

# Homework 5

$$\begin{aligned}
 Z_i &= \text{sigmoid}(w_{i1}x_1) & Z_k &= \text{sigmoid}(w_{k1}x_1) \\
 &\downarrow & & \\
 Z_i &= \text{sigmoid}(w_{i1}z_j + w_{i2}z_k) & \text{sigmoid}(w_{i1}z_j + w_{i2}z_k) \\
 &\downarrow & & \\
 g - w_{i1}z_i & & (1 - \text{sigmoid}(w_{i1}z_j + w_{i2}z_k)) \text{sigmoid}(w_{i1}z_j + w_{i2}z_k) w_{i1}
 \end{aligned}$$

$$L = \frac{1}{2}(\hat{y} - y)^2$$

$$\begin{aligned}
 \frac{\partial L}{\partial w_{ij}} &= \frac{\partial L}{\partial \hat{y}} \times \frac{\partial \hat{y}}{\partial z_i} \times \frac{\partial z_i}{\partial w_{ij}} \times \frac{\partial z_k}{\partial w_{ik}} \\
 \frac{\partial L}{\partial z_i} &= (\hat{y} - y) \cdot w_{i1}, \quad \frac{\partial z_i}{\partial z_j} = (1 - \text{sigmoid}(w_{i1}z_j)) \text{sigmoid}(w_{i1}z_j) z_{j1}, \quad \frac{\partial z_k}{\partial w_{ik}} = (1 - \text{sigmoid}(w_{k1}x_1)) \text{sigmoid}(w_{k1}x_1) x_1
 \end{aligned}$$

$$\frac{\partial L}{\partial w_{ij}} = (\hat{y} - y) w_{i1} (1 - \text{sigmoid}(w_{i1}z_j)) \text{sigmoid}(w_{i1}z_j) z_{j1} (1 - \text{sigmoid}(w_{k1}x_1)) \text{sigmoid}(w_{k1}x_1) x_1$$

$$\text{using } \text{sigmoid}(u) = \frac{1}{1+e^{-u}}$$

$$\frac{\partial L}{\partial w_{ik}} = (\hat{y} - y) w_{i1} \left( 1 - \frac{1}{1+e^{-w_{i1}z_j}} \right) \left( \frac{1}{1+e^{-w_{i1}z_j}} \right) w_{k1} \left( 1 - \frac{1}{1+e^{-w_{k1}x_1}} \right) \left( \frac{1}{1+e^{-w_{k1}x_1}} \right) x_1$$

$$\frac{\partial L}{\partial w_{ik}} = \frac{\partial L}{\partial \hat{y}} \times \frac{\partial \hat{y}}{\partial z_i} \times \frac{\partial z_i}{\partial z_k} \times \frac{\partial z_k}{\partial w_{ik}}$$

$$\frac{\partial L}{\partial z_i} = (\hat{y} - y) w_{i1} (1 - \text{sigmoid}(w_{i1}z_j + w_{i2}z_k)) \text{sigmoid}(w_{i1}z_j + w_{i2}z_k) w_{i1}, \quad \frac{\partial z_k}{\partial w_{ik}} = (1 - \text{sigmoid}(w_{k1}x_1)) \text{sigmoid}(w_{k1}x_1) x_1$$

$$\frac{\partial L}{\partial w_{ik}} = (\hat{y} - y) w_{i1} \left( 1 - \frac{1}{1+e^{-(w_{i1}z_j + w_{i2}z_k)}} \right) \left( \frac{1}{1+e^{-(w_{i1}z_j + w_{i2}z_k)}} \right) w_{k1} \left( 1 - \frac{1}{1+e^{-w_{k1}x_1}} \right) \left( \frac{1}{1+e^{-w_{k1}x_1}} \right) x_1$$

$$\frac{\partial L}{\partial w_{ij}} = \frac{\partial L}{\partial \hat{y}} \times \frac{\partial \hat{y}}{\partial z_i} \times \frac{\partial z_i}{\partial w_{ij}}$$

$$\frac{\partial L}{\partial w_{ij}} = (\hat{y} - y) w_{i1} (1 - \text{sigmoid}(w_{i1}z_j + w_{i2}z_k)) \text{sigmoid}(w_{i1}z_j + w_{i2}z_k) z_k$$

$$\frac{\partial L}{\partial w_{ij}} = \frac{\partial L}{\partial \hat{y}} \times \frac{\partial \hat{y}}{\partial z_i} \times \frac{\partial z_i}{\partial w_{ij}}$$

$$\frac{\partial L}{\partial w_{ij}} = (\hat{y} - y) w_{i1} (1 - \text{sigmoid}(w_{i1}z_j + w_{i2}z_k)) \text{sigmoid}(w_{i1}z_j + w_{i2}z_k) z_k$$

$$\frac{\partial L}{\partial w_{ij}} = \frac{\partial L}{\partial \hat{y}} \times \frac{\partial \hat{y}}{\partial z_i}$$

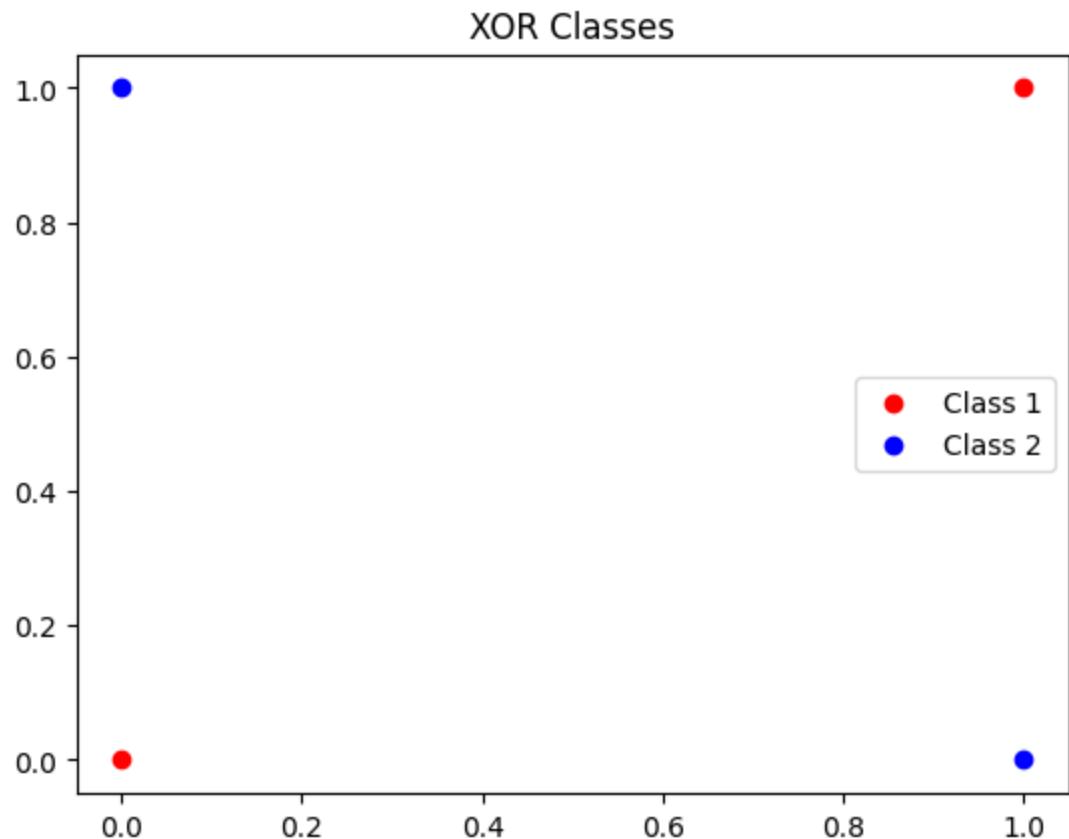
$$\frac{\partial L}{\partial w_{ij}} = (\hat{y} - y) z_k$$

# Homework 5

```
In [1]: import numpy as np  
import matplotlib.pyplot as plt
```

```
In [2]: point1 = np.array([1,1])  
point2 = np.array([0,0])  
point3 = np.array([1,0])  
point4 = np.array([0,1])  
lst = [point1, point2, point3, point4]  
points = np.array([(x, y) for x,y in lst])  
labels = [1, 1, 0, 0]
```

```
In [3]: x_coords = []  
y_coords = []  
  
for point in points:  
    x_coords.append(point[0])  
    y_coords.append(point[1])  
  
plt.scatter(x_coords[:2], y_coords[:2], color='red', label = 'Class 1')  
plt.scatter(x_coords[2:4], y_coords[2:4], color='blue', label = 'Class 2')  
plt.title('XOR Classes')  
plt.legend()  
plt.show()
```



```
In [4]: def sigmoid(val):
    return (1 / (1 + np.exp(-val)))
```

```
In [5]: def initialize_parameters(num_inputs, num_hidden_units, num_outputs):
    w1 = np.random.randn(num_inputs, num_hidden_units)
    w2 = np.random.randn(num_hidden_units, num_outputs)
    b1 = np.random.randn(2,1)
    b2 = np.random.randn()

    return w1, w2, b1, b2
```

```
In [6]: def forward_propagation(x, w1, w2, b1, b2, activation='sigmoid'):
    if activation == 'sigmoid':
        h1 = np.dot(w1, x).reshape((2,1)) + b1
        a = sigmoid(h1)
        z = np.dot(w2.T, a) + b2
        y_pred = sigmoid(z)

    return h1, a, z, y_pred
```

```
In [7]: def compute_loss(prediction, label):
    return 0.5 * (prediction - label) ** 2
```

```
In [8]: def sigmoid_derivative(output):
    return output * (1 - output)
```

```
In [9]: def backpropagation(w2, x, h1, a, z, y_pred, label):
    dL_dyPred = -(label - y_pred)

    dL_dz = dL_dyPred * sigmoid_derivative(y_pred)
    dyPred_dz = sigmoid_derivative(y_pred)

    dL_dw2 = dL_dyPred * dyPred_dz * a
    dz_dw2 = a

    dL_db2 = dL_dyPred * dyPred_dz * 1
    dz_db2 = 1

    dL_da = dL_dyPred * dyPred_dz * w2
    dz_da = w2

    dL_dh1 = dL_dyPred * dyPred_dz * sigmoid_derivative(a)
    da_dh1 = sigmoid_derivative(a)

    dL_dw1 = dL_dyPred * dyPred_dz * dz_da * da_dh1 * x
    dh1_dw1 = x

    dL_db1 = dL_dyPred * dyPred_dz * dz_da * da_dh1 * 1
    dh1_db1 = 1

    return dL_dw2, dL_db2, dL_dw1, dL_db1
```

```
In [10]: def update_parameters(w1, w1_grad, w2, w2_grad, b1, b1_grad, b2, b2_grad, learning_rate):
    w1 -= learning_rate * w1_grad
    w2 -= learning_rate * w2_grad
    b1 -= learning_rate * b1_grad
    b2 -= learning_rate * b2_grad

    return w1, w2, b1, b2
```

```
In [11]: num_inputs = 2
num_hidden_units = 2
num_outputs = 1
```

```
In [12]: def correct(x, w1, w2, b1, b2, labels):
    correct = 0
    for i in range(x.shape[0]):
        y_pred = forward_propagation(x[i], w1, w2, b1, b2)[3]
        y_pred = 1 if y_pred > 0.5 else 0
        if y_pred == labels[i]:
            correct += 1

    return f'{correct/x.shape[0] * 100:.2f}%'
```

```
In [13]: def train(points, labels, epochs=1500, learning_rate=1):
    avg_loss = []
    w1, w2, b1, b2 = initialize_parameters(num_inputs, num_hidden_units, num_outputs)
```

```
for i in range(epochs):
    total_losses = 0

    for j in range(points.shape[0]):

        x = points[j]

        label = labels[j]

        h1, a, z, y_pred = forward_propagation(x, w1, w2, b1, b2, activation)

        loss = compute_loss(float(y_pred), label)
        total_losses += loss

        dL_dw2, dL_db2, dL_dw1, dL_db1 = backpropagation(w2, x, h1, a, z)
        w1, w2, b1, b2 = update_parameters(w1, dL_dw1, w2, dL_dw2, b1, dL_db1, b2, learning_rate)

        if( i % 20 == 0 ):
            print("-----EPOCH: ", i, end=' ')
            print("-----")
            print("Training Loss: ", total_losses/len(points))
            avg_loss.append(total_losses / len(points))
            print("Percent Correct: ", correct(points, w1, w2, b1, b2, label))
            print()

    return w1, w2, b1, b2, avg_loss
```

