

These exercises will prepare you for understanding how to maximize margins, [as discussed in the lecture notes](#). You may want to review the [definition of the margin  \$\gamma\$](#) .

## 1) Margin definition

Recall that the signed distance to a point  $x$  from a hyperplane  $\theta, \theta_0$  is  $sd(x, \theta, \theta_0) = \frac{\theta^T x + \theta_0}{\|\theta\|}$ .

### Ex1a:

You start with a hyperplane  $\theta, \theta_0$  and a point  $x$ . Suppose a new separator is given, where  $\hat{\theta} = -\theta$  and  $\hat{\theta}_0 = -\theta_0$ .

Which of the following is true? the signed distance changes sign but not magnitude ▾

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### Ex1b:

You start with a hyperplane  $\theta, \theta_0$  and a point  $x$ . Suppose a new separator is given, where  $\hat{\theta} = \theta$  and  $\hat{\theta}_0 = -\theta_0$ .

Which of the following is true: both the sign and the magnitude may change ▾

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### Ex1c:

The margin of labeled point  $x, y$  with respect to separator  $\theta, \theta_0$  is:

$$\gamma(x, y, \theta, \theta_0) = \frac{y(\theta^T x + \theta_0)}{\|\theta\|}$$

Let `sd` stand for  $sd(x, \theta, \theta_0)$ , the signed distance from the separator to  $x$ . Define the margin in terms of `sd` and `y`, the label of  $x$ . Note that both of these are scalars. Provide an expression in Python syntax.

$\gamma(x, y, \theta, \theta_0) =$

Check Syntax

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**Ex1d:**

What is the sign of the signed distance when the prediction is incorrect?

Which of the following is true:

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**Ex1e:**

What is the sign of the margin when the prediction is incorrect?

Which of the following is true: could be either ▼

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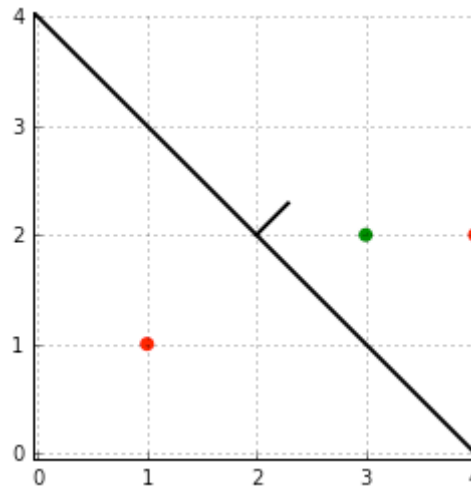
Solution: negative

**Explanation:**

The prediction is on the wrong side of the classifier, so the margin is negative.

## 2) Margin practice

What are the margins of the labeled points  $(x,y) = ((3, 2), +1)$ ,  $((1, 1), -1)$ , and  $((4, 2), -1)$  with respect to the separator defined by  $\theta = (1, 1)$ ,  $\theta_0 = -4$ ? The situation is illustrated in the figure below.



Enter the three margins in order as a Python list of three numbers. Note that you can enter  $\sqrt{x}$  as  $x^{**0.5}$  in Python.

[0.7071067811865475, 1.414213562373095, -1.414213562373095]

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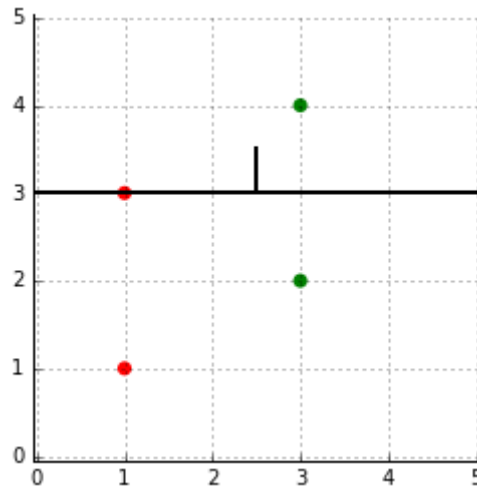
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### 3) Max Margin Separator

Consider the four points and separator:

```
data = np.array([[1, 1, 3, 3], [3, 1, 4, 2]])
labels = np.array([[-1, -1, 1, 1]])
th = np.array([[0, 1]]).T
th0 = -3
```

The situation is shown below:



**Ex3a:**

Enter the four margins in order as a Python list of four numbers.

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**Ex3b:**

A [maximum margin separator](#) is a separator that maximizes the minimum margin between that separator and all points in the dataset.

Enter  $\theta$  and  $\theta_0$  for a maximum margin separator as a Python list of three numbers.

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### Ex3c:

If you scaled this separator by a positive constant  $k$  (i.e., replace  $\theta$  by  $k\theta$ , and  $\theta_0$  by  $k\theta_0$ ), would it still be a maximum margin separator? Yes ▾

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