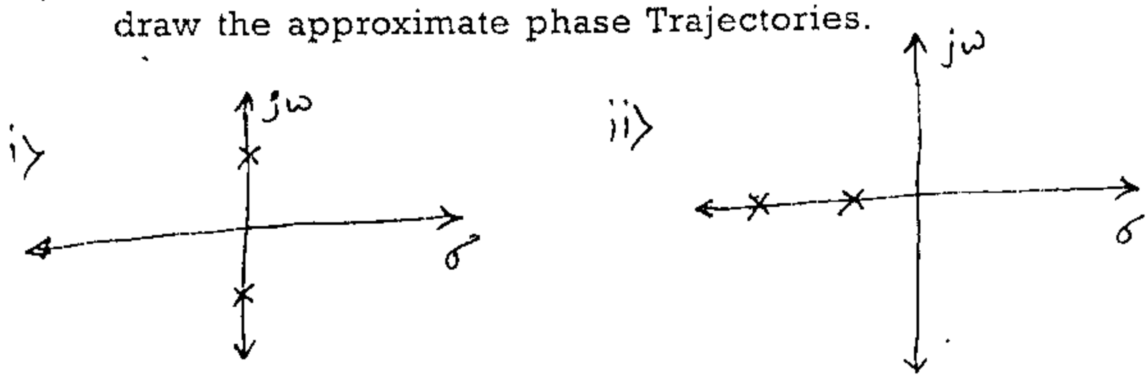
(3 Hours) **[Total Marks : 100**

N.B. : (1) Question No. **1** is **compulsory**.
(2) Answer any **four** questions out of remaining **six** questions.
(3) Assume **suitable data** if **necessary**.

1. Attempt any **five** question :— 20

(a) For a given pole zero plot in S-plane Identify singular point and draw the approximate phase Trajectories.

