Part 7: Implementing the Mini-Batch Gradient Descent

In [ ]:

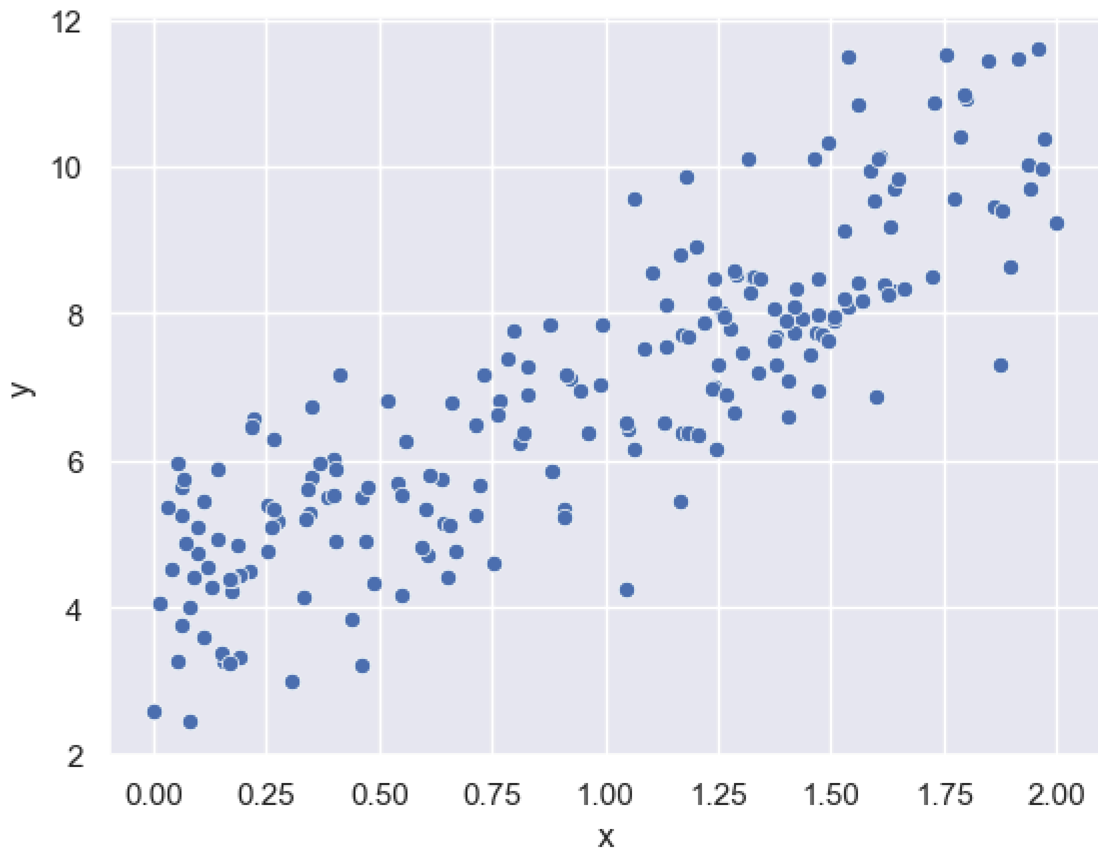
```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
sns.set_theme()
```

In [ ]:

```
data = pd.DataFrame()

data["x"] = pd.read_csv("X.csv")
data["y"] = pd.read_csv("y.csv")

sns.scatterplot(data = data, x= "x" , y = "y")
```

Out[ ]:

```
<Axes: xlabel='x', ylabel='y'>
```



In [ ]:
```
x = data["x"].to_numpy()
y = data["y"].to_numpy()
```

run_mini_batch returns $\theta_k + 1$ given θ_k

In [ ]:
```
def run_mini_batch(theta, learning_rate, batch_size, x, y):
    indices = np.random.choice(len(x), size=batch_size, replace=False)
    x_subset = x[indices]
    y_subset = y[indices]

    x_b = np.c_[np.ones(batch_size), x_subset]

    gradients = 2/batch_size * np.dot(x_b.T, np.dot(x_b, theta) - y_subset)
    theta_n = theta - learning_rate*gradients
```

```python
    return theta_n
```

