Problems

0.1. Use the disturbance observer-based approach to design and implement a PI controller for the following systems:

$$
\begin{aligned}
G(s) &= \frac{e^{-0.01s}}{(s+1)(s+10)} \\
G(s) &= \frac{2e^{-0.5s}}{(s+0.1)(s+10)^2} \\
G(s) &= \frac{0.5e^{-2s}}{(s+0.01)(s+1)^3}
\end{aligned}
$$

1. Find the approximate first order model $G_A(s) = \frac{b}{s+a}$ by neglecting the relatively small time constant(s) and small time delay while maintaining the same steady-state gain.
2. Choose the desired closed-loop pole for the proportional controller K_1 as $-2a$ where a is the dominant pole for the system while the pole for the estimator is $-3a$ to obtain the estimator gain K_2.
3. Build the MATLAB real-time function PIEstim.slx by following the tutorial in the book and simulate the closed-loop step response and input disturbance rejection. We choose sampling interval $\Delta t = 0.001$ and set the constraints on the control amplitude to be sufficiently large. A unit step reference signal is used in the simulation studies where a step input disturbance with amplitude of -1 enters the simulation at half of the simulation time.
4. Evaluate the effect of constraints on the control signal where the constraint parameters u^{max} and u^{min} are chosen to be 85 percent of the control signal's maximum amplitude from the previous step.
5. What are your observations from the constrained control simulations?

0.2. Use the disturbance observer-based approach to design a PID controller for the following systems:

$$
\begin{aligned}
G(s) &= \frac{2e^{-0.01s}}{(s-1)(s+1)} \\
G(s) &= \frac{3}{s^2} \\
G(s) &= \frac{1}{s^2+0.1s+3}
\end{aligned}
$$

1. Choose the desired closed-loop characteristic polynomial for the proportional plus derivative controller as $s^2 + 2\xi w_n s + w_n^2$ where $\xi = 0.707$ and $w_n = 3$, while the pole for the estimator is -4 to obtain the estimator gain K_3.

2. Build the MATLAB real-time function PIDEstim.slx by following Tutorial in the book and simulate the closed-loop step response and input disturbance rejection with the sampling interval $\Delta t = 0.001$ where the constraints on the control amplitude are set to be sufficiently large. In the simulations, the derivative filter time constant $\tau_f = 0.1\tau_D$. The reference signal is a unit step signal and the input disturbance signal has amplitude of -2 that enters the simulation at half of the simulation time.
3. Evaluate the effect of constraints on the control signal where the constraint parameters u^{max} and u^{min} are chosen to be 85 percent of the control signal's maximum amplitude from the previous step.
4. What are your observations from the constrained control simulations?