M.E. 2nd Semester (EE) Final Semester Examination, April, 2012
Subject : Non-Linear Control Systems (EE-1001)

Answer any FIVE questions

Questions are of equal values

Graph papers will be supplied on demand

Time : 3 hours | Full Marks : 70

1(a) Deduce nonlinear differential equations defining the dynamic behavior of an orbiting satellite[Use Lagrange's result]. Convert the same into equivalent state space form. [8]

(b) What do you mean by a **secular** term? Apply Poincare Perturbation method to explain the same for an inverted pendulum system if it is subjected to heavy viscous damping. [6]

2 (a) What is vibrational linearization? Explain with diagram. [3+2]

(b) What do you mean by identification of a nonlinear system? [2]

(c) What are the basic difference of a linear system and a nonlinear system? [3]

(d) Explain with proper example and graphical support the variety of all intentional and incidental type of nonlinearities. [4]

3 (a) Frame a table of numerical results for an example $\frac{dy}{dx} = -xy$ by 4th order Runge Kutta procedure with the following assumptions, h=0.1, y(0.2)=0.4258, find y for $0.3 \leq x \leq 0.7$ [6]

(b) Write short notes on [8]

(i) Method of least square fit

(ii) Milne method for the solution of inverted pendulum problem

4(a) Consider the linear system

$$\dot{x}_1 = -x_1 - 3x_2$$

$$\dot{x}_2 = 2x_2$$

Find the eigen values and eigenvectors of the system and prove that $P^{-1}AP$ = diag.[eigen values].

Also find the general solution of the system equation and draw the phase trajectory in R^2-plane. Consider the initial point according to your choice. [8]

(b) Compute the exponentials of the following matrices [6]

$$A = \begin{bmatrix} 1 & 2 \\ 0 & -1 \end{bmatrix}$$

5(a) Solve the initial value problem of $\dot{x} = \text{Ax}$ with suitable chosen initial point and with [7]

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

(b) Solve the problem of $\dot{x} = \text{Ax}$, where

$$A = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 \\ 2 & 0 & 1 & 0 \end{bmatrix}$$

Also show that it is nilpotent of order two. [7]

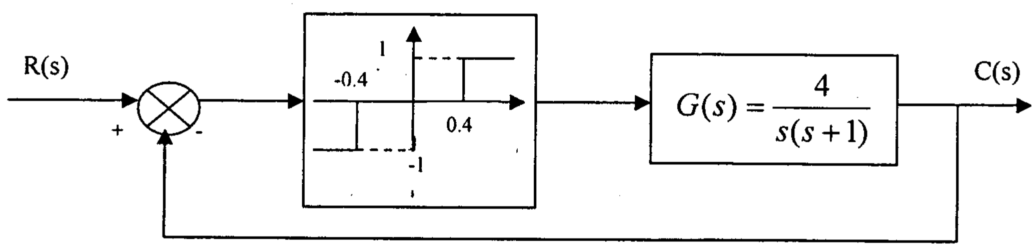
6(a) Explain the Delta method by which how can the phase-trajectory be constructed?

(b) A system is described by its dynamic equation as [7]

$$\ddot{y} + 0.6\text{y} + 1 = 0$$

Draw the phase trajectory for this system by using the method of isoclines. [7]

7. Determine the amplitude and frequency of the limit cycle of the non-linearity shown in Fig.-1 [14]



Q.-7 : Fig.-1

8(a) The state equations for a linear system are given by $\dot{x} = \text{Ax}$, where

$$A = \begin{bmatrix} -5 & 2 \\ 1 & -3 \end{bmatrix}$$

Investigate the stability of the system by finding a suitable Lyapunov function. [7]

(b) Discuss the Popov's criterion for stability of non-linear systems. [7]