd.read_csv('../../dataset/linear-regression.csv')
print(df.shape)
```

```
(1599, 12)
```

In [5]:
```
#to split the data into training, validation and testing.
import pandas as pd
from sklearn.model_selection import train_test_split

# Load the dataset
dataset_path = "../../dataset/linear-regression.csv"
data = pd.read_csv(dataset_path)

# Split the dataset into training, validation, and testing sets
train_data, test_data = train_test_split(data, test_size=0.2, random_state=42)
train_data, val_data = train_test_split(train_data, test_size=0.375, random_st

# Print the sizes of the splits
print(f"Training set size: {train_data.shape[0]}")
print(f"Validation set size: {val_data.shape[0]}")
print(f"Testing set size: {test_data.shape[0]}")
```

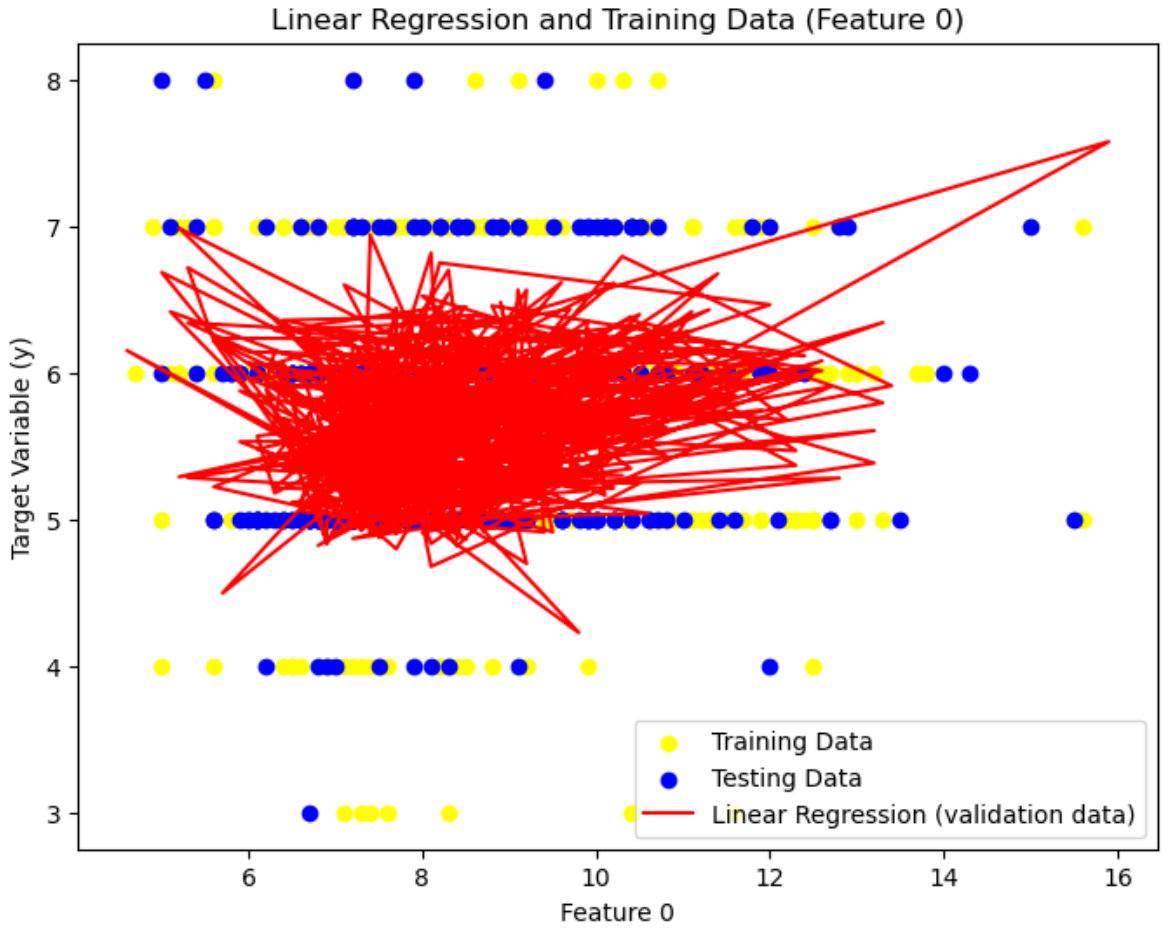
```
Training set size: 799
Validation set size: 480
Testing set size: 320
```

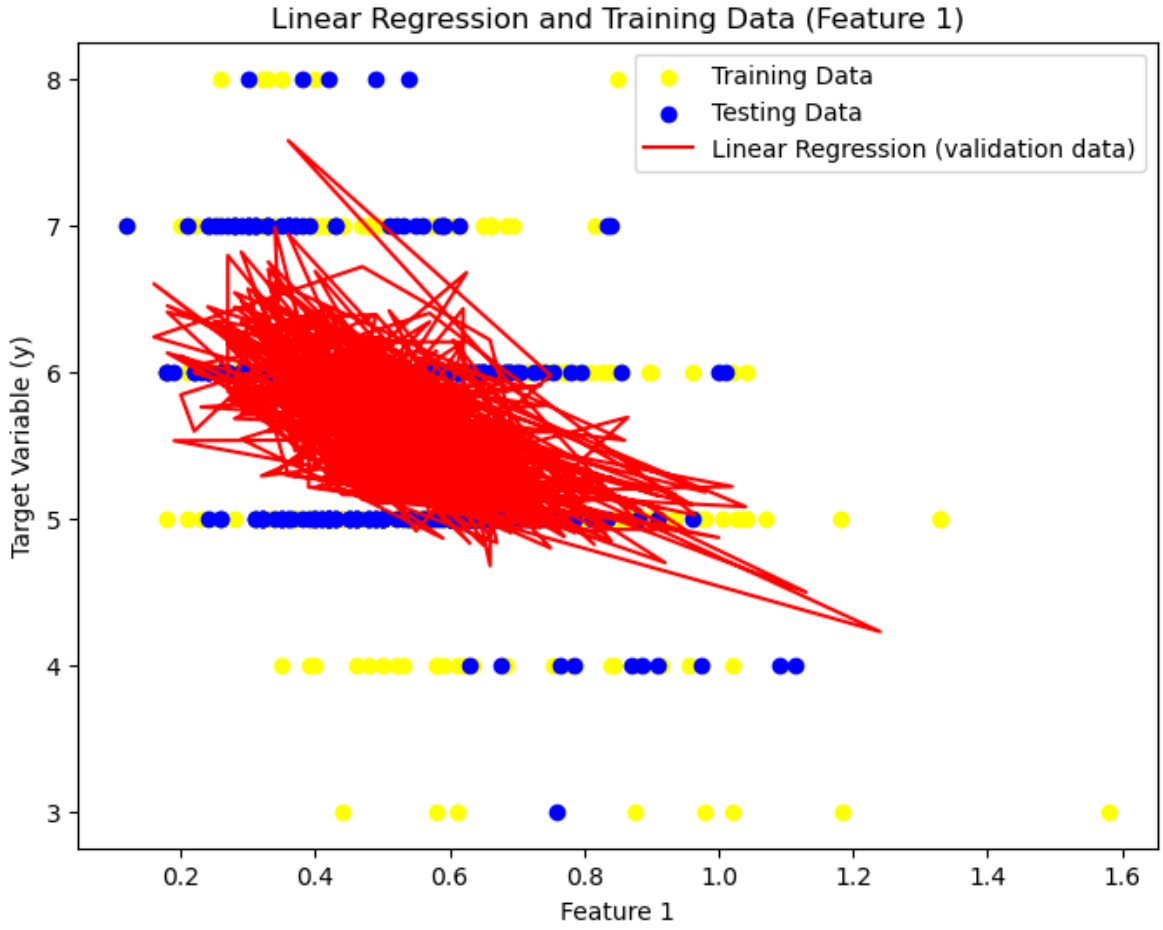
In [6]:
```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LinearRegression
from sklearn.metrics import r2_score, mean_squared_error

