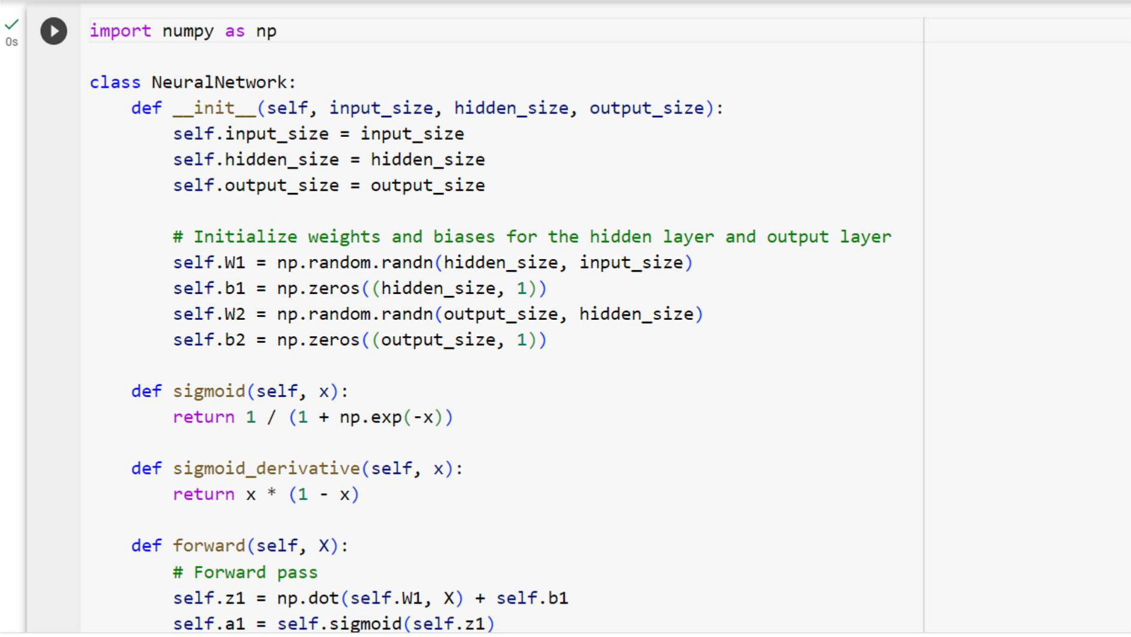
39_Sanskruti Nijai

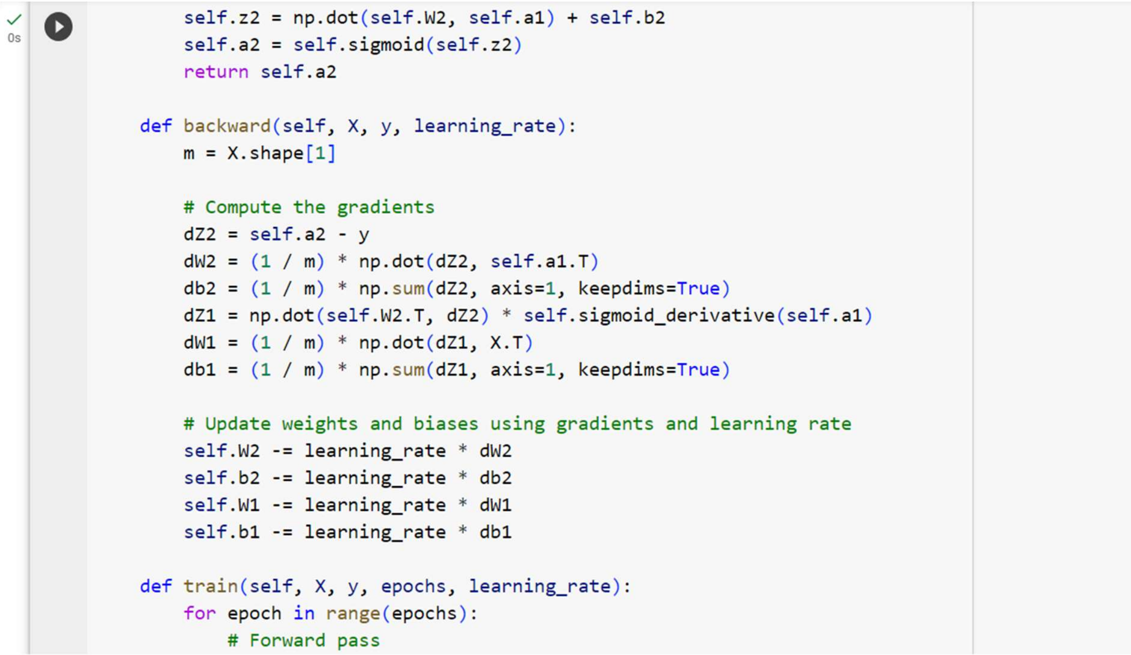
EXPERIMENT NO 04

Implement a backpropagation algorithm to train a DNN with at least 2 hidden layers.

