Linear Regression

In [3]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.axes as ax
from matplotlib.animation import FuncAnimation, PillowWriter
```

In [4]:
```
data = pd.read_csv("IceCreamData.csv")
data = data.dropna()
train_input = np.array(data['Temperature'][0:400].to_numpy().reshape(-1,1))
train_output = np.array(data['Revenue'][0:400].to_numpy().reshape(-1,1))
test_input = np.array(data['Temperature'][400:500].to_numpy().reshape(-1,1))
test_output = np.array(data['Revenue'][400:500].to_numpy().reshape(-1,1))
```

In [5]:
```
class LinearRegression:
    def __init__(self):
        self.parameters = {}

    def forward_propagation(self, train_input):
        m = self.parameters['w']
        c = self.parameters['b']
        predictions = np.multiply(m, train_input) + c
        return predictions

    def cost_function(self, predictions, train_output):
        cost = np.mean((train_output - predictions) ** 2)
        return cost

    def backward_propagation(self, train_input, train_output, predictions):
        derivatives = {}
        df = (predictions-train_output)
        dw = 2 * np.mean(np.multiply(train_input, df))
        db = 2 * np.mean(df)
        derivatives['dw'] = dw
        derivatives['db'] = db
        return derivatives
```

```
    def update_parameters(self, derivatives, learning_rate):
        self.parameters['w'] = self.parameters['w'] - learning_rate * derivatives['dw']
        self.parameters['b'] = self.parameters['b'] - learning_rate * derivatives['db']

    def train(self, train_input, train_output, learning_rate, iters):
        self.parameters['w'] = np.random.uniform(0, 1) * -1
        self.parameters['b'] = np.random.uniform(0, 1) * -1

        self.loss = []

        fig, ax = plt.subplots()
        x_vals = np.linspace(min(train_input), max(train_input), 100)
        line, = ax.plot(x_vals, self.parameters['w'] * x_vals + self.parameters['b'], color='red', label='Regression
        ax.scatter(train_input, train_output, marker='o', color='green', label='Training Data')

        ax.set_ylim(0, max(train_output) + 1)

        def update(frame):
            predictions = self.forward_propagation(train_input)
            cost = self.cost_function(predictions, train_output)
            derivatives = self.backward_propagation(train_input, train_output, predictions)
            self.update_parameters(derivatives, learning_rate)
            line.set_ydata(self.parameters['w'] * x_vals + self.parameters['b'])
            self.loss.append(cost)
            print("Iteration = {}, Loss = {}".format(frame + 1, cost))
            return line,

        ani = FuncAnimation(fig, update, frames=iters, interval=200, blit=True)
        ani.save('linear_regression_A.gif', writer='ffmpeg')

        plt.xlabel('Input')
        plt.ylabel('Output')
        plt.title('Linear Regression')
        plt.legend()
        plt.show()

        return self.parameters, self.loss
```

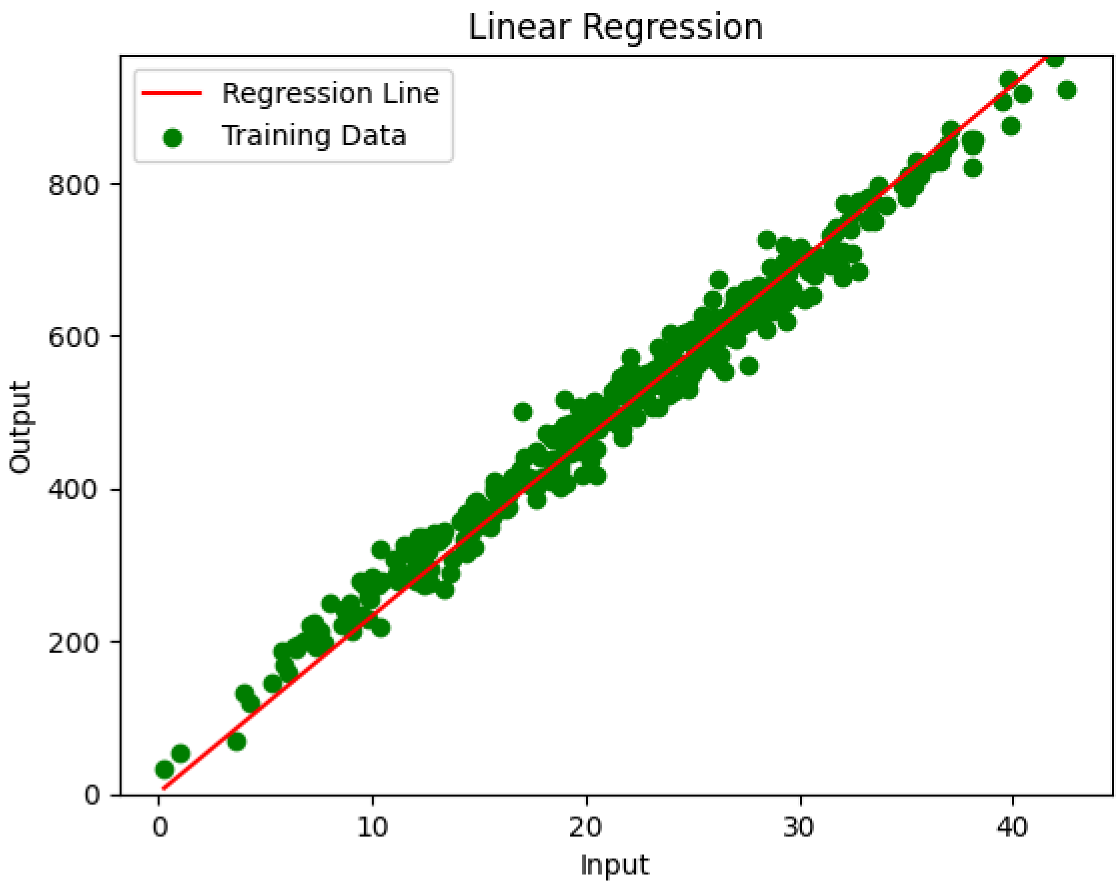
In [6]:

```
model = LinearRegression()
params, losses = model.train(train_input, train_output, learning_rate=0.001, iters=100)
```

```
Iteration = 1, Loss = 295665.57598038384
Iteration = 1, Loss = 3238.636585483572
Iteration = 1, Loss = 838.8724637860432
Iteration = 1, Loss = 819.0657828166896
Iteration = 2, Loss = 818.7890403705281
Iteration = 3, Loss = 818.6726140247036
Iteration = 4, Loss = 818.5575570071632
Iteration = 5, Loss = 818.4425649784378
Iteration = 6, Loss = 818.3276272098202
Iteration = 7, Loss = 818.2127435879624
Iteration = 8, Loss = 818.0979140866341
Iteration = 9, Loss = 817.9831386803357
Iteration = 10, Loss = 817.8684173435815
Iteration = 11, Loss = 817.7537500509007
Iteration = 12, Loss = 817.6391367768343
Iteration = 13, Loss = 817.5245774959337
Iteration = 14, Loss = 817.4100721827639
Iteration = 15, Loss = 817.2956208118999
Iteration = 16, Loss = 817.1812233579321
Iteration = 17, Loss = 817.0668797954603
Iteration = 18, Loss = 816.9525900990966
Iteration = 19, Loss = 816.8383542434636
Iteration = 20, Loss = 816.7241722031996
Iteration = 21, Loss = 816.6100439529511
Iteration = 22, Loss = 816.4959694673797
Iteration = 23, Loss = 816.3819487211572
Iteration = 24, Loss = 816.2679816889658
Iteration = 25, Loss = 816.1540683455034
Iteration = 26, Loss = 816.0402086654767
Iteration = 27, Loss = 815.9264026236048
Iteration = 28, Loss = 815.8126501946213
Iteration = 29, Loss = 815.6989513532682
Iteration = 30, Loss = 815.5853060743009
Iteration = 31, Loss = 815.4717143324873
Iteration = 32, Loss = 815.3581761026054
Iteration = 33, Loss = 815.2446913594478
Iteration = 34, Loss = 815.1312600778176
Iteration = 35, Loss = 815.0178822325281
Iteration = 36, Loss = 814.9045577984072
Iteration = 37, Loss = 814.7912867502918
Iteration = 38, Loss = 814.6780690630345
Iteration = 39, Loss = 814.5649047114961
```

