## Instructions

You are encouraged to discuss on course materials and homework. However, you must write the final solutions alone and **understand** them fully. You can consult books, notes or other resources, but not copy from them. Also, make sure the scan of your homework submission should be very clean/understandable.

Your solutions to the problems should be submitted in a jupyter notebook (using latex in markdown cells) with your responses/arguments clearly presented. Supporting files such as the source codes should also be submitted if there's any programming assignment; and be well documented. Use Python jupyter notebook to experiment with the PLA.

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## A) Problems from the Textbook

### 0.1 Learning Exercises - 20%

In the following exercises, you need to make your arguments convincing to get the points.

1. Do Exercise 1.1 of LFD.
2. Do Exercise 1.5 of LFD.

### 0.2 Perceptron Learning Algorithm -20%

In the following exercises, you need to make your arguments convincing to get the points.

1. Do Exercise 1.3-1 of LFD.
2. Do Exercise 1.3-2 of LFD.
3. Do Exercise 1.3-3 of LFD.

### 0.3 Experiments with Perceptron Learning Algorithm -30%

In the following exercises, you need to make your arguments convincing to get the points.

1. Generate a data set of size 20 as directed by Exercise 1.4 of LFD, and plot the examples $\{(x_n, y_n)\}$ as well as the target function $f$ on a plane. Be sure to mark the examples from different classes differently, and add labels to the axes of the plot.
2. Run Perceptron Learning Algorithm (PLA) on the data set above. Report the number of updates that PLA takes before converging. Plot the examples $\{(x_n, y_n)\}$, the target function $f$ , and the final hypothesis g in the same figure. Comment on whether $f$ is close to $g$.
3. Repeat everything in (2) with another randomly generated data set of size 20. Compare your results with (2).

4. Repeat everything in (2) with another randomly generated data set of size 100. Compare your results with (2).

5. Repeat everything in (2) with another randomly generated data set of size 1000. Compare your results with (2).

### 0.4 Pocket Algorithm

(30%) Do Exercise 3.2 of LFD.

1. Generate a data set of size 100 as directed by the exercise, and plot the examples $\{(x_n, y_n)\}$ as well as the target function $f$ on a plane. Be sure to mark the examples from different classes differently, and add labels to the axes of the plot. Generate a test set of size 1000 of the same nature.

2. Next, implement the pocket algorithm and run it on the data set for 1000 updates. Record $E_{in}(w(t))$, $E_{in}(w^*(t))$, $E_{out}(w(t))$, and $E_{out}(w^*(t))$ as functions of $t$ (where $E_out$ is estimated by the test set). Repeat the experiment for 20 times. Plot the average $E_{in}(w(t))$ and $E_{in}(w^*(t))$ as functions of t and briefly state your findings.