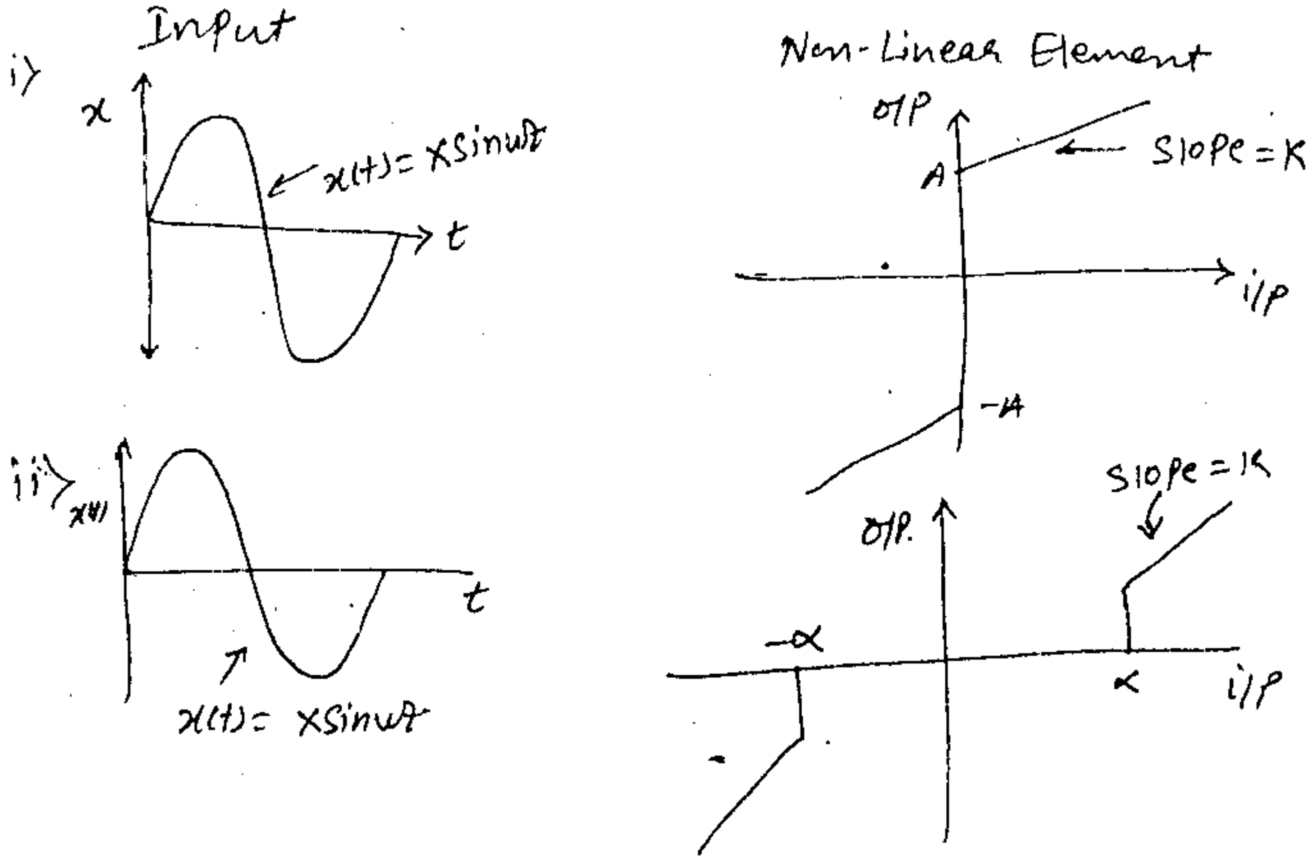


(b) Explain Jump Resonance Phenomenon for soft spring case with characateristics.

(c) Explain with justification why circular arcs are used to plot phase trajectories in delta method (δ-Method).

(d) Justify the following statement "Describing function is also called as Harmonic Linearization of Non-Linearities".

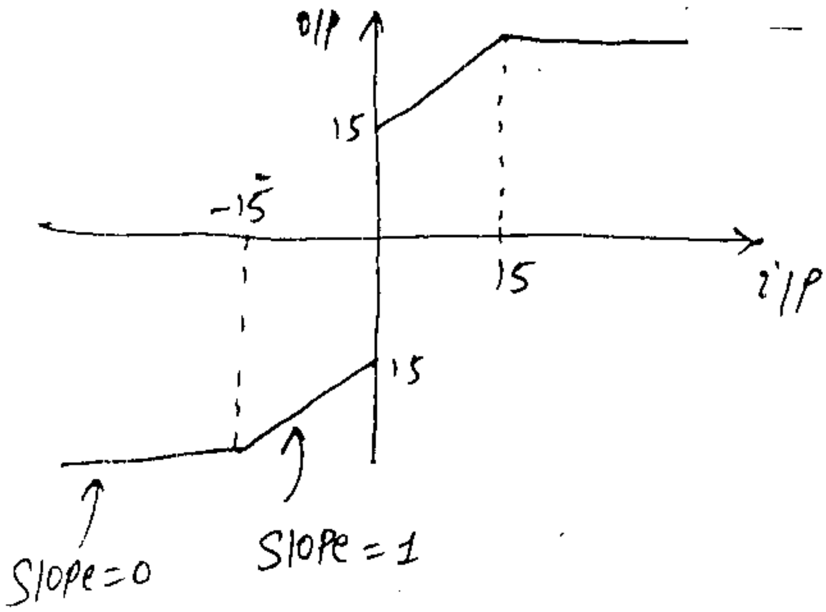
(e) With Sinusoidal input and Non-linear element characteristics shows, draw the output wave form.



(f) Explain briefly steps for improving Robustness of the system.

(g) Explain briefly MIT rule for Adaptive Countrol System.

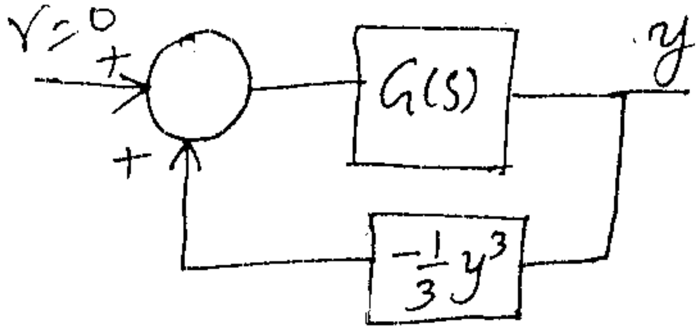
2. (a) Derive the describing function for the Non-linearity shown below.