# Load the dataset
dataset_path = "../../dataset/linear-regression.csv"
data = pd.read_csv(dataset_path)

# Split the dataset into training, validation, and testing sets
train_data, test_data = train_test_split(data, test_size=0.2, random_state=42)
train_data, val_data = train_test_split(train_data, test_size=0.375, random_st

# Prepare data for training, validation, and testing
X_train = train_data.iloc[:, :-1].values
y_train = train_data.iloc[:, -1].values

X_validation = val_data.iloc[:, :-1].values
y_validation = val_data.iloc[:, -1].values

X_test = test_data.iloc[:, :-1].values
y_test = test_data.iloc[:, -1].values

# Standardize the data
scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_validation = scaler.transform(X_validation)
X_test = scaler.transform(X_test)

# Train a linear regression model
model = LinearRegression()
model.fit(X_train, y_train)

# Make predictions
y_pred_validation = model.predict(X_validation)
y_pred_test = model.predict(X_test)

# Evaluate the model
def calculate_metrics(y_true, y_pred):
    r2 = r2_score(y_true, y_pred)
    rmse = np.sqrt(mean_squared_error(y_true, y_pred))
    return r2, rmse

# Calculate metrics for training, validation, and test sets
r2_train, rmse_train = calculate_metrics(y_train, model.predict(X_train))
r2_validation, rmse_validation = calculate_metrics(y_validation, y_pred_valida
r2_test, rmse_test = calculate_metrics(y_test, y_pred_test)

# Display the results
print("Training Set Metrics:")
print("R-squared score:", r2_train)
print("RMSE score:", rmse_train)
print("\nValidation Set Metrics:")
print("R-squared score:", r2_validation)
print("RMSE score:", rmse_validation)
```

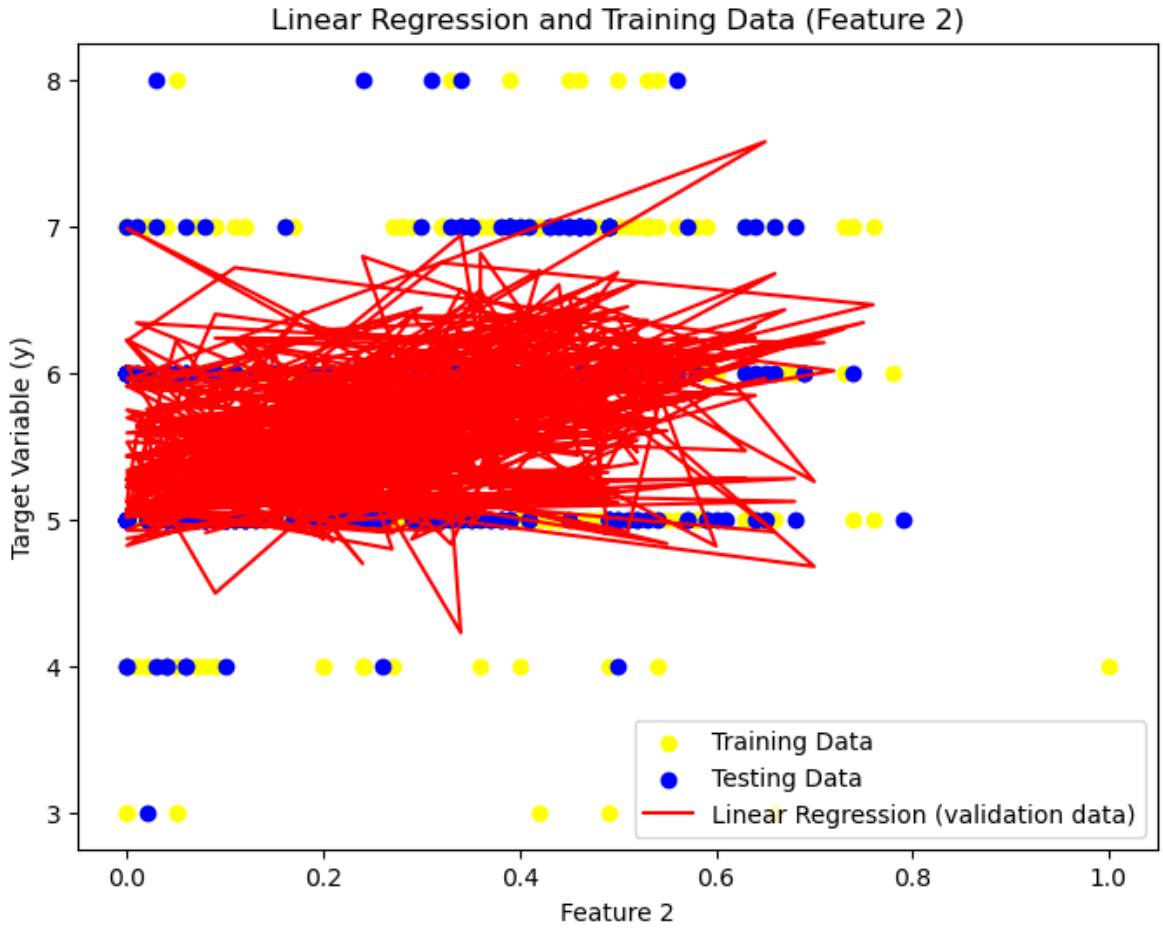
```
print("\nTest Set Metrics:")
print("R-squared score:", r2_test)
print("RMSE score:", rmse_test)
```

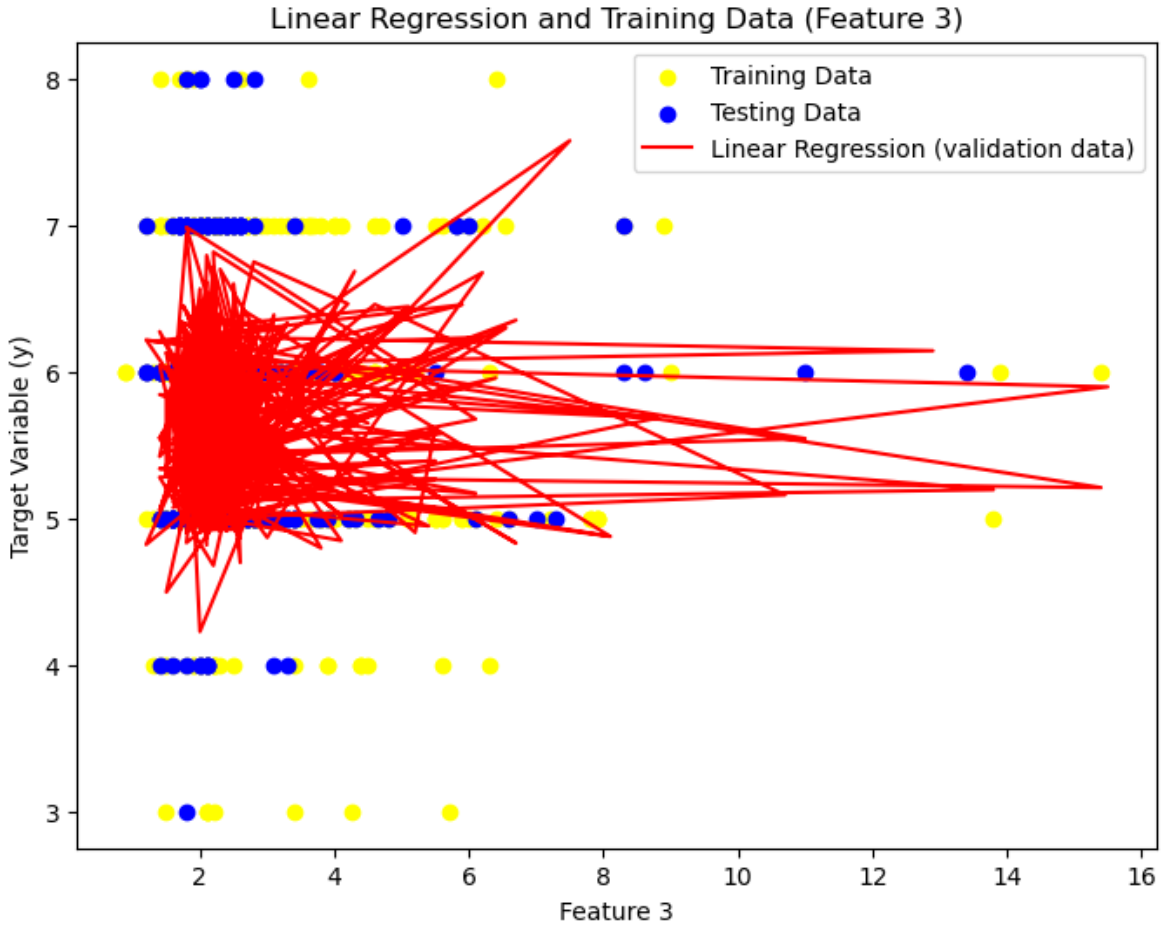
```
Training Set Metrics:
R-squared score: 0.35038464463582664
RMSE score: 0.660790294050693