```
Iteration = 40, Loss = 814.451793670551
Iteration = 41, Loss = 814.3387359150853
Iteration = 42, Loss = 814.2257314199964
Iteration = 43, Loss = 814.1127801601936
Iteration = 44, Loss = 813.9998821105996
Iteration = 45, Loss = 813.887037246147
Iteration = 46, Loss = 813.7742455417791
Iteration = 47, Loss = 813.6615069724555
Iteration = 48, Loss = 813.5488215131423
Iteration = 49, Loss = 813.4361891388223
Iteration = 50, Loss = 813.3236098244856
Iteration = 51, Loss = 813.211083545138
Iteration = 52, Loss = 813.0986102757935
Iteration = 53, Loss = 812.9861899914811
Iteration = 54, Loss = 812.8738226672391
Iteration = 55, Loss = 812.7615082781183
Iteration = 56, Loss = 812.6492467991823
Iteration = 57, Loss = 812.5370382055053
Iteration = 58, Loss = 812.4248824721745
Iteration = 59, Loss = 812.3127795742862
Iteration = 60, Loss = 812.2007294869514
Iteration = 61, Loss = 812.0887321852913
Iteration = 62, Loss = 811.9767876444384
Iteration = 63, Loss = 811.8648958395395
Iteration = 64, Loss = 811.7530567457486
Iteration = 65, Loss = 811.6412703382362
Iteration = 66, Loss = 811.5295365921806
Iteration = 67, Loss = 811.4178554827755
Iteration = 68, Loss = 811.3062269852228
Iteration = 69, Loss = 811.1946510747377
Iteration = 70, Loss = 811.0831277265472
Iteration = 71, Loss = 810.9716569158899
Iteration = 72, Loss = 810.8602386180163
Iteration = 73, Loss = 810.7488728081867
Iteration = 74, Loss = 810.6375594616766
Iteration = 75, Loss = 810.5262985537685
Iteration = 76, Loss = 810.4150900597622
Iteration = 77, Loss = 810.3039339549636
Iteration = 78, Loss = 810.192830214692
Iteration = 79, Loss = 810.081778814282
Iteration = 80, Loss = 809.9707797290746
Iteration = 81, Loss = 809.8598329344252
```

