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 γ.

1) Margin definition

Recall that the signed distance to a point x from a hyperplane θ, θ_0 is $sd(x, \theta, \theta_0) = \frac{\theta^T x + \theta_0}{\|\theta\|}$.

Ex1a:

You start with a hyperplane θ, θ_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 θ, θ_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 θ, θ_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.

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

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Ex1d:

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

Which of the following is true: could be either

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Ex1e:

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

Which of the following is true: negative

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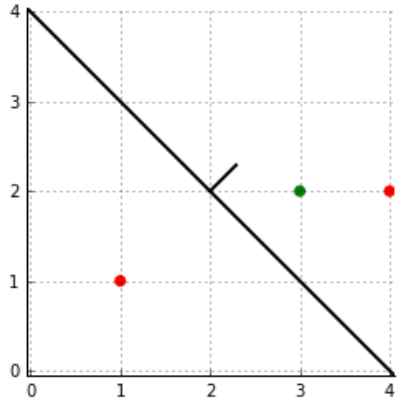
2) Margin practice

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. [1/(2)**0.5, 2/(2)**0.5, -2/(2)**0.5]

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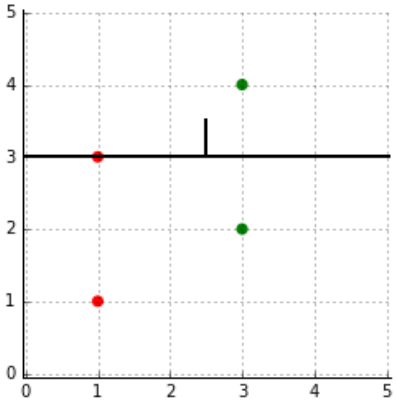
3) Max Margin Separator

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.

[0, 2, 1, -1]

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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 θ and θ_0 for a maximum margin separator as a Python list of three numbers.

[1, 0, -2]

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Ex3c:

If you scaled this separator by a positive constant k (i.e., replace θ by $k\theta$, and θ_0 by $k\theta_0$), would it still be a maximum margin separator? Yes

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