Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH (ECE)/SEM-8/EC-803E/2012

2012
MODERN 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) Lyapunov function must be

a) a scalar and negative definite function

b) a scalar and positive definite function

c) a positive semi-definite function

d) all of these.

ii) If the quadratic form of a matrix is $10\,x_1^2 + 4x_2^2 + x_3^2 + 2x_1\,x_2 - 2x_2\,x_3 - 4x_1\,x_3$, then the matrix A is

a) positive definite b) positive semidefinite

c) negative definite d) none of these.

iii) The device which converts continuous signal into a sequence of pulses is termed as

a) synchro b) amplifier

c) sampler d) integrator.

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

a) is always greater b) is always equal

c) is always less d) none of these.

v) To compute the describing function of a nonlinear element for a sinusoidal

a) the fundamental harmonic component of the output is required

b) the dead zone and saturation are to be avoided

c) the nonlinear system is to be assumed linear

d) none of these.

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

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

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

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

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

vii) A set of variables for a system is

a) not unique in general

b) never unique

c) always unique

d) may be unique.

viii) For an n-th order control system, the number of variables are

a) 1 b) n

c) n^2 d) $n/2$.

ix) If 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.

x) In an unforced system $dx/dt = f(x)$ means

a) input is zero b) input is a function of x

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

xi) 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.

xii) The free response of a system is the system with ..... signal.

a) step input

b) any input

c) no imput

d) a bounded input.

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

a) Lyapunov's function

b) Routh-Hurwitz Criterion

c) Jury stability

d) none of these.

GROUP – B

(Short Answer Type Questions)

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

2. Define nonlinear system and discuss about the common characteristics of nonlinear system.

3. Derive the small perturbation linearization technique of nonlinear system and hence find out Jacobian matrix.

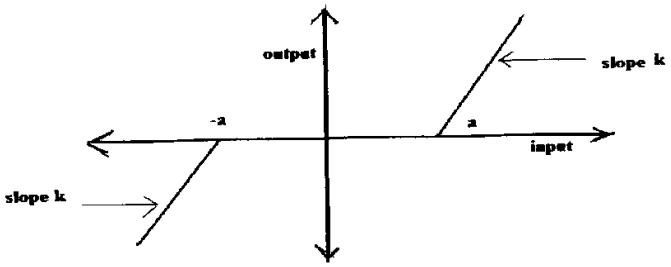
4. Find out the describing function for relay type nonlinearity.

5. Consider the following non-linear differential equation

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

Determine the points of equilibrium.

6. Using describing function analysis, determine the amplitude and frequency of the limit cycle when k = 4.



GROUP – C

(Long Answer Type Questions)

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

7. a) Define the following terms :

   i) Minimum time

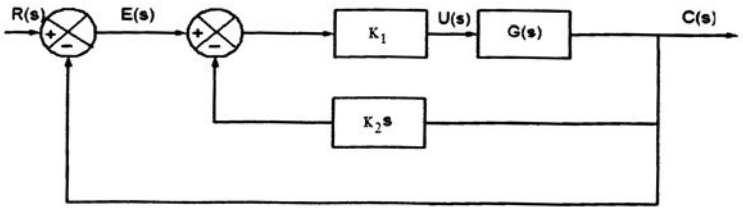
   ii) Minimum energy

   iii) Minimum fuel problem.

   b) In the following diagram shown in figure, consider that $G(s) = \frac{100}{s}$ and $R(s) = \frac{1}{s}$.

Determine the optimal values of the parameters K_1 and K_2 such that (i) $J_e = \int_0^\infty e^2(t)\,dt$ is minimized

(ii) $J_u = \int_0^\infty u^2(t)\,dt = 0.1$



2 + 2 + 2 + 9

8. The regulator shown in figure contains a plant that is described by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$ 5 + 10

And has a performance index

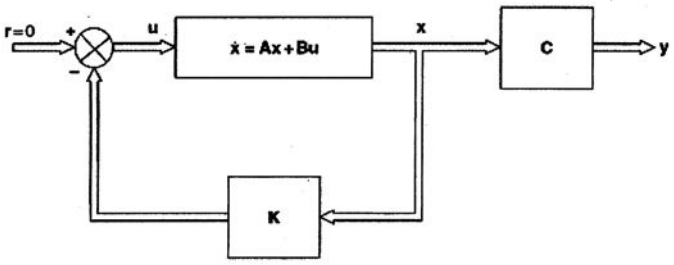
$$J = \int_0^\infty \left[x^T \begin{bmatrix} 2 & 0 \\ 0 & 1 \end{bmatrix} x + u^2 \right] dt$$

Determine,

a) the Riccati matrix P

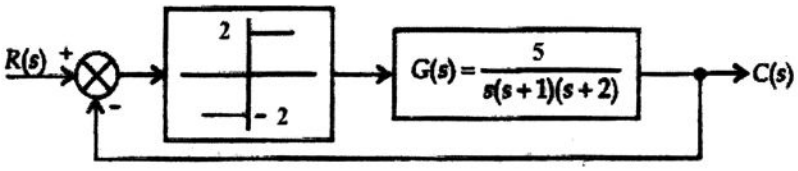
b) the state feedback matrix K

c) the closed loop eigenvalues.



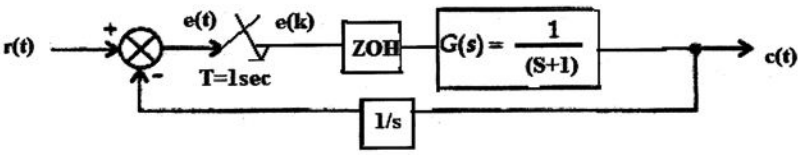
5 + 5 + 5

9. Using describing function analysis, determine the amplitude and frequency of the limit cycle. 15



10. State Shanon's sampling theorem.

For the sampled data control system shown below, find the output $c(k)$ for $r(t)$ = unit step. 5 + 10



11. a) What is limit cycle ?

b) What is the limitation of phase plane analysis ?

c) Consider the following state equations of a nonlinear system

$$\dot{X}_1 = -x_1$$

$$\dot{X}_2 = -x_1 - x_2 - x_2^3$$

Investigate the stability of the system near each point of equilibrium. 5 + 5 + 5