Registration No : | | | | | | | | | | |

Total Number of Pages : 04 **B.Tech.**

PEL7J001

7th Semester Regular Examination 2018-19

CONTROL SYSTEM ENGINEERING-II

BRANCH : EEE

Time : 3 Hours

Max Marks : 100

Q.CODE : E045

Answer Question No.1 (Part-1) which is compulsory, any EIGHT from Part-II and any TWO from Part-III.

The figures in the right hand margin indicate marks.

Part- I

Q1 **Short Answer Type Questions (Answer All-10)** **(2 x 10)**

a) Define sampling. How is a digital sequence different from sampled sequence?

b) Represent a sampled data control system with block diagram and explain each block briefly.

c) Given Z[x(k)]= X(z) find the Z-transform of :

i) $y(k) = \sum_{j=0} x(j)$

ii) $y(k) = e^{-ak}x(k)$

d) Find the inverse Z-transform of :

i) $\frac{z}{z+a}$

ii) $\frac{z^{-1}}{(1-az^{-1})^2}$

e) Why is z-transform is necessary to deal with digital signal?

f) Why convolution sum and convolution integral are considered equivalent?

g) How do you define impulse response function in digital domain?

h) What is zero order hold for digital system?

i) How non linearities in control system classified? Explain each class with example.

j) Explain dead zone and backlash.

Part- II

Q2 **Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)** **(6 x 8)**

a) The input-output of sampled data-data system is described by the difference equation

$$c(n+2) + 3c(n+1) + 4cn = r(n+1) - r(n)$$

Determine the Z-transfer function. Also obtain the weighted sequence.

b) Consider a transfer function in the s-domain

$$G_p(s) = \frac{20}{s+10}$$

i) Obtain an equivalent discrete transfer function with ZOH.

ii) Map discrete transfer function to the w plane.

iii) Compare the transfer function in the s plane and w plane.

c) Explain the spectrum analysis of sampling process to justify Shanon's sampling theorem.

d) Check if all the roots of the characteristic equation lie within the unit circle.

i) $5z^2 - 2z + 2 = 0$

ii) $z^3 - 0.2z^2 - 0.25z + 0.05 = 0$

e) A feedback system is characterized by the closed loop transfer function

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

Draw a suitable signal flow graph and therefrom construct a state model of the system.

f) Consider the following matrix that represents a plant of the system that has two state variables. The initial conditions are [1, -2].

$$\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} x(t) ; y = [-1 \quad -2] x(t)$$

i) Determine the eigen values, and using Cayley-Hamilton's theorem compute the state transition matrix of the continuous system.
ii) Determine the output of part(i) when t = 1 s.
iii) Obtain a discrete time version of the given system, and determine its state transition matrix in terms of sampling time, using linear terms only.

g) Consider a nonlinear system described by the equation

$$\dot{x}_1 = x_2$$
$$\dot{x}_2 = -(1 - / x_1 /) x_2 - x_1$$

Find the region in the state plane for which the equilibrium state of the system is asymptotically stable using Lyupunov function.

h) For the following closed-loop transfer function

$$\frac{Y(z)}{U(z)} = \frac{4(z^2 + 0.2z + 0.5)}{z^4 - 2.4z^3 + 2.09z^2 - 0.774z + 0.1008}$$

i) Obtain the phase variable representation.
ii) Obtain the controller canonical representation.
iii) Obtain the observer canonical representation

i) Consider the following state-space representation of a SISO system :

$$\begin{Bmatrix} x_1(k+1) \\ x_2(k+1) \end{Bmatrix} = \begin{bmatrix} -1.2 & -0.32 \\ 1 & 0 \end{bmatrix} \begin{Bmatrix} x_1(k) \\ x_2(k) \end{Bmatrix} + \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} u(k)$$

$$y(k) = [1 \quad 1] \begin{Bmatrix} x_1(k) \\ x_2(k) \end{Bmatrix}$$

i) Determine the steady state error.
ii) Determine the closed loop transfer function of the above system and from it obtain the corresponding forward transfer function of a unity feedback system.

j) For the following closed-loop transfer function

$$\frac{Y(z)}{U(z)} = \frac{(z + 1)}{z^2 + 1.2\, z + 0.35}$$

i) Obtain the controller canonical representation.
ii) Compute the closed loop poles.
iii) If the closed loop poles will have to be changed to -0.6 and -0.8, determine the gain of the controller.