Validation Set Metrics:
R-squared score: 0.3279296678927427
RMSE score: 0.6417555480263113

Test Set Metrics:
R-squared score: 0.41047417089904137
RMSE score: 0.6206920199022873
```

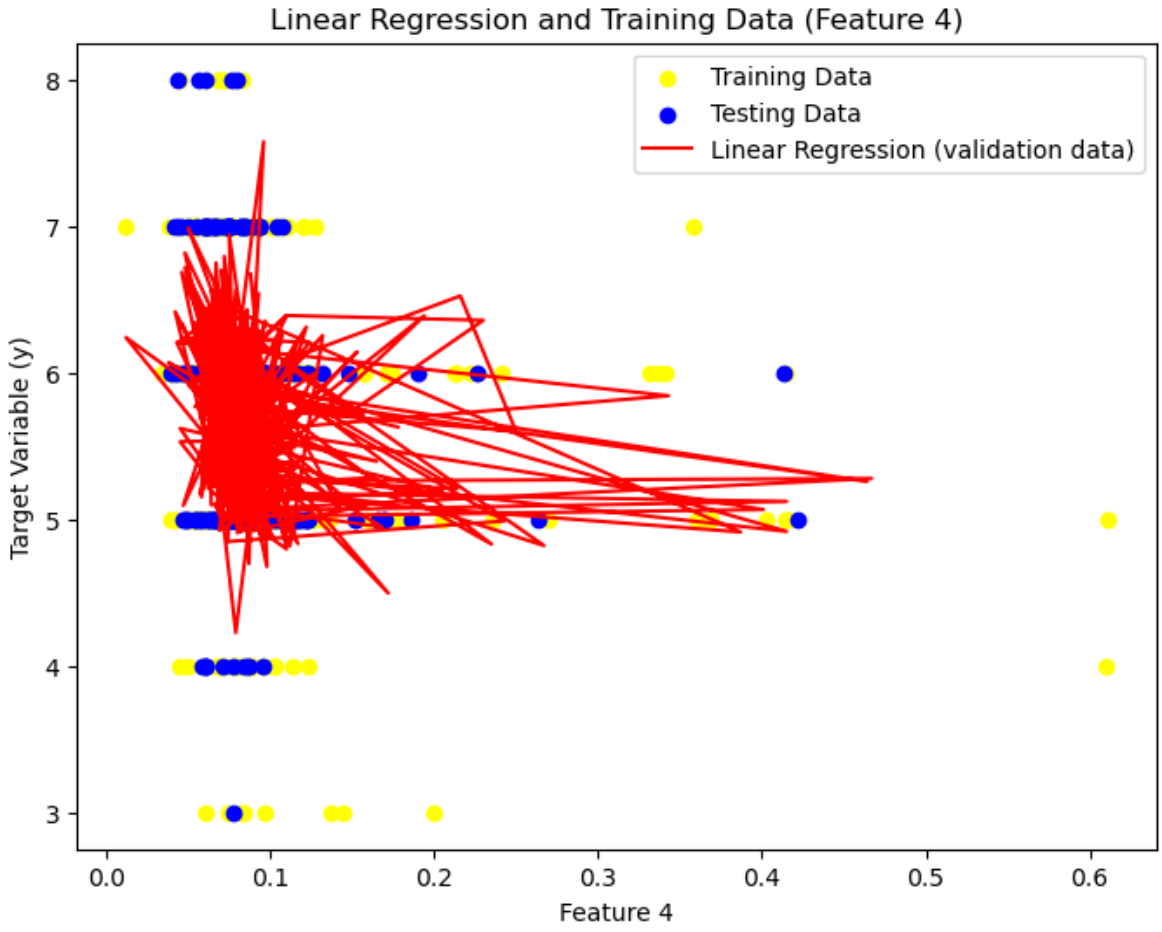
In [19]:
```
import matplotlib.pyplot as plt

