Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/M.Tech (EE)/SEM-2/MPS-201/2011

2011

ADVANCED CONTROL SYSTEMS

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.

Answer any *five* questions. 5 × 14 = 70

1. a) Define sensitivity of a control system. Discuss how sensitivity for parameter variations can be reduced by using feedback.

   b) Show how the effects of disturbance signals can be reduced by the use of feedback.

   c) Discuss briefly how the dynamic response depends on the location of poles of a system. 7 + 3 + 4

2. a) How can a non-linear spring be linearized ?

   b) Obtain the differential equation of the mechanical system shown in Figure-1. Draw the electrical analogous circuit based on force-current analogy.

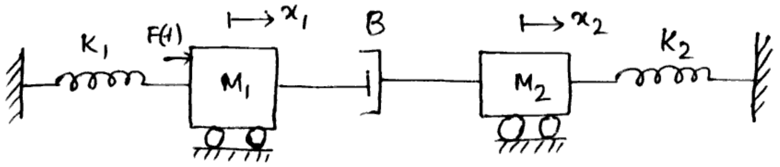

Figure-1 6 + 8

3. a) If the function $e(t)$ has the z-transform $F(z)$ and $\underset{z \to \infty}{Lim} F(z)$ exists, then prove that $\lim_{t \to 0} e^*(t) = \lim_{z \to \infty} F(z)$.

b) Find inverse z-transform of

$$F(z) = \frac{\left(1 - e^{-at}\right)z}{(z-1)\left(z - e^{-at}\right)}$$

6 + 8

4. a) Stepwise describe Liapunov's method for stability analysis in its simplest form.

b) A simple mass, spring and viscous friction is shown in Figure-2. Show that the system is stable.

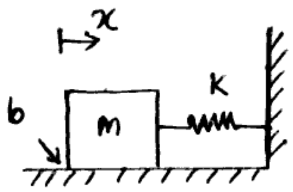

Figure-2

8 + 6

5. a) Show that the describing function of a non-linear element is given by $K_N(x, \omega) = \left(Y_1(X) \angle \phi_1\right)$ when the input to the non-linearity is $x = X \sin(\omega t)$. All symbols carry usual significances.

b) Write down the output waveform showing idealized characteristics of non-linearity having dead zone and saturation with sinusoidal input. Hence find the corresponding describing function. Find also the describing function with saturation non-linearity. 6 + 8

6. a) A system is described by

$$\dot{X} = \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} X$$

Check the controllability and observability of the system.

b) State the properties of state transition matrix.

c) A system is represented by the state and output equation given below find the poles of the system.

$$\dot{X} = \begin{bmatrix} -3 & -2 \\ -1 & 1 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

$$y = \begin{bmatrix} 1 & 2 \end{bmatrix} X.$$

6 + 3 + 5

7. a) If $F(z) = Z[e(t)]$ when $e(t)$ is Laplace transformable, prove that $Z\left[e^{\pm at} * e(t)\right] = F\left[Ze^{\pm aT}\right]$.

b) Find the Z-transform of

i) e^{at}

ii) e^{-at}

iii) $e^{-at} \cos \beta t$.

7 + 7

8. a) Explain the following :

   i) Integral control action

   ii) PID control action.

   b) What are the steps in designing a control system ? 8 + 6