## Run Model

```
In [14]: params = train(points, labels, epochs = 1000, learning_rate = 1)
print('Model Parameters: ', params[:4])
```

-----EPOCH: 0-----  
Training Loss: 0.14418220459094278  
Percent Correct: 50.00%

-----EPOCH: 20-----  
Training Loss: 0.13744700926076722  
Percent Correct: 50.00%

-----EPOCH: 40-----  
Training Loss: 0.12894022205364566  
Percent Correct: 50.00%

-----EPOCH: 60-----  
Training Loss: 0.116186314597386  
Percent Correct: 75.00%

-----EPOCH: 80-----  
Training Loss: 0.09750343544434165  
Percent Correct: 100.00%

-----EPOCH: 100-----  
Training Loss: 0.0718171287182074  
Percent Correct: 100.00%

-----EPOCH: 120-----  
Training Loss: 0.04761887219346507  
Percent Correct: 100.00%

-----EPOCH: 140-----  
Training Loss: 0.03147372952920957  
Percent Correct: 100.00%

-----EPOCH: 160-----  
Training Loss: 0.021935187562486982  
Percent Correct: 100.00%

-----EPOCH: 180-----  
Training Loss: 0.01620643665323079  
Percent Correct: 100.00%

-----EPOCH: 200-----  
Training Loss: 0.012569335650312109  
Percent Correct: 100.00%

-----EPOCH: 220-----  
Training Loss: 0.010125059916163477  
Percent Correct: 100.00%

-----EPOCH: 240-----  
Training Loss: 0.00839980914957413  
Percent Correct: 100.00%

-----EPOCH: 260-----  
Training Loss: 0.007131677987938489  
Percent Correct: 100.00%

-----EPOCH: 280-----  
Training Loss: 0.006167993057893108  
Percent Correct: 100.00%

-----EPOCH: 300-----  
Training Loss: 0.005415254600814398  
Percent Correct: 100.00%

-----EPOCH: 320-----  
Training Loss: 0.004813658205255623  
Percent Correct: 100.00%

-----EPOCH: 340-----  
Training Loss: 0.004323482991392638  
Percent Correct: 100.00%

-----EPOCH: 360-----  
Training Loss: 0.003917473505630853  
Percent Correct: 100.00%

-----EPOCH: 380-----  
Training Loss: 0.003576391826218649  
Percent Correct: 100.00%

-----EPOCH: 400-----  
Training Loss: 0.0032863205386087454  
Percent Correct: 100.00%

-----EPOCH: 420-----  
Training Loss: 0.0030369714842688  
Percent Correct: 100.00%

-----EPOCH: 440-----  
Training Loss: 0.0028205930744480403  
Percent Correct: 100.00%

-----EPOCH: 460-----  
Training Loss: 0.0026312453075178813  
Percent Correct: 100.00%

-----EPOCH: 480-----  
Training Loss: 0.002464307188501259  
Percent Correct: 100.00%

-----EPOCH: 500-----  
Training Loss: 0.0023161348404920697  
Percent Correct: 100.00%

-----EPOCH: 520-----  
Training Loss: 0.002183819605827352  
Percent Correct: 100.00%

-----EPOCH: 540-----  
Training Loss: 0.0020650138933617974  
Percent Correct: 100.00%

-----EPOCH: 560-----  
Training Loss: 0.001957803803950902  
Percent Correct: 100.00%

-----EPOCH: 580-----  
Training Loss: 0.0018606146186615816  
Percent Correct: 100.00%

-----EPOCH: 600-----  
Training Loss: 0.0017721397413030433  
Percent Correct: 100.00%

-----EPOCH: 620-----  
Training Loss: 0.0016912866247761798  
Percent Correct: 100.00%

-----EPOCH: 640-----  
Training Loss: 0.0016171351609178101  
Percent Correct: 100.00%

-----EPOCH: 660-----  
Training Loss: 0.0015489053299152249  
Percent Correct: 100.00%

-----EPOCH: 680-----  
Training Loss: 0.001485931807823486  
Percent Correct: 100.00%

-----EPOCH: 700-----  
Training Loss: 0.0014276438583409982  
Percent Correct: 100.00%

-----EPOCH: 720-----  
Training Loss: 0.001373549277343334  
Percent Correct: 100.00%

-----EPOCH: 740-----  
Training Loss: 0.0013232214743322704  
Percent Correct: 100.00%

-----EPOCH: 760-----  
Training Loss: 0.0012762890028334343  
Percent Correct: 100.00%

-----EPOCH: 780-----  
Training Loss: 0.0012324270180759781  
Percent Correct: 100.00%

-----EPOCH: 800-----  
Training Loss: 0.0011913502628879188  
Percent Correct: 100.00%

-----EPOCH: 820-----  
Training Loss: 0.001152807273990984  
Percent Correct: 100.00%

-----EPOCH: 840-----

Training Loss: 0.0011165755694067356

Percent Correct: 100.00%

-----EPOCH: 860-----

Training Loss: 0.001082457629586229

Percent Correct: 100.00%

-----EPOCH: 880-----

Training Loss: 0.0010502775244978254

Percent Correct: 100.00%

-----EPOCH: 900-----

Training Loss: 0.0010198780693851165

Percent Correct: 100.00%

-----EPOCH: 920-----

Training Loss: 0.0009911184155179493

Percent Correct: 100.00%

-----EPOCH: 940-----

Training Loss: 0.0009638720006754258

Percent Correct: 100.00%

-----EPOCH: 960-----

Training Loss: 0.000938024798555836

Percent Correct: 100.00%

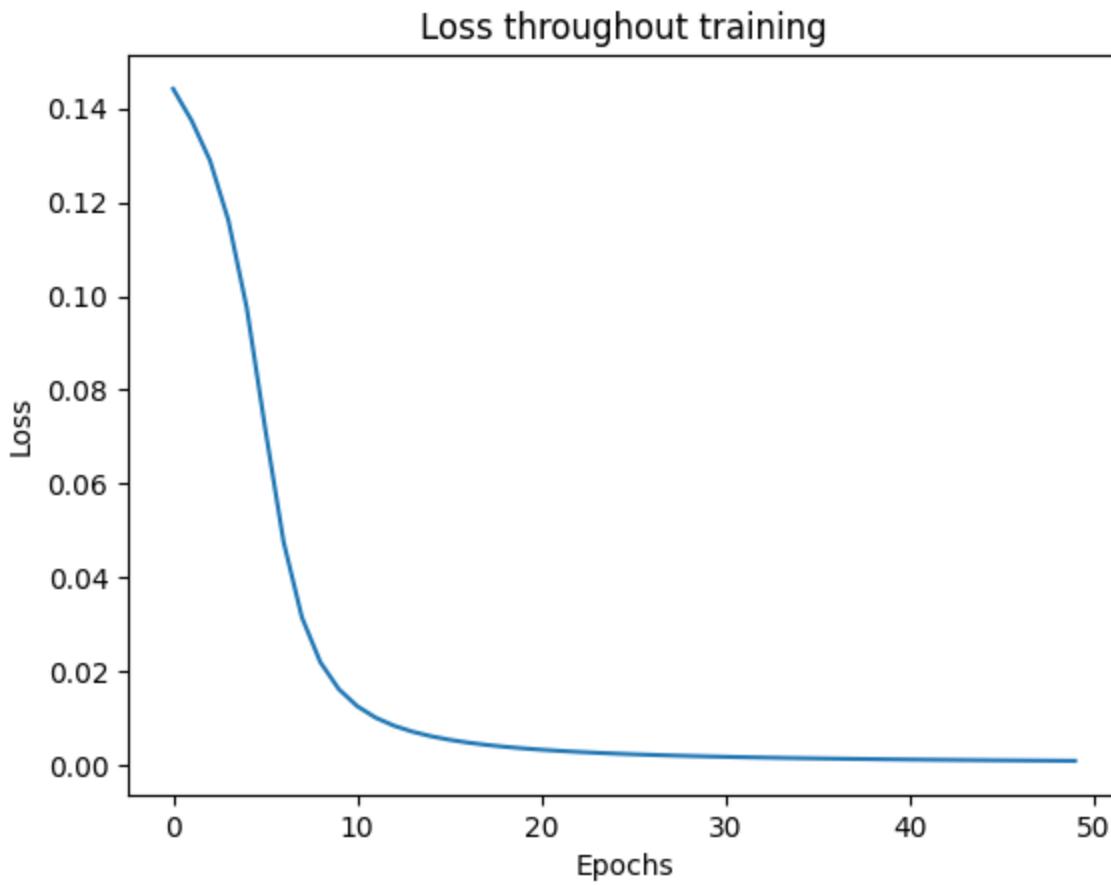
-----EPOCH: 980-----

Training Loss: 0.0009134738177256653

Percent Correct: 100.00%

Model Parameters: (array([-5.20828239, 5.08174286],  
[-5.52798175, 5.80363573]), array([-7.90092925],  
[7.43392186]), array([-2.78726309],  
[2.77059]), array([-3.43535347]))

```
In [29]: avg_loss = params[4]
plt.figure()
plt.plot(avg_loss)
plt.title('Average Loss throughout training')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.show()
```



## Hyperparameter Initialization

Through trial and error, by evaluating the model's loss graph based on the number of epochs and learning rate, I found that the model performed best when trained with 1000 epochs and with a learning rate of 1.

```
In [16]: def plot_boundaries(params):
    x_vals = np.linspace(-2, 2, 100)
    y_vals = np.linspace(-2, 2, 100)
    xx, yy = np.meshgrid(x_vals, y_vals)

    classes = np.zeros((len(y_vals), len(x_vals)))

    for i in range(len(y_vals)):
        for j in range(len(x_vals)):
            input_vector = np.array([x_vals[j], y_vals[i]])

            output = forward_propagation(input_vector, params[0], params[1])

            if output > 0.5:
                classes[i, j] = 1
            else:
                classes[i, j] = -1

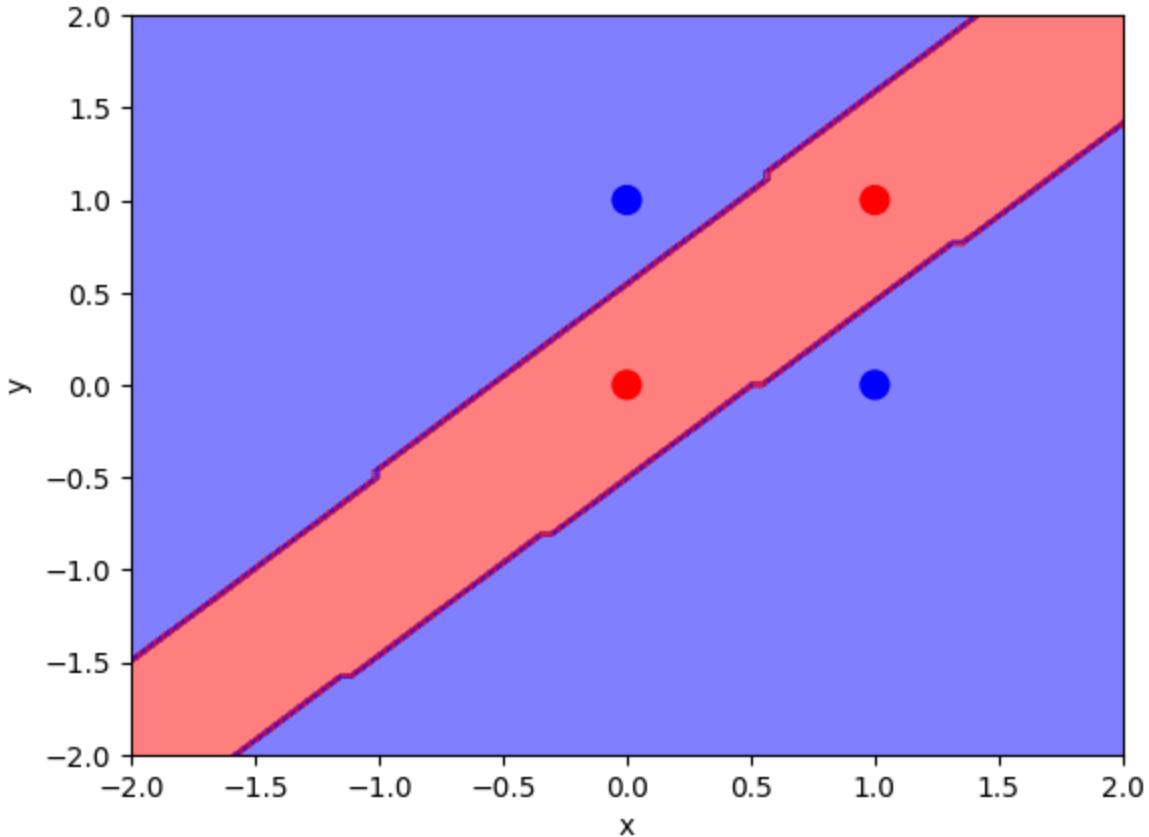
    # Plot the contour map
    plt.contourf(xx, yy, classes, alpha=0.5, colors=('blue', 'red'))
```

```

plt.scatter([0, 0, 1, 1], [1, 0, 1, 0], c=['blue', 'red', 'red', 'blue'])
plt.xlabel('x')
plt.ylabel('y')
plt.show()

plot_boundaries(params[:4])

```



## Observations

The model, trained on the 4 central points,  $(0,0)$ ,  $(1,0)$ ,  $(0,1)$ ,  $(1,1)$ , was able to classify the points perfectly when we plotted the decision boundary. As shown above, our loss was able to decrease to a value of 0.0009, meaning that when ran on our 4 points, the model performed nearly perfectly.