num_features = X_train.shape[1] # Number of features
for feature_idx in range(num_features):
    plt.figure(figsize=(8, 6))
    plt.scatter(X_train[:, feature_idx], y_train, label='Training Data', color
    plt.scatter(X_test[:, feature_idx], y_test, label='Testing Data', color='b
    plt.plot(X_validation[:, feature_idx], y_pred_validation, label='Linear Re
    plt.xlabel('Feature {}'.format(feature_idx))
    plt.ylabel('Target Variable (y)')
    plt.legend()
    plt.title('Linear Regression and Training Data (Feature {})'.format(featur
    plt.show()
```

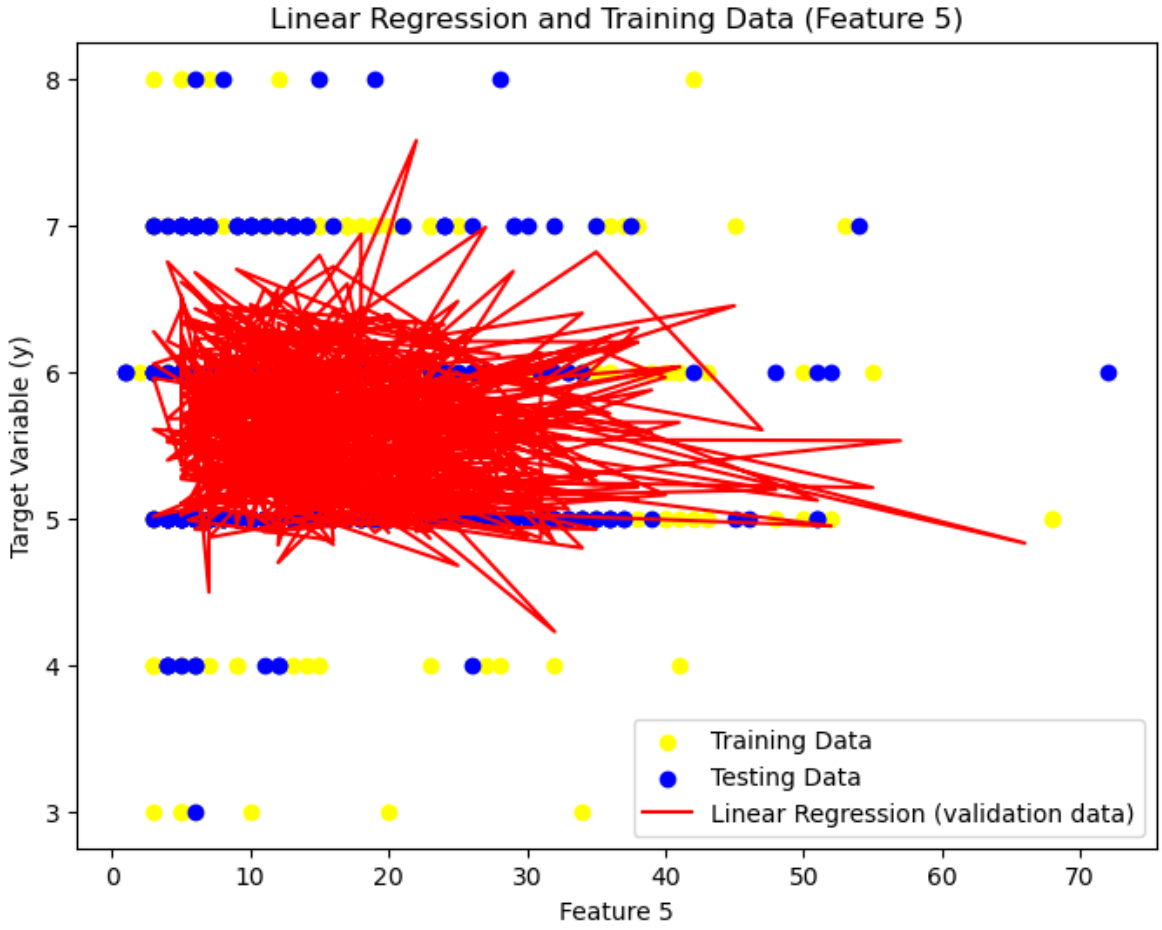


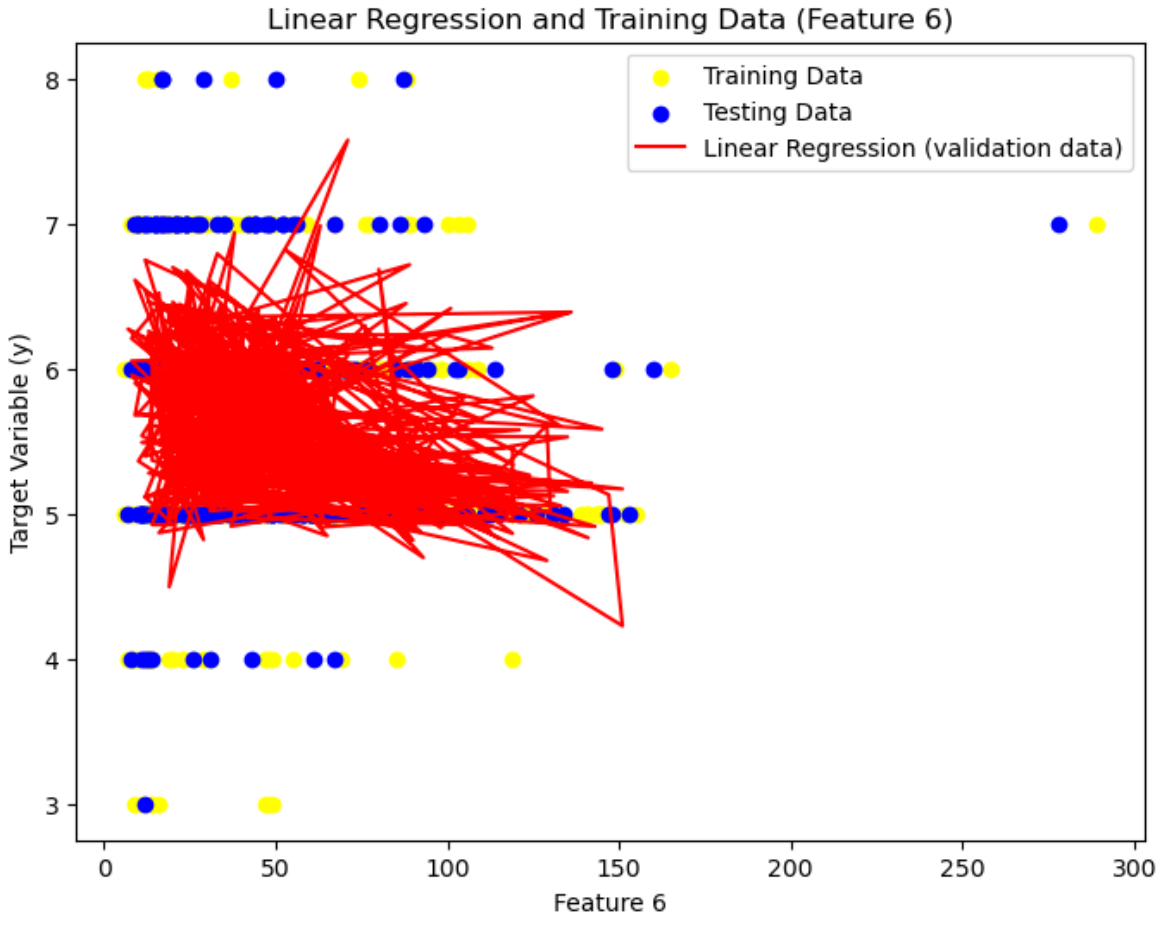

Linear Regression and Training Data (Feature 1)
Training Data
Testing Data
Linear Regression (validation data)
Target Variable (y)
Feature 1
8
7
6
5
4
3
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6

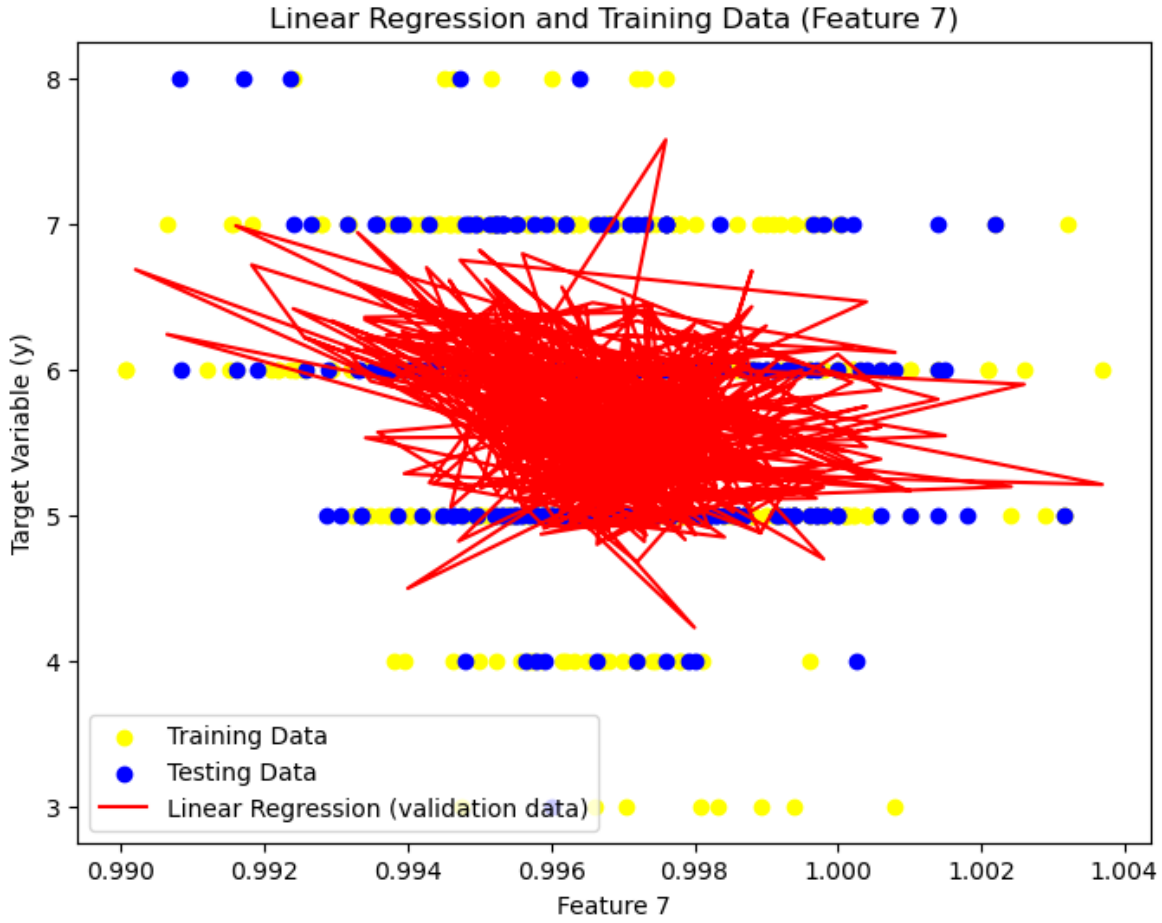

Linear Regression and Training Data (Feature 2)
Training Data
Testing Data
Linear Regression (validation data)
Target Variable (y)
Feature 2
8
7
6
5
4
3
0.0
0.2
0.4
0.6
0.8
1.0

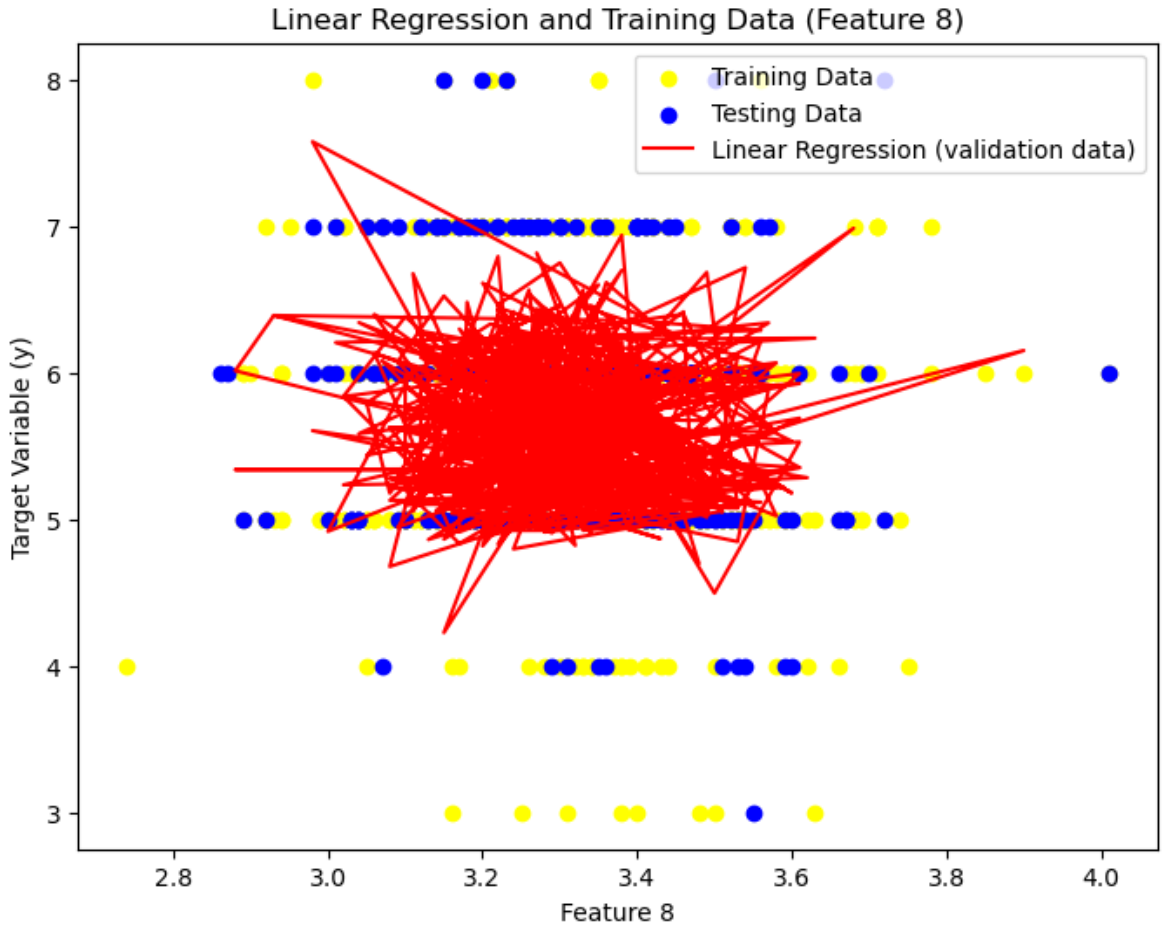

Linear Regression and Training Data (Feature 3)
