ECE 68000 Modern Control Theory
Final Project (Fall 2017)

Problem Statement:

Consider the pole-cart system described in Exercises 3.18 and Figure 3.19 of the textbook. You are asked to perform the following tasks:

(1) Derive a nonlinear dynamical model in state-space using the following state variables $x_1 = x,\ x_2 = \dot{x},\quad x_3 = \theta,\ x_4 = \dot{\theta}.$ And the output variable $y = x_1$.
(2) Obtain a linearized system model by linearizing the above system about the operating point $x = 0,\ u = 0$
(3) Analyze the stability of the open-loop system using the Lyapunov stability theory.
(4) Design a linear state feedback control law using the pole placement method assuming the state variables are measurable. Plot the state and control responses for the closed-loop control system with 3 different sets of control gain matrices.
(5) If the state measurements are not available, design a combined state feedback control with state estimator using the Separation Principle. Plot the state and control responses for the closed-loop control system.
(6) Design an optimal state feedback controller using LQR/steady-state LQR design method. In this design, you should try to use different weighting matrices and compare your results. Please show your simulation results by plotting appropriate state and control responses.

Notes:

(1) You can form a team of two to do this project. In this case, you can submit a team report that should contain a section describing the contributions from each team member. You can elect to work on the project independently.
(2) You can choose different physical systems to be controlled if you wish with approval from the instructor.
(3) You can use Matlab/Simulink (whenever appropriate) and other toolboxes available for this project, especially in for Tasks 4-6. You need to show your work in detail for Tasks 1-3.

Requirements for the final report:

A summary report should include the following sections
(1) Problem statement
(2) Summary of the numerical methods and procedures used
(3) Summary of results and discussions including necessary plots of control and state trajectories
(4) Matlab program code and any additional support materials in appendices.

Report due: The final report is due in the last class of the semester.