```
Iteration = 82, Loss = 809.7489384057004
Iteration = 83, Loss = 809.6380961182779
Iteration = 84, Loss = 809.5273060475487
Iteration = 85, Loss = 809.4165681689113
Iteration = 86, Loss = 809.3058824577809
Iteration = 87, Loss = 809.1952488895811
Iteration = 88, Loss = 809.0846674397478
Iteration = 89, Loss = 808.9741380837283
Iteration = 90, Loss = 808.8636607969827
Iteration = 91, Loss = 808.7532355549815
Iteration = 92, Loss = 808.6428623332056
Iteration = 93, Loss = 808.5325411071509
Iteration = 94, Loss = 808.4222718523208
Iteration = 95, Loss = 808.3120545442331
Iteration = 96, Loss = 808.2018891584154
Iteration = 97, Loss = 808.0917756704092
Iteration = 98, Loss = 807.9817140557644
Iteration = 99, Loss = 807.8717042900445
Iteration = 100, Loss = 807.7617463488255
```

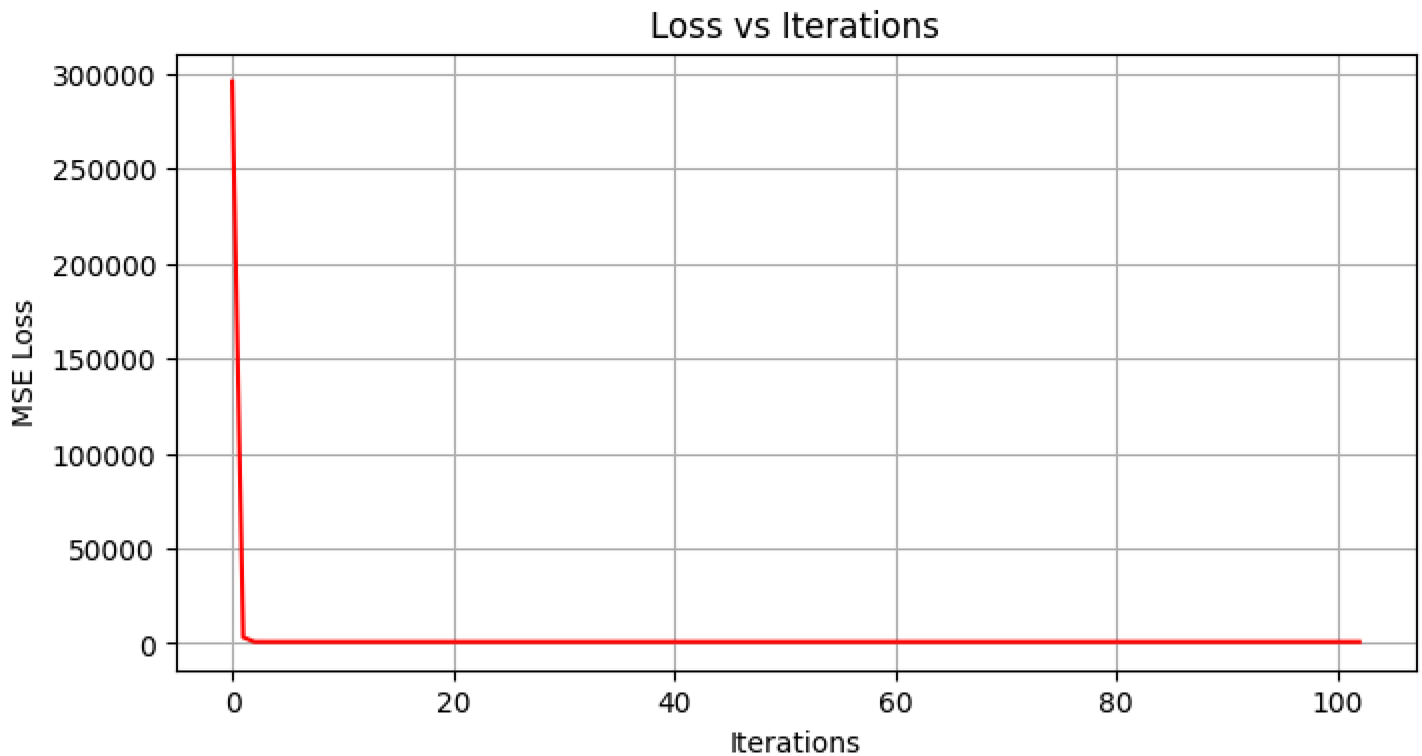


In [7]:
```
print("Final Parameters:")
print(f"Weight (w): {params['w']}")
print(f"Bias (b): {params['b']}")
print(f"Final MSE Loss: {losses[-1]}")
```

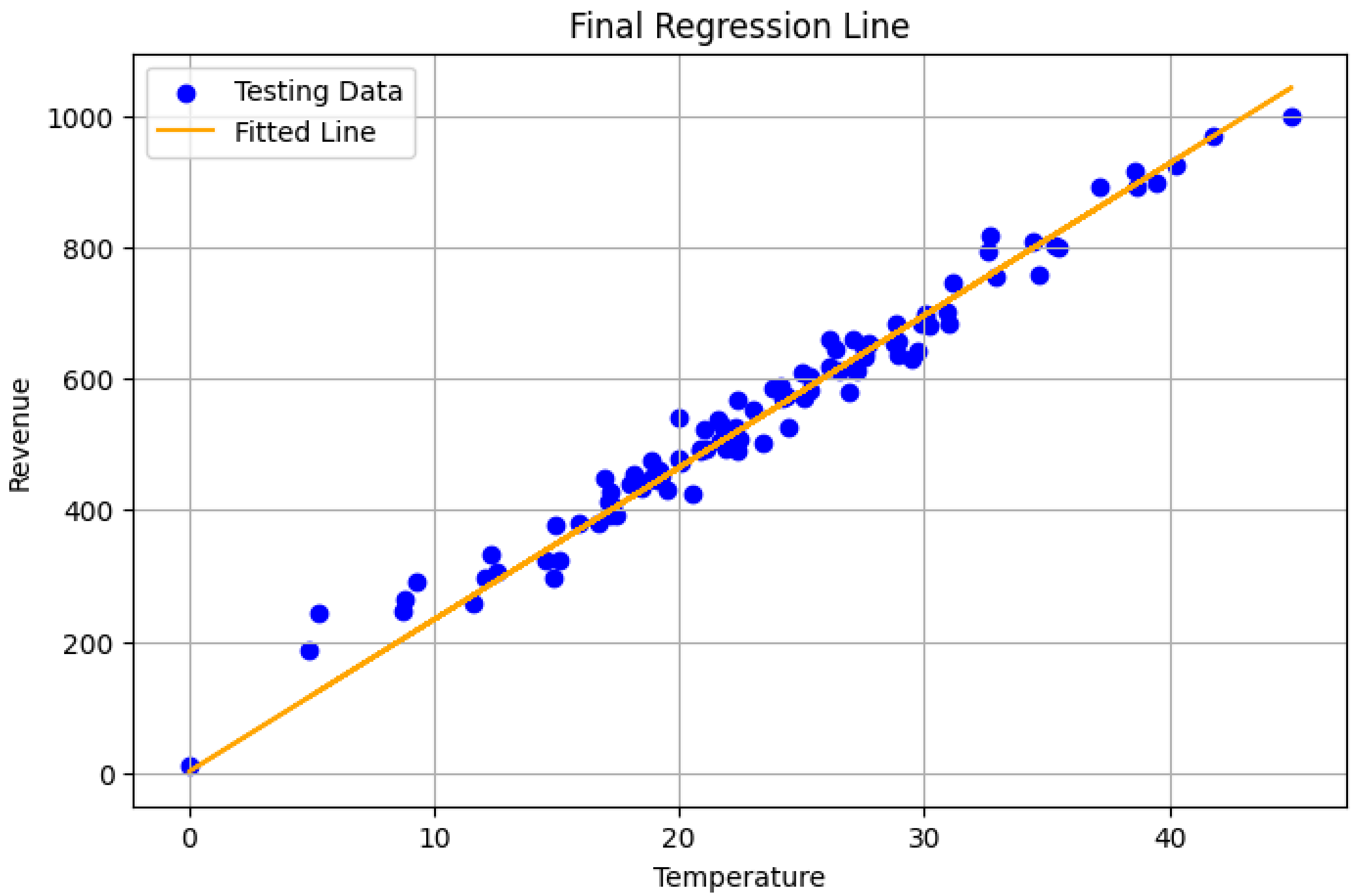
```
Final Parameters:
Weight (w): 23.147997940474003
Bias (b): 1.5646445218492966
Final MSE Loss: 807.7617463488255
```

In [8]:
```
plt.figure(figsize=(8, 4))
plt.plot(range(len(losses)), losses, color='red')
plt.title('Loss vs Iterations')
plt.xlabel('Iterations')
```

