

Industrial Automation and Robotics

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NAME:

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SIGNATURE: _____

Warnings

- This file consists of **8** pages (including cover).
- During the exam you are not allowed to exit the room for any other reason than handing your work or withdrawing from the exam.
- You are not allowed to withdraw from the exam during the first 30 minutes.
- During the exam you are not allowed to consult books or any kind of notes.
- You are not allowed to use calculators with graphic display.
- Solutions and answers can be given **either in English or in Italian**.
- Solutions and answers must be given **exclusively in the reserved space**. Only in the case of corrections, or if the space is not sufficient, use the back of the front cover.
- The clarity and the order of the answers will be considered in the evaluation.
- At the end of the test you have to **hand this file only**. Every other sheet you may hand will not be taken into consideration.

EXERCISE 1

Consider the dynamic system described by the following equations:

$$\begin{aligned}\dot{x}_1 &= x_2 \\ \dot{x}_2 &= -10x_1 - 11x_2 + 5u \\ y &= 10x_1\end{aligned}$$

1. Find the expression of the transfer function $G(s)$ from the input u to the output y .
2. Find the values of the type, dc gain and time constants of the transfer function previously obtained.

3. Discuss the stability of the transfer function.

4. Ignoring the smallest time constant of the transfer function, write the expression of the step response of the system and sketch the related plot.

EXERCISE 2

1. Explain what a discrete events system is and what is the importance of discrete events systems in the context of an industrial automation system.

2. Consider now a logical system that has to implement the function:

```
if A
X = (B and C)
else
X = (B or C)
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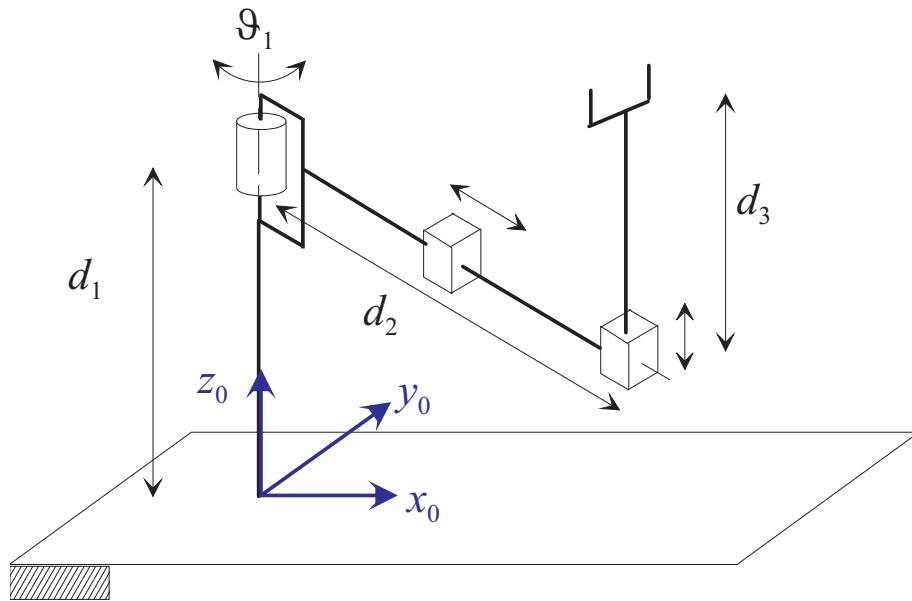
Sketch a ladder diagram that implements this logical function.

3. Sketch a Sequential Function Chart that implements an if-then-else programming structure and comment such sketch.

4. Consider now the interconnection of digital systems. Explain what is the physical layer of a bus and mention possible modes for line coding.

EXERCISE 3

Consider the following robot manipulator with 3 joints (rotational, prismatic, and prismatic):



1. Find the expression of the direct kinematics of the robot, in terms of the position coordinates of the end effector with respect to the joint variables ϑ_1 , d_2 , and d_3 .

2. Find the expression of the inverse kinematics of the robot, in terms of the joint variables ϑ_1 , d_2 , and d_3 with respect to the position coordinates of the end effector.

3. Write the expression of the Jacobian of the manipulator of this exercise.

4. Characterize the singularities of the manipulator of this exercise.