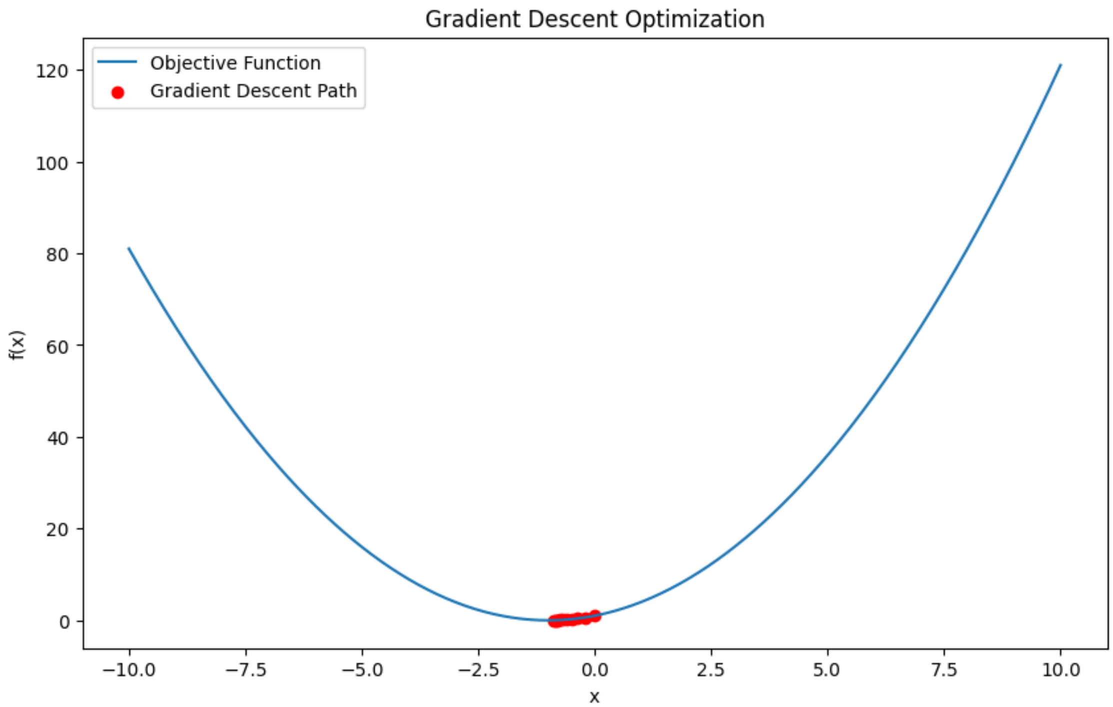
exp2-gradient-descent

[ ]:

```python
import numpy as np
import matplotlib.pyplot as plt

# Objective function: f(x) = ax^2 + bx + c
def objective_function(x, a=1, b=2, c=1):
    return a * x**2 + b * x + c

# Gradient of the objective function: df/dx = 2ax + b
def gradient(x, a=1, b=2):
    return 2 * a * x + b

# Gradient Descent Algorithm
def gradient_descent(initial_x, learning_rate, num_iterations, a=1, b=2, c=1):
    x = initial_x
    history = [x]

    print(f"{'Iteration':<10}{'x':<10}{'Gradient':<15}{'Objective Function'}")
    print("-" * 45)

    for i in range(num_iterations):
        grad = gradient(x, a, b)
        obj_value = objective_function(x, a, b, c)
        print(f"{i+1:<10}{x:<10.4f}{grad:<15.4f}{obj_value:<20.4f}")

        x = x - learning_rate * grad
        history.append(x)

    return x, history

# Parameters
initial_x = 0   # Starting point
learning_rate = 0.1   # Step size
num_iterations = 10   # Number of iterations for demonstration

# Run Gradient Descent
```

```
optimal_x, history = gradient_descent(initial_x, learning_rate, num_iterations)

print(f"\nOptimal x: {optimal_x:.4f}")
print(f"Value of the objective function at optimal x:␣
↪{objective_function(optimal_x):.4f}")

# Plot the objective function and the path taken by Gradient Descent
x_values = np.linspace(-10, 10, 400)
y_values = objective_function(x_values)

plt.figure(figsize=(10, 6))
plt.plot(x_values, y_values, label='Objective Function')
plt.scatter(history, [objective_function(x) for x in history], color='red',␣
↪label='Gradient Descent Path')
plt.xlabel('x')
plt.ylabel('f(x)')
plt.title('Gradient Descent Optimization')
plt.legend()
plt.show()
```

```
Iteration x          Gradient       Objective Function
---------------------------------------------
1         0.0000     2.0000         1.0000
2         -0.2000    1.6000         0.6400
3         -0.3600    1.2800         0.4096
4         -0.4880    1.0240         0.2621
5         -0.5904    0.8192         0.1678
6         -0.6723    0.6554         0.1074
7         -0.7379    0.5243         0.0687
8         -0.7903    0.4194         0.0440
9         -0.8322    0.3355         0.0281
10        -0.8658    0.2684         0.0180

Optimal x: -0.8926
Value of the objective function at optimal x: 0.0115
```



Gradient Descent Optimization
Objective Function
Gradient Descent Path
120
100
80
60
40
20
0
f(x)
−10.0
−7.5
−5.0
−2.5
0.0
2.5
5.0
7.5
10.0
x