```
plt.ylabel('MSE Loss')
plt.grid(True)
plt.show()
```



In [9]:
```
plt.figure(figsize=(8, 5))
plt.scatter(test_input, test_output, color='blue', label='Testing Data')
plt.plot(test_input, model.parameters['w'] * test_input + model.parameters['b'],
         color='orange', label='Fitted Line')
plt.title('Final Regression Line')
plt.xlabel('Temperature')
plt.ylabel('Revenue')
plt.legend()
plt.grid(True)
plt.show()
```



In [9]:

```

```

Linear Regression Using epoch

In [10]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.axes as ax
from matplotlib.animation import FuncAnimation, PillowWriter
```

In [11]:
```
data = pd.read_csv("IceCreamData.csv")
data = data.dropna()
train_input = np.array(data['Temperature'][0:400].to_numpy().reshape(-1,1))
train_output = np.array(data['Revenue'][0:400].to_numpy().reshape(-1,1))
test_input = np.array(data['Temperature'][400:500].to_numpy().reshape(-1,1))
test_output = np.array(data['Revenue'][400:500].to_numpy().reshape(-1,1))
```

In [12]:
```
# This Linear Regression have Batch gradient Descent Process.

class LinearRegression:
    def __init__(self):
        self.parameters = {}

    def forward_propagation(self, train_input):
        w = self.parameters['w']
        b = self.parameters['b']
        predictions = np.multiply(w, train_input) + b
        return predictions

    def cost_function(self, predictions, train_output):
        cost = np.mean((train_output - predictions) ** 2)
        return cost

    def back_propagation(self, predictions, train_input, train_output):
        df = (predictions - train_output)
        dw = 2 * np.mean(np.multiply(train_input, df))
        db = 2 * np.mean(df)
        return {'dw': dw, 'db': db}

    def update_parameters(self, derivatives, learning_rate):
        self.parameters['w'] -= learning_rate * derivatives['dw']
        self.parameters['b'] -= learning_rate * derivatives['db']

    def train(self, train_input, train_output, learning_rate=0.01, epochs=1000):
        self.parameters['w'] = 0.0
        self.parameters['b'] = 0.0

        losses = []
        predictions_over_time = []

        for epoch in range(epochs):
```

```
            preds = self.forward_propagation(train_input)
            cost = self.cost_function(preds, train_output)
            losses.append(cost)

            derivatives = self.back_propagation(preds, train_input, train_output)
            self.update_parameters(derivatives, learning_rate)

            # Save predictions for animation every 10 epochs
            if (epoch + 1) % 10 == 0:
                predictions_over_time.append(preds.copy())

            # Display the progress
            if (epoch + 1) % 100 == 0:
                print(f"Epoch {epoch+1}/{epochs}, Cost: {cost:.4f}, w: {self.parameters['w']:.4f}, b: {self.parameter

        return losses, predictions_over_time

    def predict(self, input_data):
        return self.forward_propagation(input_data)
```

