ENGINEERING & MANAGEMENT EXAMINATIONS, JUNE – 2008

CONTROL SYSTEMS

SEMESTER - 6

Time : 3 Hours] [Full Marks : 70

GROUP – A

(Multiple Choice Type Questions)

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

i) A set of state variables for a system is

a) not unique in general b) always unique

c) never unique d) may be unique.

ii) State variable approach converts an *n*th order system into

a) *n* second order integro-differential equation

b) two differential equations

c) *n* first order differential equations

d) a lower order system.

iii) If both eigenvalues of a second order system are real, equal & negative of each other; the origin in the phase portraits is termed as

a) the nodal point b) the focus point

c) the saddle point d) none of these.

iv) The 2nd order system $\dot{X} = AX$ has $A = \begin{pmatrix} -1 & -1 \\ 1 & 0 \end{pmatrix}$. The values of its damping & natrural frequencies are

a) 1 & 1 b) 0·5 & 1

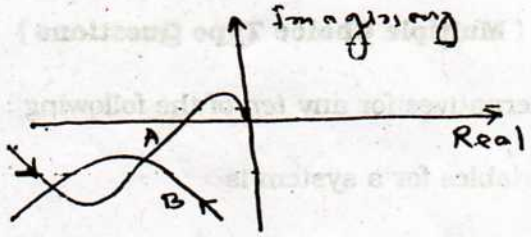
c) 0·707 & 2 d) 1·41 & 1.

v) Lyapunov's stability criterion can be used for determination of

a) linear system b) non-linear system

c) both (a) & (c) d) none of these.

vi) In the figure below :



a) *A* has unstable limit cycle & *B* has stable limit cycle

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

c) both *A* & *B* have unstable limit cycle

d) none of these.

vii) Lyapunov function is

a) energy function b) work function

c) state function d) output function.

viii) Describing function is based on

a) Harmonic linearization b) System linearization

c) Degree of non-linearity d) None of these.

ix) If $A = \begin{bmatrix} -0.5 & 0 \\ 0 & -2 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, then

a) system is controllable b) system is uncontrollable

c) system is undefined d) none of these.

x) A linear system is described by the state equations

$$\begin{bmatrix} \dot{X}_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} R$$

$C = X_2$

where R & C are the input & output respectively. The transfer function is

a) $\frac{1}{S+1}$ b) $\frac{1}{(S+1)^2}$

c) $\frac{1}{S-1}$ d) $\frac{1}{(S-1)^2}$. ☐

xi) In series RLC circuit, the number of state variables is

a) 3 b) 2

c) 1 d) none of these. ☐

xii) The transfer function of a zero order hold circuit is

a) $\frac{1-e^{-TS}}{S}$ b) $\frac{1+e^{-TS}}{S}$

c) $\frac{1+e^{-TS}}{S}$ d) none of these. ☐

GROUP – B

(Short Answer Type Questions)

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

2. Obtain the state variable model of the system whose transfer function is given by

$$\frac{Y(S)}{U(S)} = \frac{S^2 + 3S + 3}{S^3 + 2S^2 + 3S + 1}$$

3. Determine the unit step response in closed form for the system given by

$$X(k+1) = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix} X(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k) \text{ for all } k \geq 0 \text{ with } X(0) = 0.$$

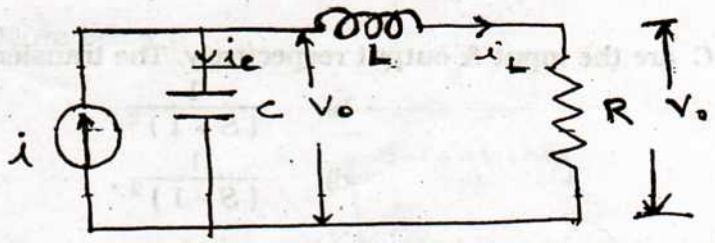
4. Given $A = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -4 & 2 \\ 0 & 0 & -10 \end{bmatrix}$; $B = [1 \quad 0 \quad -1]^T$; & $C = [1 \; 0 \; 1]$. Determine the similarity transformation matrix P to transform the system.

$\dot{X} = AX + BU$ & output

$Y = CX$ to the controllable canonical form.

5. Find the describing function of on-off non-linearity.

6. Consider the network shown in the figure. Obtain the state variable formulation.



GROUP – C

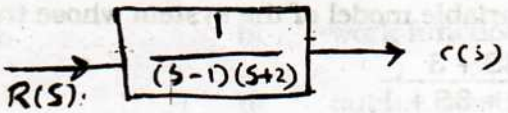
(Long Answer Type Questions)

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

7. a) Define phase plane, phase trajectory & phase portrait.

b) Define singular points. Give the detail classification of singular points.

c) For the linear system shown, sketch the phase trajectories using isocline method.



d) Show that the following quadratic form is positive definite.

$v(x) = 8x_1^2 + x_2^2 + 4x_3^2 + 2x_1 x_2 - 4x_1 x_3 - 2x_2 x_3$. 3 + 4 + 5 + 3

8. a) Solve the following difference equation using *Z*-transform method.

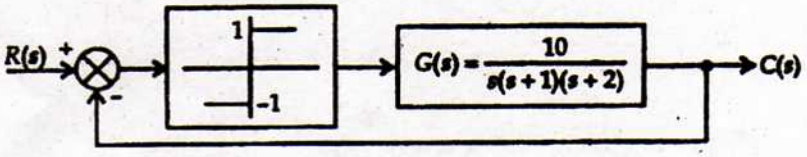
$x(k+2) + 3x(k+1) + 2x(k) = 0,\ x(0) = 0,\ x(1) = 1.$

b) Obtain the discrete time state equation for the continuous time system given in problem, 8 (a) assuming sampling time, $T = 0{\cdot}1$ sec.

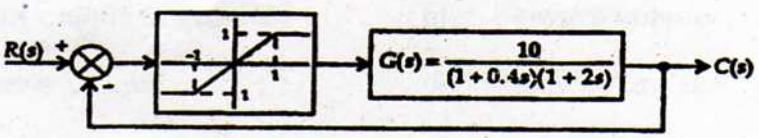
c) In continuous time, a system is given by the transfer function,

$G(s) = \frac{k}{s+a}$. Find the *Z*-transfer function, $G(z)$. 6 + 6 + 3

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



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



10 + 5

10 a) State Lyapunov's direct method of investigating stability of non-linear system.

b) A linear system is described by the state equation $\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x$. Investigate the stability of this system using Lyapunov's theorem.

c) Consider the system defined by $\dot{X} = AX + BU$,

where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

By using feedback control $u = -kx$, it is desired to have closed loop poles at $s = -1 \pm j$, $s = -10$. Determine the state feedback gain matrix k. 4 + 5 + 6

11. Write short notes on *any three* of the following : 3 × 5 = 15

a) Regulator problems.

b) Harmonic linearization.

c) Computer control.

d) Non-conservative systems.

e) Feedback controller.

END