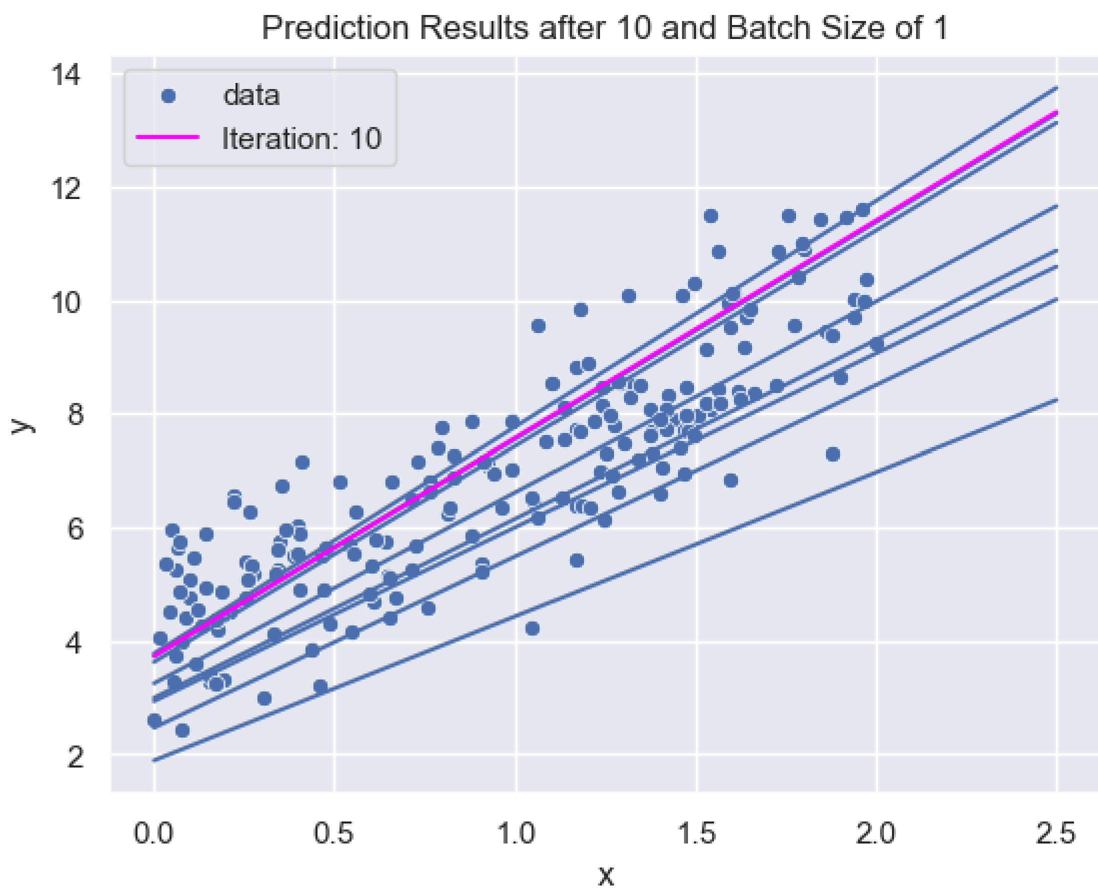
In [ ]:
```python
def get_mean_squared_error(theta, x, y):
    y_pred = theta[0] + theta[1]*x
    mse = np.sum((y-y_pred)**2) / len(x)

    return mse
```

