The exam will be graded IFF the following recommendations have been taken into account:

- Write clearly so that the teacher can easily understand your answers
- Write your name, surname, and student id on each sheet you deliver for evaluation
- For each exercise/question report clearly the number and sub-number (if present)
- You are not allowed to use any programmable device (e.g., smartphone, calculator, etc.)
- You can use pen or pencil, paper will be provided, you cannot use notes or books

Exercise 1 (Cognitive Architectures) (1+2+3+1 points)
Two main paradigms for the design of cognitive systems have been presented during classes, with hybrid approached, among the two resulting in being the most common ones. Answer the following:

a) How planning could be use in a hybrid architecture including deliberative and reactive components?

b) What is planning? Formalize a planning problem and its components.

c) Using PPDL, define the planning problem of a sailor moving a wolf, a goat, and a cabbage across a river (you might need to use conditional effects in actions …):
   - The boat is tiny and can only carry one passenger at a time
   - If the sailor leaves the wolf and the goat alone together, the wolf will eat the goat.
   - If the sailor leaves the goat and the cabbage alone together, the goat will eat the cabbage.

d) Is the previous problem solvable using pure STRIPS definitions instead of ADL? Explain why.

Exercise 2 (Natural Language Processing) (1+2+1 points)
With reference to the Part of Speech (POS) tagging problem answer the following questions:

a) What is POS tagging about? Describe it shortly add make an example

b) Describe what is a Hidden Markov Model and how it can be used for POS tagging

c) Could LSTM networks be used for POS tagging? How?

Exercise 3 (Human Robot Interaction) (2+3+1+1 points)
Let’s assume you are designing an interactive sliding door to make “more interesting” the lobby entrance at the “Mighty Magic Motel” in Cernusco sul Naviglio.

a) What kind of sensors and actuators might be needed for the interaction? For each of them describe its purpose. Provide also a sketch of the door with the sensors and discuss their placement.

b) Not to be predictable, i.e., boring, the sliding door should have different patterns of behaviors and generate different reactions. Provide 3 of such patterns, describe which reactions they are supposed to induce, and how sensors are used in each of those.

c) Discuss the role of time in human robot interaction in general.

d) Discuss the role of time in the suggested cases.

Exercise 4 (Neural Networks) (2+2+1+2 points)
With reference to the lectures on Feed Forward Neural Networks and Deep Learning answer the following:

a) Describe the perceptron model, draw it, provide its output formula and its training algorithm.

b) Describe the backpropagation algorithm and discuss the difference w.r.t. the perceptron learning algorithm. Derive the backpropagation formula for the output layer in a FFNN with SSE loss function.

c) Describe in details the issue of vanishing gradient in recurrent neural networks

d) How Long-Short Term Memories face the issues of vanishing gradient, provide a description of the LSTM model and some possible examples of structural learning problems.