ECE-521 Control Systems II
Homework 6

Due Date: Tuesday May 11

Note: For any problem you use Matlab and/or Simulink on, I want you to turn in your Simulink model and the Matlab driver.

[1] For the system with model

$$\begin{aligned} \dot{\underline{x}}(t) &= \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -24 & -10 \end{bmatrix} \underline{x}(t) + \begin{bmatrix} 0 \\ 10 \\ -80 \end{bmatrix} u(t) \\ y(t) &= [1\ 0\ 0]\, \underline{x}(t) \end{aligned}$$

and state variable (observer) feedback form

$$u(t) = Fr(t) - K\tilde{\underline{x}}(t)$$

Using the Simulink model that implements a full order observer from last week,

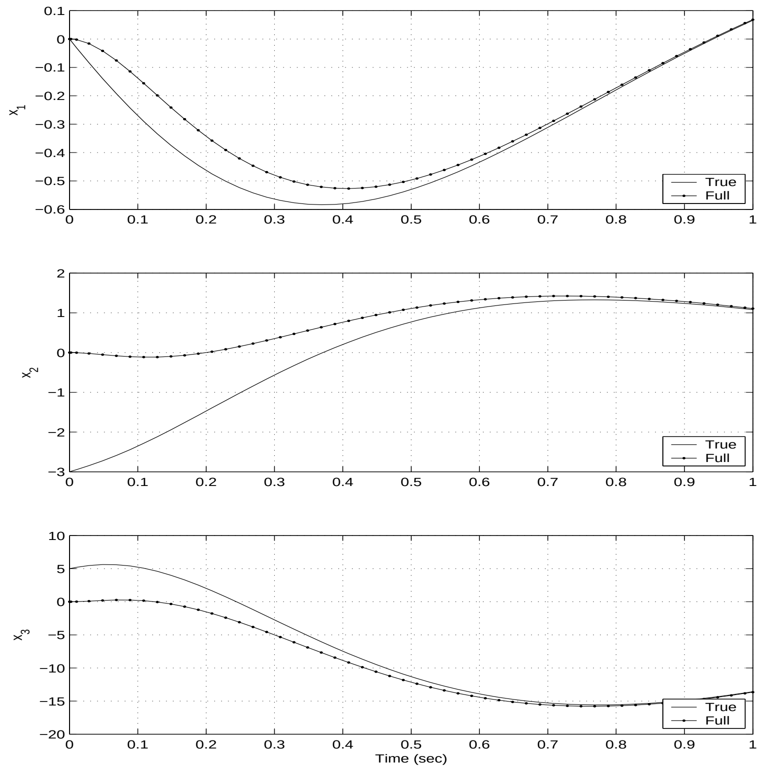
- place the closed loop (state feedback) poles at $-1 \pm 2j$ and -5.
- place the observer poles at $[-10\ \ -10\ \ -5]$
- assume $\hat{\underline{x}}(0) = \underline{0}$ and $\underline{x}(0) = [0\ \ -3\ 5]^T$

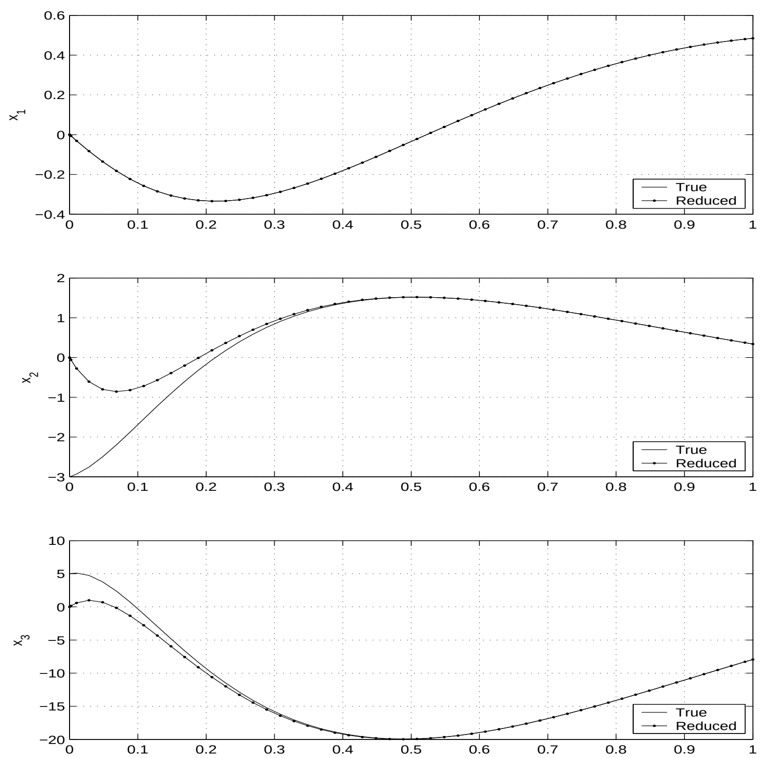
Run the simulation for 4 seconds, with no input (only the initial conditions) and plot the true and estimated states on one plot. Use **subplot** and plot measured and estimated x_1 on one plot, measured and estimated x_2 on a second plot, etc. Be sure to use different line types and a legend.