Moreover, we can visualize such decision boundaries using a mesh grid, where we set a region that we want our grid to cover. Then we run each point in our grid through our model and compute our predictions, using a color to denote each specific predicted class. The point where the colors interchange is our 'boundary'.

## Introduce Noise

```
In [17]: def generate_noise(points, size, noise_std, labels):
    points = points.copy()
    labels = labels.copy()
```

```
labels = np.array(labels * size)

for point in points:
    new_points = np.array(list(point) * size)
    points_noise = np.random.normal(loc=0.0, scale=noise_std, size=new_p
    noise_final = points_noise + new_points

pairs = list(zip(noise_final[::2], noise_final[1::2]))
pairs = np.array([(x, y) for x,y in pairs])

return pairs, labels
```

```
In [18]: num_inputs = 2
num_hidden_units = 2
num_outputs = 1

labels = [1, 1, 0, 0]

noise, final_labels = generate_noise(points, 100, 0.5, labels)

w1, w2, b1, b2 = initialize_parameters(num_inputs, num_hidden_units, num_out
```

## Standard Deviation of 0.5

```
In [19]: params_noise = train(noise, final_labels, epochs = 5000, learning_rate = 1.5
```

-----EPOCH: 0-----  
Training Loss: 0.1510187319067718  
Percent Correct: 51.00%

-----EPOCH: 20-----  
Training Loss: 0.13627670196277358  
Percent Correct: 53.00%

-----EPOCH: 40-----  
Training Loss: 0.13504366530517165  
Percent Correct: 54.00%

-----EPOCH: 60-----  
Training Loss: 0.13452843966712125  
Percent Correct: 55.00%

-----EPOCH: 80-----  
Training Loss: 0.1342497931198047  
Percent Correct: 55.00%

-----EPOCH: 100-----  
Training Loss: 0.13406626554363943  
Percent Correct: 55.00%

-----EPOCH: 120-----  
Training Loss: 0.1339289661363952  
Percent Correct: 55.00%

-----EPOCH: 140-----  
Training Loss: 0.13381815108138967  
Percent Correct: 55.00%

-----EPOCH: 160-----  
Training Loss: 0.1337245809891388  
Percent Correct: 54.00%

-----EPOCH: 180-----  
Training Loss: 0.13364382524078997  
Percent Correct: 53.00%

-----EPOCH: 200-----  
Training Loss: 0.13357422340701905  
Percent Correct: 52.00%

-----EPOCH: 220-----  
Training Loss: 0.13351294060161567  
Percent Correct: 52.00%

-----EPOCH: 240-----  
Training Loss: 0.13345520330099112  
Percent Correct: 52.00%

-----EPOCH: 260-----  
Training Loss: 0.13339983835766783  
Percent Correct: 52.00%

-----EPOCH: 280-----  
Training Loss: 0.13334795126443455  
Percent Correct: 52.00%

-----EPOCH: 300-----  
Training Loss: 0.13330011149510143  
Percent Correct: 52.00%

-----EPOCH: 320-----  
Training Loss: 0.133256230420441  
Percent Correct: 51.00%

-----EPOCH: 340-----  
Training Loss: 0.1332159725175757  
Percent Correct: 51.00%

-----EPOCH: 360-----  
Training Loss: 0.13317896184817524  
Percent Correct: 51.00%

-----EPOCH: 380-----  
Training Loss: 0.13314484847519467  
Percent Correct: 52.00%

-----EPOCH: 400-----  
Training Loss: 0.13311332294734773  
Percent Correct: 52.00%

-----EPOCH: 420-----  
Training Loss: 0.13308411517578225  
Percent Correct: 52.00%

-----EPOCH: 440-----  
Training Loss: 0.13305698958473586  
Percent Correct: 52.00%

-----EPOCH: 460-----  
Training Loss: 0.133031740015922  
Percent Correct: 52.00%

-----EPOCH: 480-----  
Training Loss: 0.1330081852603174  
Percent Correct: 52.00%

-----EPOCH: 500-----  
Training Loss: 0.1329861653312329  
Percent Correct: 52.00%

-----EPOCH: 520-----  
Training Loss: 0.13296553839424546  
Percent Correct: 52.00%

-----EPOCH: 540-----  
Training Loss: 0.1329461782361948  
Percent Correct: 52.00%

-----EPOCH: 560-----  
Training Loss: 0.13292797216672989  
Percent Correct: 52.00%

-----EPOCH: 580-----  
Training Loss: 0.132910819265922  
Percent Correct: 52.00%

-----EPOCH: 600-----  
Training Loss: 0.13289462891018428  
Percent Correct: 52.00%

-----EPOCH: 620-----  
Training Loss: 0.13287931952393697  
Percent Correct: 52.00%

-----EPOCH: 640-----  
Training Loss: 0.13286481751620152  
Percent Correct: 53.00%

-----EPOCH: 660-----  
Training Loss: 0.13285105637023062  
Percent Correct: 53.00%

-----EPOCH: 680-----  
Training Loss: 0.13283797586102297  
Percent Correct: 53.00%

-----EPOCH: 700-----  
Training Loss: 0.13282552138067977  
Percent Correct: 53.00%

-----EPOCH: 720-----  
Training Loss: 0.13281364335543644  
Percent Correct: 53.00%

-----EPOCH: 740-----  
Training Loss: 0.13280229674115376  
Percent Correct: 53.00%

-----EPOCH: 760-----  
Training Loss: 0.13279144058629277  
Percent Correct: 53.00%

-----EPOCH: 780-----  
Training Loss: 0.13278103765308227  
Percent Correct: 53.00%

-----EPOCH: 800-----  
Training Loss: 0.13277105408883075  
Percent Correct: 53.00%

-----EPOCH: 820-----  
Training Loss: 0.13276145914022083  
Percent Correct: 53.00%

-----EPOCH: 840-----  
Training Loss: 0.13275222490401103  
Percent Correct: 53.00%

-----EPOCH: 860-----  
Training Loss: 0.1327433261079349  
Percent Correct: 53.00%

-----EPOCH: 880-----  
Training Loss: 0.13273473991578527  
Percent Correct: 53.00%

-----EPOCH: 900-----  
Training Loss: 0.13272644575078696  
Percent Correct: 53.00%

-----EPOCH: 920-----  
Training Loss: 0.13271842513149087  
Percent Correct: 53.00%

-----EPOCH: 940-----  
Training Loss: 0.13271066151468447  
Percent Correct: 53.00%

-----EPOCH: 960-----  
Training Loss: 0.13270314014033394  
Percent Correct: 53.00%

-----EPOCH: 980-----  
Training Loss: 0.13269584787447358  
Percent Correct: 53.00%

-----EPOCH: 1000-----  
Training Loss: 0.13268877304732069  
Percent Correct: 53.00%

-----EPOCH: 1020-----  
Training Loss: 0.1326819052857223  
Percent Correct: 53.00%

-----EPOCH: 1040-----  
Training Loss: 0.13267523534123402  
Percent Correct: 53.00%

-----EPOCH: 1060-----  
Training Loss: 0.1326687549174297  
Percent Correct: 53.00%

-----EPOCH: 1080-----  
Training Loss: 0.1326624565020811  
Percent Correct: 53.00%

-----EPOCH: 1100-----  
Training Loss: 0.13265633321118148  
Percent Correct: 53.00%

-----EPOCH: 1120-----  
Training Loss: 0.13265037865201032  
Percent Correct: 53.00%

-----EPOCH: 1140-----  
Training Loss: 0.13264458681132982  
Percent Correct: 53.00%

-----EPOCH: 1160-----  
Training Loss: 0.1326389519724223  
Percent Correct: 53.00%

-----EPOCH: 1180-----  
Training Loss: 0.13263346866142556  
Percent Correct: 53.00%

-----EPOCH: 1200-----  
Training Loss: 0.13262813161995918  
Percent Correct: 53.00%

-----EPOCH: 1220-----  
Training Loss: 0.1326229357981148  
Percent Correct: 53.00%

-----EPOCH: 1240-----  
Training Loss: 0.13261787636013633  
Percent Correct: 53.00%

-----EPOCH: 1260-----  
Training Loss: 0.1326129486948506  
Percent Correct: 53.00%

-----EPOCH: 1280-----  
Training Loss: 0.13260814842404775  
Percent Correct: 53.00%

-----EPOCH: 1300-----  
Training Loss: 0.1326034714041295  
Percent Correct: 53.00%

-----EPOCH: 1320-----  
Training Loss: 0.13259891371885896  
Percent Correct: 53.00%

-----EPOCH: 1340-----  
Training Loss: 0.13259447166336089  
Percent Correct: 53.00%

-----EPOCH: 1360-----  
Training Loss: 0.13259014172124742  
Percent Correct: 53.00%

-----EPOCH: 1380-----  
Training Loss: 0.13258592053767615  
Percent Correct: 53.00%

-----EPOCH: 1400-----  
Training Loss: 0.13258180489134117  
Percent Correct: 53.00%

-----EPOCH: 1420-----  
Training Loss: 0.13257779166802192  
Percent Correct: 53.00%

-----EPOCH: 1440-----  
Training Loss: 0.13257387783761362  
Percent Correct: 53.00%

-----EPOCH: 1460-----  
Training Loss: 0.1325700604357571  
Percent Correct: 53.00%

-----EPOCH: 1480-----  
Training Loss: 0.13256633655044275  
Percent Correct: 53.00%

-----EPOCH: 1500-----  
Training Loss: 0.1325627033133819  
Percent Correct: 53.00%

-----EPOCH: 1520-----  
Training Loss: 0.13255915789554457  
Percent Correct: 53.00%

-----EPOCH: 1540-----  
Training Loss: 0.1325556975060578  
Percent Correct: 53.00%

-----EPOCH: 1560-----  
Training Loss: 0.13255231939359788  
Percent Correct: 53.00%

-----EPOCH: 1580-----  
Training Loss: 0.1325490208494549  
Percent Correct: 53.00%

-----EPOCH: 1600-----  
Training Loss: 0.13254579921155585  
Percent Correct: 53.00%

-----EPOCH: 1620-----  
Training Loss: 0.1325426518688686  
Percent Correct: 53.00%

-----EPOCH: 1640-----  
Training Loss: 0.13253957626575297  
Percent Correct: 53.00%

-----EPOCH: 1660-----  
Training Loss: 0.13253656990595156  
Percent Correct: 53.00%

-----EPOCH: 1680-----  
Training Loss: 0.13253363035602952  
Percent Correct: 53.00%

-----EPOCH: 1700-----  
Training Loss: 0.13253075524815622  
Percent Correct: 53.00%

-----EPOCH: 1720-----  
Training Loss: 0.13252794228219378  
Percent Correct: 53.00%

-----EPOCH: 1740-----  
Training Loss: 0.13252518922710269  
Percent Correct: 53.00%

-----EPOCH: 1760-----  
Training Loss: 0.13252249392170706  
Percent Correct: 53.00%

-----EPOCH: 1780-----  
Training Loss: 0.1325198542748819  
Percent Correct: 54.00%

-----EPOCH: 1800-----  
Training Loss: 0.13251726826523402  
Percent Correct: 54.00%

-----EPOCH: 1820-----  
Training Loss: 0.1325147339403504  
Percent Correct: 54.00%

-----EPOCH: 1840-----  
Training Loss: 0.13251224941568635  
Percent Correct: 54.00%

-----EPOCH: 1860-----  
Training Loss: 0.13250981287316146  
Percent Correct: 54.00%

-----EPOCH: 1880-----  
Training Loss: 0.13250742255952347  
Percent Correct: 54.00%

