http://www.makaut.com

Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(ICE)/SEM-5/IC-504/2009-10

2009

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) 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.

   ii) For a system $\dot{X} = AX$, the state transition matrix can be expressed as

   a) $\sum_{r=0}^{\infty} \frac{A^r t}{r!}$ b) $\sum_{r=0}^{\infty} \frac{A^r t^r}{r!}$

   c) $\sum_{r=0}^{\infty} \frac{(At)^{r-1}}{r!}$ d) $\sum_{r=0}^{\infty} (At)^r$.

iii) 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.

iv) $X(k+1) = AX(k) + Bu(K)$ is a

a) Non-linear equation

b) Linear time invariant difference equation

c) Dynamic non-linear equation

d) None of these.

v) Phase plane analysis generally restricted to

a) third order system

b) first order system

c) second order system

d) any order system.

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

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

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

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

d) None of these.

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

Fig.

a) with pure hysteresis

b) with dead zone and hysteresis

c) with dead zone

d) with none of these.

viii) $X = f(X)$ is called

a) a servo system

b) non-linear system

c) a linear system

d) an autonomous system.

ix) The phase portrait of a second order system shown below in the y_1 , y_2 plane as

Fig

a) stable focus b) unstable focus

c) stable nodal point d) none of these.

x) In an autonomous system, the points in the phase-plane at which the derivatives of all the state variables are zero, are termed

a) non-singular points b) singular points

c) non-equilibrium points d) none of these.

xi) Hysterisis in a mechanical transmission is termed as

a) damping b) backlash

c) dead zone d) drift.

xii) If the time varying behaviour of all the states and input are known, the transient response of output can be determined with the help of

a) D and C matrix b) D and B matrix

c) A and B matrix d) A and C matrix.

GROUP – B

(Short Answer Type Questions)

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

2. a) Examine the sign definiteness of the following quadratic form :

$$2x_1^2 + 3x_2^2 + 3x_3^2 + 2x_1 x_2 + 4x_2 x_3$$

b) For a given state equation $X = AX + Bu$, where $B = \begin{pmatrix} 0 \\ 2 \end{pmatrix}$, find damped natural frequency, peak overshooting % and settling time (5% tolerance) for a step input. 2 + 3

3. Consider the dynamics of the system represented by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Formulate the Lyapunov function to test asymptototic stability of the system. 5

4. A system is described by the following differential equation. Represent the system in state space.

$$\frac{d^3x}{dt^3} + 3\frac{d^2x}{dt^2} + 4\frac{dx}{dt} + 4x = u_1(t) + 4u_3(t)$$

and outputs are 5

$$y_1 = 4\frac{dx}{dt} + 3u_1$$

$$y_2 = \frac{d^2x}{dt^2} + 4u_2 + u_3$$

5. a) Define Sate transition matrix.

b) Find the STM of the following state equation :

$$X = \begin{pmatrix} 1 & 0 \\ 1 & 1 \end{pmatrix} X + \begin{pmatrix} 1 \\ 1 \end{pmatrix} u.$$ 1 + 4

6. Find the inversre Z transform of the following siscrete system :

$$F(z) = \frac{4x^2 - 2z}{z^3 - 5z^2 + 8z - 4}.$$ 5

GROUP – C

(Long Answer Type Questions)

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

7. a) What do you mean in the sense of Lyapunov asymptotic stability, global stability and local stability ?

   b) Consider the system

   $\dot{x}_1 = -x_2 + ax_1 x_2^2$

   $\dot{x}_1 = x_1 - bx_1^2 x_2$

   where $a \neq b$.

   Find the condition of the stability of this system using Lyapunov's theorem assuming that the Lyapunov function $V(x) = \frac{1}{2} x_1^2 + \frac{1}{2} x_2^2$. 5 + 10

8. The block diagram of a linear time invariant system is given in *figure*.

Fig.

   a) Write down the state variable equations for the system in matrix form assuming state vector to be $[x_1(t)\ x_2(t)]^T$.

   b) Find out the state transition matrix.

   c) Determine $y(t)$, $t \geq 0$, when the initial values of the state at time $t = 0$ are $x_1(0) = 1$ and $x_2(0) = 1$ for step input. 4 + 5 + 6

9. a) What do you understand by
   i) controllability
   ii) observability of a linear continuous system ?

   b) Determine the following system is completely controllable or not :

Math

   c) Obtain the eigenvalue & eigenvectors for a system described by the state matrices : 4 + 6 + 5

Math

10. a) What is limit cycle ?

   b) Prove the final value theorem of Z transform.

   c) A regulator system has a plant

$$\frac{Y(s)}{U(s)} = \frac{10}{(s+1)(s+2)(s+3)} .$$

   by using the state feedback control $u = -kx$, it is desire to place the closed loop poles at $-2 \pm j\sqrt{3}$ and -10. Determine the necessary state feedback gain matrix K. 3 + 6 + 6

11. Answer any *three* of the following : 3 × 5
   a) Reduced order observer
   b) Zero order hold
   c) Sampling theorem of digital control system
   d) Bilinear transformation.