Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B.TECH (ICE)/SEM-5/IC-504/2010-11

2010-11

ADVANCE CONTROL SYSTEM

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) det A^{-1}, where A is a metrix, is given by

      a) $\dfrac{1}{\det A}$

      b) $\det\left(\dfrac{1}{A}\right)$

      c) both (a) & (b) are correct

      d) none of these.

   ii) The given matrix $\begin{bmatrix} 4 & -4 & 2 \\ -4 & 5 & -2 \\ 2 & -2 & 1 \end{bmatrix}$ is

      a) positive semi-definite

      b) negative semi-definite

      c) positive definite

      d) negative definite.

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

a) linear system

b) non-linear system

c) both (a) & (b)

d) autonomous system.

iv) If A = $\begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$, the e^{At} will be

a) $\begin{bmatrix} e^t & 0 \\ te^t & p^t \end{bmatrix}$

b) $\begin{bmatrix} 0 & e^t \\ e^t & te^t \end{bmatrix}$

c) $\begin{bmatrix} e^t & 0 \\ e^t & te^t \end{bmatrix}$

d) $\begin{bmatrix} te^t & 0 \\ e^t & e^t \end{bmatrix}$.

v) Consider the following properties attributed to state model of a system :

i) State model is unique

ii) State model can be derived from the system transfer function

iii) State model can be derived from time variant systems. Of these statements :

a) i, ii & iii are correct

b) i & ii are correct

c) ii & iii are correct

d) i & iii are correct.

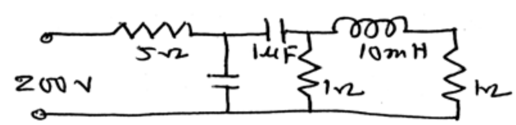
vi) The minimum number of states necessary to describe the network shown in a state variable form is

a) 2

b) 3

c) 4

d) 6.



vii) The derivative term in PID controller makes a system response

a) slow

b) fast

c) neither slow nor fast

d) no effect.

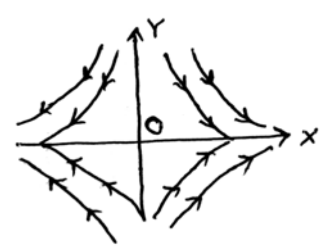
viii) The phase portrait of a non-linear system is shown in the following figure. Here the origin is

a) stable focus

b) vortex

c) stable node

d) saddle point.

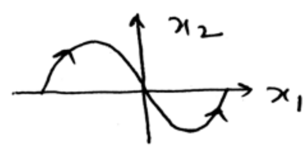


ix) Z transform of sin ωt is

a) $\dfrac{Z\,(Z - \cos\,\omega t)}{Z^2 - 2Z\cos\,\omega t + 1}$ b) $\dfrac{Z\,\sin\omega t}{Z^2 - 2Z\cos\,\omega t + 1}$

c) $\dfrac{Z\,(Z - \sin\,\omega t)}{Z^2 - 2Z\cos\,\omega t + 1}$ d) $\dfrac{Z\,\cos\,\omega t}{Z^2 - 2Z\,\sin\,\omega t + 1}$.

x) For the figure shown, the nodal point is



a) stable

b) unstable

c) oscillatory

d) singular point.

xi) Which one is correct output of the system shown ?

$\xrightarrow{A \sin \omega t}$ *non-linear drives* $\xrightarrow[y\,(t)]{}$

a) periodic b) Sinusoidal

c) Aperiodic d) Chaotic.

xii) In similarity transformation

a) There is no change in characteristic equation

b) There is no change of eigenvalues

c) There is no change in transfer function

d) all of these.

GROUP – B

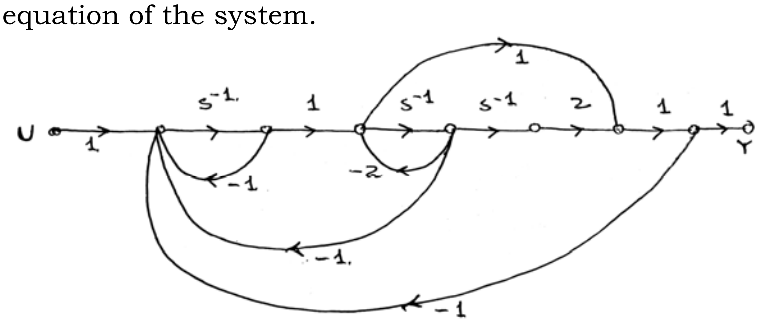
(Short Answer Type Questions)

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

2. Derive transfer function corresponding to the following state model :

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u \,;\; Y = [1 \quad 0]\, X$$

3. The state diagram of a linear system is shown in figure below. Assign the state variables & write the dynamic equation of the system.