-----EPOCH: 1900-----  
Training Loss: 0.13250507678453588  
Percent Correct: 54.00%

-----EPOCH: 1920-----  
Training Loss: 0.13250277391903342  
Percent Correct: 54.00%

-----EPOCH: 1940-----  
Training Loss: 0.132500512392888  
Percent Correct: 54.00%

-----EPOCH: 1960-----  
Training Loss: 0.1324982906929159  
Percent Correct: 54.00%

-----EPOCH: 1980-----  
Training Loss: 0.13249610736075693  
Percent Correct: 54.00%

-----EPOCH: 2000-----  
Training Loss: 0.13249396099074492  
Percent Correct: 54.00%

-----EPOCH: 2020-----  
Training Loss: 0.1324918502277907  
Percent Correct: 54.00%

-----EPOCH: 2040-----  
Training Loss: 0.1324897737652909  
Percent Correct: 54.00%

-----EPOCH: 2060-----  
Training Loss: 0.13248773034307343  
Percent Correct: 54.00%

-----EPOCH: 2080-----  
Training Loss: 0.13248571874539025  
Percent Correct: 54.00%

-----EPOCH: 2100-----  
Training Loss: 0.13248373779896253  
Percent Correct: 54.00%

-----EPOCH: 2120-----  
Training Loss: 0.13248178637108357  
Percent Correct: 54.00%

-----EPOCH: 2140-----  
Training Loss: 0.1324798633677834  
Percent Correct: 54.00%

-----EPOCH: 2160-----  
Training Loss: 0.13247796773205625  
Percent Correct: 54.00%

-----EPOCH: 2180-----  
Training Loss: 0.13247609844215363  
Percent Correct: 54.00%

-----EPOCH: 2200-----  
Training Loss: 0.13247425450994207  
Percent Correct: 54.00%

-----EPOCH: 2220-----  
Training Loss: 0.13247243497932612  
Percent Correct: 54.00%

-----EPOCH: 2240-----  
Training Loss: 0.13247063892473673  
Percent Correct: 54.00%

-----EPOCH: 2260-----  
Training Loss: 0.13246886544968278  
Percent Correct: 54.00%

-----EPOCH: 2280-----  
Training Loss: 0.13246711368536554  
Percent Correct: 54.00%

-----EPOCH: 2300-----  
Training Loss: 0.13246538278935477  
Percent Correct: 54.00%

-----EPOCH: 2320-----  
Training Loss: 0.1324636719443243  
Percent Correct: 54.00%

-----EPOCH: 2340-----  
Training Loss: 0.1324619803568459  
Percent Correct: 54.00%

-----EPOCH: 2360-----  
Training Loss: 0.1324603072562401  
Percent Correct: 54.00%

-----EPOCH: 2380-----  
Training Loss: 0.13245865189348177  
Percent Correct: 54.00%

-----EPOCH: 2400-----  
Training Loss: 0.13245701354015924  
Percent Correct: 54.00%

-----EPOCH: 2420-----  
Training Loss: 0.13245539148748464  
Percent Correct: 54.00%

-----EPOCH: 2440-----  
Training Loss: 0.1324537850453551  
Percent Correct: 54.00%

-----EPOCH: 2460-----  
Training Loss: 0.13245219354146132  
Percent Correct: 54.00%

-----EPOCH: 2480-----  
Training Loss: 0.13245061632044433  
Percent Correct: 54.00%

-----EPOCH: 2500-----  
Training Loss: 0.13244905274309654  
Percent Correct: 54.00%

-----EPOCH: 2520-----  
Training Loss: 0.13244750218560777  
Percent Correct: 54.00%

-----EPOCH: 2540-----  
Training Loss: 0.13244596403885314  
Percent Correct: 54.00%

-----EPOCH: 2560-----  
Training Loss: 0.1324444377077224  
Percent Correct: 54.00%

-----EPOCH: 2580-----  
Training Loss: 0.13244292261048965  
Percent Correct: 54.00%

-----EPOCH: 2600-----  
Training Loss: 0.1324414181782207  
Percent Correct: 54.00%

-----EPOCH: 2620-----  
Training Loss: 0.13243992385421918  
Percent Correct: 54.00%

-----EPOCH: 2640-----  
Training Loss: 0.13243843909350736  
Percent Correct: 54.00%

-----EPOCH: 2660-----  
Training Loss: 0.13243696336234326  
Percent Correct: 54.00%

-----EPOCH: 2680-----  
Training Loss: 0.13243549613777078  
Percent Correct: 54.00%

-----EPOCH: 2700-----  
Training Loss: 0.13243403690720318  
Percent Correct: 54.00%

-----EPOCH: 2720-----  
Training Loss: 0.13243258516803716  
Percent Correct: 54.00%

-----EPOCH: 2740-----  
Training Loss: 0.13243114042729823  
Percent Correct: 54.00%

-----EPOCH: 2760-----  
Training Loss: 0.1324297022013149  
Percent Correct: 54.00%

-----EPOCH: 2780-----  
Training Loss: 0.13242827001542096  
Percent Correct: 54.00%

-----EPOCH: 2800-----  
Training Loss: 0.13242684340368488  
Percent Correct: 54.00%

-----EPOCH: 2820-----  
Training Loss: 0.13242542190866474  
Percent Correct: 54.00%

-----EPOCH: 2840-----  
Training Loss: 0.1324240050811877  
Percent Correct: 54.00%

-----EPOCH: 2860-----  
Training Loss: 0.1324225924801533  
Percent Correct: 54.00%

-----EPOCH: 2880-----  
Training Loss: 0.1324211836723583  
Percent Correct: 54.00%

-----EPOCH: 2900-----  
Training Loss: 0.13241977823234255  
Percent Correct: 54.00%

-----EPOCH: 2920-----  
Training Loss: 0.13241837574225523  
Percent Correct: 54.00%

-----EPOCH: 2940-----  
Training Loss: 0.13241697579173828  
Percent Correct: 54.00%

-----EPOCH: 2960-----  
Training Loss: 0.1324155779778279  
Percent Correct: 54.00%

-----EPOCH: 2980-----  
Training Loss: 0.13241418190487209  
Percent Correct: 54.00%

-----EPOCH: 3000-----  
Training Loss: 0.13241278718446106  
Percent Correct: 54.00%

-----EPOCH: 3020-----  
Training Loss: 0.13241139343537353  
Percent Correct: 54.00%

-----EPOCH: 3040-----  
Training Loss: 0.13241000028353278  
Percent Correct: 54.00%

-----EPOCH: 3060-----  
Training Loss: 0.13240860736197432  
Percent Correct: 54.00%

-----EPOCH: 3080-----  
Training Loss: 0.13240721431082395  
Percent Correct: 54.00%

-----EPOCH: 3100-----  
Training Loss: 0.13240582077728194  
Percent Correct: 54.00%

-----EPOCH: 3120-----  
Training Loss: 0.13240442641561637  
Percent Correct: 54.00%

-----EPOCH: 3140-----  
Training Loss: 0.13240303088716152  
Percent Correct: 54.00%

-----EPOCH: 3160-----  
Training Loss: 0.1324016338603208  
Percent Correct: 54.00%

-----EPOCH: 3180-----  
Training Loss: 0.13240023501057402  
Percent Correct: 54.00%

-----EPOCH: 3200-----  
Training Loss: 0.13239883402048677  
Percent Correct: 54.00%

-----EPOCH: 3220-----  
Training Loss: 0.13239743057972217  
Percent Correct: 54.00%

-----EPOCH: 3240-----  
Training Loss: 0.13239602438505252  
Percent Correct: 54.00%

-----EPOCH: 3260-----  
Training Loss: 0.13239461514037187  
Percent Correct: 54.00%

-----EPOCH: 3280-----  
Training Loss: 0.13239320255670756  
Percent Correct: 54.00%

-----EPOCH: 3300-----  
Training Loss: 0.1323917863522292  
Percent Correct: 54.00%

-----EPOCH: 3320-----  
Training Loss: 0.13239036625225697  
Percent Correct: 54.00%

-----EPOCH: 3340-----  
Training Loss: 0.13238894198926623  
Percent Correct: 54.00%

-----EPOCH: 3360-----  
Training Loss: 0.13238751330288903  
Percent Correct: 54.00%

-----EPOCH: 3380-----  
Training Loss: 0.13238607993991192  
Percent Correct: 54.00%

-----EPOCH: 3400-----  
Training Loss: 0.1323846416542696  
Percent Correct: 54.00%

-----EPOCH: 3420-----  
Training Loss: 0.13238319820703454  
Percent Correct: 54.00%

-----EPOCH: 3440-----  
Training Loss: 0.132381749366401  
Percent Correct: 54.00%

-----EPOCH: 3460-----  
Training Loss: 0.1323802949076658  
Percent Correct: 54.00%

-----EPOCH: 3480-----  
Training Loss: 0.13237883461320255  
Percent Correct: 54.00%

-----EPOCH: 3500-----  
Training Loss: 0.1323773682724312  
Percent Correct: 54.00%

-----EPOCH: 3520-----  
Training Loss: 0.1323758956817841  
Percent Correct: 54.00%

-----EPOCH: 3540-----  
Training Loss: 0.13237441664466462  
Percent Correct: 54.00%

-----EPOCH: 3560-----  
Training Loss: 0.13237293097140274  
Percent Correct: 54.00%

-----EPOCH: 3580-----  
Training Loss: 0.13237143847920493  
Percent Correct: 54.00%

-----EPOCH: 3600-----  
Training Loss: 0.1323699389920994  
Percent Correct: 54.00%

-----EPOCH: 3620-----  
Training Loss: 0.13236843234087747  
Percent Correct: 54.00%

-----EPOCH: 3640-----  
Training Loss: 0.13236691836302963  
Percent Correct: 54.00%

-----EPOCH: 3660-----  
Training Loss: 0.13236539690267882  
Percent Correct: 54.00%

-----EPOCH: 3680-----  
Training Loss: 0.13236386781050835  
Percent Correct: 54.00%

-----EPOCH: 3700-----  
Training Loss: 0.1323623309436878  
Percent Correct: 54.00%

-----EPOCH: 3720-----  
Training Loss: 0.13236078616579458  
Percent Correct: 54.00%

-----EPOCH: 3740-----  
Training Loss: 0.13235923334673283  
Percent Correct: 54.00%

-----EPOCH: 3760-----  
Training Loss: 0.1323576723626494  
Percent Correct: 54.00%

-----EPOCH: 3780-----  
Training Loss: 0.1323561030958482  
Percent Correct: 54.00%

-----EPOCH: 3800-----  
Training Loss: 0.1323545254347008  
Percent Correct: 54.00%

-----EPOCH: 3820-----  
Training Loss: 0.13235293927355668  
Percent Correct: 54.00%

-----EPOCH: 3840-----  
Training Loss: 0.13235134451265082  
Percent Correct: 54.00%

-----EPOCH: 3860-----  
Training Loss: 0.13234974105801092  
Percent Correct: 54.00%

-----EPOCH: 3880-----  
Training Loss: 0.13234812882136232  
Percent Correct: 54.00%

-----EPOCH: 3900-----  
Training Loss: 0.1323465077200331  
Percent Correct: 54.00%

-----EPOCH: 3920-----  
Training Loss: 0.13234487767685774  
Percent Correct: 54.00%

-----EPOCH: 3940-----  
Training Loss: 0.13234323862008124  
Percent Correct: 54.00%

-----EPOCH: 3960-----  
Training Loss: 0.13234159048326252  
Percent Correct: 54.00%

-----EPOCH: 3980-----  
Training Loss: 0.13233993320517767  
Percent Correct: 54.00%

-----EPOCH: 4000-----  
Training Loss: 0.13233826672972399  
Percent Correct: 54.00%

-----EPOCH: 4020-----  
Training Loss: 0.1323365910058239  
Percent Correct: 54.00%

-----EPOCH: 4040-----  
Training Loss: 0.13233490598732958  
Percent Correct: 54.00%

-----EPOCH: 4060-----  
Training Loss: 0.13233321163292827  
Percent Correct: 54.00%

-----EPOCH: 4080-----  
Training Loss: 0.13233150790604833  
Percent Correct: 54.00%

-----EPOCH: 4100-----  
Training Loss: 0.1323297947747664  
Percent Correct: 54.00%

-----EPOCH: 4120-----  
Training Loss: 0.13232807221171494  
Percent Correct: 54.00%

-----EPOCH: 4140-----  
Training Loss: 0.13232634019399225  
Percent Correct: 54.00%

-----EPOCH: 4160-----  
Training Loss: 0.1323245987030717  
Percent Correct: 54.00%