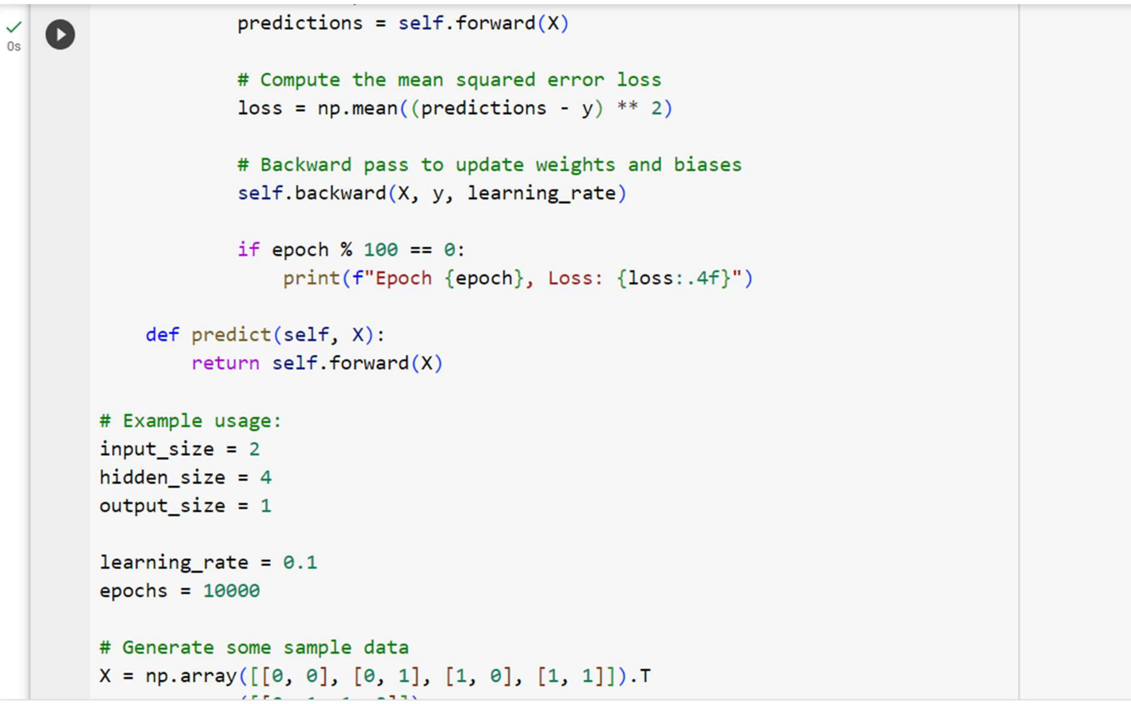
Code and output:



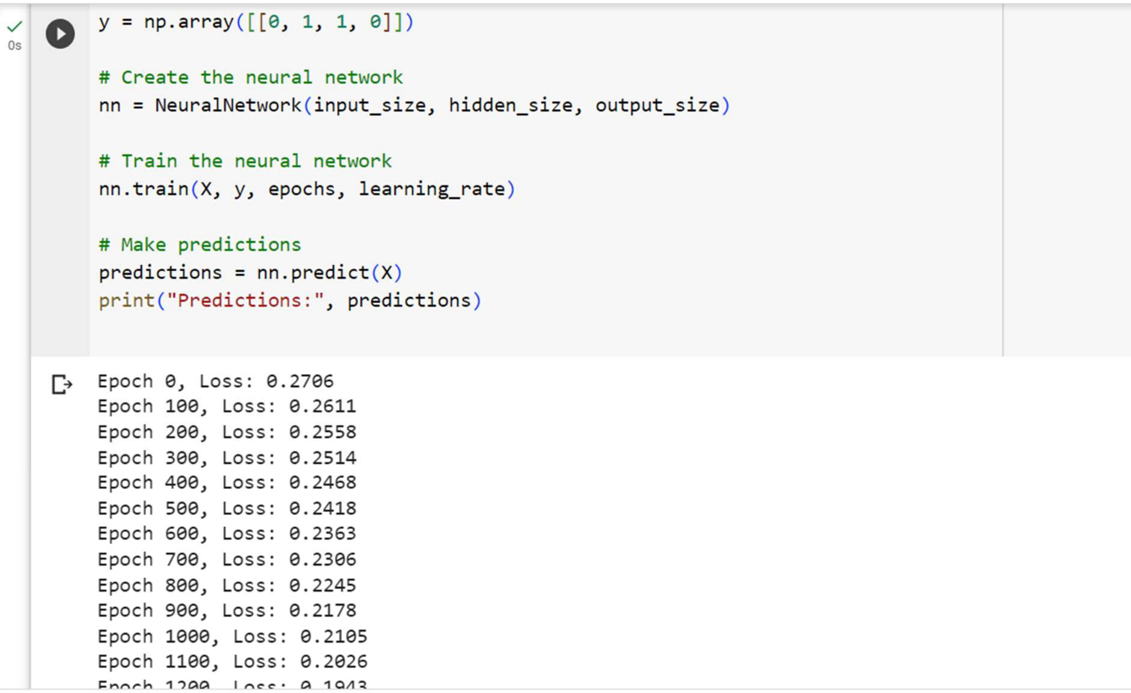
```
import numpy as np

class NeuralNetwork:
    def __init__(self, input_size, hidden_size, output_size):
        self.input_size = input_size
        self.hidden_size = hidden_size
        self.output_size = output_size

        # Initialize weights and biases for the hidden layer and output layer
        self.W1 = np.random.randn(hidden_size, input_size)
        self.b1 = np.zeros((hidden_size, 1))
        self.W2 = np.random.randn(output_size, hidden_size)
        self.b2 = np.zeros((output_size, 1))

    def sigmoid(self, x):
        return 1 / (1 + np.exp(-x))

    def sigmoid_derivative(self, x):
        return x * (1 - x)

    def forward(self, X):
        # Forward pass
        self.z1 = np.dot(self.W1, X) + self.b1
        self.a1 = self.sigmoid(self.z1)
```



```
        self.z2 = np.dot(self.W2, self.a1) + self.b2
        self.a2 = self.sigmoid(self.z2)
        return self.a2

    def backward(self, X, y, learning_rate):