Training Data
Testing Data
Linear Regression (validation data)
Target Variable (y)
Feature 3
8
7
6
5
4
3
2
4
6
8
10
12
14
16

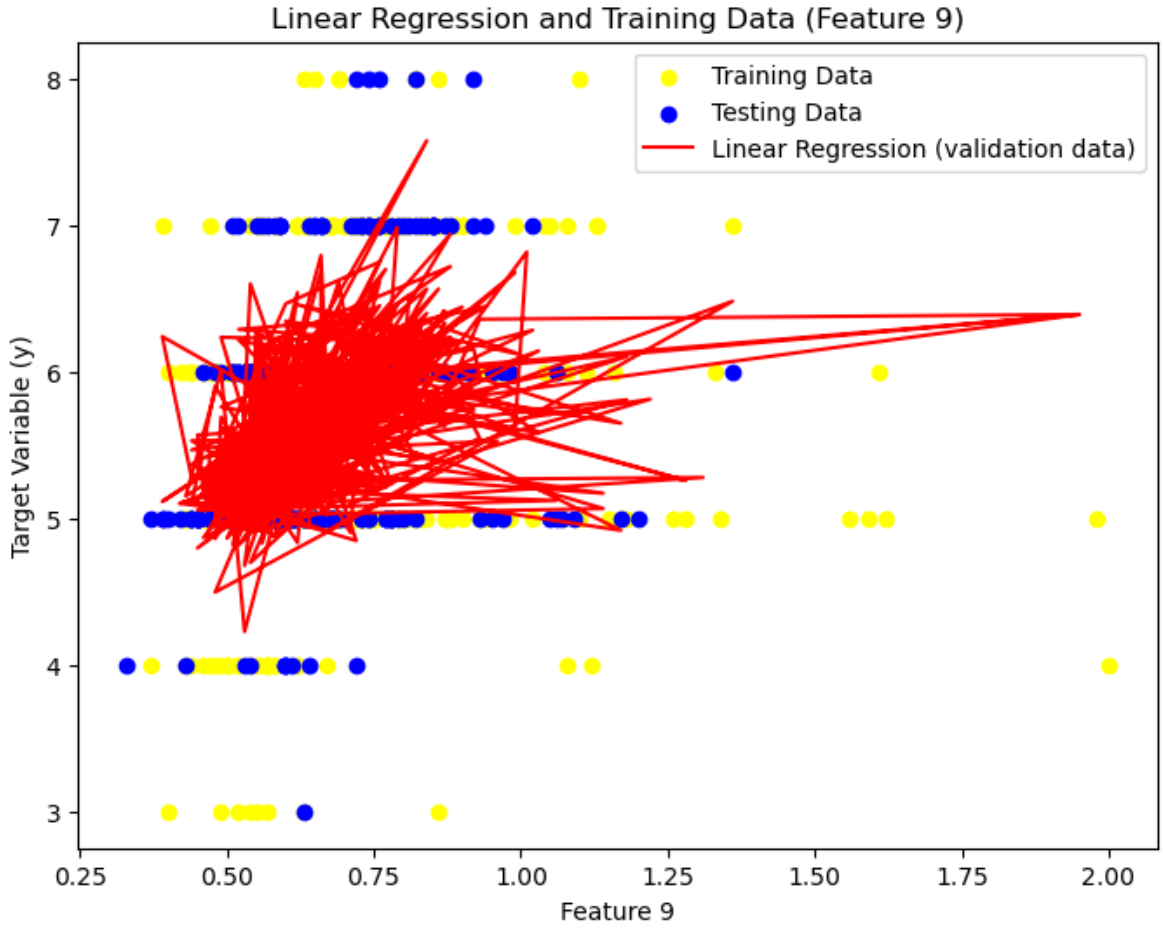

Linear Regression and Training Data (Feature 4)
Training Data
Testing Data
Linear Regression (validation data)
Target Variable (y)
Feature 4
8
7
6
5
4
3
0.0
0.1
0.2
0.3
0.4
0.5
0.6


Linear Regression and Training Data (Feature 5)
Target Variable (y)
Feature 5
Training Data
Testing Data
Linear Regression (validation data)
8
7
6
5
4
3
0
10
20
30
40
50
60
70


Linear Regression and Training Data (Feature 6)
Target Variable (y)
Feature 6
Training Data
Testing Data
Linear Regression (validation data)
8
7
6
5
4
3
0
50
100
150
200
250
300


Linear Regression and Training Data (Feature 7)
Target Variable (y)
Feature 7
Training Data
Testing Data
Linear Regression (validation data)
8
7
6
5
4
3
0.990
0.992
0.994
0.996
0.998
1.000
1.002
1.004

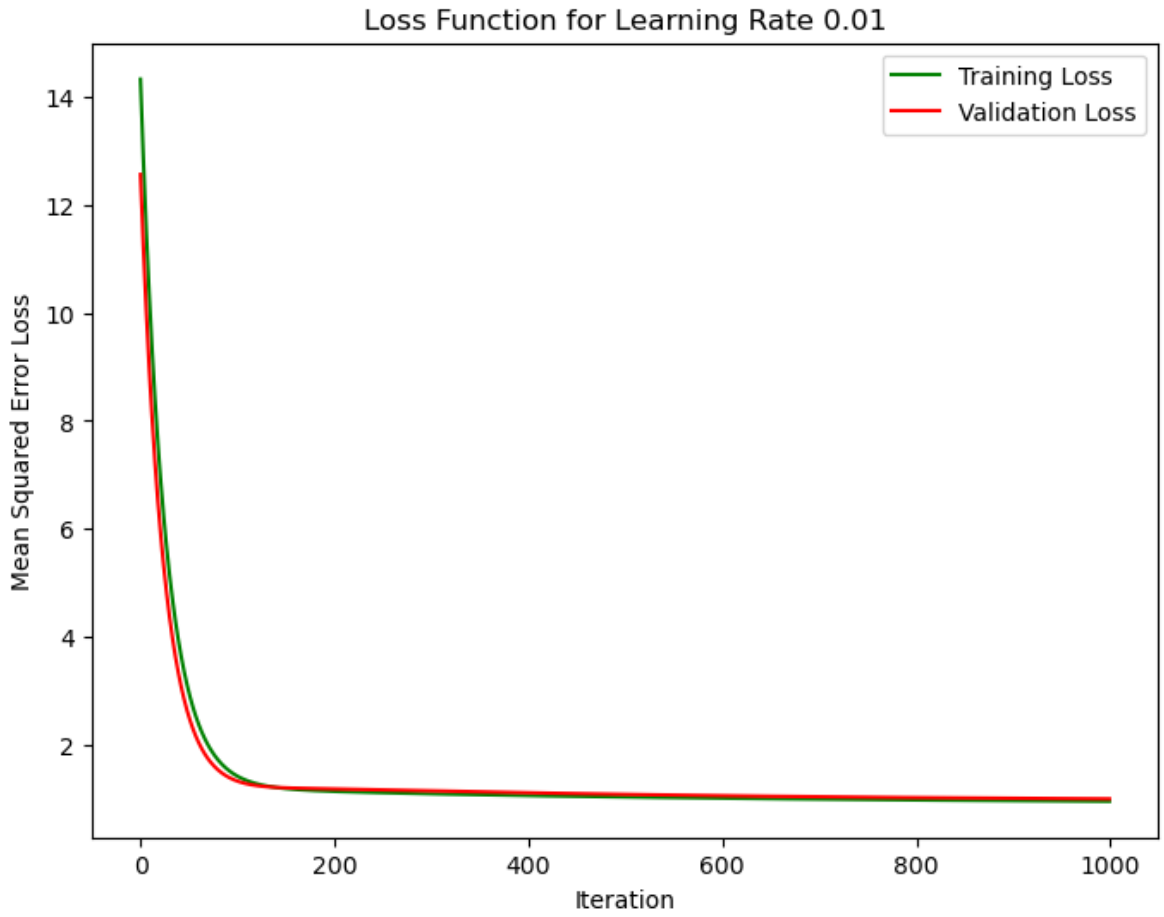

Linear Regression and Training Data (Feature 8)
Target Variable (y)
Feature 8
Training Data
Testing Data
Linear Regression (validation data)
8
7
6
5
4
3
2.8
3.0
3.2
3.4
3.6