-----EPOCH: 4180-----  
Training Loss: 0.13232284772471417  
Percent Correct: 54.00%

-----EPOCH: 4200-----  
Training Loss: 0.13232108724888048  
Percent Correct: 54.00%

-----EPOCH: 4220-----  
Training Loss: 0.13231931726964563  
Percent Correct: 54.00%

-----EPOCH: 4240-----  
Training Loss: 0.13231753778511515  
Percent Correct: 54.00%

-----EPOCH: 4260-----  
Training Loss: 0.13231574879734073  
Percent Correct: 54.00%

-----EPOCH: 4280-----  
Training Loss: 0.13231395031224003  
Percent Correct: 54.00%

-----EPOCH: 4300-----  
Training Loss: 0.13231214233951624  
Percent Correct: 54.00%

-----EPOCH: 4320-----  
Training Loss: 0.13231032489257907  
Percent Correct: 54.00%

-----EPOCH: 4340-----  
Training Loss: 0.13230849798846814  
Percent Correct: 54.00%

-----EPOCH: 4360-----  
Training Loss: 0.13230666164777685  
Percent Correct: 54.00%

-----EPOCH: 4380-----  
Training Loss: 0.13230481589457832  
Percent Correct: 54.00%

-----EPOCH: 4400-----  
Training Loss: 0.13230296075635245  
Percent Correct: 54.00%

-----EPOCH: 4420-----  
Training Loss: 0.13230109626391426  
Percent Correct: 54.00%

-----EPOCH: 4440-----  
Training Loss: 0.1322992224513438  
Percent Correct: 54.00%

-----EPOCH: 4460-----  
Training Loss: 0.13229733935591778  
Percent Correct: 54.00%

-----EPOCH: 4480-----  
Training Loss: 0.13229544701804083  
Percent Correct: 54.00%

-----EPOCH: 4500-----  
Training Loss: 0.13229354548118039  
Percent Correct: 54.00%

-----EPOCH: 4520-----  
Training Loss: 0.1322916347918008  
Percent Correct: 54.00%

-----EPOCH: 4540-----  
Training Loss: 0.13228971499929962  
Percent Correct: 54.00%

-----EPOCH: 4560-----  
Training Loss: 0.13228778615594497  
Percent Correct: 54.00%

-----EPOCH: 4580-----  
Training Loss: 0.13228584831681314  
Percent Correct: 54.00%

-----EPOCH: 4600-----  
Training Loss: 0.13228390153972858  
Percent Correct: 54.00%

-----EPOCH: 4620-----  
Training Loss: 0.1322819458852034  
Percent Correct: 54.00%

-----EPOCH: 4640-----  
Training Loss: 0.1322799814163791  
Percent Correct: 54.00%

-----EPOCH: 4660-----  
Training Loss: 0.1322780081989683  
Percent Correct: 54.00%

-----EPOCH: 4680-----  
Training Loss: 0.13227602630119772  
Percent Correct: 54.00%

-----EPOCH: 4700-----  
Training Loss: 0.13227403579375194  
Percent Correct: 54.00%

-----EPOCH: 4720-----  
Training Loss: 0.13227203674971766  
Percent Correct: 54.00%

-----EPOCH: 4740-----  
Training Loss: 0.13227002924452896  
Percent Correct: 54.00%

-----EPOCH: 4760-----  
Training Loss: 0.13226801335591318  
Percent Correct: 54.00%

-----EPOCH: 4780-----  
Training Loss: 0.13226598916383722  
Percent Correct: 54.00%

-----EPOCH: 4800-----  
Training Loss: 0.13226395675045455  
Percent Correct: 54.00%

-----EPOCH: 4820-----  
Training Loss: 0.13226191620005304  
Percent Correct: 54.00%

-----EPOCH: 4840-----  
Training Loss: 0.13225986759900255  
Percent Correct: 54.00%

-----EPOCH: 4860-----  
Training Loss: 0.13225781103570405  
Percent Correct: 54.00%

-----EPOCH: 4880-----  
Training Loss: 0.13225574660053804  
Percent Correct: 54.00%

-----EPOCH: 4900-----  
Training Loss: 0.13225367438581456  
Percent Correct: 54.00%

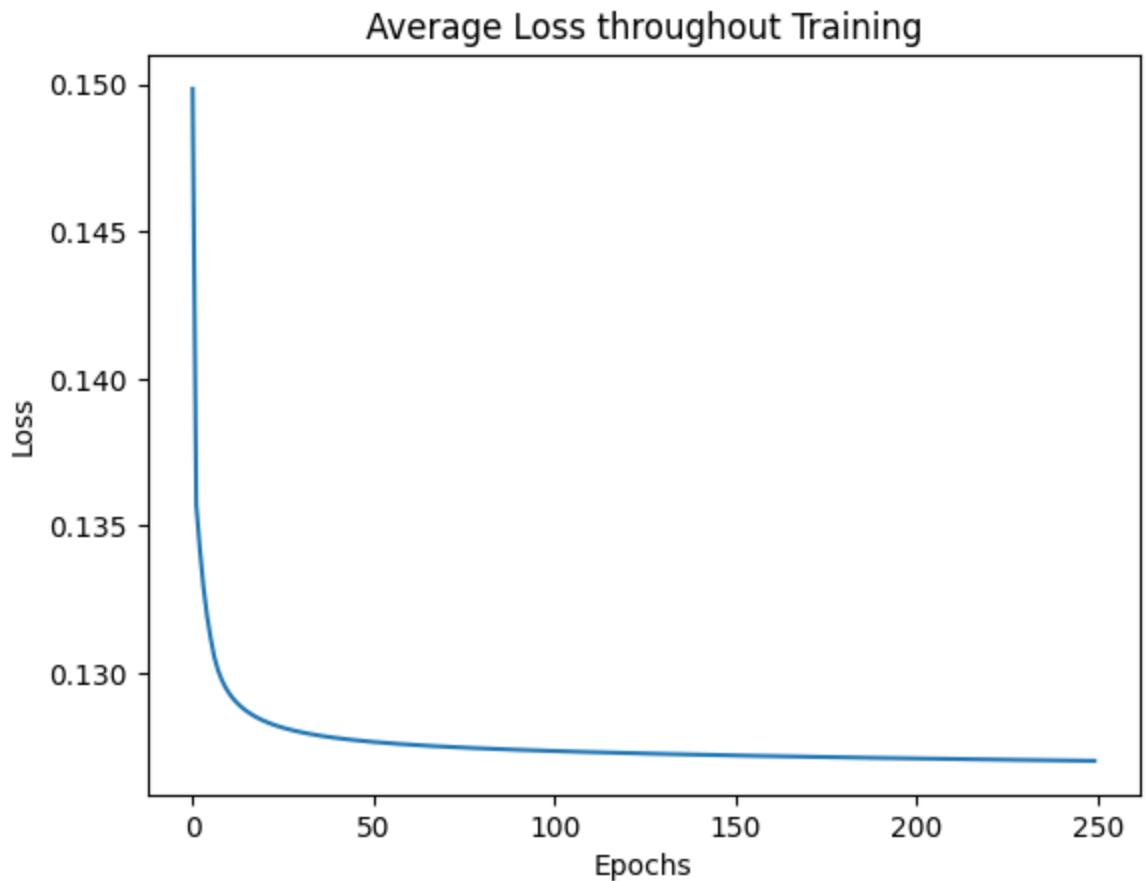
-----EPOCH: 4920-----  
Training Loss: 0.1322515944857224  
Percent Correct: 54.00%

-----EPOCH: 4940-----  
Training Loss: 0.13224950699627933  
Percent Correct: 54.00%

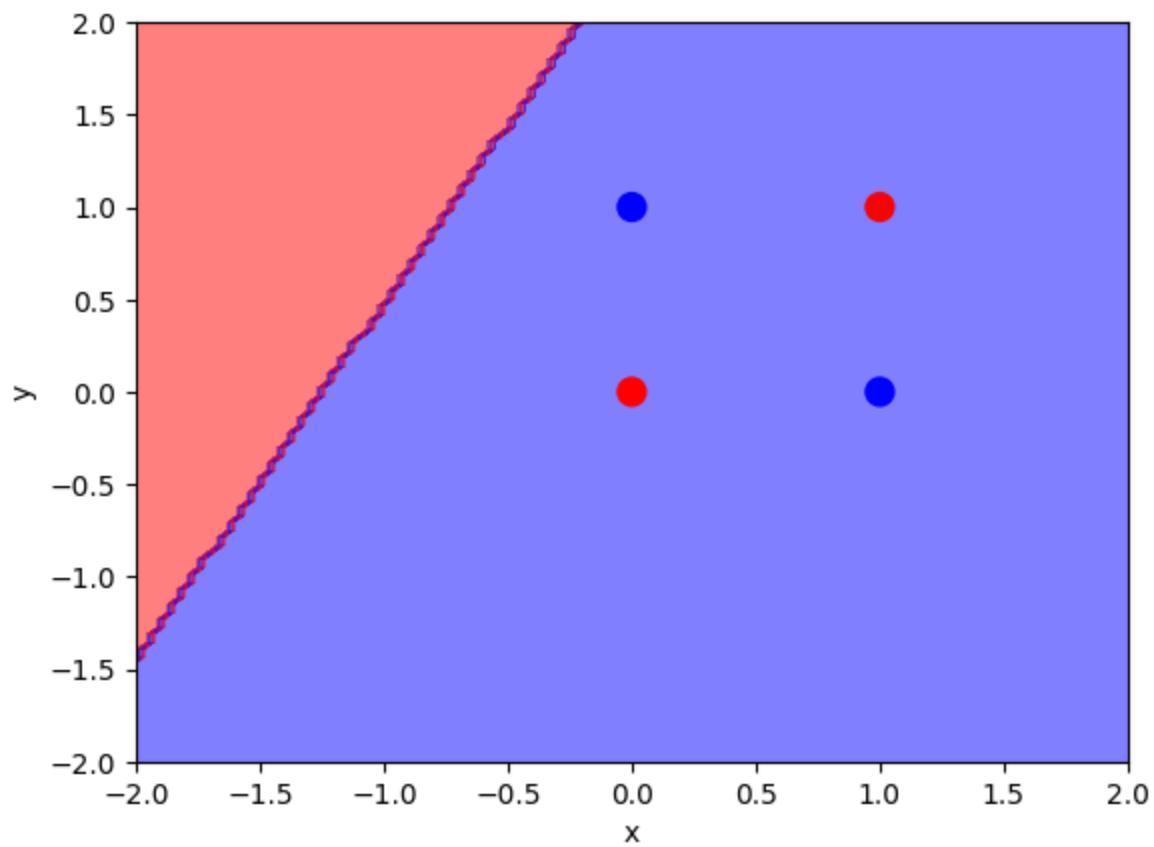
-----EPOCH: 4960-----  
Training Loss: 0.13224741201528267  
Percent Correct: 54.00%

-----EPOCH: 4980-----  
Training Loss: 0.13224530964226003  
Percent Correct: 54.00%

```
In [30]: avg_loss = params_noise[4]
plt.figure(1)
plt.plot(avg_loss)
plt.title('Average Loss throughout Training')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.show()
```



```
In [21]: plot_boundaries(params_noise[:4])
```



## Standard Deviation of 1

```
In [22]: num_inputs = 2
num_hidden_units = 2
num_outputs = 1

labels = [1, 1, 0, 0]

noise, final_labels = generate_noise(points, 100, 1, labels)

w1, w2, b1, b2 = initialize_parameters(num_inputs, num_hidden_units, num_out
```

```
In [23]: params_noise = train(noise, final_labels, epochs = 5000, learning_rate = 1.5
```

-----EPOCH: 0-----  
Training Loss: 0.14871360077570345  
Percent Correct: 67.00%

-----EPOCH: 20-----  
Training Loss: 0.12744147294173488  
Percent Correct: 64.00%

-----EPOCH: 40-----  
Training Loss: 0.12554529385289878  
Percent Correct: 65.00%

-----EPOCH: 60-----  
Training Loss: 0.12457505000590642  
Percent Correct: 67.00%

-----EPOCH: 80-----  
Training Loss: 0.1239497564439289  
Percent Correct: 67.00%

-----EPOCH: 100-----  
Training Loss: 0.12349252228564976  
Percent Correct: 67.00%

-----EPOCH: 120-----  
Training Loss: 0.12313115864422564  
Percent Correct: 67.00%

-----EPOCH: 140-----  
Training Loss: 0.1228300599431821  
Percent Correct: 67.00%

-----EPOCH: 160-----  
Training Loss: 0.12256958083431783  
Percent Correct: 67.00%

