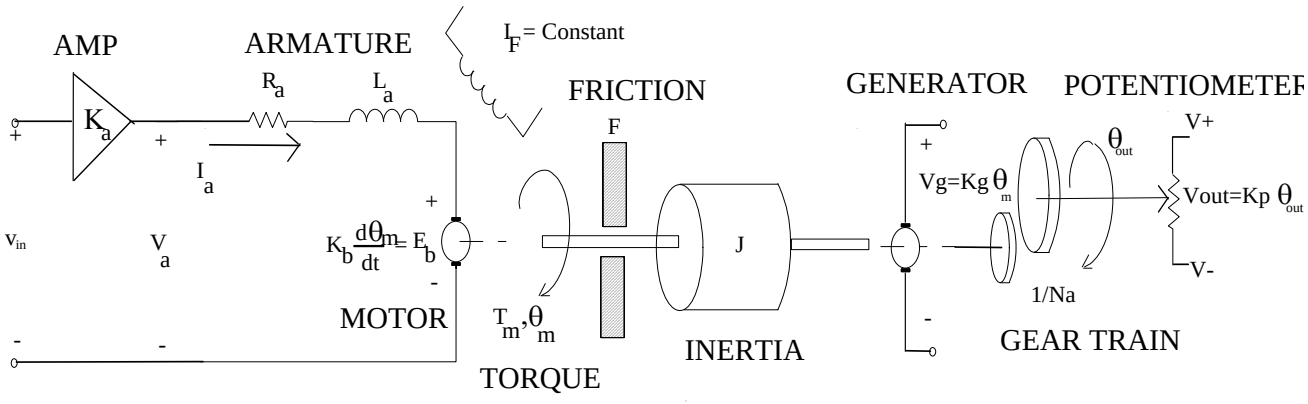
Due Monday, February 25 EE/MFS599 HW#9

Recall the functional block diagram for our Motomatic armature-controlled DC servomotor in our Controls Lab:




Using methods learned in class, we found the open-loop transfer function of the Motomatic to be:

$$\frac{V_{out}}{V_{in}} = \frac{210.9}{s^2 + 5.27s}$$

1. a) Use Matlab's tf2ss() command to find a continuous-time state space representation of the form $\begin{matrix} \dot{x} = Ax + Bw,\ x(0^+) \\ y = Cx + Dw \end{matrix}$ for this system. What are values of n,m, and p (i.e., what are the the number of states, inputs, and outputs, respectively)?
   a) What are the eigenvalues of the open loop system? How do they relate to the poles of the transfer function? (hint: use the eig() command in Matlab)
   b) Looking at the open-loop eigenvalues, would you classify our servo as asymptotically stable, marginally stable, or unstable?
   c) Simulate your open-loop state-space system in Simulink using an initial state of $x(0) = [10\ 0]^T$ (hint: let C be the 2x2 identity matrix so that the output is the state vector, x. You will also have to make D a 2x1 matrix of zeroes). Given your answer to part b), does the output of your simulation make sense?
2.
   a) Find the controllability matrix, M=[B AB $A^2B$ … $A^{n-1}B$] and verify that the system is completely controllable by verifying that the rank of the controllability matrix is n (hint: you can use the ctrb() and rank() commands in Matlab)
   b) If the system is completely controllable, then we can use state feedback to completely specify the eigenvalues of the closed-loop system. Use the place() command in Matlab to find the value of K for the feedback control, w=-Kx, which will set the closed-loop eigenvalues to {-16,-17}
   c) Simulate your closed-loop state-space system in Simulink using an initial state of $x(0) = [10\ 0]^T$ (hint: you will need to connect a 2x1 gain block -K to the output of your Simulink model and feed the output of this block it back to the input )
   d) Do your states decay to zero now?