3.8
4.0


Linear Regression and Training Data (Feature 9)
Training Data
Testing Data
Linear Regression (validation data)
Target Variable (y)
Feature 9
8
7
6
5
4
3
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

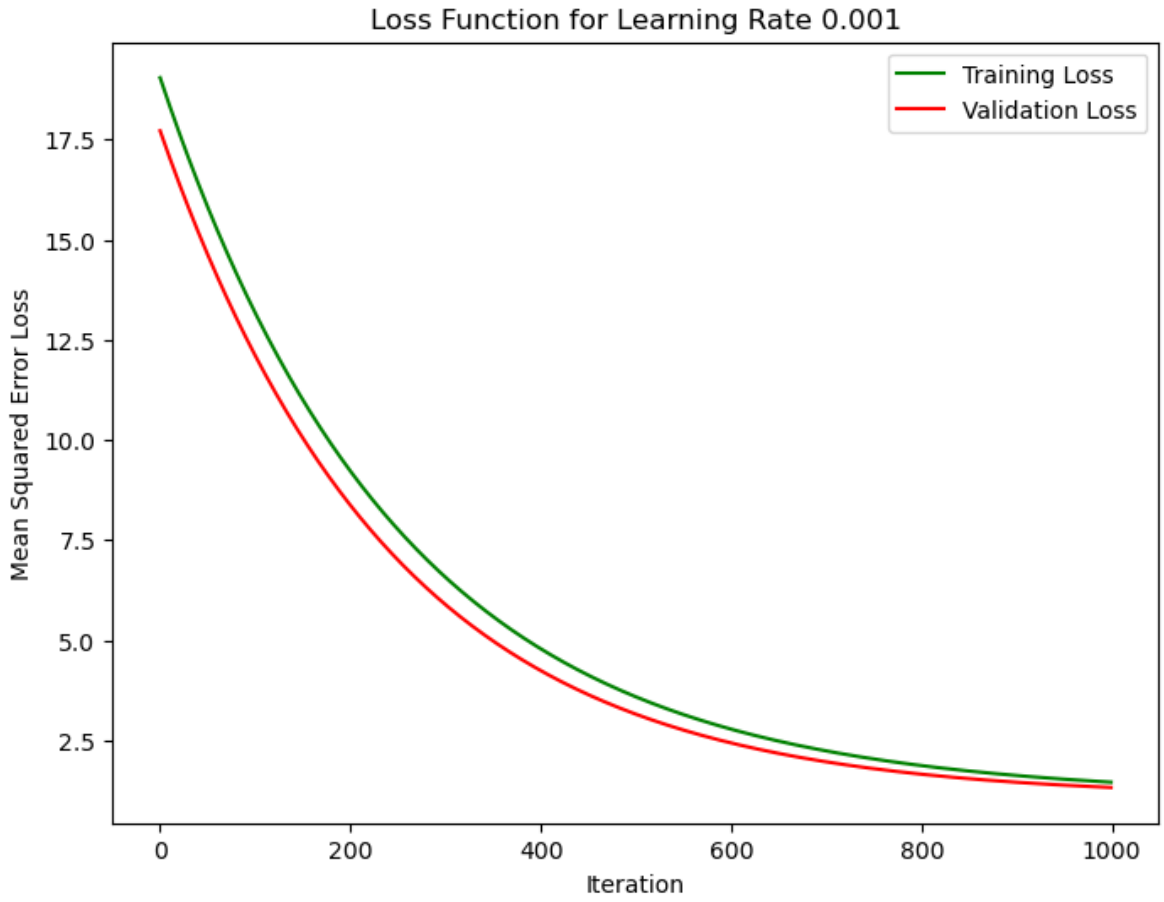

Linear Regression and Training Data (Feature 10)
Training Data
Testing Data
Linear Regression (validation data)
Target Variable (y)
Feature 10
8
7
6
5
4
3
9
10
11
12
13
14
15

In [20]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import r2_score, mean_squared_error

# Load the dataset
dataset_path = "../../dataset/linear-regression.csv"
data = pd.read_csv(dataset_path)

# Split the dataset into training, validation, and testing sets
train_data, test_data = train_test_split(data, test_size=0.2, random_state=42)
train_data, val_data = train_test_split(train_data, test_size=0.375, random_st

# Prepare data for training, validation, and testing
X_train = train_data.iloc[:, :-1].values
y_train = train_data.iloc[:, -1].values

X_validation = val_data.iloc[:, :-1].values
y_validation = val_data.iloc[:, -1].values

X_test = test_data.iloc[:, :-1].values
y_test = test_data.iloc[:, -1].values

# Define the gradient ascent function with feature scaling
def gradient_ascent_with_scaling(X, y, learning_rate, num_iterations):
    num_samples, num_features = X.shape
    theta = np.random.rand(num_features)  # Initialize parameters with random
    loss_history_train = []
    loss_history_val = []

    X_scaled = (X - np.min(X, axis=0)) / (np.max(X, axis=0) - np.min(X, axis=0

    for _ in range(num_iterations):
        y_pred = np.dot(X_scaled, theta)
        gradient = -2 * np.dot(X_scaled.T, y - y_pred) / num_samples
        theta -= learning_rate * gradient

        loss_train = np.mean((y - y_pred) ** 2)
        loss_history_train.append(loss_train)

        X_validation_scaled = (X_validation - np.min(X_validation, axis=0)) /
        y_pred_validation = np.dot(X_validation_scaled, theta)
        loss_val = np.mean((y_validation - y_pred_validation) ** 2)
        loss_history_val.append(loss_val)

    return theta, loss_history_train, loss_history_val

# Define hyperparameters
learning_rates = [0.01, 0.001, 0.0001]
num_iterations = 1000

# Initialize lists to store results
r2_scores = []
rmse_scores = []
```

