M.E. 2nd Semester (EE) Final Examination, April, 2013
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) What is 'Perturbation method'? Use Perturbation method to solve the case of a simple pendulum with no damping and no external torque(T) applied. Define 'secular term'.

(b) The following table gives the time-temperature values of a thermal system. Apply least square fit method to find out the coefficients of the general curve satisfying the data available from the table.

Sl. No.	time	temperature
1	1	1
2	2	8
3	3	27
4	4	64

(8+6)

2(a) Obtain the amplitude and phase of free oscillations of a second order nonlinear system by Krylov and Bogoliubov method.

(b) Develop state space representation of an inverted pendulum moving on a cart. (7+7)

3(a) Apply Fourth order Runge- Kutta method to solve the first order differential equation $\frac{dy}{dx} = -xy$ with the following assumptions

h=0.15

y(0.3)=0.4725

and y varies from $0.3<x<0.9$

(b) What do you mean vibrational linearization?

(c) Apply Adams method to solve the equation of a simple pendulum when driven by a constant torque T. System constants may be taken as per your choice. (6+3+5)

4(a) Consider the linear system

$$\dot{x}_1 = -x_1 - 3x_2$$
$$\dot{x}_2 = 2x_2$$

Find the eigenvalues and eigenvectors of the above system and find an invertible matrix such that $P^{-1}AP$ = diagonal. [2+2+2]

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. [2+2]

(b) Consider a nonlinear system where the input and the output are related through the differential equation

$$y(t) = x^2\, dx/dt + 2x$$

Determine the describing function of the systems. [4]

5(a) Solve the initial value problem of $\dot{x} = Ax$ with initial point x(0) and A are respectively given below. [7]

$$A = \begin{bmatrix} -2 & -1 \\ 1 & -2 \end{bmatrix} \qquad x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

(b) Solve the initial value problem of $\dot{x} = Ax$ where [7]

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

Initial point may be chosen.

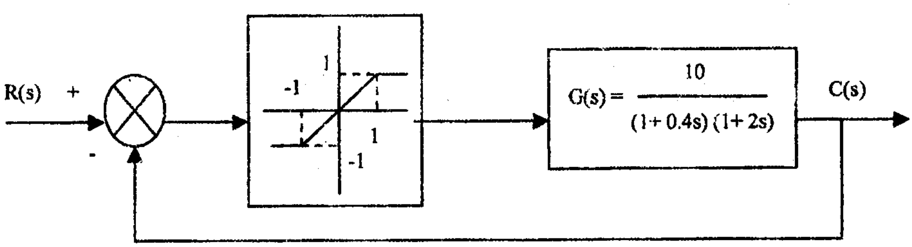
6(a) Explain the Pell's method by which how can the phase-trajectory be constructed. [4]

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

$$dX/dt = \begin{bmatrix} -1 & 0 \\ 1 & -2 \end{bmatrix} \quad ; \quad X(0) = \begin{bmatrix} 2 \\ 3 \end{bmatrix}$$

Construct the state trajectories by Isoclines technique and investigate the stability of the system. Explain all the steps systematically. [10]

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 equation for a linear system are given by $\dot{x} = Ax$, where

$$A = \begin{bmatrix} -5 & 1 & -2 \\ 1 & 0 & -1 \\ 3 & 2 & 4 \end{bmatrix}$$

Investigate the stability of the system by finding a suitable Lyapnouv function. [8]

(b) Discuss the Popov's criterion for stability of non-linear systems. [6]