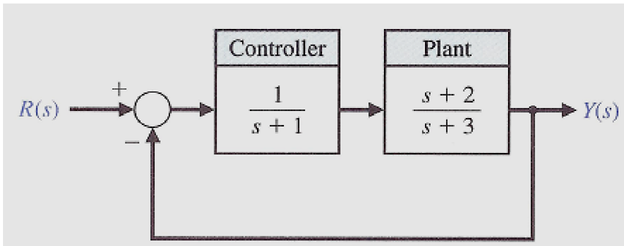
Modern Control Systems   ELG 4157 / SYS 5100

MATLAB Assignment 1

Q1) Consider the unity feedback control system depicted in the figure:



(a) Compute the closed-loop transfer function using the **series** and **feedback** functions.

(b) Obtain the closed-loop system unit step response using the **step** function and verify that the final value of the output is 2/5.

Q2) (a) Using the **ss** function determine a state variable representation for each of the following two transfer functions without state feedback:

$$G(s) = \frac{3s^2 + 10s + 1}{s^2 + 8s + 5}$$

$$G(s) = \frac{s + 14}{s^3 + 3s^2 + 3s + 1}$$

(b) Consider the system in its state space representation:

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -2 & -5 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u,$$

$$y = [1 \quad 0 \quad 0]\mathbf{x}.$$

Use the **tf** function, determine the transfer function of the system, then use **lism** and **plot** functions to plot the system response to the initial condition:

$$\mathbf{x}(0) = [0 \quad -1 \quad 1]^T \text{ for } 0 \le t \le 10.$$

Compute also the state transition matrix using **expm** function and determine:

$$\mathbf{x}(t) \text{ at } t = 10$$

for the same initial condition above. Compare the result with the obtained system response.

Q3) Use **ctrb** and **obsv** functions to determine if the two systems are controllable and observable:

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 \\ -2 & -4.5 \end{bmatrix}\mathbf{x} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}u,$$

$$y = [1 \quad 0]\mathbf{x}.$$

$$\dot{\mathbf{x}} = \begin{bmatrix} -1 & 1 & 0 \\ 4 & 0 & -3 \\ -6 & 8 & 10 \end{bmatrix}\mathbf{x} + \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}u,$$

$$y = [1 \quad 2 \quad 1]\mathbf{x}.$$

Q4) Consider the second order system:

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 \\ -1 & 2 \end{bmatrix}\mathbf{x} + \begin{bmatrix} 1 \\ 1 \end{bmatrix}u,$$

$$y = [1 \quad -1]\mathbf{x}$$

Use **acker** function to find a state feedback gain matrix **K** so that the closed-loop poles are placed at:

$$s_1 = -1 \quad \text{and} \quad s_2 = -2.$$

Q5) Consider the third order system:

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -4.3 & -1.7 & -6.7 \end{bmatrix}\mathbf{x} + \begin{bmatrix} 0 \\ 0 \\ 0.35 \end{bmatrix}u$$

$$y = [0 \quad 1 \quad 0]\mathbf{x} + [0]u.$$

Use **acker** function to design a state feedback compensator matrix **K** and a state observer matrix **L** to place the closed-loop system poles at:

$$s_{1,2} = -1.4 \pm 1.4j,\ s_3 = -2$$

and the observer poles at:

$$s_{1,2} = -18 \pm 5j,\ s_3 = -20$$

Then obtain the overall closed-loop system response using **initial** and **plot** functions. Use zero initial values.