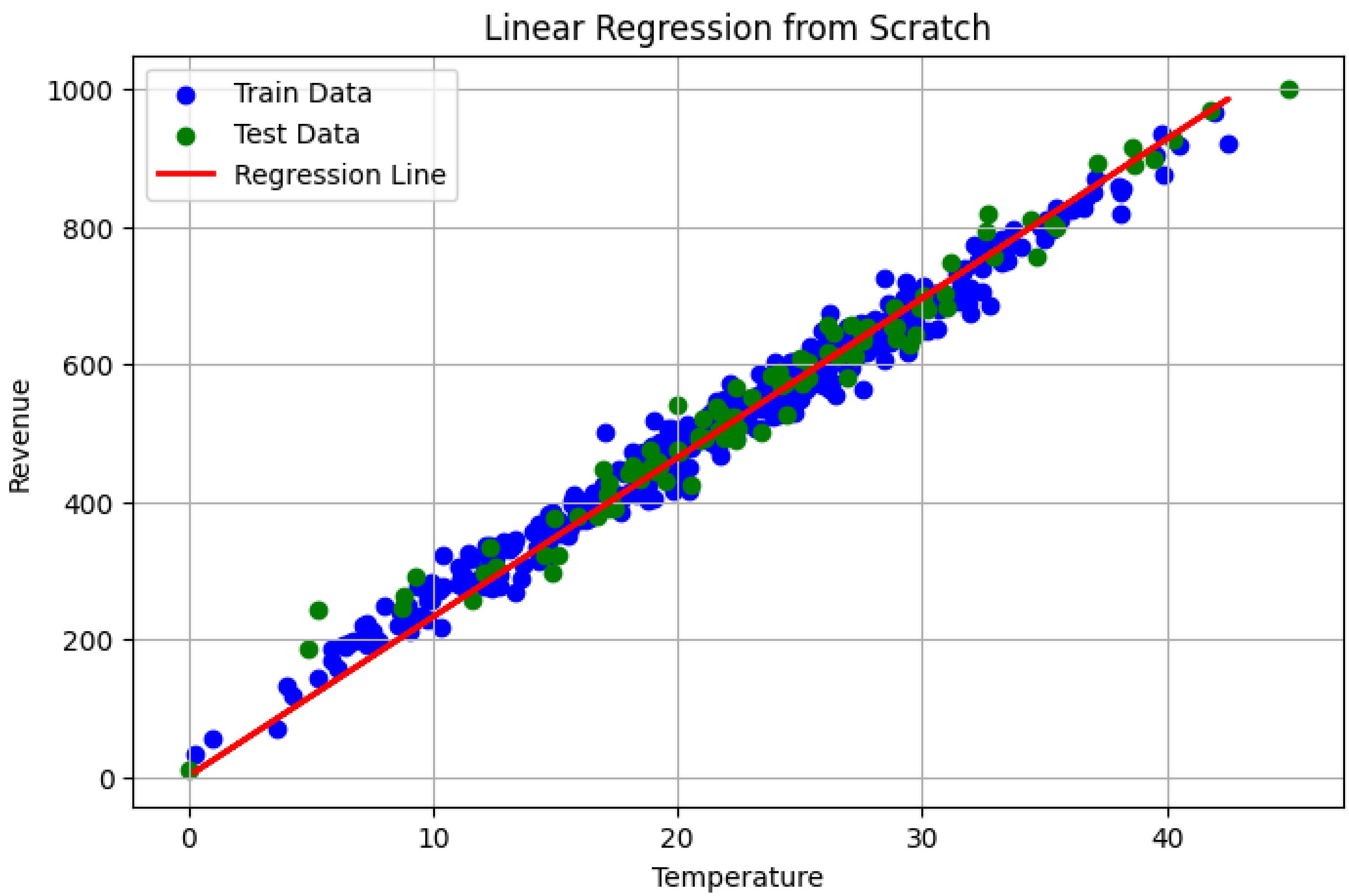
In [13]:
```
model = LinearRegression()
learning_rate = 0.001
epochs = 50

losses, predictions_over_time = model.train(train_input, train_output, learning_rate, epochs)

print("Trained Parameters:", model.parameters)
```

```
Trained Parameters: {'w': np.float64(23.152170419043937), 'b': np.float64(1.461005386478103)}
```

