Chapter 5
MATLAB Toolboxes

Exercise 1 – Control Design

Task:

i. Given the state-space system dynamics:

$$\frac{dx(t)}{dt} = Ax(t) + Bu(t)$$

$$y(t) = Cx(t) + Du(t)$$

where, $x \in \mathbb{R}^2$ is the state vector, $u \in \mathbb{R}$ is the scalar input, $y \in \mathbb{R}^2$ is the output vector.

$$A = \begin{bmatrix} 0 & 1 \\ 2 & 3 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, D = \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

ii. Under state feedback, the controller needs to be designed for the desired commanded/ reference signals $r = \begin{bmatrix} x_1^* \\ x_2^* \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$.

iii. The above differential equation is integrated using the Euler's method, with a step size of $\Delta t = 0.001\ second$.

iv. The initial conditions are given by $\begin{bmatrix} x_{1_0} \\ x_{2_0} \end{bmatrix} = \begin{bmatrix} 1 \\ -3 \end{bmatrix}$.

Steps to do:

a) Design the controller u using the Pole-Placement method (using the **`place`** function), where the desired pole location is at (-3, -5).

b) Plot the states and control responses against time.

c) Show the pole locations using the **`pzmap`** function.

Exercise 2 – Optimization Design

Task:

Minimize the function using the **Interior-point-convex** `quadprog` algorithm:

$$f(x) = \frac{1}{2}x_1^2 + 2x_2^2 - 2x_1x_2 - 3x_1 - 5x_2$$

such that

$$\begin{aligned} x_1 + 3x_2 &\leq 5 \\ -2x_1 + 7x_2 &\leq 9 \\ x_1 + 2x_2 &\leq 4 \\ 0 \leq x_1,\ 0 &\leq x_2 \end{aligned}$$

Steps to do:

a) In 1st case, perform the above minimization by writing the **MATLAB code and functions**.

b) In 2nd case, perform the above minimization by the **Optimization app**.

Exercise 3 – Statistics

Task:

Create Intelligence Quotient (IQ) Object using Normal Distribution with μ (mean) equal to 130 and σ (standard deviation) equal to 15 for IQ range $87 \leq IQ \leq 185$

Questions:

i. Plot pdf and cdf for IQ above using normal distribution.
ii. What is the probability that people have an IQ between 160 and 180.

Assume that people with IQ below than 96 and over than 165 have already passed away, so their IQ are no longer used for analysis:

iii. Plot and compare pdf for Normalized IQ before and the new IQ distribution.
iv. What is now the probability that a person has an IQ between 160 and 180?

Steps to do:

1. Make normalized distribution objects.
2. Define the probability.
3. Truncate the distribution objects.
4. Plot two difference distribution in one figure.