-----EPOCH: 180-----  
Training Loss: 0.12233800238873459  
Percent Correct: 67.00%

-----EPOCH: 200-----  
Training Loss: 0.12212792221487272  
Percent Correct: 66.00%

-----EPOCH: 220-----  
Training Loss: 0.12193445949569501  
Percent Correct: 67.00%

-----EPOCH: 240-----  
Training Loss: 0.12175428731414159  
Percent Correct: 67.00%

-----EPOCH: 260-----  
Training Loss: 0.1215850750490219  
Percent Correct: 67.00%

-----EPOCH: 280-----  
Training Loss: 0.12142514956278559  
Percent Correct: 68.00%

-----EPOCH: 300-----  
Training Loss: 0.1212732809907099  
Percent Correct: 68.00%

-----EPOCH: 320-----  
Training Loss: 0.12112854340703211  
Percent Correct: 68.00%

-----EPOCH: 340-----  
Training Loss: 0.1209902223295059  
Percent Correct: 68.00%

-----EPOCH: 360-----  
Training Loss: 0.12085775236410731  
Percent Correct: 68.00%

-----EPOCH: 380-----  
Training Loss: 0.12073067464652798  
Percent Correct: 69.00%

-----EPOCH: 400-----  
Training Loss: 0.1206086074986989  
Percent Correct: 69.00%

-----EPOCH: 420-----  
Training Loss: 0.12049122602614078  
Percent Correct: 69.00%

-----EPOCH: 440-----  
Training Loss: 0.12037824783083924  
Percent Correct: 69.00%

-----EPOCH: 460-----  
Training Loss: 0.12026942294198255  
Percent Correct: 69.00%

-----EPOCH: 480-----  
Training Loss: 0.12016452667274159  
Percent Correct: 69.00%

-----EPOCH: 500-----  
Training Loss: 0.12006335451482712  
Percent Correct: 69.00%

-----EPOCH: 520-----  
Training Loss: 0.11996571845602878  
Percent Correct: 69.00%

-----EPOCH: 540-----  
Training Loss: 0.11987144429361875  
Percent Correct: 69.00%

-----EPOCH: 560-----  
Training Loss: 0.11978036964635777  
Percent Correct: 69.00%

-----EPOCH: 580-----  
Training Loss: 0.11969234245805443  
Percent Correct: 70.00%

-----EPOCH: 600-----  
Training Loss: 0.11960721984842829  
Percent Correct: 70.00%

-----EPOCH: 620-----  
Training Loss: 0.1195248672107367  
Percent Correct: 70.00%

-----EPOCH: 640-----  
Training Loss: 0.11944515748604553  
Percent Correct: 70.00%

-----EPOCH: 660-----  
Training Loss: 0.11936797056518504  
Percent Correct: 70.00%

-----EPOCH: 680-----  
Training Loss: 0.11929319278414276  
Percent Correct: 70.00%

-----EPOCH: 700-----  
Training Loss: 0.11922071648887494  
Percent Correct: 70.00%

-----EPOCH: 720-----  
Training Loss: 0.1191504396526341  
Percent Correct: 70.00%

-----EPOCH: 740-----  
Training Loss: 0.11908226553386156  
Percent Correct: 70.00%

-----EPOCH: 760-----  
Training Loss: 0.11901610236614454  
Percent Correct: 70.00%

-----EPOCH: 780-----  
Training Loss: 0.11895186307414306  
Percent Correct: 70.00%

-----EPOCH: 800-----  
Training Loss: 0.1188894650110775  
Percent Correct: 69.00%

-----EPOCH: 820-----  
Training Loss: 0.11882882971454106  
Percent Correct: 69.00%

-----EPOCH: 840-----  
Training Loss: 0.1187698826782336  
Percent Correct: 69.00%

-----EPOCH: 860-----  
Training Loss: 0.11871255313779233  
Percent Correct: 69.00%

-----EPOCH: 880-----  
Training Loss: 0.11865677386930966  
Percent Correct: 69.00%

-----EPOCH: 900-----  
Training Loss: 0.1186024809994192  
Percent Correct: 69.00%

-----EPOCH: 920-----  
Training Loss: 0.11854961382604241  
Percent Correct: 69.00%

-----EPOCH: 940-----  
Training Loss: 0.11849811464903849  
Percent Correct: 69.00%

-----EPOCH: 960-----  
Training Loss: 0.11844792861011082  
Percent Correct: 69.00%

-----EPOCH: 980-----  
Training Loss: 0.11839900354140545  
Percent Correct: 69.00%

-----EPOCH: 1000-----  
Training Loss: 0.1183512898222961  
Percent Correct: 69.00%

-----EPOCH: 1020-----  
Training Loss: 0.11830474024390064  
Percent Correct: 69.00%

-----EPOCH: 1040-----  
Training Loss: 0.1182593098809088  
Percent Correct: 69.00%

-----EPOCH: 1060-----  
Training Loss: 0.1182149559703303  
Percent Correct: 69.00%

-----EPOCH: 1080-----  
Training Loss: 0.11817163779680047  
Percent Correct: 70.00%

-----EPOCH: 1100-----  
Training Loss: 0.11812931658409836  
Percent Correct: 69.00%

-----EPOCH: 1120-----  
Training Loss: 0.11808795539255261  
Percent Correct: 69.00%

-----EPOCH: 1140-----  
Training Loss: 0.1180475190220272  
Percent Correct: 69.00%

-----EPOCH: 1160-----  
Training Loss: 0.1180079739201947  
Percent Correct: 69.00%

-----EPOCH: 1180-----  
Training Loss: 0.1179692880958174  
Percent Correct: 69.00%

-----EPOCH: 1200-----  
Training Loss: 0.11793143103677142  
Percent Correct: 69.00%

-----EPOCH: 1220-----  
Training Loss: 0.11789437363256271  
Percent Correct: 69.00%

-----EPOCH: 1240-----  
Training Loss: 0.11785808810109233  
Percent Correct: 69.00%

-----EPOCH: 1260-----  
Training Loss: 0.11782254791944384  
Percent Correct: 69.00%

-----EPOCH: 1280-----  
Training Loss: 0.1177877277584748  
Percent Correct: 69.00%

-----EPOCH: 1300-----  
Training Loss: 0.11775360342100524  
Percent Correct: 69.00%

-----EPOCH: 1320-----  
Training Loss: 0.11772015178340636  
Percent Correct: 69.00%

-----EPOCH: 1340-----  
Training Loss: 0.11768735074040328  
Percent Correct: 69.00%

-----EPOCH: 1360-----  
Training Loss: 0.1176551791529134  
Percent Correct: 69.00%

-----EPOCH: 1380-----  
Training Loss: 0.11762361679875388  
Percent Correct: 69.00%

-----EPOCH: 1400-----  
Training Loss: 0.11759264432605723  
Percent Correct: 69.00%

-----EPOCH: 1420-----  
Training Loss: 0.11756224320924448  
Percent Correct: 69.00%

-----EPOCH: 1440-----  
Training Loss: 0.11753239570741339  
Percent Correct: 69.00%

-----EPOCH: 1460-----  
Training Loss: 0.11750308482500492  
Percent Correct: 69.00%

-----EPOCH: 1480-----  
Training Loss: 0.11747429427462197  
Percent Correct: 69.00%

-----EPOCH: 1500-----  
Training Loss: 0.11744600844187673  
Percent Correct: 69.00%

-----EPOCH: 1520-----  
Training Loss: 0.11741821235215433  
Percent Correct: 69.00%

-----EPOCH: 1540-----  
Training Loss: 0.11739089163918318  
Percent Correct: 69.00%

-----EPOCH: 1560-----  
Training Loss: 0.1173640325153102  
Percent Correct: 69.00%

-----EPOCH: 1580-----  
Training Loss: 0.11733762174338436  
Percent Correct: 69.00%

-----EPOCH: 1600-----  
Training Loss: 0.11731164661015893  
Percent Correct: 69.00%

-----EPOCH: 1620-----  
Training Loss: 0.11728609490112268  
Percent Correct: 69.00%

-----EPOCH: 1640-----  
Training Loss: 0.11726095487668417  
Percent Correct: 69.00%

-----EPOCH: 1660-----  
Training Loss: 0.11723621524962764  
Percent Correct: 69.00%

-----EPOCH: 1680-----  
Training Loss: 0.11721186516377217  
Percent Correct: 69.00%

-----EPOCH: 1700-----  
Training Loss: 0.1171878941737639  
Percent Correct: 69.00%

-----EPOCH: 1720-----  
Training Loss: 0.11716429222593842  
Percent Correct: 69.00%

-----EPOCH: 1740-----  
Training Loss: 0.11714104964019172  
Percent Correct: 69.00%

-----EPOCH: 1760-----  
Training Loss: 0.11711815709280449  
Percent Correct: 69.00%

-----EPOCH: 1780-----  
Training Loss: 0.11709560560016401  
Percent Correct: 69.00%

-----EPOCH: 1800-----  
Training Loss: 0.11707338650333611  
Percent Correct: 69.00%

-----EPOCH: 1820-----  
Training Loss: 0.11705149145343505  
Percent Correct: 69.00%

-----EPOCH: 1840-----  
Training Loss: 0.11702991239775176  
Percent Correct: 69.00%

-----EPOCH: 1860-----  
Training Loss: 0.11700864156659374  
Percent Correct: 69.00%

-----EPOCH: 1880-----  
Training Loss: 0.11698767146080012  
Percent Correct: 69.00%

-----EPOCH: 1900-----  
Training Loss: 0.11696699483989148  
Percent Correct: 69.00%

-----EPOCH: 1920-----  
Training Loss: 0.11694660471082122  
Percent Correct: 69.00%

-----EPOCH: 1940-----  
Training Loss: 0.11692649431729532  
Percent Correct: 69.00%

-----EPOCH: 1960-----  
Training Loss: 0.1169066571296267  
Percent Correct: 69.00%

-----EPOCH: 1980-----  
Training Loss: 0.11688708683509791  
Percent Correct: 69.00%

-----EPOCH: 2000-----  
Training Loss: 0.11686777732880164  
Percent Correct: 69.00%

-----EPOCH: 2020-----  
Training Loss: 0.11684872270493452  
Percent Correct: 69.00%

-----EPOCH: 2040-----  
Training Loss: 0.11682991724851881  
Percent Correct: 69.00%

-----EPOCH: 2060-----  
Training Loss: 0.11681135542752864  
Percent Correct: 69.00%

-----EPOCH: 2080-----  
Training Loss: 0.1167930318853994  
Percent Correct: 69.00%

-----EPOCH: 2100-----  
Training Loss: 0.11677494143389915  
Percent Correct: 69.00%

-----EPOCH: 2120-----  
Training Loss: 0.11675707904634239  
Percent Correct: 69.00%

-----EPOCH: 2140-----  
Training Loss: 0.11673943985112864  
Percent Correct: 69.00%

-----EPOCH: 2160-----  
Training Loss: 0.11672201912558787  
Percent Correct: 69.00%

-----EPOCH: 2180-----  
Training Loss: 0.11670481229011634  
Percent Correct: 69.00%

-----EPOCH: 2200-----  
Training Loss: 0.116687814902588  
Percent Correct: 69.00%

-----EPOCH: 2220-----  
Training Loss: 0.11667102265302642  
Percent Correct: 69.00%

-----EPOCH: 2240-----  
Training Loss: 0.11665443135852409  
Percent Correct: 69.00%

-----EPOCH: 2260-----  
Training Loss: 0.11663803695839575  
Percent Correct: 69.00%

-----EPOCH: 2280-----  
Training Loss: 0.11662183550955349  
Percent Correct: 69.00%

-----EPOCH: 2300-----  
Training Loss: 0.1166058231820923  
Percent Correct: 69.00%

-----EPOCH: 2320-----  
Training Loss: 0.11658999625507577  
Percent Correct: 69.00%

-----EPOCH: 2340-----  
Training Loss: 0.11657435111251031  
Percent Correct: 69.00%

-----EPOCH: 2360-----  
Training Loss: 0.1165588842394998  
Percent Correct: 69.00%

-----EPOCH: 2380-----  
Training Loss: 0.11654359221857033  
Percent Correct: 69.00%

-----EPOCH: 2400-----  
Training Loss: 0.11652847172615644  
Percent Correct: 69.00%

-----EPOCH: 2420-----  
Training Loss: 0.11651351952924237  
Percent Correct: 69.00%

-----EPOCH: 2440-----  
Training Loss: 0.11649873248214802  
Percent Correct: 69.00%

-----EPOCH: 2460-----  
Training Loss: 0.11648410752345445  
Percent Correct: 69.00%