4. Determine controllability & observability properties of the following system :

$$A = \begin{bmatrix} -2 & 1 \\ 1 & -2 \end{bmatrix}, \quad b = \begin{bmatrix} 1 \\ 0 \end{bmatrix}; \; c = \begin{bmatrix} 1 & -1 \end{bmatrix}$$

5. Consider the linear system $\dot{X} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} X$

   Using Lyapunov analysis, determine the stability of the equilibrium state.

6. Find the eigenvalues & eigenvectors for the following matrix :

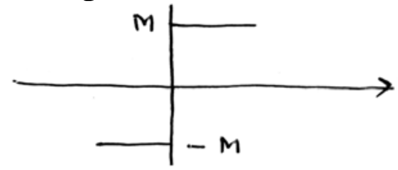
$$\begin{bmatrix} -4 & 1 & 0 \\ 0 & -3 & 1 \\ 0 & 0 & -2 \end{bmatrix}$$

GROUP – C

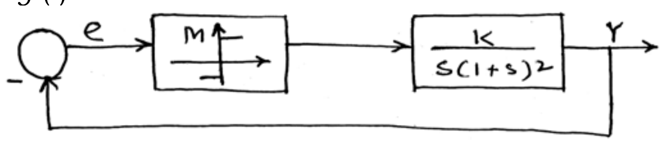
(Long Answer Type Questions)

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

7. a) Find describing function for the non-linearity shown.



b) Consider the system shown in figure. Using the describing function analysis, show that a stable limit cycle exists for all values of $k > 0$. Find the amplitude & frequency of the limit cycle when $k = 4$ & plot $y(t)$ versus t.



8. A regulator system has the plant :

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ 20 \cdot 6 & 0 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

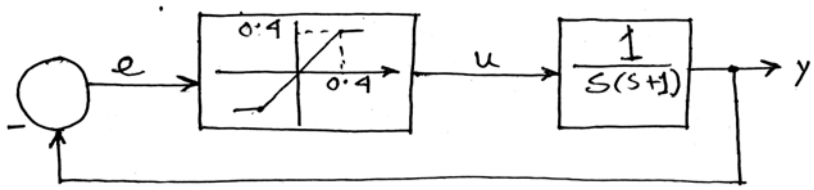
$Y = [\ 1 \quad 0\ ]\ X.$

a) Design a control law $u = -\,k\,X$ so that the closed loop system has eigenvalues at $-\,1.8 \pm j\,2{\cdot}4$.

b) Design a first order state observer to estimate the state vector. The observer matrix is required to have eigen-values at $-\,8, -\,8$. 7 + 8

9. Consider the system shown in figure in which the non-linear element is a power amplifier with gain equal to 1, which saturates for error magnitude greater than 0.4. Given the initial condition : $e(0) = 1{\cdot}6$, $\dot{e}(0) = 0$. Plot phase trajectories

& comment upon the effect of saturation on the transient behaviour of the system. Use the method of isoclines for construction of phase trajectories :



10. a) Explain the following terms :

   i) Equilibrium point
   ii) Asymptotic stability
   iii) Asymptotic stability in the large.
   iv) Instability
   v) Indefiniteness of scalar functions.

   b) Check the stability of the system described by

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

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

   by use of the variable gradient method. 5 + 10

11. a) Give three different canonical state variable models corresponding to the transfer function

$$G(z) = \frac{4z^3 - 12z^2 + 13z - 7}{(z-1)^2 (z-2)}.$$

   b) Consider the system

$$X(k+1) = F\,X(k) + g\,u(k) \; ; \; X(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

$$Y(k) = c\,X(k).$$

$$\text{with } F = \begin{bmatrix} 0 & 1 \\ -0\cdot16 & -1 \end{bmatrix}; \; g = \begin{bmatrix} 1 \\ 1 \end{bmatrix}; \; c = [\,1 \;\; 0\,]$$

   Find the closed loop form solution for Y (k) when $u(k)$ is unit step sequence. 9 + 6