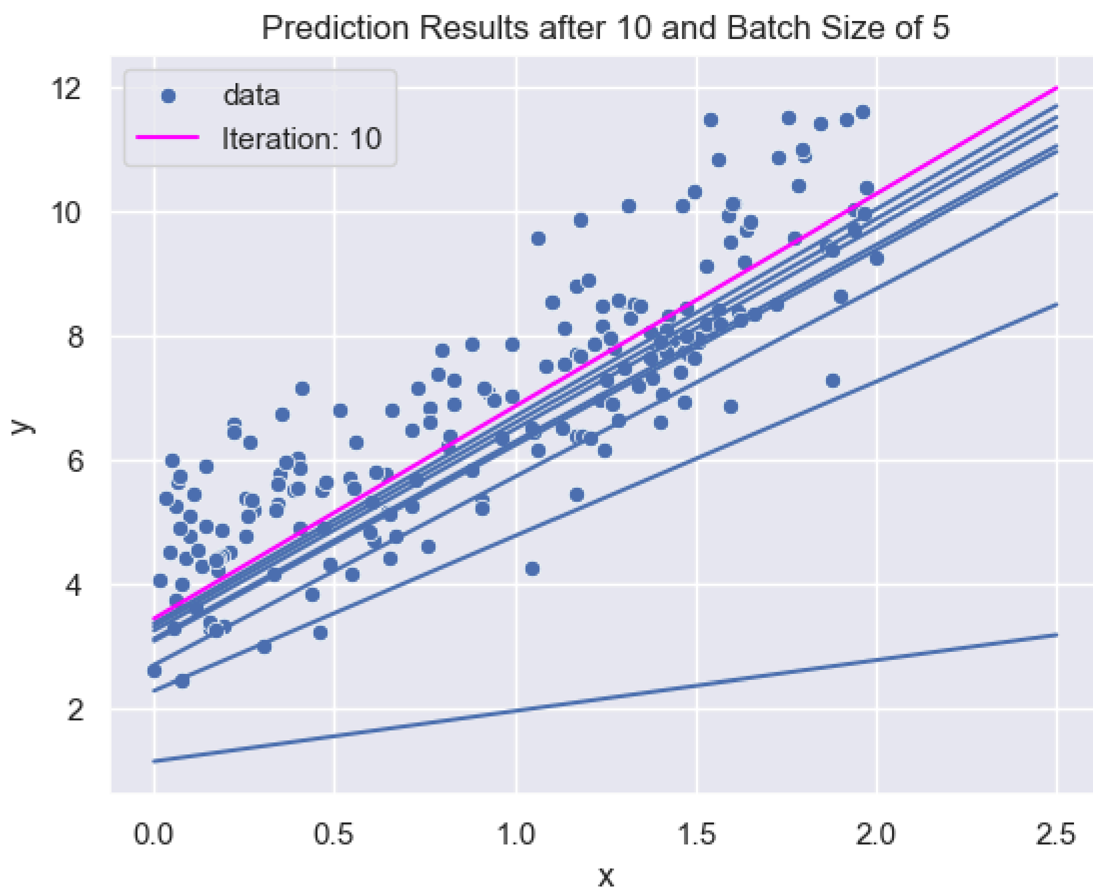
In [ ]:
```python
def plot_batch(theta, current_iter, n_iterations):
    x_pred = np.arange(0,3, 0.5)
    y_pred = theta[0] + theta[1]*x_pred
    y_pred

    if current_iter != n_iterations - 1:
        sns.lineplot(x = x_pred, y = y_pred, color = "#4c72b0")
    else:
        sns.lineplot(x = x_pred, y = y_pred, label = f"Iteration: {current_iter+1}", color = "magenta")
```

In [ ]:
```python
learning_rate = 0.1
batch_sizes = [1, 5, 10]
n_iterations = 10

theta = np.empty((n_iterations, 2, len(batch_sizes)))
mse = np.empty((n_iterations, len(batch_sizes)))
```