-----EPOCH: 2480-----  
Training Loss: 0.11646964167306059  
Percent Correct: 69.00%

-----EPOCH: 2500-----  
Training Loss: 0.11645533202936634  
Percent Correct: 69.00%

-----EPOCH: 2520-----  
Training Loss: 0.11644117576657363  
Percent Correct: 69.00%

-----EPOCH: 2540-----  
Training Loss: 0.11642717013210165  
Percent Correct: 69.00%

-----EPOCH: 2560-----  
Training Loss: 0.1164133124441099  
Percent Correct: 69.00%

-----EPOCH: 2580-----  
Training Loss: 0.11639960008912373  
Percent Correct: 69.00%

-----EPOCH: 2600-----  
Training Loss: 0.1163860305197572  
Percent Correct: 69.00%

-----EPOCH: 2620-----  
Training Loss: 0.11637260125252996  
Percent Correct: 69.00%

-----EPOCH: 2640-----  
Training Loss: 0.11635930986577205  
Percent Correct: 69.00%

-----EPOCH: 2660-----  
Training Loss: 0.11634615399761299  
Percent Correct: 69.00%

-----EPOCH: 2680-----  
Training Loss: 0.11633313134405202  
Percent Correct: 69.00%

-----EPOCH: 2700-----  
Training Loss: 0.1163202396571045  
Percent Correct: 69.00%

-----EPOCH: 2720-----  
Training Loss: 0.1163074767430219  
Percent Correct: 69.00%

-----EPOCH: 2740-----  
Training Loss: 0.11629484046058064  
Percent Correct: 69.00%

-----EPOCH: 2760-----  
Training Loss: 0.11628232871943898  
Percent Correct: 69.00%

-----EPOCH: 2780-----  
Training Loss: 0.11626993947855623  
Percent Correct: 69.00%

-----EPOCH: 2800-----  
Training Loss: 0.1162576707446728  
Percent Correct: 69.00%

-----EPOCH: 2820-----  
Training Loss: 0.1162455205708485  
Percent Correct: 69.00%

-----EPOCH: 2840-----  
Training Loss: 0.11623348705505622  
Percent Correct: 69.00%

-----EPOCH: 2860-----  
Training Loss: 0.11622156833882782  
Percent Correct: 69.00%

-----EPOCH: 2880-----  
Training Loss: 0.11620976260595135  
Percent Correct: 69.00%

-----EPOCH: 2900-----  
Training Loss: 0.11619806808121554  
Percent Correct: 69.00%

-----EPOCH: 2920-----  
Training Loss: 0.11618648302920188  
Percent Correct: 69.00%

-----EPOCH: 2940-----  
Training Loss: 0.11617500575311909  
Percent Correct: 69.00%

-----EPOCH: 2960-----  
Training Loss: 0.11616363459368156  
Percent Correct: 69.00%

-----EPOCH: 2980-----  
Training Loss: 0.1161523679280267  
Percent Correct: 69.00%

-----EPOCH: 3000-----  
Training Loss: 0.1161412041686726  
Percent Correct: 69.00%

-----EPOCH: 3020-----  
Training Loss: 0.11613014176251088  
Percent Correct: 69.00%

-----EPOCH: 3040-----  
Training Loss: 0.11611917918983704  
Percent Correct: 69.00%

-----EPOCH: 3060-----  
Training Loss: 0.11610831496341283  
Percent Correct: 69.00%

-----EPOCH: 3080-----  
Training Loss: 0.11609754762756298  
Percent Correct: 69.00%

-----EPOCH: 3100-----  
Training Loss: 0.11608687575730198  
Percent Correct: 69.00%

-----EPOCH: 3120-----  
Training Loss: 0.11607629795749144  
Percent Correct: 69.00%

-----EPOCH: 3140-----  
Training Loss: 0.11606581286202591  
Percent Correct: 69.00%

-----EPOCH: 3160-----  
Training Loss: 0.11605541913304623  
Percent Correct: 69.00%

-----EPOCH: 3180-----  
Training Loss: 0.11604511546017944  
Percent Correct: 69.00%

-----EPOCH: 3200-----  
Training Loss: 0.11603490055980437  
Percent Correct: 69.00%

-----EPOCH: 3220-----  
Training Loss: 0.11602477317434103  
Percent Correct: 69.00%

-----EPOCH: 3240-----  
Training Loss: 0.11601473207156372  
Percent Correct: 69.00%

-----EPOCH: 3260-----  
Training Loss: 0.11600477604393702  
Percent Correct: 69.00%

-----EPOCH: 3280-----  
Training Loss: 0.11599490390797212  
Percent Correct: 69.00%

-----EPOCH: 3300-----  
Training Loss: 0.11598511450360598  
Percent Correct: 69.00%

-----EPOCH: 3320-----  
Training Loss: 0.11597540669359814  
Percent Correct: 69.00%

-----EPOCH: 3340-----  
Training Loss: 0.11596577936294857  
Percent Correct: 69.00%

-----EPOCH: 3360-----  
Training Loss: 0.11595623141833317  
Percent Correct: 69.00%

-----EPOCH: 3380-----  
Training Loss: 0.11594676178755697  
Percent Correct: 69.00%

-----EPOCH: 3400-----  
Training Loss: 0.11593736941902484  
Percent Correct: 69.00%

-----EPOCH: 3420-----  
Training Loss: 0.11592805328122827  
Percent Correct: 69.00%

-----EPOCH: 3440-----  
Training Loss: 0.11591881236224814  
Percent Correct: 69.00%

-----EPOCH: 3460-----  
Training Loss: 0.11590964566927316  
Percent Correct: 69.00%

-----EPOCH: 3480-----  
Training Loss: 0.11590055222813189  
Percent Correct: 69.00%

-----EPOCH: 3500-----  
Training Loss: 0.11589153108284057  
Percent Correct: 69.00%

-----EPOCH: 3520-----  
Training Loss: 0.11588258129516311  
Percent Correct: 69.00%

-----EPOCH: 3540-----  
Training Loss: 0.11587370194418505  
Percent Correct: 69.00%

-----EPOCH: 3560-----  
Training Loss: 0.1158648921258994  
Percent Correct: 69.00%

-----EPOCH: 3580-----  
Training Loss: 0.11585615095280652  
Percent Correct: 69.00%

-----EPOCH: 3600-----  
Training Loss: 0.11584747755352347  
Percent Correct: 69.00%

-----EPOCH: 3620-----  
Training Loss: 0.11583887107240626  
Percent Correct: 69.00%

-----EPOCH: 3640-----  
Training Loss: 0.11583033066918258  
Percent Correct: 69.00%

-----EPOCH: 3660-----  
Training Loss: 0.11582185551859535  
Percent Correct: 69.00%

-----EPOCH: 3680-----  
Training Loss: 0.11581344481005626  
Percent Correct: 69.00%

-----EPOCH: 3700-----  
Training Loss: 0.11580509774730953  
Percent Correct: 69.00%

-----EPOCH: 3720-----  
Training Loss: 0.11579681354810464  
Percent Correct: 69.00%

-----EPOCH: 3740-----  
Training Loss: 0.11578859144387924  
Percent Correct: 69.00%

-----EPOCH: 3760-----  
Training Loss: 0.11578043067944951  
Percent Correct: 69.00%

-----EPOCH: 3780-----  
Training Loss: 0.11577233051271091  
Percent Correct: 69.00%

-----EPOCH: 3800-----  
Training Loss: 0.11576429021434594  
Percent Correct: 69.00%

-----EPOCH: 3820-----  
Training Loss: 0.11575630906754006  
Percent Correct: 69.00%

-----EPOCH: 3840-----  
Training Loss: 0.11574838636770632  
Percent Correct: 69.00%

-----EPOCH: 3860-----  
Training Loss: 0.11574052142221668  
Percent Correct: 69.00%

-----EPOCH: 3880-----  
Training Loss: 0.11573271355014049  
Percent Correct: 69.00%

-----EPOCH: 3900-----  
Training Loss: 0.11572496208199064  
Percent Correct: 69.00%

-----EPOCH: 3920-----  
Training Loss: 0.11571726635947636  
Percent Correct: 69.00%

-----EPOCH: 3940-----  
Training Loss: 0.11570962573526229  
Percent Correct: 69.00%

-----EPOCH: 3960-----  
Training Loss: 0.11570203957273413  
Percent Correct: 69.00%

-----EPOCH: 3980-----  
Training Loss: 0.11569450724577088  
Percent Correct: 69.00%

-----EPOCH: 4000-----  
Training Loss: 0.11568702813852212  
Percent Correct: 69.00%

-----EPOCH: 4020-----  
Training Loss: 0.11567960164519205  
Percent Correct: 69.00%

-----EPOCH: 4040-----  
Training Loss: 0.11567222716982883  
Percent Correct: 69.00%

-----EPOCH: 4060-----  
Training Loss: 0.11566490412611907  
Percent Correct: 69.00%

-----EPOCH: 4080-----  
Training Loss: 0.11565763193718798  
Percent Correct: 69.00%

-----EPOCH: 4100-----  
Training Loss: 0.11565041003540459  
Percent Correct: 69.00%

-----EPOCH: 4120-----  
Training Loss: 0.1156432378621916  
Percent Correct: 69.00%

-----EPOCH: 4140-----  
Training Loss: 0.11563611486784055  
Percent Correct: 69.00%

-----EPOCH: 4160-----  
Training Loss: 0.11562904051133127  
Percent Correct: 69.00%

-----EPOCH: 4180-----  
Training Loss: 0.11562201426015614  
Percent Correct: 69.00%

-----EPOCH: 4200-----  
Training Loss: 0.11561503559014807  
Percent Correct: 69.00%

-----EPOCH: 4220-----  
Training Loss: 0.1156081039853143  
Percent Correct: 69.00%

-----EPOCH: 4240-----  
Training Loss: 0.1156012189376721  
Percent Correct: 69.00%

-----EPOCH: 4260-----  
Training Loss: 0.11559437994709049  
Percent Correct: 69.00%

-----EPOCH: 4280-----  
Training Loss: 0.11558758652113492  
Percent Correct: 69.00%

-----EPOCH: 4300-----  
Training Loss: 0.11558083817491543  
Percent Correct: 69.00%

-----EPOCH: 4320-----  
Training Loss: 0.11557413443093958  
Percent Correct: 69.00%

-----EPOCH: 4340-----  
Training Loss: 0.1155674748189676  
Percent Correct: 69.00%

-----EPOCH: 4360-----  
Training Loss: 0.11556085887587221  
Percent Correct: 69.00%

-----EPOCH: 4380-----  
Training Loss: 0.11555428614550133  
Percent Correct: 69.00%

-----EPOCH: 4400-----  
Training Loss: 0.11554775617854322  
Percent Correct: 69.00%

-----EPOCH: 4420-----  
Training Loss: 0.1155412685323967  
Percent Correct: 69.00%

-----EPOCH: 4440-----  
Training Loss: 0.11553482277104254  
Percent Correct: 69.00%

-----EPOCH: 4460-----  
Training Loss: 0.11552841846491894  
Percent Correct: 69.00%

-----EPOCH: 4480-----  
Training Loss: 0.11552205519079996  
Percent Correct: 69.00%

-----EPOCH: 4500-----  
Training Loss: 0.11551573253167584  
Percent Correct: 69.00%

-----EPOCH: 4520-----  
Training Loss: 0.1155094500766372  
Percent Correct: 69.00%

-----EPOCH: 4540-----  
Training Loss: 0.11550320742076135  
Percent Correct: 69.00%

-----EPOCH: 4560-----  
Training Loss: 0.11549700416500112  
Percent Correct: 69.00%

-----EPOCH: 4580-----  
Training Loss: 0.11549083991607693  
Percent Correct: 69.00%

-----EPOCH: 4600-----  
Training Loss: 0.11548471428637017  
Percent Correct: 69.00%

-----EPOCH: 4620-----  
Training Loss: 0.11547862689381999  
Percent Correct: 69.00%

-----EPOCH: 4640-----  
Training Loss: 0.11547257736182219  
Percent Correct: 69.00%

-----EPOCH: 4660-----  
Training Loss: 0.11546656531912979  
Percent Correct: 69.00%

-----EPOCH: 4680-----  
Training Loss: 0.11546059039975697  
Percent Correct: 69.00%

