MECE-744: Nonlinear Controls **Computer Project #5**

Spring 2015-2016 (Sem: 2155) *Due 05-10-16*

Instructions: Use Matlab/Simulink to solve all problems. Save your work in an m-file and an slx-file. Project write-up should include the following:

1. a project write-up with clearly defined answers and any required hand calculations.
2. a print out of the Matlab command window showing your Matlab solution answers, if applicable. Clearly define each solution and the part to which it pertains.
3. a print out copy of your m-file program and any Simulink diagrams.
4. a print out copy of clearly labeled Figures/Plots
5. a soft copy of your program required to run all the problem parts (place it in the mycourses dropbox shell)

Design an "optimal" continuous time PID control law with unity output feedback for the following nonlinear open-loop plant:

$$\ddot{x} + 0.15x\dot{x} + |\dot{x}| + 2x = u$$

Design a cost function for your numerical optimal solution to meet the following closed-loop performance specifications for a unit-step input at time = 0 sec to the closed-loop system:

- a maximum overshoot of < 10%
- a peak time of < 0.6 sec
- a 5% settling time of < 1 sec with zero steady-state error
- a peak input controller effort to the plant of < 120
- a steady-state controller effort to the plant of < 5

You should use Simulink to simulate the closed-loop response using a fixed time step size of 0.01 and the "ode5" integrator solver with a final simulation time of 10 sec for the optimization routine and with the initial conditions set to zero. Also use the following derivative filter for the "D" action control filtering noise due to the "D" action.

$$\boxed{\frac{s}{0.06s+1}} \text{ in place of the "Derivative" block}$$

You must use numerical optimization to solve the problem!

Also make sure to start your unit-step input at time = 0 sec!!!

- What are your final values for your design PID gain?
- What is final value of your cost function?
- What are your final values for your weighting functions Q and R?
- Plot your closed-loop output and control effort responses over a 2 second time period on two separate figure plots.
- Also, plot the open-loop response of only the open-loop plant model for a unit-step input over a 10 second time period. Do not include the PID control of any feedback for your response.

Hint: Try $K_p = K_i = 1$ and $K_D = 0.1$ for your initial guesses of the PID gains.