Industrial Automation and Robotics

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NAME:

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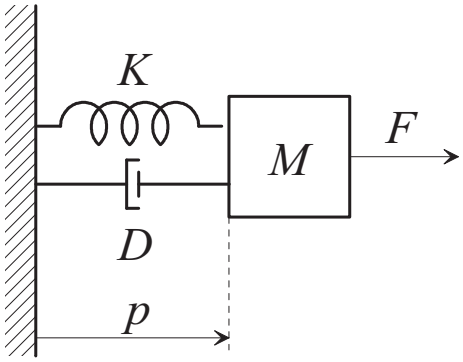
SIGNATURE: _____

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

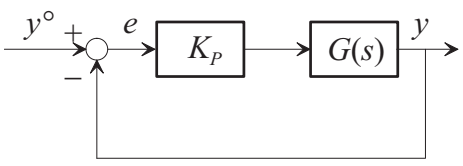
Consider the mechanical system depicted in the picture:



The system is composed by a body of mass M subjected to a viscous friction force, proportional to speed through the coefficient D, and an elastic force, proportional to position through the coefficient K.

1. Setting $M = 1$, $K = 1$, $D = 2$, find the transfer function $G(s)$ from the force F to the position p.

2. Consider now the block diagram sketched in the picture:



where $K_P = 100$, while $G(s)$ is the transfer function computed previously. Sketch the asymptotic Bode plot of the magnitude of the loop transfer function of the control system.

3. Compute the crossover frequency and check that the phase margin of the control system is positive.

4. Check that the closed loop polynomial of the system (denominator of the transfer function from y^o to y) has negative real part roots.

EXERCISE 2

1. Consider the Ladder Diagram programming language for PLCs. List the types of timers that can be included in a Ladder Diagram, briefly explaining how they work.

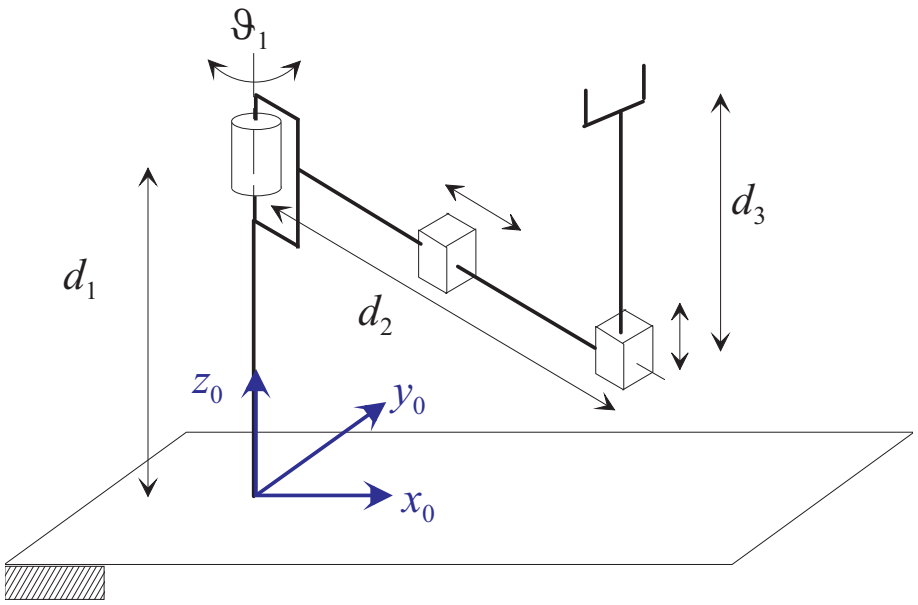
2. Consider now the following process: pressing a button **START** a light turns on for one minute. After such time interval, the light turns off and for 10 minutes pressing the button **START** cannot turn on the light. Program the system with a Ladder Diagram code.

3. Explain the difference between a soft real time system and a hard real time system, citing one example for both.

4. Consider now the Ethernet protocol for the digital communication on a bus: briefly describe how the access to the bus among the various agents is handled.

EXERCISE 3

Consider the following robot manipulator with 3joints (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. Define what is the (positional) Jacobian of a generic manipulator.

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

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