[2] Now implement a minimum order observer in Simulink, as is done in Figure 12-17, for this system. Place both observer poles at -10. Run the simulation (no input, only initial conditions) for 1 second and plot

- the true state for the system with the full order observer and the state estimated from the full order observer on one page (three graphs, one for each state)
- the true state for the system with the reduced order observer and the states estimated from the reduced order observer on one page (three graphs)

You should note that the "true" states for the two systems are different, since the estimates of the states are different, so the feedback is different, etc. Your results should look like the following:

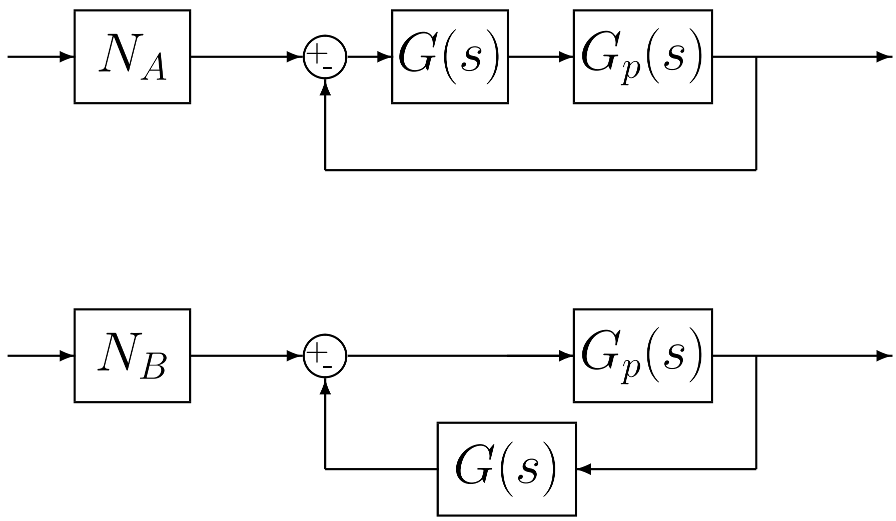




3 You should see that the reduced order observer seems to converge much more quickly than the full order observer. This is because one of the poles of the full order observer is at -5, making this the dominant pole. Move this pole farther away and rerun the simulation to convince yourself the two systems behave identically when the dominant observer poles are the same.

Turn in your two graphs.

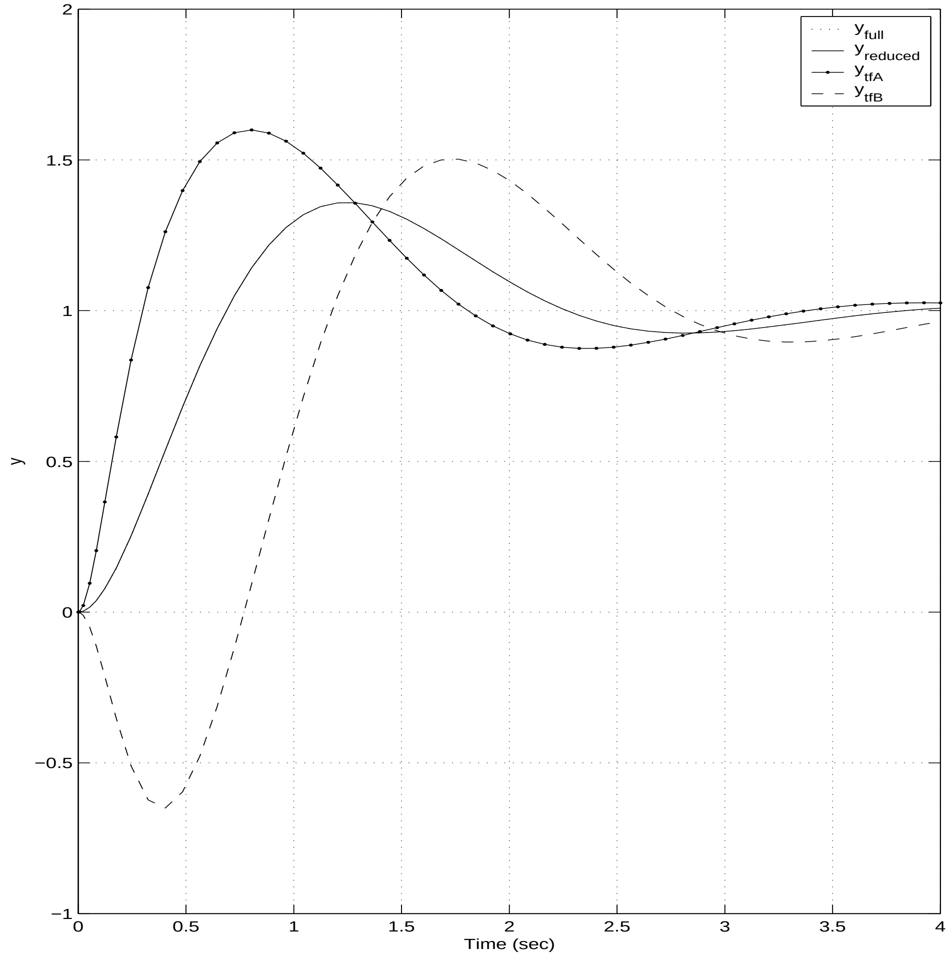
4 Add Simulink models for both configuration A and configuration B for the minimum order observer-controller transfer function model to your existing model, as shown below:



Here $G(s)$ is the transfer function of the observer controller (See Program 12-12 in the text for using Matlab to compute $G(s)$) and $G_p(s)$ is the plant. From previous homework problems we have

$$
\begin{aligned}
N_A &= 1 + \frac{1}{G_p(0)G(0)} \\
N_B &= G(0) + \frac{1}{G_p(0)}
\end{aligned}
$$

Set all initial conditions to zero, and simulate the systems with a step input for 4 seconds If the dominant poles of the full order observer are the same as those of the reduced order observer, you should get results similar to the following:



y_full
y_reduced
y_tfA
y_tfB
2
1.5
1
0.5
0
−0.5
−1
y
0
0.5
1
1.5
2
2.5
3
3.5
4
Time (sec)