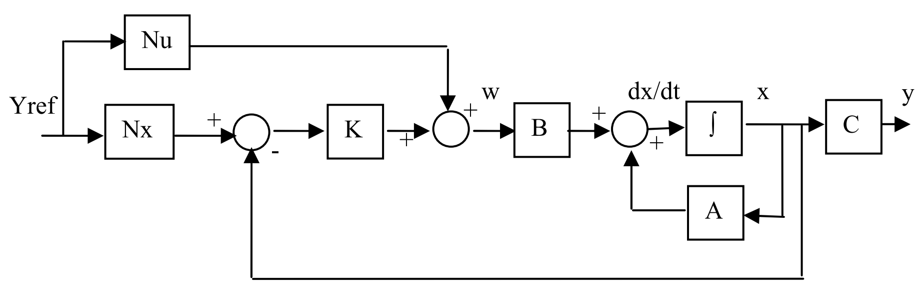
Due Wednesday, February 27 EE/MFS599 HW#10

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. In HW#9, we used Matlab's tf2ss() command to find a continuous-time state space representation of the form $\begin{array}{l}\dot{x} = Ax + Bw,\ x(0^+)\\ y = Cx + Dw\end{array}$ for this system. We also verified that the resulting system was completely controllable. Now, we want to use optimal control theory (LQR), to find an optimal feedback gain, K(∞), for this system.
   a) Use Matlab's lqr() command in the form [K,S,E] = LQR(A,B,Q,R) to find the optimal value of the feed back control, w=-Kx, that will minimize the linear quadratric cost function, $J = \int_0^\infty 1/2x^T Qx + 1/2w^T Rwdt$ using a 2x2 identity matrix for Q and R=1.
   b) What are the closed-loop eigenvalues (E) for your LQR system? Is the closed-loop system stable?
   c) Go back and repeat part a) but this time substitute A+αI for A where α = 16. Now check the eigenvalues of the closed-loop system. Are the real parts less than -16?
   d) Simulate your LQR closed-loop state-space system from part c) using 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)
2. The 'R' in LQR stands for regulator (dRoop). Most industrial control applications require that we track a reference signal, not just regulate (droop). To this end, consider the tracking architecture:



   a) For your servo system state space model, what are the dimensions of yref, Nx, and Nu?
   b) Use the equations given today in class to find the values of yref, Nx, and Nu
   c) Simulate your tracker architecture in Simulink using an initial state of $x(0) = [0\ 0]^T$ and a yref = 5.0 volts. How long does it take $y = x_1$ = Vout to settle within 2% of its final value? What is the overshoot on y?
   d) Now, let yref = r(t) = a unit ramp. Does your tracker follow a ramp? What is the steady-state error for a ramp?