        m = X.shape[1]

        # Compute the gradients
        dZ2 = self.a2 - y
        dW2 = (1 / m) * np.dot(dZ2, self.a1.T)
        db2 = (1 / m) * np.sum(dZ2, axis=1, keepdims=True)
        dZ1 = np.dot(self.W2.T, dZ2) * self.sigmoid_derivative(self.a1)
        dW1 = (1 / m) * np.dot(dZ1, X.T)
        db1 = (1 / m) * np.sum(dZ1, axis=1, keepdims=True)

        # Update weights and biases using gradients and learning rate
        self.W2 -= learning_rate * dW2
        self.b2 -= learning_rate * db2
        self.W1 -= learning_rate * dW1
        self.b1 -= learning_rate * db1

    def train(self, X, y, epochs, learning_rate):
        for epoch in range(epochs):
            # Forward pass
```

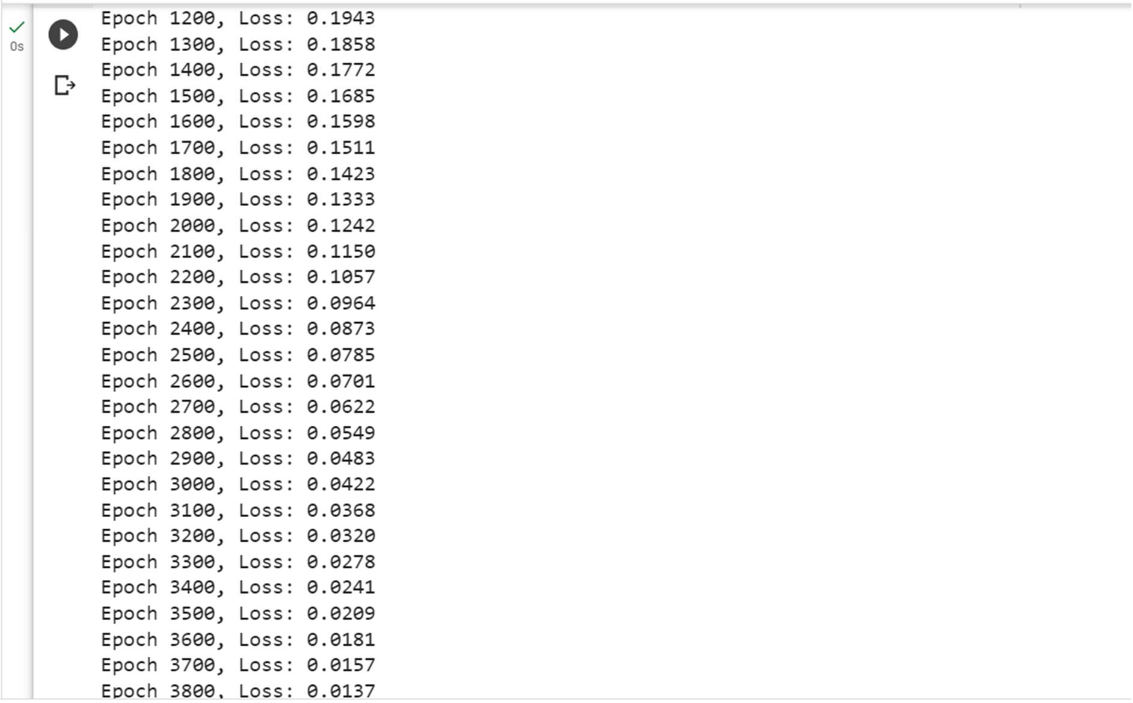


```
            predictions = self.forward(X)

            # Compute the mean squared error loss
            loss = np.mean((predictions - y) ** 2)

            # Backward pass to update weights and biases
            self.backward(X, y, learning_rate)

            if epoch % 100 == 0:
                print(f"Epoch {epoch}, Loss: {loss:.4f}")

    def predict(self, X):
        return self.forward(X)

# Example usage:
input_size = 2
hidden_size = 4
output_size = 1

learning_rate = 0.1
epochs = 10000

# Generate some sample data
X = np.array([[0, 0], [0, 1], [1, 0], [1, 1]]).T
```

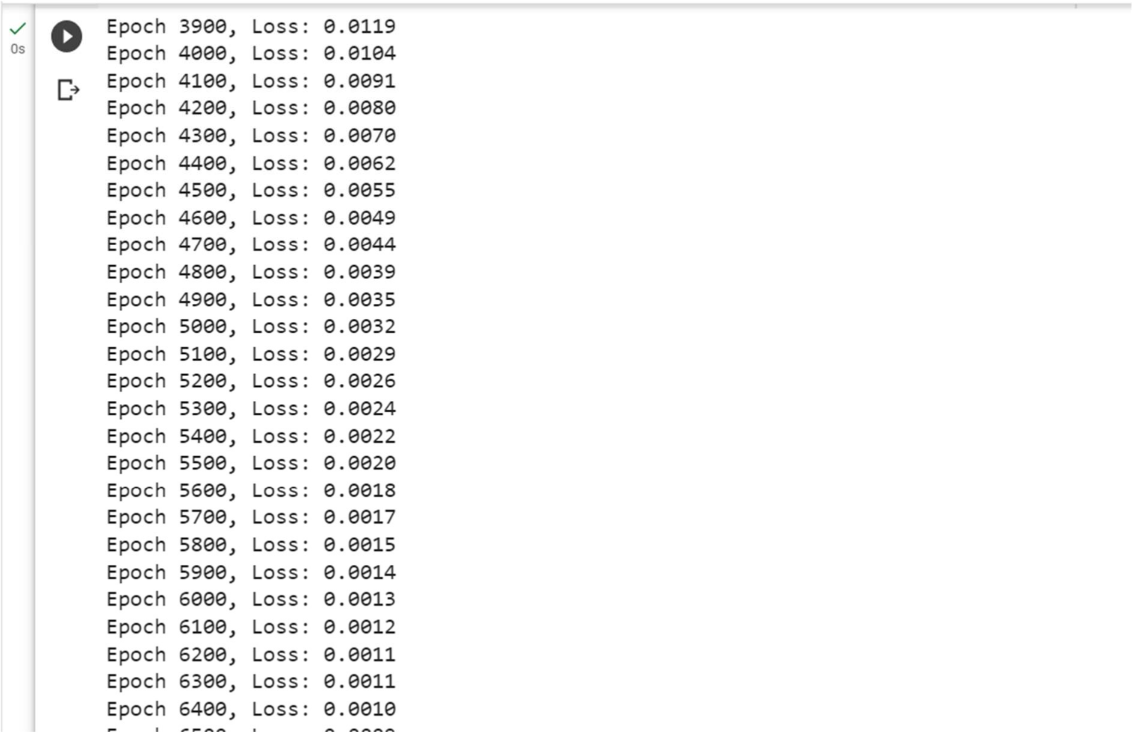


```
y = np.array([[0, 1, 1, 0]])

# Create the neural network
nn = NeuralNetwork(input_size, hidden_size, output_size)

# Train the neural network
nn.train(X, y, epochs, learning_rate)

# Make predictions
predictions = nn.predict(X)
print("Predictions:", predictions)
```

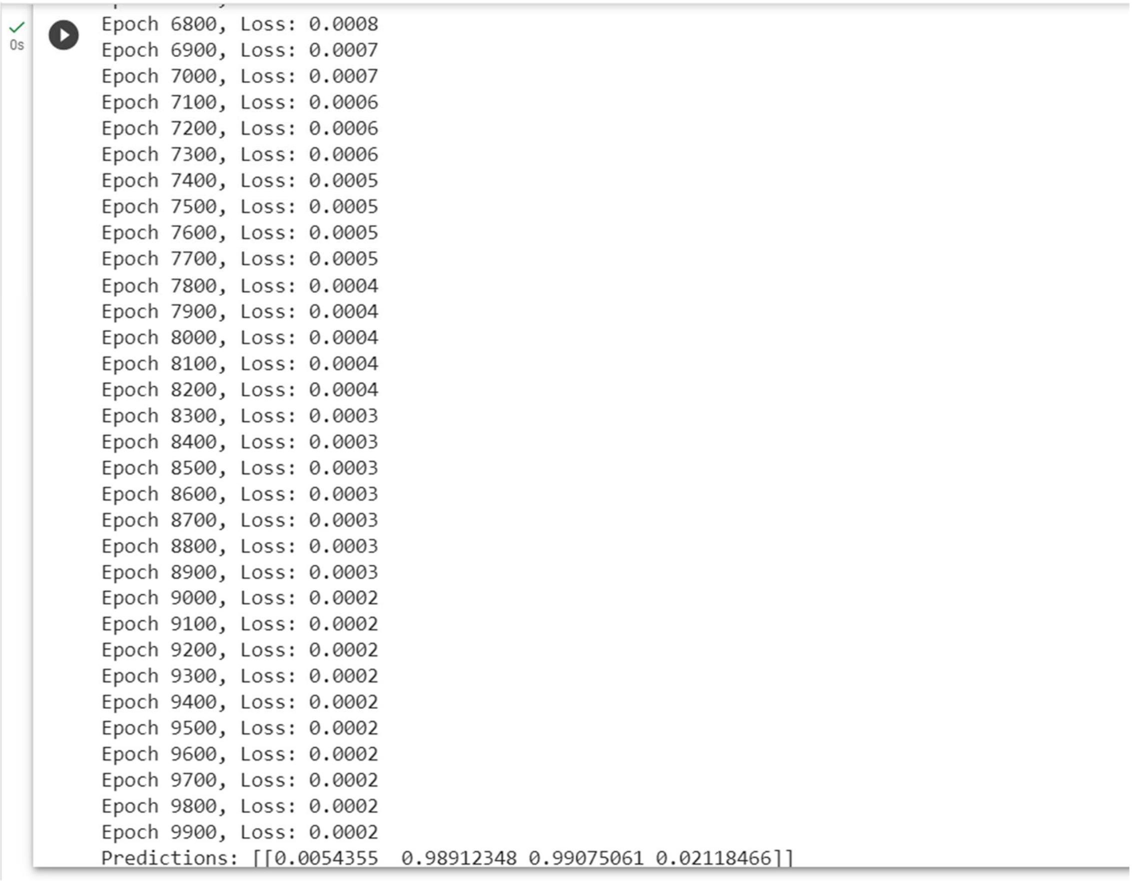
```
Epoch 0, Loss: 0.2706
Epoch 100, Loss: 0.2611
Epoch 200, Loss: 0.2558
Epoch 300, Loss: 0.2514
Epoch 400, Loss: 0.2468
Epoch 500, Loss: 0.2418
Epoch 600, Loss: 0.2363
Epoch 700, Loss: 0.2306
Epoch 800, Loss: 0.2245
Epoch 900, Loss: 0.2178
Epoch 1000, Loss: 0.2105
Epoch 1100, Loss: 0.2026
Epoch 1200, Loss: 0.1943
```



```
Epoch 1200, Loss: 0.1943
Epoch 1300, Loss: 0.1858
Epoch 1400, Loss: 0.1772
Epoch 1500, Loss: 0.1685