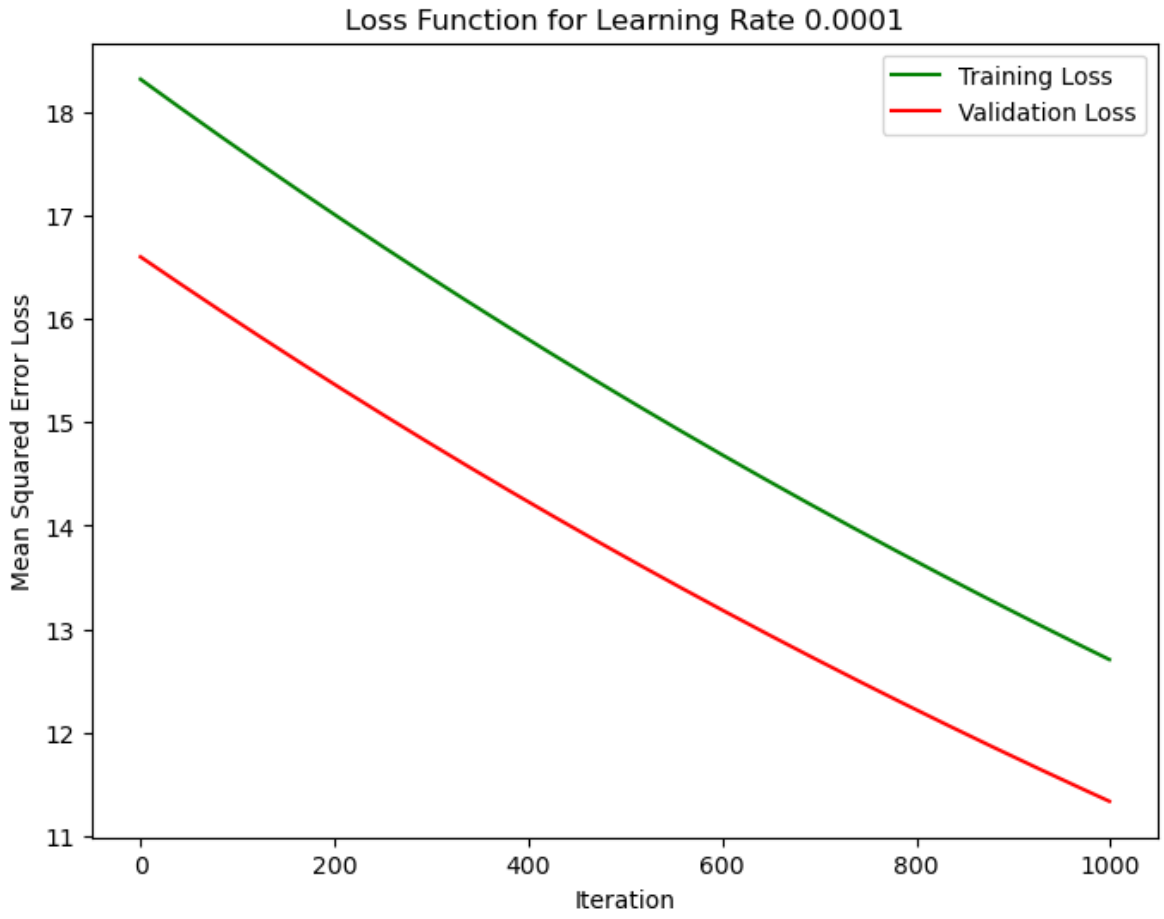
```
# Perform gradient ascent with scaling for each learning rate
for learning_rate in learning_rates:
    # Train the model using gradient ascent with feature scaling
    theta, loss_history_train, loss_history_val = gradient_ascent_with_scaling

    # Make predictions for the test set
    X_test_scaled = (X_test - np.min(X_test, axis=0)) / (np.max(X_test, axis=0
    y_pred_test = np.dot(X_test_scaled, theta)

    # Calculate R-squared and RMSE for the test set
    r2_test = r2_score(y_test, y_pred_test)
    rmse_test = mean_squared_error(y_test, y_pred_test, squared=False)

    # Plot the loss function for the training and validation sets
    plt.figure(figsize=(8, 6))
    plt.plot(range(num_iterations), loss_history_train, label='Training Loss',
    plt.plot(range(num_iterations), loss_history_val, label='Validation Loss',
    plt.xlabel('Iteration')
    plt.ylabel('Mean Squared Error Loss')
    plt.title(f'Loss Function for Learning Rate {learning_rate}')
    plt.legend()
    plt.show()

    # Store R-squared and RMSE scores
    r2_scores.append(r2_test)
    rmse_scores.append(rmse_test)

    print(f"Learning Rate: {learning_rate}")
    print(f"R-squared score for test set: {r2_test}")
    print(f"RMSE score for test set: {rmse_test}")
    print("\n")
```




```
Learning Rate: 0.01
R-squared score for test set: -0.5497361579240279
RMSE score for test set: 1.0063606012203838
```




```
Learning Rate: 0.001
R-squared score for test set: -0.9427209709287399
RMSE score for test set: 1.1267562015061734
```




```
Learning Rate: 0.0001
R-squared score for test set: -18.420378007469996
RMSE score for test set: 3.562489413199572
```