

**WRITE FIRST NAME, LAST NAME, AND ID NUMBER (“MATRICOLA”) ON YOUR ASSIGNMENT. TIME: 1.5 hours.**

**FIRST NAME:** .....

**LAST NAME:** .....

**ID NUMBER:** .....



## **Question 1 [6 points]**

1. Introduce the classification problem in machine learning.
2. With reference to linear binary classification:
  - briefly describe the perceptron algorithm and the logistic regression model
  - point out the main difference among the two.

---

[Solution: Question 1]

---

[Solution: Question 1]

## Question 2 [6 points]

Assume you are given data  $\{x_i\}_{i=1,\dots,m}$ ,  $x_i \in \mathbb{R}^d$ , that you would like to represent (approximately) using a small number  $k < d$  of “parameters”.

1. Describe a linear technique to perform this reduction and, for a given number of reduced parameters find a closed form expression for this approximation.
2. Discuss the relation between the number of parameters and the (average) approximation error.

---

[Solution: Question 2]

---

[Solution: Question 2]

### **Question 3 [6 points]**

Give the definition of on-average-replace-one-stable algorithms and discuss the relation between (OAROS) stability and overfitting.

---

[Solution: Question 3]

---

[Solution: Question 3]

## Question 4 [6 points]

Assume you have data  $(x_i, y_i)$ ,  $i = 1, \dots, m$ ,  $x_i \in \mathbb{R}^d$ ,  $y_i \in \mathbb{R}$  and you would like to learn a (non-linear) model that approximates the outputs  $y_i$  with their predictions

$$\hat{y} := h(x)$$

You would like to do so under the assumption that the labels  $y_i$  have been generated by the (unknown) model

$$y_i = f(x_i) + e_i$$

where  $e_i$  are i.i.d. zero mean Gaussian noises with unknown variance  $\sigma^2$ .

1. State this learning problem in the context of Gaussian Processes (i.e. assume  $f(x)$  is a realization from a Gaussian Process with zero mean and known covariance function) and write the corresponding estimate  $h(x)$ .
2. In this framework, describe a procedure to estimate the unknown noise variance  $\sigma^2$ .

---

[Solution: Question 4]

---

[Solution: Question 4]