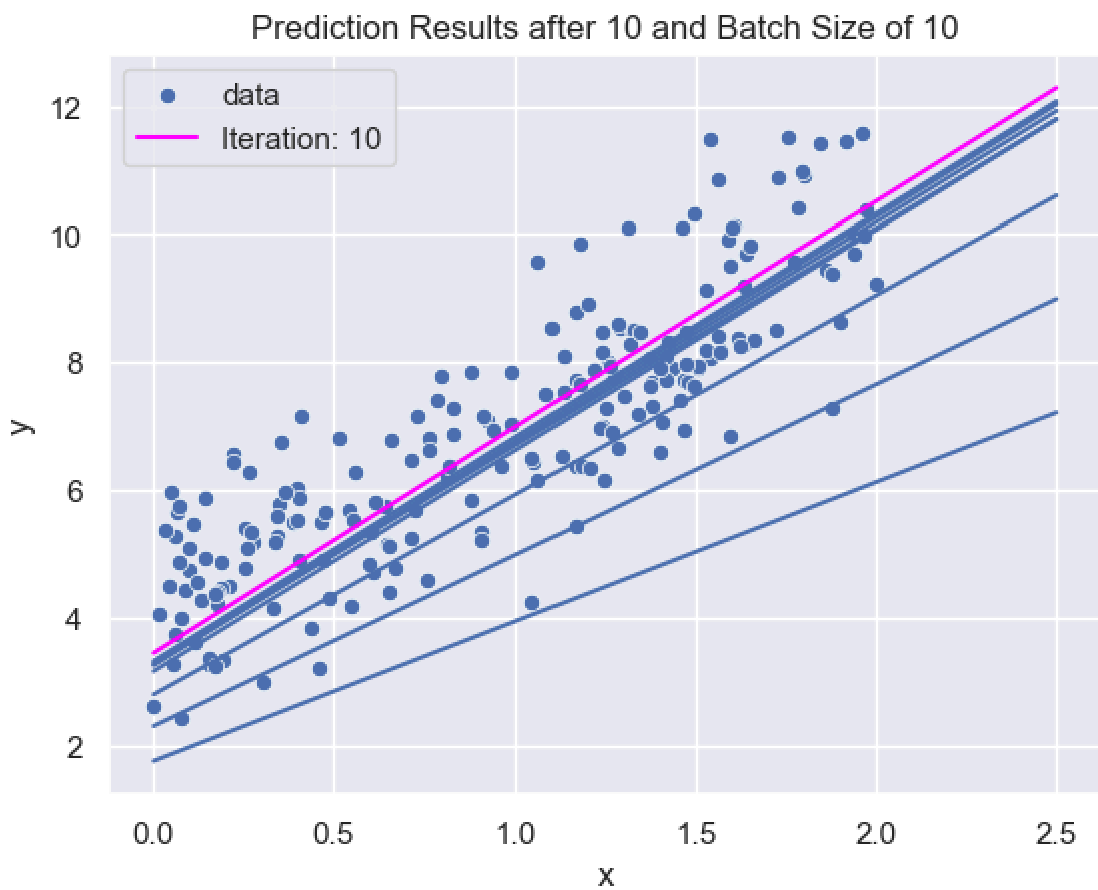
In [ ]:
```python
for b in range(len(batch_sizes)):
    sns.scatterplot(data=data, x="x", y="y", label="data")

    theta[0, :, b] = np.random.randn(2)
    mse[0, b] = get_mean_squared_error(theta[0, :, b], x, y)


    for i in range(1, n_iterations):


        theta[i, :, b] = run_mini_batch(theta[i-1, :, b], learning_rate, batch_sizes[b], x, y)


        plot_batch(theta[i, :, b], i, n_iterations)
```

```
        mse[i, b] = get_mean_squared_error(theta[i, :, b], x, y)

    plt.title(f"Prediction Results after {n_iterations} and Batch Size of {batch_sizes[b]}")
    plt.show()
```