In [14]:
```
train_predictions = model.predict(train_input)
test_predictions = model.predict(test_input)

train_mse = np.mean((train_output - train_predictions) ** 2)
test_mse = np.mean((test_output - test_predictions) ** 2)

print(f"\nTrain MSE: {train_mse:.4f}")
print(f"Test MSE: {test_mse:.4f}")
```

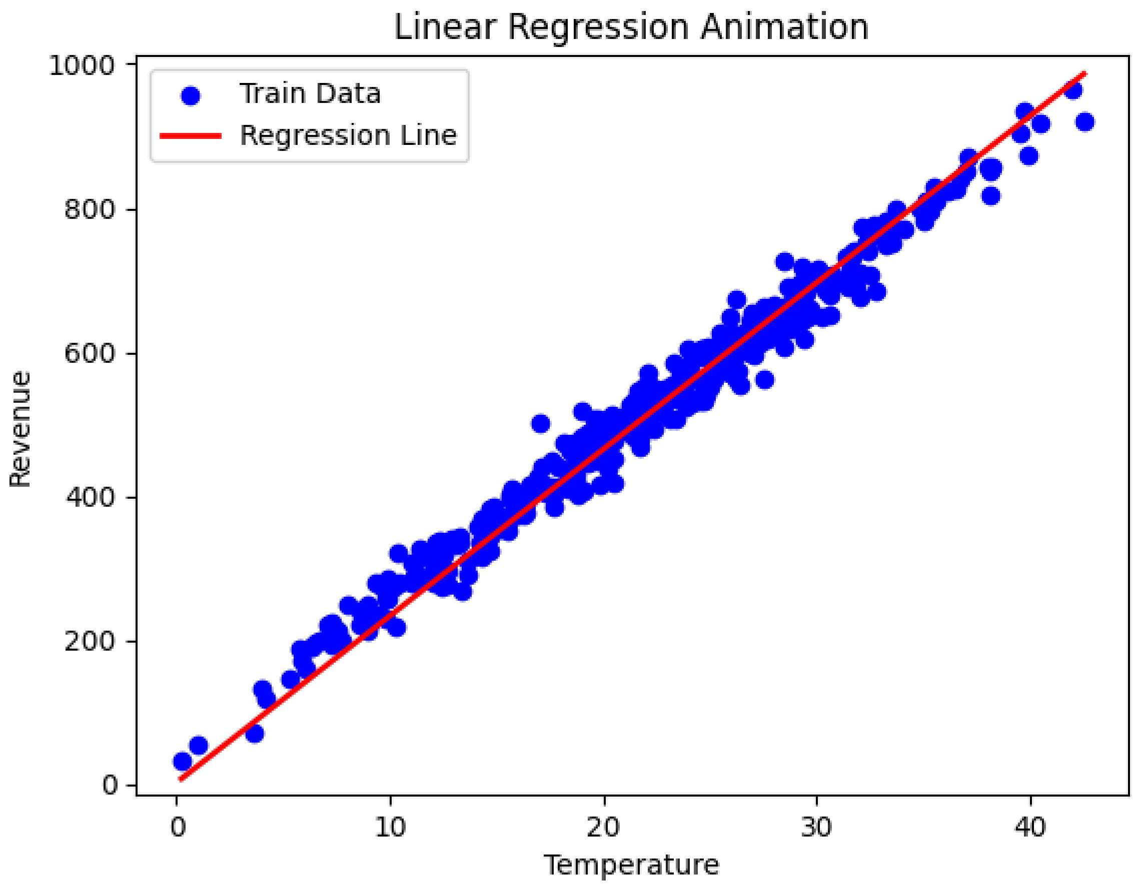
```
Train MSE: 808.7403
Test MSE: 980.3907
```

In [15]:
```
plt.figure(figsize=(8, 5))
plt.scatter(train_input, train_output, color='blue', label='Train Data')
plt.scatter(test_input, test_output, color='green', label='Test Data')
plt.plot(train_input, train_predictions, color='red', linewidth=2, label='Regression Line')
plt.xlabel('Temperature')
plt.ylabel('Revenue')
plt.title('Linear Regression from Scratch')
plt.legend()
plt.grid(True)
plt.show()
```



In [16]:
```
fig, ax = plt.subplots()
ax.scatter(train_input, train_output, color='blue', label='Train Data')
```

