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Paper Code : EE-601

CONTROL SYSTEM - II

Time Allotted : 3 Hours | *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for and any *ten* of the following : $10 \times 1 = 10$

   i) If the trajectories of a non-linear system are eventually trapped into the closed curve, then it can be concluded that

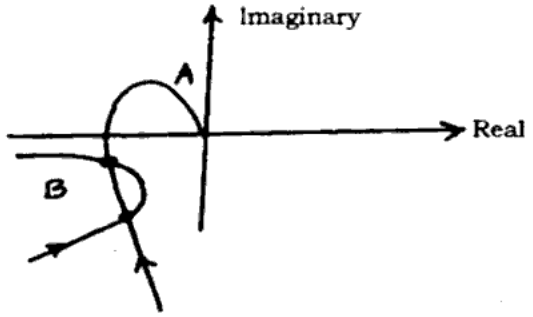
   a) a stable steady-state oscillation will never be attained

   b) a stable state oscillation results with the voltage oscillating with fixed amplitude

   c) asymptotic stability has been attained

   d) the system is unstable.

ii) In the figure below :



a) *A* and *B* have stable limit cycle.

b) *A* has stable limit cycle & *B* has unstable limit cycle.

c) *A* has unstable limit cycle and *B* has stable limit cycle.

d) None of these are true.

iii) The state and output equations of a system are as under

$$\begin{bmatrix} x_1 & (t) \\ x_2 & (t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} x_1 & (t) \\ x_2 & (t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u\,(t)$$

output equation $c\,(t) = [\,1 \quad 1\,] \begin{bmatrix} x_1 & (t) \\ x_2 & (t) \end{bmatrix}$.

The system is

a) neither state controllable nor output controllable

b) state controllable but not output controllable

c) output controllable but not state controllable

d) both state & output controllable.

iv) In a discrete time system, the stability is found by

a) Lyapunov function

b) Routh-Hurwitz criterion

c) Jury's stability criteria

d) model reduction criteria.

v) $V(x, y) = 25(x - y)^2$, this function is

a) positive definite

b) negative definite

c) positive semi-definite

d) negative semi-definite.

vi) A system is described by the state equation

$\dot{X} = AX + BV$. The output being $Y = CX$ where

$A = \begin{bmatrix} -4 & -1 \\ 3 & -1 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$, $C = [\,1 \quad 0\,]$. The transfer function $G(S)$ of the system is

a) $\dfrac{s}{s^2 + 5s + 7}$ b) $\dfrac{1}{s^2 + 5s + 7}$

c) $\dfrac{s}{s^2 + 3s + 2}$ d) $\dfrac{1}{s^2 + 3s + 2}$.

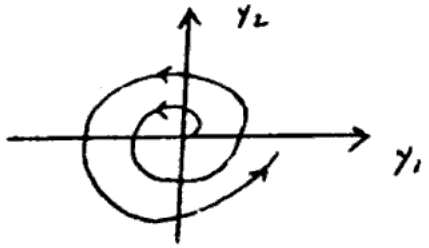
vii) For a system described by

$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, the eigenvalues are

a) $-1, -2$ b) $0, 3$

c) $1, -2$ d) $0, -3$.

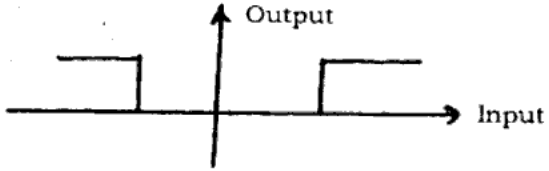
viii) The phase portrait of the second order system shown below in the $y_1\ y_2$ phase has



a) stable focus b) unstable focus

c) stable nodal point d) unstable nodal point.

ix) The input-output characteristics of a non-linearity is shown. The non-linearity is called



a) backlash non-linearity

b) relay with pure hysteresis

c) relay with dead zone and hysteresis

d) relay with dead zone.

x) $Y(k + 1) = AX(k) + BV(k)$ is a

a) non-linear equation

b) linear time invariant difference equation

c) a dynamic non-linear equation

d) autonomous equation.

xi) The inverse Z transform of the function

$$\frac{Tze^{-aT}}{(z-e^{-aT})^2} \text{ is}$$

a) te^{-at} b) e^{-at}

c) $1-e^{-at}$ d) $\frac{t^n}{n!}$.

xii) Jump resonance characteristics can be found in

a) Chaotic system

b) second order non-linear system

c) higher order non-linear system

d) linear time varying system.