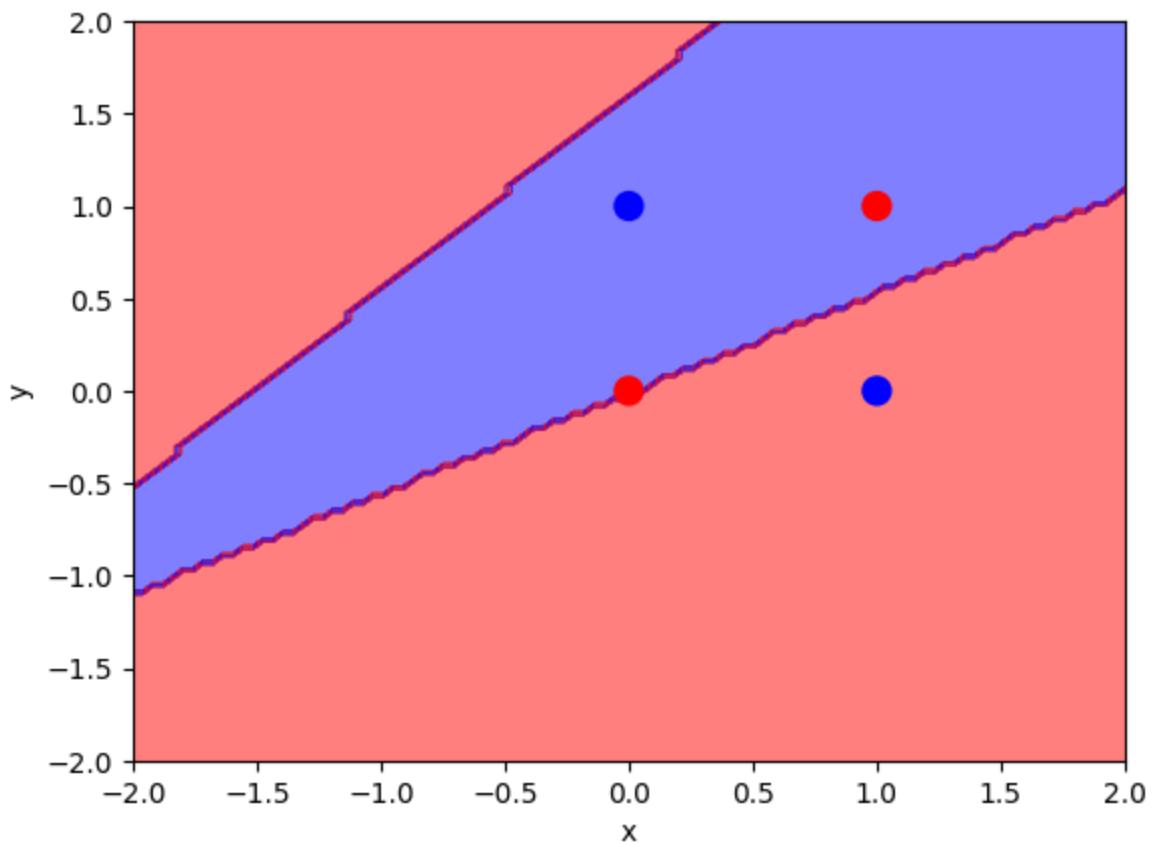
-----EPOCH: 4700-----  
Training Loss: 0.11545465224288382  
Percent Correct: 69.00%

-----EPOCH: 4720-----  
Training Loss: 0.1154487504927646  
Percent Correct: 69.00%

-----EPOCH: 4740-----  
Training Loss: 0.11544288479863644  
Percent Correct: 69.00%

```
-----EPOCH: 4760-----
Training Loss: 0.11543705481463179
Percent Correct: 69.00%  
  
-----EPOCH: 4780-----
Training Loss: 0.11543126019969131
Percent Correct: 69.00%  
  
-----EPOCH: 4800-----
Training Loss: 0.1154255006174796
Percent Correct: 69.00%  
  
-----EPOCH: 4820-----
Training Loss: 0.11541977573630209
Percent Correct: 69.00%  
  
-----EPOCH: 4840-----
Training Loss: 0.11541408522902487
Percent Correct: 69.00%  
  
-----EPOCH: 4860-----
Training Loss: 0.11540842877299429
Percent Correct: 69.00%  
  
-----EPOCH: 4880-----
Training Loss: 0.11540280604996062
Percent Correct: 69.00%  
  
-----EPOCH: 4900-----
Training Loss: 0.11539721674600133
Percent Correct: 69.00%  
  
-----EPOCH: 4920-----
Training Loss: 0.1153916605514473
Percent Correct: 69.00%  
  
-----EPOCH: 4940-----
Training Loss: 0.11538613716081036
Percent Correct: 69.00%  
  
-----EPOCH: 4960-----
Training Loss: 0.11538064627271172
Percent Correct: 69.00%  
  
-----EPOCH: 4980-----
Training Loss: 0.1153751875898124
Percent Correct: 69.00%
```

```
In [24]: plot_boundaries(params_noise[:4])
```



## Standard Deviation of 2

```
In [25]: num_inputs = 2
num_hidden_units = 2
num_outputs = 1

labels = [1, 1, 0, 0]

noise, final_labels = generate_noise(points, 100, 2, labels)

w1, w2, b1, b2 = initialize_parameters(num_inputs, num_hidden_units, num_out
```

```
In [26]: params_noise = train(noise, final_labels, epochs = 5000, learning_rate = 1.5
```

-----EPOCH: 0-----  
Training Loss: 0.14984931310343322  
Percent Correct: 48.00%

-----EPOCH: 20-----  
Training Loss: 0.13572581576450923  
Percent Correct: 60.00%

-----EPOCH: 40-----  
Training Loss: 0.13420729689154706  
Percent Correct: 63.00%

-----EPOCH: 60-----  
Training Loss: 0.13291412858182008  
Percent Correct: 62.00%

-----EPOCH: 80-----  
Training Loss: 0.13192575203557058  
Percent Correct: 61.00%

-----EPOCH: 100-----  
Training Loss: 0.13116945930161825  
Percent Correct: 61.00%

-----EPOCH: 120-----  
Training Loss: 0.13053742119396944  
Percent Correct: 62.00%

-----EPOCH: 140-----  
Training Loss: 0.13010292775930446  
Percent Correct: 61.00%

-----EPOCH: 160-----  
Training Loss: 0.12978057588084238  
Percent Correct: 61.00%

-----EPOCH: 180-----  
Training Loss: 0.12953043518743582  
Percent Correct: 62.00%

-----EPOCH: 200-----  
Training Loss: 0.12932885443960312  
Percent Correct: 62.00%

-----EPOCH: 220-----  
Training Loss: 0.1291617599671746  
Percent Correct: 62.00%

-----EPOCH: 240-----  
Training Loss: 0.12902028657526915  
Percent Correct: 63.00%

-----EPOCH: 260-----  
Training Loss: 0.12889853735881476  
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-----EPOCH: 280-----  
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-----EPOCH: 300-----  
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-----EPOCH: 320-----  
Training Loss: 0.12861579060149575  
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-----EPOCH: 340-----  
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-----EPOCH: 360-----  
Training Loss: 0.1284742995557286  
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-----EPOCH: 380-----  
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-----EPOCH: 400-----  
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-----EPOCH: 420-----  
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-----EPOCH: 440-----  
Training Loss: 0.12826077785807605  
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-----EPOCH: 460-----  
Training Loss: 0.1282177731562894  
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-----EPOCH: 480-----  
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-----EPOCH: 500-----  
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Training Loss: 0.1280743332283231  
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Training Loss: 0.1280441885858294  
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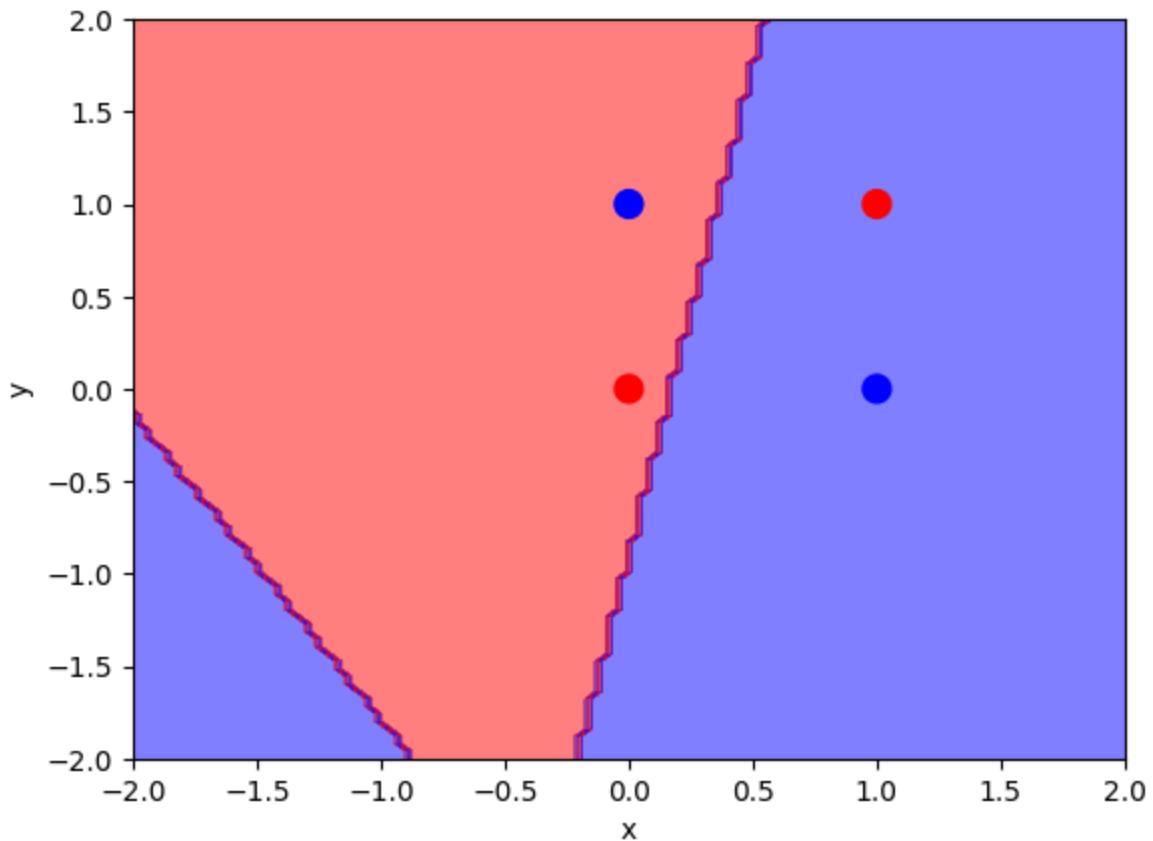
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-----EPOCH: 4740-----  
Training Loss: 0.12703602943008901  
Percent Correct: 63.00%

```
-----EPOCH: 4760-----
Training Loss: 0.12703451922517528
Percent Correct: 63.00%  
  
-----EPOCH: 4780-----
Training Loss: 0.1270330156635656
Percent Correct: 63.00%  
  
-----EPOCH: 4800-----
Training Loss: 0.12703151869889315
Percent Correct: 63.00%  
  
-----EPOCH: 4820-----
Training Loss: 0.12703002828541055
Percent Correct: 63.00%  
  
-----EPOCH: 4840-----
Training Loss: 0.12702854437797653
Percent Correct: 63.00%  
  
-----EPOCH: 4860-----
Training Loss: 0.12702706693204188
Percent Correct: 63.00%  
  
-----EPOCH: 4880-----
Training Loss: 0.12702559590363738
Percent Correct: 63.00%  
  
-----EPOCH: 4900-----
Training Loss: 0.12702413124936046
Percent Correct: 63.00%  
  
-----EPOCH: 4920-----
Training Loss: 0.12702267292636388
Percent Correct: 63.00%  
  
-----EPOCH: 4940-----
Training Loss: 0.1270212208923432
Percent Correct: 63.00%  
  
-----EPOCH: 4960-----
Training Loss: 0.1270197751055252
Percent Correct: 63.00%  
  
-----EPOCH: 4980-----
Training Loss: 0.1270183355246572
Percent Correct: 64.00%
```

```
In [27]: plot_boundaries(params_noise[:4])
```



## Observations/Report

I noticed that the model performed worse with any level of noise, than without the noise which means that the model needs more tuning in order to be able to generalize to unseen data. When trained on noisy data that was 0.5 standard deviations from our central points, (1,1), (1,0), (0,1), (0,0), the model achieved an accuracy of 54%, which is significantly lower than the accuracy of the model trained on just our 4 points: 100%. The model trained on data 1 standard deviation from our central points performed the best on the noisy data and achieved an accuracy of 69%, and graphically better classifies the central points than the other two models. The final model was trained on noisy data 2 standard deviations away from the central points and achieved an accuracy of 63%.