CS / B.Tech / EE / NEW / SEM-6 / EE-601 / 2013

2013

CONTROL SYSTEMS-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 × 1 = 10

   i) The state equation of a linear system is given by $X = AX + BU$ where $A = \begin{bmatrix} 0 & 2 \\ -2 & 0 \end{bmatrix}$ and $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$.

   The state transition matrix of the system is

   a) $\begin{bmatrix} e^{2t} & 2 \\ 0 & e^{2t} \end{bmatrix}$ b) $\begin{bmatrix} e^{-2t} & 0 \\ 0 & e^{-2t} \end{bmatrix}$

   c) $\begin{bmatrix} \sin 2t & \cos 2t \\ -\cos 2t & \sin 2t \end{bmatrix}$ d) $\begin{bmatrix} \cos 2t & \sin 2t \\ -\sin 2t & \cos 2t \end{bmatrix}$.

   ii) The inverse Z-transform of the function $\frac{T_z}{(z-1)^2}$ is

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

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

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   iii) A 5 × 7 matrix has all entries equal to –1. The rank of the system is

   a) 1 b) 5

   c) 0 d) 7.

   iv) 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) $B(SI - A)^{-1}D + B$.

   v) The number of state variables required to describe a series *R-L-C* network is

   a) 1 b) 2

   c) 3 d) 0.

   vi) The property satisfied by a state transition matrix is

   a) $\phi(0) = 1$ b) $\phi^{-1}(t) = \phi(t)$

   c) $[\phi(t)]^k = \phi(-kt)$ d) $\phi(t) \cdot \phi^T(t) = I$.

   vii) If the eigenvalues of a second order system are real, equal in magnitude and opposite in sign then the origin in the phase portrait is termed as

   a) the nodal point b) the focus

   c) the saddle point d) critical point.

   viii) The transfer function of a zero order hold is

   a) $\frac{1 - e^{-st}}{s}$ b) $\frac{1 + e^{-st}}{s}$

   c) $\frac{1 + e^{st}}{s}$ d) $\frac{1 - e^{st}}{s}$.

   ix) An anti-aliasing filter is a

   a) Band pass filter

   b) Band reject filter

   c) Low pass filter

   d) High pass filter.

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x) The Z-transform of a signal is given by

$$C(z) = \frac{1}{4} z^{-1} \left(1 - z^{-4}\right) \frac{1}{(1 - z^{-1})^2}$$

Its final value will be

a) $\frac{1}{4}$ b) zero

c) 1 d) ∞ (infinity).

xi) The z-transform of the function $\frac{1}{s+1}$ is

a) $\left(\frac{z}{z - e^{-T}}\right)$ b) $\frac{z^2}{(z - e^{-T})}$

c) $\frac{z}{(z - e^{T})}$ d) $\frac{z}{(z + e^{-T})}$.

xii) The inverse Z-transform of the function $\frac{T_z}{(z-1)^2}$ is

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

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

xiii) For the difference equation $x[k+2] + 4x[k+1] + 5x[k] = 0$, the initial condition are $x[0] = 0$, and $x[1] = 1$. The value of $x[2]$ is

a) 4 b) 3

c) – 4 d) – 9.

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xiv) In the following set of equations identify the non-linear systems

(A) $\frac{d^3y(t)}{dt^3} + t^2 \frac{d^2y(t)}{dt^2} + \frac{dy}{dt} = 40 \sin \omega t$

(B) $\frac{d^2y(t)}{dt^2} + \frac{1}{t}\frac{dy}{dt} + y = 4e^{-t}$

(C) $\left\{\frac{d^2y(t)}{dt^2}\right\}^2 + \frac{dy(t)}{dt} + y = 5t$

(D) $\frac{d^2y(t)}{dt^2} + ty^2 = e^{-2t}$

a) A and B b) C only

c) C and D d) all of these.

GROUP – B

(Short Answer Type Questions)

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

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

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

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 $x[0] = 0$, $x[1] = 1$.

4. Compute the Z-transform of the function

$x(t) = A \sin \omega t \, u(t)$

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5. a) For the dynamic system given by the state space equation :

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$, formulate

the Lyapunov function to test the asymptotic stability of the system.

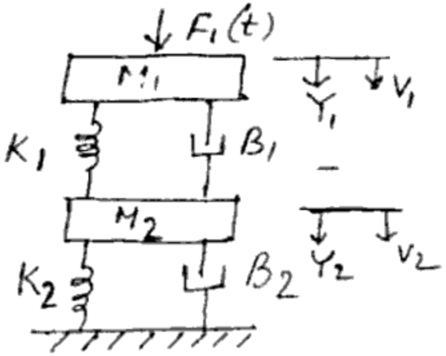
b) State Lyapunov's theorem on stability. 4 + 1

6. Consider a system given by

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 3 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

Check for the state controllability.

7. For the mechanical system shown in the figure below, obtain the state model in standard form, with the velocity of M_2 as the output :



8. Draw the phase plane plot of a system described by $x = x^3 - x$.

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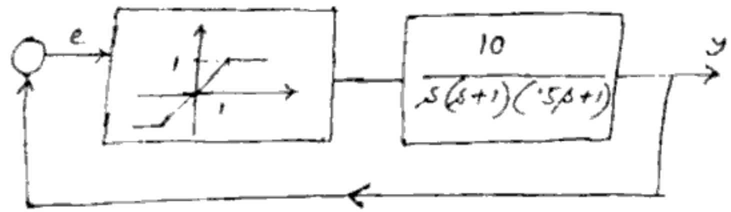
GROUP – C
(Long Answer Type Questions)

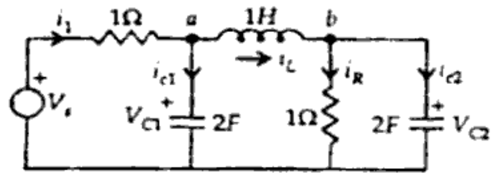
Answer any *three* of the following. 3 × 15 = 45

9. a) Find out the describing function for a practical relay. Explain how a stable and unstable limit cycle can be determined using Nyquist method.

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



10. a) Write the state equation for the circuit below :



b) Determine the state feedback gain matrix, so that closed loop poles of the following linear system are located at – 2, – 5 and – 6.

$$x = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -30 & -11 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(t),\ y = [\ 1\ \ 0\ \ 0\ ]\ x.$$

7 + 8

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11. Determine $x(k)$ of the system, given by the following equation. Where $x_1(0) = 1$ and $x_2(0) = 1$.

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ -3 & -5 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

12. a) Find the sampled data system function for the figure below :

b) Obtain the final value of C (KT) for a unit step input with sampling period = 1 sec. 9 + 6

13. Write short notes on any *three* of the following : 3 × 5

a) Jump resonance

b) Anti-aliasing filter

c) Different types of singular points

d) Harmonic linearisation

e) Dead zone type non-linearity and its effect on stability of a system

f) Shannon's sampling criterion.

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