HOMEWORK #3
DUE 28-JAN-2016 @ 6PM

1. *Saturating Actuator*: Given the system below, and a compensator that is a proportional gain: K(s) = 20, in a normal feedback configuration, but the actuator saturates at ±1. That is, for any command, |u|≤ 1, you get it, but outside of those bounds, u sits at either +1 or -1 depending. That is:

$$G(s) = \frac{1}{s(s+1)^2}$$

$$u_{act} = \begin{cases} -1 & u_{cmd} \leq -1 \\ u & |u_{cmd}| \leq 1 \\ +1 & u_{cmd} \geq 1 \end{cases}$$

Use root locus techniques to describe the time history of the system, y(t), from a very small initial condition, y(0)=ε. Comment on the "effective gain" of the entire system for both large and small outputs.

2. *Bode Plots*: Sketch the gain and phase Bode plots for the following systems. Draw the asymptotes and indicate the magnitude and phase (approximately) at each of the corner frequencies. You may check you plots in MATLAB, but only **after** having sketched them by hand first.

a. $L(s) = \frac{1}{(s+1)^2(s^2+2s+4)}$

b. $L(s) = \frac{4s(s+10)}{(s+100)(4s^2+5s+4)}$

c. $L(s) = \frac{(s+2)^2}{s^2(s+10)(s^2+6s+25)}$

d. $L(s) = \frac{(s+2)}{s(s+10)}\frac{1}{s^2-1}$

3. *Lead Compensation*: Given the plant below, design a lead compensator, D(s), that has a phase margin, PM ≥ 50° and a bandwidth, ω_{BW} > 20rad/s. Verify your design with MATLAB, and then refine it. (use only a single lead)

$$G(s) = \frac{50000}{s(s + 10)(s + 50)}$$

4. *Lag Compensation*: Given the plant below, design a lag compensator using Bode methods to meet the following specifications:

$$G(s) = \frac{K}{s\left(\frac{s}{5} + 1\right)(s/50 + 1)}$$

    i. Phase Margin, PM ≥ 40°

    ii. Steady state error to a unit ramp (ε_{ss}) < 0.01

Verify and refine your design using MATLAB (that is, first do the design by hand, to the level of asymptotes on the Bode sketches, and solve for your compensator, then redo it with MATLAB and see how much better you can do).