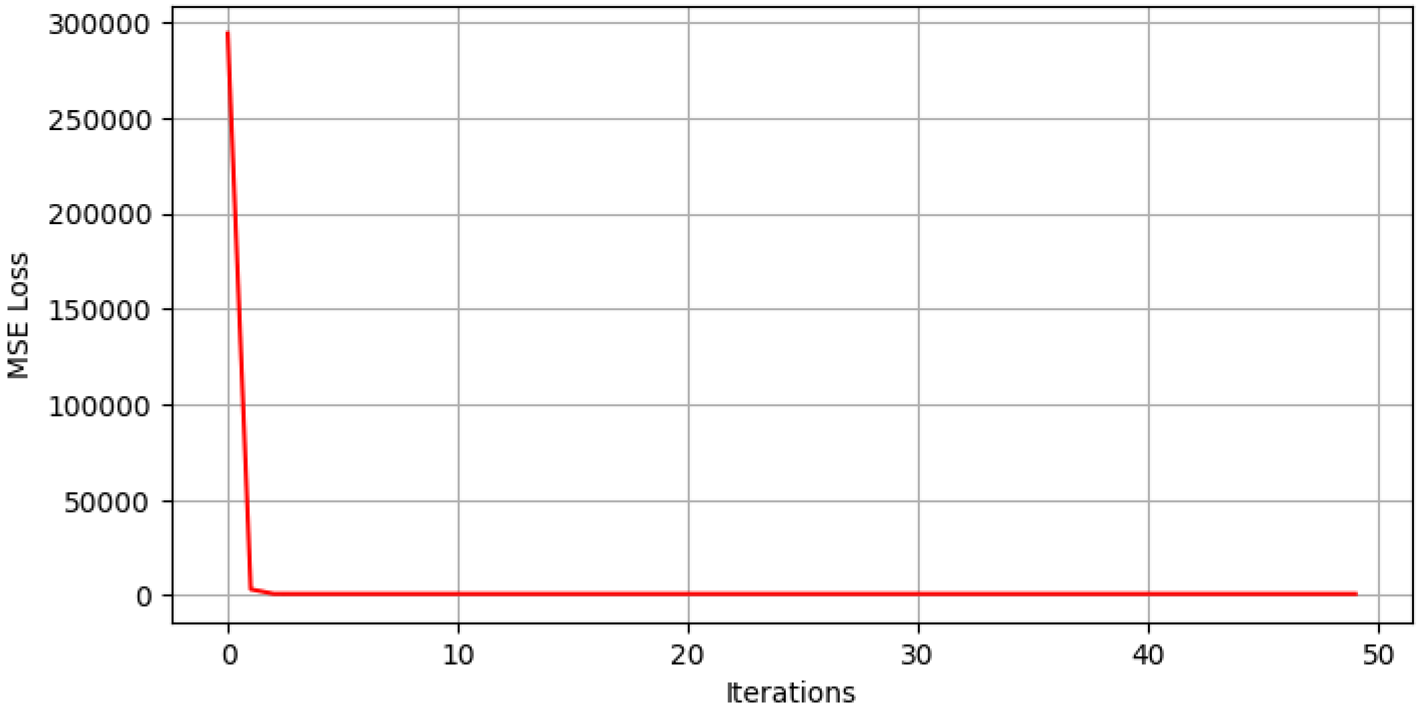
```
line, = ax.plot([], [], color='red', linewidth=2, label='Regression Line')
ax.set_xlabel('Temperature')
ax.set_ylabel('Revenue')
ax.set_title('Linear Regression Animation')
ax.legend()

def animate(i):
    sorted_idx = np.argsort(train_input.flatten())
    x_sorted = train_input.flatten()[sorted_idx]
    y_sorted = predictions_over_time[i].flatten()[sorted_idx]
    line.set_data(x_sorted, y_sorted)
    return line,

ani = FuncAnimation(fig, animate, frames=len(predictions_over_time), interval=50, blit=True)
plt.show()
```



In [17]:
```
writer = PillowWriter(fps=30)
ani.save("LinearRegression.gif", writer=writer)
print("Animation saved as LinearRegression.gif")
```

```
Animation saved as LinearRegression.gif
```

In [18]:
```
# ------------------------------
plt.figure(figsize=(8, 4))
plt.plot(range(len(losses)), losses, color='red')
plt.xlabel('Iterations')
plt.ylabel('MSE Loss')
plt.grid(True)
plt.show()
```



MSE Loss
300000
250000
200000
150000
100000
50000
0
0
10
20
30
40
50
Iterations