Epoch 1600, Loss: 0.1598
Epoch 1700, Loss: 0.1511
Epoch 1800, Loss: 0.1423
Epoch 1900, Loss: 0.1333
Epoch 2000, Loss: 0.1242
Epoch 2100, Loss: 0.1150
Epoch 2200, Loss: 0.1057
Epoch 2300, Loss: 0.0964
Epoch 2400, Loss: 0.0873
Epoch 2500, Loss: 0.0785
Epoch 2600, Loss: 0.0701
Epoch 2700, Loss: 0.0622
Epoch 2800, Loss: 0.0549
Epoch 2900, Loss: 0.0483
Epoch 3000, Loss: 0.0422
Epoch 3100, Loss: 0.0368
Epoch 3200, Loss: 0.0320
Epoch 3300, Loss: 0.0278
Epoch 3400, Loss: 0.0241
Epoch 3500, Loss: 0.0209
Epoch 3600, Loss: 0.0181
Epoch 3700, Loss: 0.0157
Epoch 3800, Loss: 0.0137
```



```
Epoch 3900, Loss: 0.0119
Epoch 4000, Loss: 0.0104
Epoch 4100, Loss: 0.0091
Epoch 4200, Loss: 0.0080
Epoch 4300, Loss: 0.0070
Epoch 4400, Loss: 0.0062
Epoch 4500, Loss: 0.0055
Epoch 4600, Loss: 0.0049
Epoch 4700, Loss: 0.0044
Epoch 4800, Loss: 0.0039
Epoch 4900, Loss: 0.0035
Epoch 5000, Loss: 0.0032
Epoch 5100, Loss: 0.0029
Epoch 5200, Loss: 0.0026
Epoch 5300, Loss: 0.0024
Epoch 5400, Loss: 0.0022
Epoch 5500, Loss: 0.0020
Epoch 5600, Loss: 0.0018
Epoch 5700, Loss: 0.0017