k) A linear second order servo described by the equation

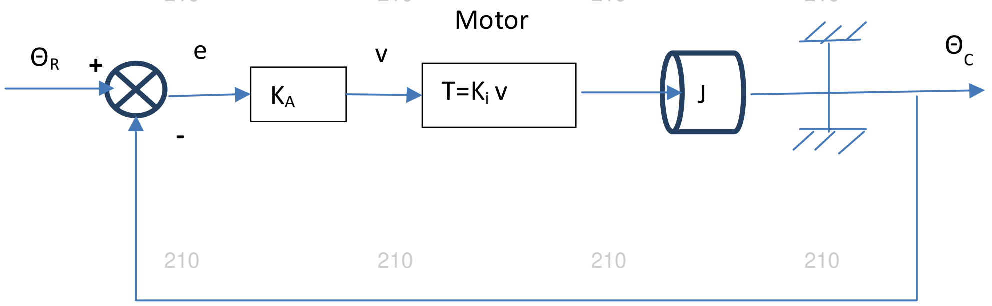
$$\ddot{e} + 2\varepsilon\, \omega_n \dot{e} + {\omega_n}^2 e = 0$$

Where $\varepsilon = 0.15, \omega_n = 1, e(0) = 1.5, \dot{e}(0) = 0$

Determine the singular points. Construct the phase trajectory using the method of the isoclines.

I) The position control system as shown in figure has coulomb friction C at the output shaft. Plot the phase trajectory for a unit step inputr and zero initial conditions. Calculate and plot the time response of the error and find the value of the steady state error.

Given $\sqrt{(K/J)}$ =1.2 rad/sec, $(C/K) = 0.3\ rad$ where K= K_A K_1



Part-III

Long Answer Type Questions (Answer Any Two out of Four)

Q3 Consider the following state-space equation $\begin{Bmatrix}\dot{x}_1\\ \dot{x}_2\end{Bmatrix} = \begin{bmatrix}-2 & -1\\ 2 & -5\end{bmatrix}\begin{Bmatrix}x_1\\ x_2\end{Bmatrix};$ **(16)**

$$y = [-1 \quad -2]$$

With initial conditions :

$$\begin{Bmatrix}x_1(0)\\ x_2(0)\end{Bmatrix} = X(0) = \begin{Bmatrix}1\\ 0\end{Bmatrix}$$

a) Determine the Eigenvalue, and use Cayley-Hamilton's theorem to compute the state transition matrix of the continuous system.

b) Determine the output of part (a) at t= 1 s.

c) Obtain a discrete-time version of the given system and determine its state transition matrix in terms of sampling time, using linear terms only.

d) Determine the output of the discrete system at t=1 s by using a sampling period of 0.1 s.

Q4 Consider the following open-loop transfer function of a unity feedback digital control system: **(16)**

$$G(z) = \frac{K(z+1)}{(z-1)(z-0.4)}$$

Draw a root-locus plot of this system with T= 0.1. Determine the value of K for marginal stability and its value for obtaining a maximum percentage overshoot of 20% due to step input.

Q5 Consider the following state-space system : **(16)**

$$\begin{Bmatrix}x_1(k+1)\\ x_2(k+1)\end{Bmatrix} = \begin{bmatrix}-1.2 & -0.35\\ 1 & 0\end{bmatrix}\begin{Bmatrix}x_1(k)\\ x_2(k)\end{Bmatrix} + \begin{Bmatrix}1\\ 1\end{Bmatrix} u(k)$$

$$y(k) = [1 \quad 0]\begin{Bmatrix}x_1(k)\\ x_2(k)\end{Bmatrix}$$

a) Design a controller so that the closed loop poles are -0.6 and -0.8.

b) Design a state estimator that is four time faster than the plant with controller.

c) Draw a block diagram showing details of the controller and stare estimator.

Q6 An instrument servo system used for positioning a load may be adequately represented by Figure 1 and the backlash characteristic is given by Figure 2. **(16)**

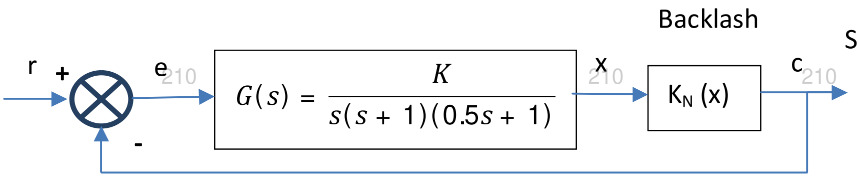


Figure 1

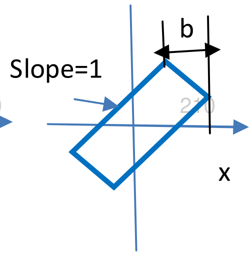


Figure 2

a) Using the db gain phase analysis show that the system is stable for K=1.

b) If the value of K is raised to 5, show that limit cycle exits.

c) Investigate the stability of these limit cycles and determine their frequency and b/X.

Given :

b/X	0	0.2	0.4	1	1.4	1.6	1.8	1.9	2.0
$\lvert \boldsymbol{K_N(X)} \rvert$	1	0.954	0.882	0.592	0.367	0.248	0.125	0.064	0
$< \boldsymbol{K_N(X)}$	0	-6.7^0	-13.4^0	-32.5^0	-46.6^0	-55.2^0	-66^0	-69.8^0	-90^0