

EXERCISE 1

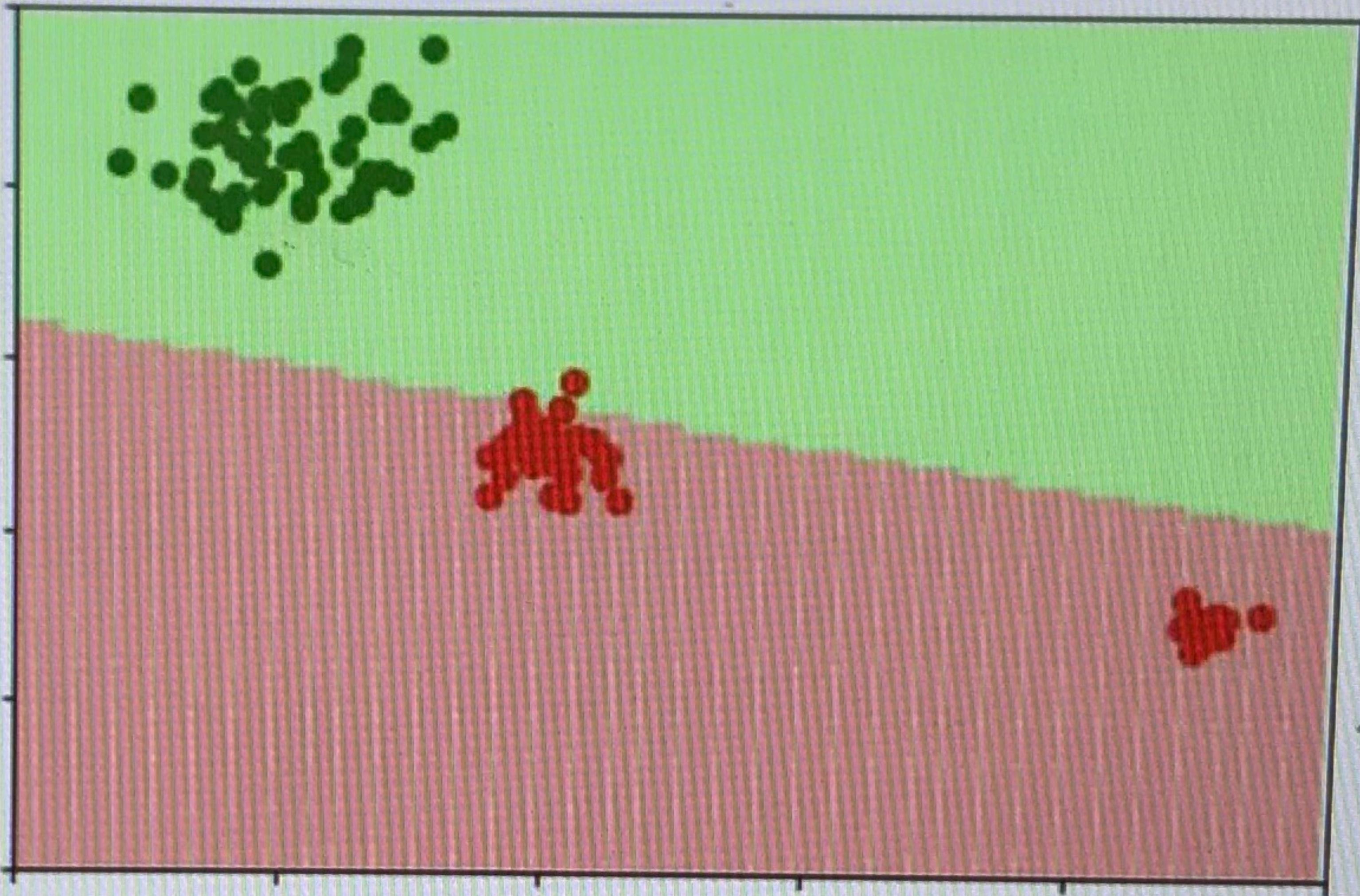
Consider the following dataset, containing samples of a function f :

x_1	x_2	x_3	f
0.6	3	1	4.6
1	2	3	2.1
4	4	1	10

1. Assume you want to estimate f . What problem are we dealing with? Provide the mathematical formulation of a model that could be used for this problem.
2. Illustrate an algorithmic technique that can be used to train the chosen model.

EXERCISE 2

Consider the following dataset (with red and green classes).



1. Is this dataset *linearly separable*? Explain your answer.
2. Which approach could reasonably produce the shown boundary?
3. Which approach would you expect NOT to produce the separation boundary shown in the figure? Why?

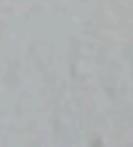
EXERCISE 3

Consider binary classification (classes: + and -):

1. Show an example consisting of a classifier and a simple dataset where the *accuracy* metric fails to correctly quantify the classifier quality.
2. Discuss whether more reliable metrics exist and provide the details.



EXERCISE 4

1. Give a short explanation of the *Kernel trick* (kernel substitution). What is the necessary condition for applying the kernel trick?
2. Consider a linear model for binary classification, i.e. $\mathbf{y}(\mathbf{x}; \mathbf{w}) = \mathbf{w}^T \mathbf{x}$, without regularization. Provide an example of applying the kernel trick on this problem. In detail:
 - provide the mathematical formulation of the method in its original form;
 - explain why it is possible to apply the kernel trick; 
 - choose a kernel function and provide the “kernelized” formulation of the method.

Note: Consider the identity $(\mathbf{X}^T \mathbf{X} + \lambda I)^{-1} \mathbf{X}^T = \mathbf{X}^T (\mathbf{X} \mathbf{X}^T + \lambda I)^{-1}$.

EXERCISE 5

Consider designing an Artificial Neural Network for a multi-class classification problem.

1. Provide a formal definition of the output unit
2. Provide a formal definition of the loss function



EXERCISE 6

1. Describe the kinds of problems for which Principal components Analysis (PCA) can be used.
2. Provide an example of a practical problem (not just an abstract one) for which PCA is useful, describe a possible outcome of PCA on such problem, and discuss the practical utility of such solution.