Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech/EE(OLD)/SEM-6/EE-603/2013

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 : $10 \times 1 = 10$

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

      a) Liapunov function

      b) Routh-Hurwitz Criterion

      c) Jury stability

      d) none of these.

   ii) Phase plane analysis s generally restricted to

      a) Second order system

      b) Third order system

      c) First order system

      d) Any order system.

iii) The free response of a system is the system with

a) step input

b) any input

c) no input

d) a bounded input signal.

iv) If both the eigen-values 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

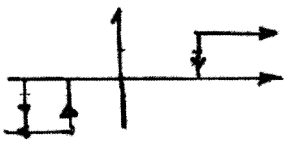
d) The unstable focus point.

v) The second order system $X = AX$ has $A = \begin{bmatrix} -1 & -1 \\ 1 & 0 \end{bmatrix}$ damping and natural frequencies are

a) 1 and 1 b) 0·5 and 1

c) 0·707 and 2 d) 1·41 and 1.

vi) The input-output characteristics of the control system relay shown in the figure below is



a) with pure hysteresis

b) with dead zone and hysteresis

c) with dead zone

d) none of these.

vii) For analysis of non-linear system by describing function, it is assumed that linear part of the system act as

a) Low pass filter

b) High-pass filter

c) Band-pass filter

d) Band elimination filter.

viii) Describing Function analysis is based on

a) Harmonic linearization

b) System linearization

c) Degree of non-linearity

d) input output ratio based on 2nd harmonic.

ix) An Identity matrix of order 3 *x* 3 has a Rank

a) 1 b) 2

c) 3 d) 0.

x) Which of the following properties are associated with the state transition matrix $\phi(t)^2$?

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

b) $\phi(t_1 / t_2) = \phi(t_1) \cdot \phi^{-1}(t_2)$

c) $\phi(t_1 - t_2) = \phi(-t_2) \cdot \phi(t_1)$

d) none of these.

xi) Compared to coulomb friction force, the force of stiction

a) is always greater b) is always equal

c) is always less d) is none of these.

xii) For a single input, 4 state and 2 output system, the dimension of C matrix is

a) 4×4 b) 2×4

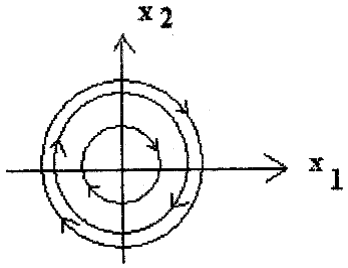
c) 4×2 d) 4×1.

xiii) If the quadratic form of matrix is $-2x_1^2 - x_2^2 - 2x_1x_2$, then the matrix A is

a) positive definite b) positive semi-definite

c) negative definite d) none of these.

xiv) The phase portrait (for different initial conditions) is shown below represents a



a) Undamped autonomous system

b) Underdamped autonomous system

c) Overdamped autonomous system

d) None of these.

GROUP – B

(Short Answer Type Questions)

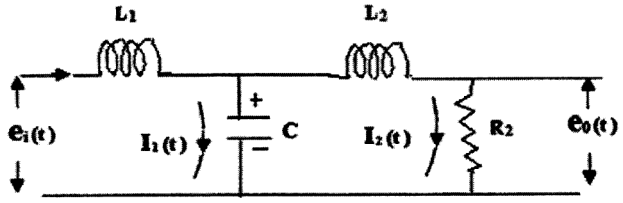
Answer any *three* of the following. $3 \times 5 = 15$

2. Find the inverse z-transform of $X(z) = (1 + 3z^{-1})/(1 + 3z^{-1} + 2z^{-2})$ when $|z| > 2$.

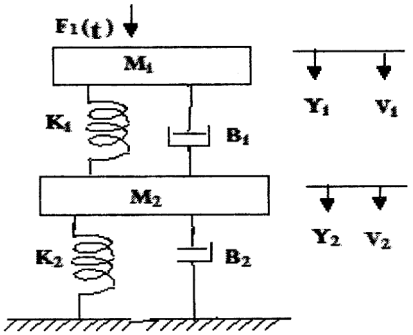
3. A linear system with single input and output is described by $d^3c(t)/dt^3 + d^2c(t)/dt^2 + 4dc(t)/dt + c(t) = 5u(t)$.

Write the state equations in matrix form and represent it in the block diagram.

4. Obtain the state model of the given electrical network in the standard form.



5. For the mechanical system shown in fig. below, obtain the state model in standard form. Assume velocity of M_2 as output



6. Find out the describing function for dead zone with saturation nonlinearity.

7. Consider the system defined by

$\dot{x} = Ax + Bu$

$y = Cx$

Where, $A = \begin{bmatrix} -1 & 0 & 1 \\ 1 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix}$

Obtain the transfer function $Y(s)/U(s)$.

8. Is the following system is completely observable ?

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u,\ y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} x$$

GROUP – C

(Long Answer Type Questions)

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

9. a) (i) What is limit cycle ?

   (ii) What is jump response ?

   b) What is the limitation of phase plane analysis ?

   c) Consider the following state equations of a nonlinear system

$$\begin{bmatrix} \dot{x}_1 = -x_1 + x_2^2 \\ \dot{x}_2 = -x_2 \end{bmatrix}$$

   Determine the equilibrium points and investigate the stability of the system. 6 + 2 + 7

10. a) Consider the following second order non-linear differential equation

$$\left(\frac{dx}{dt}\right)^2 + x^2\left(\frac{dx}{dt} - 1\right) + x = 0$$

   (i) Determine the points of equilibrium

   (ii) Investigate the stability of the system near each point of equilibrium.

   b) Determine the range of values of K by applying the Liapunov's second method for the given system dynamics

$$\begin{bmatrix} \dot{x}_1 = x_2 \\ \dot{x}_2 = -x_2 + x_3 \\ \dot{x}_3 = -kx_1 - 4x_3 \end{bmatrix}$$

   When the given scalar function is

$$V(X) = 5kx_1^2 + 2kx_1x_2 + 20x_2^2 + 8x_2x_3 + x_3^2$$

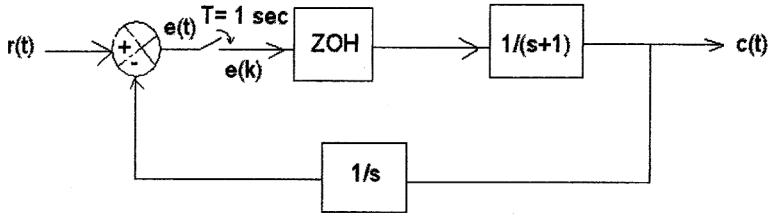
   7 + 8

11. a) Find out the describing function for dead zone with saturation nonlinearity.

    b) Determine the type of singular point and draw the phase plane portrait for the Vander pole equation using graphical method. 5 + 10

12. a) State and derive Shanon's sampling theorem.

    b) For the sampled-data control system shown below, find the output $c(k)$ for $r(t)$ = Unit step



5 + 10

13. a) Define Controllability and observability.

    b) Derive the solution of the non-homogenous state equation of forced system.

    c) For a system, $A = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$

    Calculate state transition matrix using Laplace transformation method. 5 + 5 + 5

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

    a) Nonlinear Relay

    b) Stability analysis by phase plane analysis

    c) Stable and unstable limit cycle

    d) Backlash non-linearity

    e) Mapping of *s*-plane to *z*-plane

    f) Harmonic linearization.