MeEn 595R – Autonomous Systems
Homework #1

You are to design a Kalman filter to estimate the states of an autonomous underwater vehicle (AUV) moving forward through the water along its longitudinal axis. The dynamics of the AUV are described by the equations of motion

$$m\dot{v} + bv = F(t)$$
$$\dot{x} = v$$

where v is the velocity of the vehicle, x is its position, and F is an applied thrust from the drive propeller. The vehicle has a mass (m) of 100 kg and a linear drag coefficient (b) of 20 N-s/m. You are to simulate the motion of the UUV for 50 s with an input thrust profile given by

$$F(t) = \begin{cases} 50\ \text{N} & 0 \le t < 5 \\ -50\ \text{N} & 25 \le t < 30 \\ 0\ \text{N} & \text{otherwise} \end{cases}$$

You have a measurement of the UUV position having a noise covariance of 0.001 m^2. The process noise covariance associated with the velocity state is 0.01 m^2/s^2, while the process noise covariance associated with the position state 0.0001 m^2. You are to implement your Kalman filter with a sample period of 0.05 s.

Create the following plots:

- Position and velocity states and state estimates versus time.
- Estimation error and error covariance versus time.
- Kalman gains versus time.

Exercise your system. Try inputs of different magnitudes and types. Change the process and measurement noise characteristics. Provide poor initial condition guesses for your state estimates – note the error dynamics that result.

Some questions to consider:

- Does your estimator work as expected?
- How does the covariance change between the prediction and measurement update?
- Do your gains have any interesting transient characteristics? How does increasing the measurement noise affect your Kalman gains? Decreasing the measurement noise?

Some hints:

- You'll need to express the equations of motion in state-space form.
- For a linear system, the easiest approach is to implement your equations of motion as discrete-time difference equations (as done in your book). You can use the c2d command in Matlab to convert your equations of motion from continuous to discrete-time.