Homework #4, BioE 2696/ECE 2695 Control Theory in Neuroscience, Spring 2009
(Provided by Prof. Patrick Loughlin)

Problem 1: For the feedback control system shown in Figure 1, specify the range of K for which the system is stable. If the system can not be stabilized, demonstrate why not.

a) $G(s) = \frac{1}{s-1}$ $\quad H(s) = K$

b) $G(s) = \frac{1}{s^2+1}$ $\quad H(s) = K$

c) $G(s) = \frac{1}{s^2-1}$ $\quad H(s) = 1 + Ks$

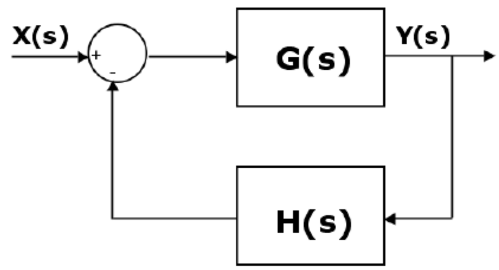

Figure 1: **Feedback model**

Problem 2: Implement the inverted pendulum (InP) model $G(s) = \frac{1}{Js^2 - mgh}$, and controller $H(s) = K_P + K_D s + \frac{K_I}{s}$, in a closed-loop feedback system illustrated below, using Simulink in Matlab. For the InP parameters, use $J = 81.1[Kgm^2]$, $m = 83.3[Kg]$, $h = 0.896[m]$, and $g = 9.8[\frac{m}{s^2}]$. For the controller parameters, implement **a)** proportional-dertivative (PD) control ($K_P = 1065[\frac{Nm}{rad}]$, $K_D = 349[\frac{Nms}{rad}]$, $K_I = 0$), and **b)** proportional-integral-derivative (PID) control (K_P, K_D same as part **a**, $K_I = 126[\frac{Nm}{srad}]$. In each case, first use a step function as the external disturbance to the system then use a sinusoidal disturbance with $f = 0.25[Hz]$. Compare your results between **a** and **b**.

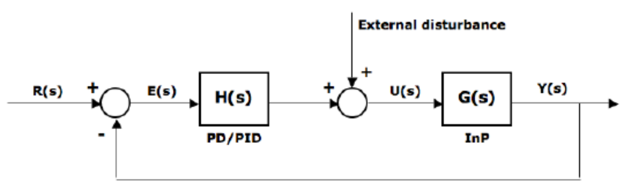

Figure 2: **Closed-loop feedback system**

Problem 3: Include a time delay (TD) in the system and repeat problem 2. Use different delay values, e.g., 100, 150, 200, 250, and 300 millisecond, and observe the system behavior. What is the maximum delay the system can tolerate before becoming unstable?

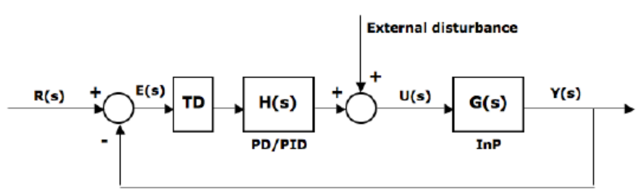

Figure 3: **Closed-loop feedback system with time delay**