ASEN 4114/5114 Homework 1

Due: Monday, February 3, 2025 at 11:59 pm on Canvas. Please assemble a single PDF file for submission that includes your Matlab/Simulink code/diagrams, plots, and explanations of your work and the results. Label sections to correspond with those in the assignment. Don't make it difficult to locate the text/code/plots for each section.

1. [10pts] Find the parameters R_M, L_M, K_τ, J_m, and K_B from the motor specification sheet, noting units. Also, find the total gear ratio N from the motor shaft to the load shaft, and estimate the load shaft moment of inertial J_L. Use these to quantify the parameters in the transfer function relating V_P to θ_L. Also, estimate the potentiometer scale factor K_s from the data file posted on Canvas.

2. [20pts] Simulate the system relating power amp voltage V_P to sensor voltage V_S using a single transfer function block from the Continuous library in Simulink. I suggest you compute polynomial coefficients in a separate m-file (as in the intro_sims.m example), so the simulink system can be built using simple variable names from the workspace. Use a sinusoidal power amp input voltage (1V peak, 1Hz), and plot the corresponding input and output signals, with appropriate units. Does the output follow the input closely?

3. [10pts] Derive the closed loop transfer function between reference angle θ_R and load shaft angle θ_L when the controller has a proportional-plus-derivative (PD) control law, i.e.

$$V_p = G_p(\theta_R - \theta_L) + G_D \frac{d}{dt}(\theta_R - \theta_L).$$

Determine the DC gain of the closed loop system.

4. [20pts] Construct a Simulink model of the control system including both proportional and derivative control. DO NOT create one block that represents the closed loop transfer function derived in Part 3. Instead, create a second block for the control law itself and then connect it in a unity-feedback control system with the Plant block from part 2. Label this block diagram with signal names and units.

5. [10pts] Plot the simulated step response (0.4 radian amplitude) of this closed loop control system using a proportional gain of 10 V/rad and a derivative gain of 0.1 V/rad/s. Compare the steady state tracking behavior to that predicted by the DC gain calculated in part 3.

6. [20pts] Repeat part 5, but use sinusoid reference signals at 0.4 rad amplitude, with frequencies of 0.2 Hz and 2 Hz. Comment on the relative tracking ability of the system at these two frequencies.