(b) Consider a Non-linear system given by— 1

$$\frac{d}{dt}[\ddot{z} + \dot{z} + z] = \frac{1}{3}Z^3$$

Show that the system can be separated in to one linear and one non-linear part as shown in figure below. Determine Transfer function G(s). Assume $Z(0) = \dot{Z}(0) = 0$.



Also calculate describing function of $f(y) = \frac{1}{3}y^3$. And Estimate, The frequency and amplitude of possible limit cycle.

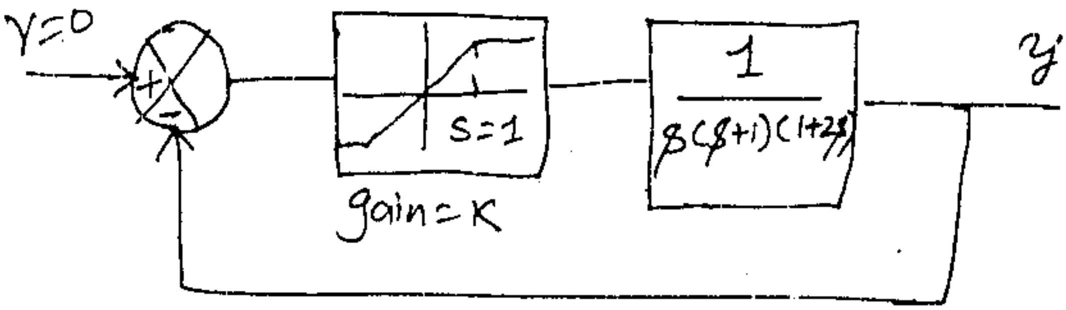
3. (a) Construct phase Trajectory starting at initial point $(x(0) = 1; \dot{x}(0) = 0)$, for the non-linear system described by $\ddot{x} + 2\dot{x} + x^3 = 0$. Use delta Method. 1

(b) Consider a Simple Harmonic Motion given by— 1

$$\frac{d^2x}{dt^2} + w_0^2 x = 0$$

Obtain the phase trajectory using Isochine method. (Assume suitable value of w_0).

Consider a Non-linear system shown in **figure** with saturating amplifier having gain 'K' for a system to stay stable. What would be the frequency and amplitude, mature of the limit cycle for gain K = 3 ? 10



(b) Using Second Method of Liapunov, examine the stability of the System given by— 10

$$\dot{x} = Ax \text{ where } A = \begin{bmatrix} -1 & -2 \\ 1 & -4 \end{bmatrix}$$

5. (a) For the system given below find all equilibrium points and determine type of each isolated equilibrium points. 10

(i) $\dot{x}_1 = x_1^3 + x_2;\ \dot{x}_2 = x_1 - x_1^3$

(ii) $\dot{x}_1 = x_1(2 - x_2);\ \dot{x}_2 = 2x_1^2 - x_2$

(b) A plant is described by— 10

$$\dot{x}_1 = -x_1 - x_2 + x_3 + u$$

$$\dot{x}_2 = x_1$$

$$\dot{x}_3 = x_2 \qquad \text{where } u = x_1 - x_3 - (2x_1 + x_3)^3$$

Show that x = 0 is globally Asymptotically stable equilibrium point.

Use $V(x) = x_1^2 + \frac{1}{2}x_2^2 + \frac{1}{2}x_3^2 + x_1 + x_3$

6. (a) Examine the stability at origin using Krasovskii's Method for a system given below :— 10

$$\dot{x}_1 + x_1,\ \dot{x}_2 = 4x_1 - 2x_2 + x_2^3$$

(b) Using variable gradient Method construct a suitable Liapunov function for a system given below :— 10

$$\dot{x}_1 = -x_1 + 4x_1^2;\ \dot{x}_2 = -2x_2$$

7. (a) Explain different schemes of Adaptive Control Systems.

(b) Consider a unity feedback system with Plant Transfer function. Detemine whether the system is stable for these uncertain co-efficients.

$$G(s) = \frac{a}{s(s+b)(s+c)}$$

where— $4 \le a \le 6$

$-2 \le b \le 3$

$1 \le c \le 4$

———S———