

[This question paper contains 4 printed pages.]

Your Roll No.

3215

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MEE

Paper—EE.602

NON-LINEAR CONTROL THEORY

Time : 3 Hours

Maximum Marks : 100

(Write your Roll No. on the top immediately
on receipt of this question paper.)

Attempt any five questions.

1. (a) The output $y(t)$ of a non-linear device is related to the input $x(t)$ through the following differential equation :

$$y(t) = 4\dot{X}^2 + 6X + 3X^2 \dot{X} \quad 10$$

Determine the describing function of this device.

- (b) Show that following systems are non-linear :

(i) $y = mX + c$

(ii) $\ddot{y} = 5X + 6 + 5Y$

(iii) $\frac{X}{\text{X}} \rightarrow \boxed{y = y_0 \left(\frac{X}{X_0} \right)^2} \xrightarrow{Y} \boxed{Z = Z_0 \sqrt{\frac{Y}{Y_0}}} \rightarrow Z$

10

2. (a) Given the non-linear system :

$$\dot{X}_1 = X_2$$

$$\dot{X}_2 = \left(0.1 - \frac{10}{3} X_2^2 \right) X_2 - X_1 + X_1^3$$

[P. T. O.]

- (i) Determine the equilibrium points of the system.
 (ii) Check the possible existence of limit cycle.

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- (b) Linearize the non-linear system described by :

$$\dot{X}_1 = X_1 + 2X_2 + X_1X_2^2$$

$$\dot{X}_2 = 2X_1 + X_2 - X_1^2X_2$$

around its equilibrium point at the origin and examine the stability of the system. 10

3. (a) Explain the concept of absolute stability in non-linear system. Also state and explain the popov's criterion of stability. 10

- (b) Using variable gradient method construct the Liapvnov's function and chede the stability of the system described by :

$$\dot{X}_1 = X_2$$

$$\dot{X}_2 = -X_2 - X_1^3 \quad 10$$

4. (a) Verify that $V = X_1^4 + X_1^2 + 2X_1X_2 + 2X_2^2$ is a suitable Liapvnov's function. for the system described by :

$$\dot{X}_1 = X_2$$

$$\dot{X}_2 = -X_2 - X_1^3 \quad 10$$

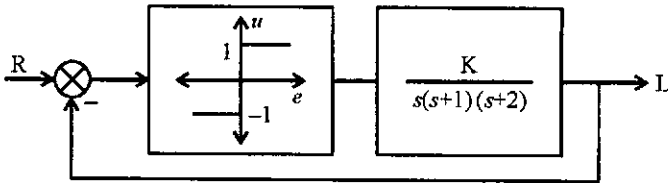
- (b) Consider the following non-linear differential equation :

$$\ddot{X} + \dot{X} + X^2 - 1 = 0$$

Draw the phase plane trajectory using delta method,
if initial conditions are :

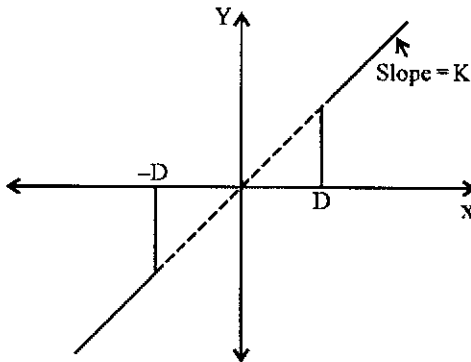
$$X(0)=3 \text{ and } \dot{X}(0)=0 \quad 10$$

5. Determine whether the system shown in fig. exhibit a self sustained oscillation. If so, determine the stability, frequency and amplitude of the oscillation using describing function method. 20



6. (a) Describe the chaotic and Bifurcation phenomenons in non-linear system. Give atleast one example for each case. 8
- (b) Derive the describing function of the element whose input and output characteristic is shown in fig.

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[P. T. O.]

7. (a) Describe the different types of singular points and discuss their importance in stability analyses of non-linear system. 10
- (b) A linear autonomous system is described by the state equation

$$\dot{X} = AX$$

where
$$A = \begin{bmatrix} -4K & 4K \\ 2K & -6K \end{bmatrix}$$

Find the restriction on the parameter 'K' to guarantee stability of the system. 10

8. Write short notes on the following : $5 \times 4 = 20$
- (a) Model reference adaptive controller.
- (b) Fuzzy PID controller.
- (c) Application of neural network in non-linear control.
- (d) Krasovskii's Theorem.