Epoch 5800, Loss: 0.0015
Epoch 5900, Loss: 0.0014
Epoch 6000, Loss: 0.0013
Epoch 6100, Loss: 0.0012
Epoch 6200, Loss: 0.0011
Epoch 6300, Loss: 0.0011
Epoch 6400, Loss: 0.0010
```



```
Epoch 6800, Loss: 0.0008
Epoch 6900, Loss: 0.0007
Epoch 7000, Loss: 0.0007
Epoch 7100, Loss: 0.0006
Epoch 7200, Loss: 0.0006
Epoch 7300, Loss: 0.0006
Epoch 7400, Loss: 0.0005
Epoch 7500, Loss: 0.0005
Epoch 7600, Loss: 0.0005
Epoch 7700, Loss: 0.0005
Epoch 7800, Loss: 0.0004
Epoch 7900, Loss: 0.0004
Epoch 8000, Loss: 0.0004
Epoch 8100, Loss: 0.0004
Epoch 8200, Loss: 0.0004
Epoch 8300, Loss: 0.0003
Epoch 8400, Loss: 0.0003
Epoch 8500, Loss: 0.0003
Epoch 8600, Loss: 0.0003
Epoch 8700, Loss: 0.0003
Epoch 8800, Loss: 0.0003
Epoch 8900, Loss: 0.0003
Epoch 9000, Loss: 0.0002
Epoch 9100, Loss: 0.0002
Epoch 9200, Loss: 0.0002
Epoch 9300, Loss: 0.0002
Epoch 9400, Loss: 0.0002
Epoch 9500, Loss: 0.0002
Epoch 9600, Loss: 0.0002
Epoch 9700, Loss: 0.0002
Epoch 9800, Loss: 0.0002
Epoch 9900, Loss: 0.0002
Predictions: [[0.0054355  0.98912348 0.99075061 0.02118466]]
```