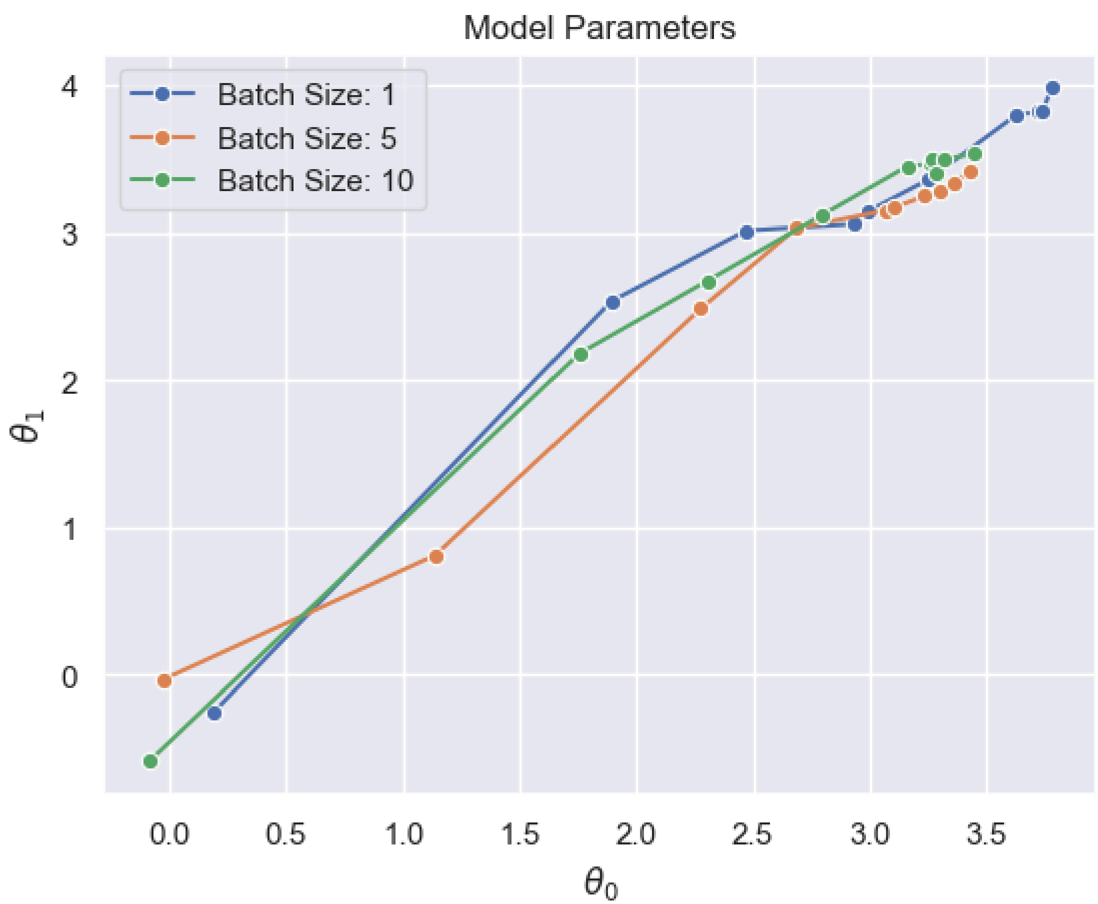


Prediction Results after 10 and Batch Size of 5
data
Iteration: 10
y
x
12
10
8
6
4
2
0.0
0.5
1.0
1.5
2.0
2.5



In [ ]:
```
for b in range(len(batch_sizes)):
    theta_0 = theta[:, 0, b]
    theta_1 = theta[:, 1, b]

    sns.lineplot(x = theta_0, y = theta_1, marker = "o", label = f"Batch Size: {batch_sizes[b]}")
plt.xlabel(r"$\theta_0$")
plt.ylabel(r"$\theta_1$")
plt.title("Model Parameters")
```

Out[ ]:
```
Text(0.5, 1.0, 'Model Parameters')
```



In [ ]:
```python
for b in range(len(batch_sizes)):
    sns.lineplot(x = np.arange(n_iterations), y = mse[:,b], label = f"Batch Size: {batch_sizes[b]}")

plt.xlabel("Iterations")
plt.ylabel("Mean Squared Error")
plt.title(f"Mean Squared Error of Differing Batch Sizes after {n_iterations} Iterations")
```

Out[ ]:
```
Text(0.5, 1.0, 'Mean Squared Error of Differing Batch Sizes after 10 Iterations')
```

Mean Squared Error of Differing Batch Sizes after 10 Iterations
Batch Size: 1
Batch Size: 5
Batch Size: 10
Mean Squared Error
0
10
20
30
40
50
60
0
2
4
6
8
Iterations