GROUP – B
(Short Answer Type Questions)

Answer any *three* of the following $3 \times 5 = 15$

2. The state equation of a linear time invariant system is given by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

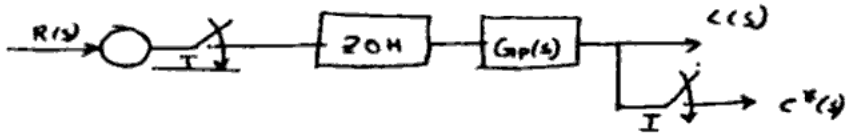
Find the characteristic equation and the state transition matrix using the Caley-Hamilton theorem.

3. Obtain the Z-transform of

$$x(t) = \begin{cases} \cos \omega t & , \ t \geq 0 \\ 0 & , \ t < 0 \end{cases}.$$

4. Find the describing function for Dead-zone with saturation type of non-linearity.

5. Obtain pulse transfer function of the system shown below with $T = 2$ sec and $G_p(s) = \frac{20}{s(s+5)}$.



6. The overall transfer function of a SISO system is given by

$$\frac{Y(s)}{U(s)} = \frac{s^2+3s+2}{s^3+9s^2+26s+24}$$

Obtain the state equation.

GROUP – C
(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. A system is characterized by the following state equation :

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 3 & -1 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u, \ Y = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

a) Find the transfer function of the system.

b) Draw the block diagram of the above transfer function.

c) Compute the state transition matrix.

d) Obtain the solution to the state equation for a unit step input under zero initial conditions.

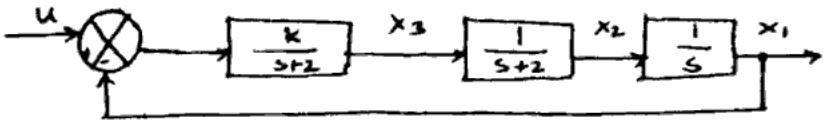
$4 + 3 + 4 + 4$

8. a) Enumerate Lyapunov's direct stability criterion.

   b) Determine whether the following quadratic form is positive definite :

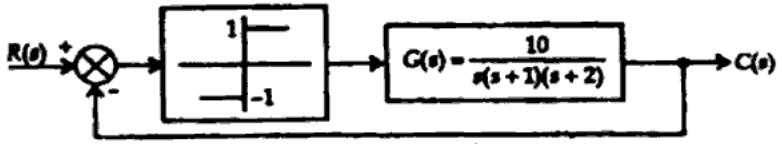
$$Q = -x_1^2 - 3x_2^2 - 11x_3^2 - 2x_1x_2 - 4x_2x_3 - 2x_1x_3$$

   c) Determine the stability range for the gain k of the system shown below :

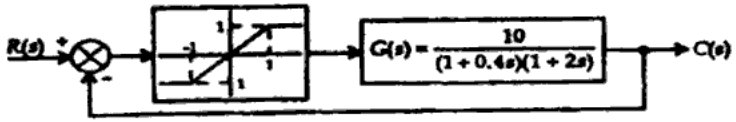


3 + 3 + 9

9. a) Determine the amplitude and frequency of the limit cycle of the non-linearity shown below :



   b) Determine the stability of the system shown in figure below :



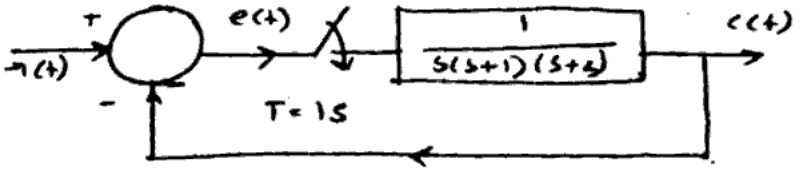
10 + 5

10. a) Draw the phase trajectory for the linear system having the following state equations :

$$\dot{x}_1 = x_2 \text{ and } \dot{x}_2 = 2x_1 + x_2$$

   b) What do you mean by 'Asymptotic stability' and 'Global asymptotic stability' ? 10 + 5

11. a) A closed loop system is shown below. Find the characteristic equation of z-domain for the sampled data system. State whether the system is stable or not.



   b) What is meant by 'Anti-aliasing filters' ? 12 +

12. Write short notes on any *three* of the following : 3 ×

   a) Jump resonance

   b) Controllability and observability

   c) State space model of field controlled d.c. motor

   d) Pole placement method

   e) Mapping of S-plane to Z-plane.