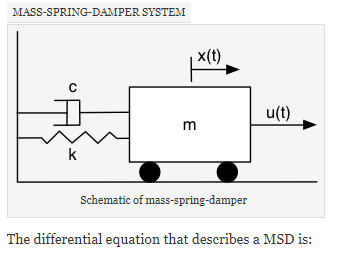
MAE 3723, System Analysis – Spring 2019

Homework Assignment #13

***Homework Assignment #13 - Due at 11:59 pm, Friday, May 3rd, in the Homework 13 Dropbox.***

***Upload THIS MS Word file!***

**Problem 1**  We will be exploring PID Control of the Spring-Mass-Damper system shown. The file: ***ControlsExampleV1.m*** plots the free response of this system for an initial displacement. You will modify this file to add the PID Controller equation, and will be answering questions about the system. This will be more like a Lab, and less like a typical engineering homework assignment. Note: you will be asked to “make the system behave well”. Behaving well means the system arrives at the set point quickly with minimal overshoot or oscillation.

1. Run ***ControlsExampleV1.m*** and describe the system response shown in the plot. Type all of your answers in RED.

Second Order system with initial conditions

1. Add PD (Proportional and Derivative) control to the simulation by modifying the Force Equation to become: F=kp \* (sp\_x - x) + kd\*(0 - xdot); . Explore different values of kp (keeping kd = 0 ) and describe the effect kp has on the system response.

Kp values shortens the rise time but increases the natural frequency.

1. Explore different values of kd (keeping kp = 0 ) and describe the effect kd has on the system response.

Kd acts as a dampener, reducing the overshoot of the system.

1. Explore the combined effect of kp and kd. Try to find values that drive the system to the set point quickly and precisely. What values did you choose? What did you observe?

Kp = 3000

Kd =300

An increase in Kp increased the rise time and Kd increased the settling time of the system.

1. Continue to explore the combined effect of kp and kd. Try to find values that drive the system to the set point quickly and precisely, while keeping the maximum force at 200 or less. What did you observe?

Kp =199 and Kd =25 led to a good behavior but but the system is not able to reach the setpoint.

1. We will add Integral Control to the system by using the derivPID() function with ODE45(). The initial conditions must be changed to: [1, 0, 0]. Set kp and kd to zero. Explore the effect if ki alone. What did you observe?

The system approaches the setpoint while oscilating but does not appear to be dampening out. A small value of Ki is needed to pull the system towards the setpoint in comparison with Kp. Values of Ki too large will lead to an unstable system.

1. Set kp = 0 and ki = 10. Explore the effect of kd in combination with ki=10. Try to find a value of kd that makes the system behave well. What did you observe? What value of kd did you prefer? What is noticeably wrong with the system behavior?

The system starts off in a free response and then is forced to the setpoint. A value of Kd = 3.75 has a slow rise to the setpoint but there is still a period that the system is in free response.

1. Explore the effect of all three k values. Try to find a combination that makes the system behave well. What did you observe? What value of k’s did you prefer? Did you achieve “good behavior”?

Kp =4000, Kd = 110, Ki =20

The system reaches a value close to the setpoint very quickly but there is still a very small steady state error.

1. Explore the effect of all three k values. Try to find a combination that makes the system behave well while keeping the maximum force below 200. What did you observe? What value of k’s did you prefer? Did you achieve “good behavior”?

Kp =200, Kd = 25, Ki =185

The system reaches the setpoint in around 5 seconds without overshoot.

1. Explore the effect of changing the setpoint to 4, 8 16, 20. What did you observe? Did you maintain “good behavior” without changine the gains?

As the error of the term gets larger, the system tends to overshoot but still reaches steady state with a small settling time. The maximum force also increased

1. Using the same k values as previously, change the value of the set point to 5. Did you still have “good behavior”?

Yes