Third Simulation Project. Control engineering.

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"In accordance with the Tecnológico de Monterrey Student Code of Honor, my performance in this exam will be guided by academic honesty."

NAME: ______________________________________ **STUDENT NUMBER:** ___________

$\boldsymbol{a}$:_________ $\boldsymbol{b}$:___________ $\boldsymbol{c}$:__________

You should upload a **word** or **PDF** file in which all the results are provided. The word or PDF must contain images of the Simulnk ® diagram, the transfer function of the system, the control equation, the Sisotool plots (if needed), the output of the system, the state variables and the input to the system. Also, you can do your mathematical computation on a paper and include images of them.

The report should be presented by System. You should also include all the Matlab® files that you consider necessary and that you used during the exam. These files (.m or .mdl) together with the report can be included in a ZIP file. The exam will be graded with the word or PDF file in the first instance.

If a problem cannot be solved, please, explain why and include the justification in your report.

The exam is **individual** and depends on the following parameters. If there were 2 people with the same data, both exams will be cancelled with a violation to Academic Honesty will be reported, with a final grade of the course equal to 1/100.

$\boldsymbol{a} = Birth\ Day$, $\boldsymbol{b} = Birth\ Month$ and $\boldsymbol{c} = b + 3$

(For instance, for someone born in Sep 16th $a = 16, b = 9$ and $c = 19$)

1. (15) For the following system, design a state feedback control such that the following system becomes stable. Obtain any state space representation for the system in order to design the controller.

$$G1(s) = \frac{4s + 45}{(s + 2a)(s - b)(s - 3c)}$$

Make sure that the initial conditions of the system are different than 0 to secure the transient on the control.
Minimum expected plots: Output in open loop, Open in closed loop, input and state variables in closed loop.
Minimum expected screen shots: State space model, Simulink Model, Command to obtain K and its value.

2. (25) For the following system, design a control action u(t)=-K x(t)+v to follow a constant reference r(t)=2. Obtain any state space representation for the system

$$G2(s) = \frac{2s - 27}{(s - a/2)(s + b)(s - 2c)}$$

Minimum expected plots: Output in open loop, Output with reference comparison in closed loop, input and state variables in closed loop.
Minimum expected screen shots: State space model, Simulink Model, Command to obtain K and its value, computation of the value for v.

Make sure that the initial conditions of the observer are different than the ones of the system. If the plot of the plant states and the observed states is not included, the problem will not be graded.

3. (5p) For the following system, design a control action u(t)=-K o(t)+v to follow a constant reference **r(t)=3**.
   Assume that the state variables are not available and o(t) are the observer's state variables.
   The poles in closed loop should be in [-4.5 -7.3 -6.2].
   The input to the system should be **bounded** and limited to a maximum value of 3 units.
   The value for variable x_2 should never be negative and the maximum value that x_3 can have is 2.

$$A = \begin{bmatrix} a+c & 0 & 0 \\ -1 & a & 3 \\ 2 & 0 & b \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 7 \\ 0 \end{bmatrix} \quad C = [2 \quad 3 \quad 0]$$

Minimum expected plots: Output in open loop, Output with reference comparison, input and a plot with the observed and the real state variable for each state variable. Include separate plots for u, x_2 and x_3 to show that the listed transient conditions are met***. Make sure that the initial conditions of the observer are different than the ones of the system.*** If the plot of the plant states and the observed states is not included, the problem will not be graded.

Minimum expected screen shots: State space model, Simulink Model, Value of gain K, Value of gain L, computation of the value for v. Make sure to use the observer's state variables for the state feedback simulation.

4. (30) For the following system, design a control action u(t)=-K o(t)+v to follow a constant reference r(t)=4. Assume that the state variables are not available and o(t) are the observer's state variables. Obtain any state space representation for the system.

$$G2(s) = \frac{43.7}{(s-2a)(s-2b)(s-2c)}$$

Minimum expected plots: Output in open loop, Output with reference comparison, input and a plot with the observed and the real state variable for each state variable***.***

Make sure that the initial conditions of the observer are different than the ones of the system. If the plot of the plant states and the observed states is not included, the problem will not be graded.

Minimum expected screen shots: State space model, Simulink Model, Command to obtain K and its value, Value of gain L, computation of the value for v. Make sure to use the observer's state variables for the state feedback simulation.

5. (25) For the following system, design **independently** a PID controller and a Compensator to follow a Reference r(t)=7.
   The maximum error allowed in the compensator is 5%.
   Make sure that the input to the system from the compensator is lower than the input from the PID.
   Settling time is not an issue for this problem.

$$G2(s) = \frac{47\ e^{-0.003s}}{s^2 + as + 150}$$

Minimum expected plots: Output in open loop, Output with reference comparison, PID signal (Input to the plant from the PID), Compensator signal (Input to the plant with the compensator), Input comparison among PID and Compensator.

Minimum expected screen shots: State space model with both controllers, Simulink Model, Design for PID (as many screenshots as needed), Design of the Compensator.

Extra points:

1. (30) Design a control action to follow a reference r(t)=sin(**3**t) for the following system.

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a/2 & b & -c \end{bmatrix}, B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$$

Minimum expected plots: Output in open loop, Output with reference comparison, input and state variables on independent scopes.
Minimum expected screen shots: State space model, Simulink Model, Computation for the controller (as many screenshots as needed).