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MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

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 any *ten* of the following : $10 \times 1 = 10$

i) Liapunov function must be

a) a scalar and negative definite function

b) a scalar and positive definite function

c) a positive semi-definite function

d) all of these.

ii) The inverse Z-transform of the function $TZ/(Z-1)^2$ is

a) KT b) $(KT)^2$

c) e^{-KT} d) 1.

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iii) In discrete time system, the stability is found by

a) Liapunov function

b) Routh-Hurwitz criterion

c) Jury stability

d) None of these.

iv) Phase plane analysis is generally restricted to

a) Second order system

b) Third order system

c) First order system

d) Any order system.

v) If both the eigenvalues of a second order system are real and negative, then it is termed as

a) The saddle point

b) The nodal point

c) The focus point

d) The unstable focus point.

vi) If $A = \begin{bmatrix} -0.5 & 0 \\ 0 & -2 \end{bmatrix}$ and $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$

a) System is controllable

b) System is uncontrollable

c) System is undefined

d) None of these.

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vii) In order to design a linear system by pole placement technique, the first step to be carried out is

a) Find the location of the poles of the system

b) Check the damping and natural frequency

c) Carry out the controllability test

d) Check the observability.

viii) For the state variable equation $X = AX + BU$, $Y = CX + DU$, the transfer function is

a) $D + C(SI - A)^{-1}B$ b) $B(SI - A)^{-1}C + B$

c) $B(SI - A)^{-1}B + C$ d) $B(SI - A)^{-1}D + B$.

ix) The transfer function of a zero order hold is

a) $(1 - e^{-st})/s$ b) $(1 + e^{-st})/s$

c) $(1 - e^{st})/s$ d) $(1 \mp e^{st})/s$.

x) In a series R-L-C circuit, the number of state variables is

a) 3 b) 2

c) 1 d) 0.

xi) For all x in the state plane, $V(x) = x_1^2 + x_2^2$ is

a) Positive definite b) Positive semi-definite

c) Negative definite d) Indefinite.

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xii) Hysteresis in a mechanical transmission is termed as

a) Damping b) Backlash

c) Dead zone d) Drift.

xiii) For the difference equation

$x(k + 2) + 4x(k + 1) + 5x(k) = 0$, the initial conditions are $x(0) = 0$ and $x(1) = 1$. The value of $x(2)$ is

a) 4 b) – 4

c) – 9 d) 0.

xiv) The device which converts as continuous signal into a sequence of pulses is termed as

a) Synchro b) Amplifier

c) Sampler d) Integrator.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. For the following system, obtain the state space equation

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y = u$$

where y = output and u = input.

3. Solve the difference equation

$x(n + 2) + 3x(n + 1) + 2x(n) = u(n)$. The initial conditions are $x(0) = 0$, $x(1) = 1$.

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4. A system is described by

$$\dot{x}_1 = -x_1 + x_2 + x_1(x_1^2 + x_2^2)$$

$$\dot{x}_2 = -x_1 - x_2 + x_2(x_1^2 + x_2^2)$$

Determine the asymptotic stability using Lyapunov's second method.

5. Consider the system

$$\dot{x}_1 = x_2$$

$$\dot{x}_2 = -x_1$$

Draw its phase portrait by isoclines method.

6. The state space representation of a system is

$$\dot{x}_1 = -x_1 + u$$

$$\dot{x}_2 = x_1 - 2x_2 + u$$

Comment on controllability and observability of the system.

GROUP – C

(Long Answer Type Questions)

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

7. a) Describe the advantages of the state space analysis over the classical control system analysis. 4

   b) In what condition all the closed loop poles of a system can be arbitrarily positioned ? 2

   c) Consider the following differential equation of a system :

$$\frac{d^3y(t)}{dt^3} + 9\frac{d^2y(t)}{dt^2} + 11\frac{dy(t)}{dt} + 6y(t) = 3x(t)$$

   Convert it into state space form and find state feedback gain K, so that the closed loop poles will be located at – 3, – 4 and – 5 respectively. Obtain the closed system matrix. 3 + 2 + 4

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8. a) Define Lyapunov first and second theorem. 5

   b) Test the sign definiteness of the following quadratic scalar function :

$$V(X) = x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 6x_3x_4 - 2x_1x_3.$$ 3

   c) Consider the following non-linear difference equation

$$\frac{d^2x}{dt^2} + x^2 + \left(\frac{dx}{dt}\right)^2 - 2x + \frac{dx}{dt} = 0$$

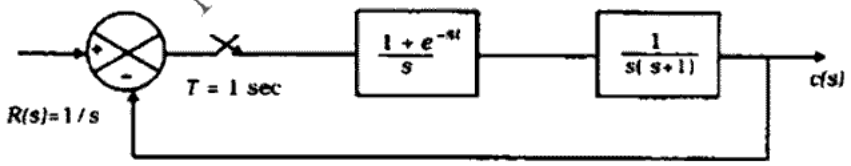
   Determine the points of equilibrium points. 3

   d) In continuous time, a system is given by the transfer function

$$G(s) = \frac{K}{(s+a)}$$

   Find the Z-transfer function $G(z)$. 4

9. a) Find the time response of system shown in figure.



   10

   b) Given $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$. Determine $\phi(k) = A^k$. using Cayley-Hamilton method. 5

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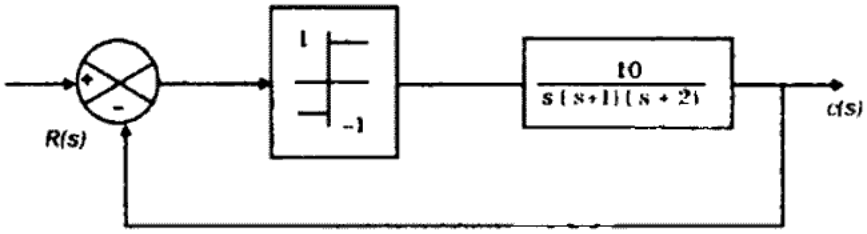
10. a) Derive describing function of a relay with saturation & dead zone nonlinearity. 7

b) Consider the system shown below. Using the describing function method, investigate the possibility of a limit cycle in the system :



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11. Writer short notes on any *three* of the following : 3 × 5

a) Harmonic linearization

b) Anti-aliasing filter

c) Limit cycle

d) Shannon's sampling criterion

e) Properties of state transition matrix.

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