MECH 7710 Due: 4/30/20

MECH 7710 Homework Assignment #4

(LQG Regulation)

Please limit the number of plots. You can simply state the answer. Show the "important" plots to demonstrate your estimator or controller is working. Simulate the systems for about 5-10 time constants (which will depend on you controller). This will allow you to see the transient response of your controller as well has it behavior at steady state with the disturbances acting on it.

1. Lets consider a simple $1/s^2$ plant (i.e. a frictionless cart with m=10 kg). We are going to create an LQG (linear quadratic guassian) compensator which is simply a Kalman filter combined with a LQR controller. Lets say we can measure position (σ=0.1 m). The process disturbance on the system is a Force with statistics ~ N(0,1.0]).
   a) Simulate the system with an LQR controller (select $R_{xx}=C^TC$ – i.e. place the roots on the symmetric root locus) and a Kalman Filter. Start the System from rest 10 m away from the regulated position (0 m).
   b) Where are the poles of your estimator? Where are the poles of your controller? Calculate the equivalent combined compensator and comment on what it looks like. What is the effect of changing R_{uu} (look at control effort, position error, time response, etc.)
   c) Change R_{uu} to move the poles outside of the Kalman Filter poles. Repeat parts (a) and (b). What affect does this have on your response. How much controller authority do you use?
   d) Now let $R_{xx}=I$. Repeat parts (a) and (b) What is the affect of increasing diagonal term of R_{xx} associated with the second state (i.e. $R_{xx}[2,2]$ - look at the poles and control response). Does this make intuitive sense?

2. Lets consider the same system as in problem #1, but with position and velocity measurements. The velocity sensor noise is given as σ=0.03 m/sec and the position measurement remains σ=0.1. The process disturbance on the system is again a Force with statistics ~ N(0,1.0). Notice that we now use the velocity measurement as a "sensor" as opposed to an "input" as we did in problem #3 on HW #6. This is because for full state feedback we must estimate velocity – therefore velocity is now a state.

   a) Simulate the system with an LQR controller and a Kalman Filter. Start the System from rest 10 m away from the regulated position (0 m). How has the velocity sensor affected our compensator and estimator. Do we get better performance.