ECSE 403 lab assignment
Fall 2018 , assignment 3
Instructor: Prof. P. E. Caines
Due 12^{th} october 2018

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1 Objective

The main goal of this assignment is to become familiar with Cart systems, and find system parameters.

2 Your responsibility

Your responsibility is to answer all questions which have been asked throughout this assignment and submit all your answers in addition to Matlab codes and Simulink results.
Notice: You have to first finish Lab assignment 2.

3 Model Description

The equation described in lab 1 and lab 2, is the equation of the DC motor, on the cart systems. In order to derive the equations for the mechanical system, we need following set of parameters in addition to parameters given in the previous sessions:

- $kg = 3.7$ to 1 be the internal gear ratio
- $r = 0.0064\ m$ be the motor gear radius
- $mc = 0.526\ K_g$ be the cart mass.
- $kth = 0.00153\ rad/counts$ be the pendulum angle gain.

- $mp = 0.106\ K_g$ be the pendulum mass.
- kx =(use the gain you found in previous assignment) be the linear position gain.

4 Questions

4.1 Linearity of the system

1. Consider two arbitrary input signals $x_1(t)$,$x_2(t)$. Find the response of the system to these two signals $H\{x_1(t)\}$,$H\{x_2(t)\}$.(voltage as input and velocity as the output). Plot an arbitrary linear combination of the response signals $aH\{x_1(t)\} + bH\{x_2(t)\}$. Now use the expression $ax_1(t)+bx_2(t)$ as input signal, Plot the response of the system to this signal $H\{ax_1(t)+bx_2(t)\}$ and compare it with previous plot. [15 marks]
   Hint:In order to export the data from Simulink environment you can use *To Works space* block.

2. As you know, sine waves are eigenfunction of an LTI system. Using a sine wave with amplitude 2 and frequency of 1 Hz, check whether or not the system is LTI. [5 marks]

3. Suppose someone argue that the divergence from practical measurements and theoretical ones is due to a hidden feedback loop. Do you agree with that person? Justify your answer. [10 marks]

4. Explain possible sources of non-linearity of the system. [10 marks]

4.2 System Identification

1. Derive the open loop transfer function of the cart from mechanical and electrical first principles.(consider voltage as the input and velocity as the output). [You have to submit this part next week along with Lab assignment 2] [10 marks]

2. Calculate the coefficients of these transfer function using given constants in *Model description section*. [10 marks]

3. Find the step response of the system, defining cart's velocity as the output of the system.(voltage as input and velocity as the output). [10 marks]
   Hint: Note that in order to achieve the velocity of the cart you need to differentiate cart's position in Simulink.
   Hint: You can refer to lab manual to find a way to filter out the noise in the output signal.

4. Estimate the coefficients of the transfer function by measuring the time constant and gain of the step response. [10 marks]
   Hint: The system with velocity as the output, is a first order system.

5. Using *To workspace* command, plot your estimated step response and actual step response of the system on one figure. [10 marks]

6. Explain possible reasons for the differences between aforementioned plots. [10 marks]

7. Using frequencies $w = [0.1, 1, 10, 100]$, plot the bode diagram of the system experimentally. [10 marks]

8. Using your estimated parameters, define the transfer function in Matlab and plot bode diagram of the system and compare it with previous question. [10 marks]

9. Find the step response of the system with defining position as the output.(voltage as the input and position as the output). [10 marks]

10. Using frequencies $w = [0.1, 1, 10, 100]$, plot the bode diagram of the system experimentally.(voltage as the input and position as the output) [10 marks]