CL 686 : Advanced Process Control
Nonlinear System 1 (Group A): Computing Assignment 3

- **File containing continuous time linear perturbation model:**

  System1_ Continuous_ LinMod.mat

- **Problem :** Simulate closed loop servo and regulatory control behavior for state feedback control

  - Plant simulation using nonlinear dynamic equations. Plant Initial Condition

$$\mathbf{X}(0) = \mathbf{X}_s + \begin{bmatrix} 0.005 & 2 & -2 \end{bmatrix}^T$$

  - Luenberger Observer Initial Condition:

$$\widehat{\mathbf{x}}(0) = \begin{bmatrix} 0 & 0 & 0 \end{bmatrix}^T$$

  - *Simulation Time:* $t_f = 25$, $T = 0.1$ and $N_s = 250$
  - *Control Problem:Servo followed by regulatory*

$$\begin{aligned} \mathbf{r}(k) &= \begin{bmatrix} 0 & 0 \end{bmatrix}^T \text{ for } t < 6 \text{ and for } t \geq 12 \\ \mathbf{r}(k) &= \begin{bmatrix} -5 & 0 \end{bmatrix}^T \text{ for } 6 \leq t < 12 \\ d(k) &= 0 \text{ for } t < 18 \\ d(k) &= 0.1 \text{ for } t \geq 18 \end{aligned}$$

  - *Input Constraints*

$$\mathbf{U}_L = \begin{bmatrix} 0 & 0 \end{bmatrix}^T \quad \text{and} \quad \mathbf{U}_H = \begin{bmatrix} 250 & 60 \end{bmatrix}^T$$

- **Controller: Discrete time state feedback control law designed using pole placement method**

  Let **M = sum of digits in your roll number**.

  - **Case M is even number:** Use **Innovation Bias Approach** for controller synthesis (ref. lecture notes for algorithm)

$$\begin{aligned} \text{Controller poles} &\equiv \begin{bmatrix} 0.7 & 0.4 & 0.2 \end{bmatrix}^T \\ \text{Observer poles} &\equiv \begin{bmatrix} 0.3 & 0.4 & 0.5 \end{bmatrix}^T \\ \text{Innovation Filter } (\alpha) &= 0.8 \end{aligned}$$

  - **Case M is odd number:** Use **State Augmentation (Input Bias) Approach** for controller synthesis (ref. lecture notes for algorithm)

$$\begin{aligned} \text{Controller poles} &\equiv \begin{bmatrix} 0.7 & 0.4 & 0.2 \end{bmatrix}^T \\ \text{Observer poles} &\equiv \begin{bmatrix} 0.3 & 0.4 & 0.45 & 0.5 & 0.6 \end{bmatrix}^T \end{aligned}$$

  Use *place* command in Matlab Control System Toolbox to design pole placement controller and observer.

- Plot results
  - $\mathbf{Y}(k)$ v/s k and $\mathbf{R}(k)$ v/s k in same figure where
  - $\mathbf{U}(k)$ v/s k using stairs function
  - $\mathbf{D}(k)$ v/s k using stairs function
  - State estimation error plots: $(\mathbf{X}(k) - \widehat{\mathbf{X}}(k))$ v/s k
  - Innovation plot: $\mathbf{e}(k)$ v/s k
  - $\mathbf{x}_s(k)$ v/s k
  - $\mathbf{u}_s(k)$ v/s k