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

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B.Tech
PEL7J001

7th Semester Regular / Back Examination 2019-20
CONTROL SYSTEM ENGINEERING - II
BRANCH : EEE
Max Marks : 100
Time : 3 Hours
Q.CODE : HRB030

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

a) Why a zero-order hold device is used instead of a first-order hold for data extrapolation?
b) Prove that the eigen values remain invariant under linear transformation.
c) Define output controllability and state controllability?
d) Describe different peculiar phenomena in a nonlinear system.
e) Define state observer in brief?
f) For a scalar function, define positive definiteness, negative semi-definiteness and indefiniteness.
g) $\ddot{x} + 3x + 0.6\dot{x} + x^2$=0.Comment the stability of the singular point?
h) Find the z-transform of $z[1(t-4T)]$
i) What is hump resonance?
j) Show the difference between continuous-time analog signal and the continuous-time quantized signal. Is there any difference between sampled signal and quantized signal?

Part- II

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

a) Consider a discreet time system described by $y(K+2) + 0.25y(K+1) - 0.125y(K) = 3r(K+1) - r(K)$. The system is initially relaxed (y(k)=0,K<0) is excited by the input $r(K) = (-1^K)U(K)$. Obtain the transfer function and find out y(k).
b) Solve the difference equation using Z- transformer method: C(k+2)+3C(k+1)+2C(k)=U(k). C(0)=1, C(k)=0, where K<0.
c) For discrete time system with T=0.1s the characteristics equation is given by $(Z-0.99)(Z^2-05Z+1)) = 0$. Show that the system is marginally stable and find the frequency at which the system is oscillate?
d) A control system is found to be Un-controllable. Discuss the conditions how it can be made controllable?
e) Draw the phase portrait of the system described by $x = -\dot{x} + x^3$. Comment the stability of the singular point?
f) A control system is described by $\ddot{x} + f(\dot{x}) + g(x) = 0$. Suggest and illustrate a suitable method of construction of Phase Trajectory. What do you understand by singular points in case of Nonlinear systems?
g) Draw the phase trajectory of a system described by $\dddot{x} + \ddot{x} + x = 0$, Given the initial condition $x_0 = +\sqrt{2}, y_0 = 0$.
h) Investigate the stability of the system is described by : $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ -1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$. Use Lyapunov's method of stability. You may take a Lyapunov function $V(x) = x_1^2 + x_2^2$.
i)
$$\dot{x}_1 = x_2$$
$$\dot{x}_2 = -x_1^3 - x_2$$
Prove that system is globally asymptotically stable using Lyapunov function $V(x) = \alpha x_1^4 + \beta x_1^2 + x_1 x_2 + x_2^2$. What is the values of α and β.

j) For a system having the describing function given by N=0.99$X_m^{-1} < -35$ where X_m is the peak value of the sinusoidal function determine the amplitude and frequency of the limit cycle.

k) Find inverse Z-transform of X(z)=$\frac{Z(z+1)}{(z-1)^3}$, X(z) = $\frac{z^2}{(z-1)^2(z-e^{-aT})}$

l) Determine the state feedback gain matrix K of the system :$\dot{X} = AX + Bu$; $y = Cx$, where $A = \begin{pmatrix} 0 & 1 \\ 20.6 & 0 \end{pmatrix}$, $B = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$, $C = [1 \quad 0]$, such that the closed-loop poles are at $-1.8 \pm j2.4$.

Part-III

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

Q3 a) For the following system determine the equilibrium point & discuss the stability of each equilibrium using Lyapunov's (indirect) linearization method **(8)**

$$\dot{x}_1 = x_1(1 - x_1) - \frac{1}{2}x_1x_2$$
$$\dot{x}_2 = x_2(1 - x_2) + \frac{1}{2}x_1x_2$$

Clarify each equilibrium point (node, saddle etc.) and use the results to sketch the flow of trajectories in the (x_1, x_2) plane.

b) Using Laplace transforms method, obtain STM for $A = \begin{pmatrix} 0 & 1 \\ -20 & -9 \end{pmatrix}$. **(8)**

Q4 Design the state feedback controller for the following system and derive the parameters k_1, k_2 and k_3, which set the system poles to -8.0 and -12± $4i$ **(16)**

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} 0 & 4 & 0 \\ -3 & 0 & 2 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u$$
$$y = [1 \quad 0 \quad 0] \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix}$$

Show that the above system is reachable. Is it also observable?

Q5 For a unity feedback system, the discrete time transfer function $G(z) = \frac{K(Z+0.9)}{(Z-1)(Z-07)}$. Find the value of K for the stability using (i) Bilinear transformation and (ii) Jury's stability test? **(16)**

Q6 The continuous time state-space representation of a two tank system is : **(16)**

$$\frac{dx(t)}{dt} = \begin{bmatrix} -0.0197 & 0 \\ 0.0178 & -0.0129 \end{bmatrix} x(t) + \begin{bmatrix} 0.0263 \\ 0 \end{bmatrix} u(t)$$
$$y = [0 \quad 1]x(t)$$

a) Sample the system with the sampling period $T = 12$.

b) Verify that the pulse transfer operator for the system is :

$$H(q) = \frac{0.030q + 0.026}{q^2 - 1.65q + 0.68}$$