Exercise 2:

Demonstrate the Perceptron Learning Algorithm on the above data, using a learning rate of 1.0 and initial weight values of:

$$w_0 = -1.5$$
$$w_1 = 0$$
$$w_2 = 2$$

The first three steps are shown below. You should continue until all items are correctly classified.

Iteration	w_0	w_1	w_2	Item	x_1	x_2	Class	$s = w_0 + w_1 x_1 + w_2 x_2$	Action
1	-1.5	0	2	a	0	1	-1	+0.5	Subtract
2	-2.5	0	1	b	2	0	-1	-2.5	None
3	-2.5	0	1	c	1	1	+1	-1.5	Add

Answer

Iteration	w_0	w_1	w_2	Item	x_1	x_2	Class	$s = w_0 + w_1 x_1 + w_2 x_2$	Action
1	-1.5	0	2	**a**	**0**	**1**	**-1**	+0.5	Subtract
2	-2.5	0	1	**b**	**2**	**0**	**-1**	-2.5	None
3	-2.5	0	1	**c**	**1**	**1**	**+1**	-1.5	Add
4	-1.5	1	2	**a**	**0**	**1**	**-1**	+0.5	Subtract
5	-2.5	1	1	**b**	**2**	**0**	**-1**	-0.5	None
6	-2.5	1	1	**c**	**1**	**1**	**+1**	-0.5	Add
7	-1.5	2	2	**a**	**0**	**1**	**-1**	+0.5	Subtract
8	-2.5	2	1	**b**	**2**	**0**	**-1**	+1.5	Subtract
9	-3.5	0	1	**c**	**1**	**1**	**+1**	-2.5	Add
10	-2.5	1	2	**a**	**0**	**1**	**-1**	-0.5	None
11	-2.5	1	2	**b**	**2**	**0**	**-1**	-0.5	None
12	-2.5	1	2	**c**	**1**	**1**	**+1**	+0.5	None

Explanation: Changes to weights marked in yellow.

at epoch 1:

- it1 is a false positive and needs subtraction. w_1 is updated from 0 to 1
- it2 is a true negative. But w_1 is updated from 0 to 1 anyway
- it3 is a false negative and needs addition. w_1 is updated from 0 to 1

At epoch 2:

- it4 is a false positive and needs subtraction. w_1 is updated from 1 to 2
- it5 is a true negative. But w_1 is updated from 1 to 2 anyway.
- it6 is a false negative and needs addition. w_1 is reduced from 1 to 0. w_0 increased from 2.5 to 3.5

At epoch 3:

- it7 is a false positive and needs subtraction. w_1 is reduced from 2 to 1. w_0 increased from 1.5 to 2.5

- it8 is a false positive and needs subtraction. w_1 is reduced from 2 to 1 and w_2 is increased from 1 to 2
- it9 is a false negative and needs addition. w_1 is increased from 0 to 1 and w_2 is increased from 1 to 2. w_0 reduced from 3.5 to 2.5

At epoch 4:

- it10 is a true negative. No change required
- it11 is a true negative. No change required
- it12 is a true positive. No change required

I don't understand the logic behind the decision on whether to adjust, and if the decision is make an adjustment, which weight to adjust. In particular iteration 2 & 5. I thought that if no change was required we didn't change. And yet in these two iterations we make a change to the weights.

- In the case of iteration 2, the only explanation I can think of is that the result (-2.5) is too negative and we want the negative number to be closer to zero. Lets accept that hypothesis for now.
- In the case of iteration 5, I really don't understand why we change it, because -0.5 is the final answer in iteration 11. There seems to be no need to make any change and yet we do.

Notes from the Video

- The decision about how to change w_0 depends on the initial state of the Perceptron. We change it by +/- η.
- The decision about how to change the weight depends on the x value and the target output.
- If $g(s)$ is 0 and we want it to be 1, then we want to reduce s. If x is negative, we use a negative weight. Conversely, if x is positive we use a positive weight. We want the product to increase. The easiest way to achieve that is to multiply x_1 by η and add that to w_1.
- The reverse is true for If $g(s)$ is 1 and we want it to be 0, we do the opposite.

How might this change the answer for question 2:

I think there is a more direct route to achieve the same outcome, which I try to demonstrate below and in the attached ipynb

Iteration	w_0	w_1	w_2	Item	x_1	x_2	Class	$s = w_0 + w_1 x_1 + w_2 x_2$	Action
1	-1.5	0	2	**a**	**0**	**1**	**-1**	+0.5	Subtract
2	-2.5	0	1	**b**	**2**	**0**	**-1**	-2.5	None
3	-2.5	0	1	**c**	**1**	**1**	**+1**	-1.5	Add
4	-2.5	0	2	**a**	**0**	**1**	**-1**	-0.5	None
5	-1.5	0	1	**b**	**2**	**0**	**-1**	-1.5	None
6	-1.5	0	1	**c**	**1**	**1**	**+1**	-0.5	Add
7	-2.5	0	2	**a**	**0**	**1**	**-1**	-0.5	None
8	-0.5	0	1	**b**	**2**	**0**	**-1**	-0.5	None
9	-0.5	0	1	**c**	**1**	**1**	**+1**	+0.5	None