



Con. 5613-09.

SP-6605

(3 Hours)

[ Total Marks : 100

N.B.:(1) Question No. 1 is compulsory.

(2) Attempt any four questions from remaining six questions.

(3) Assume suitable data if needed.

1. Attempt any four of the following :—

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(a) A scalar non linear system is described by the differential equation—

$$\dot{x}(t) = f(x(t)), \quad x \in \mathbb{R}$$

where non linear function satisfies :

$$f(0) = 0$$

$$f(x) < 0 ; x > 0$$

$$f(x) > 0 ; x < 0.$$

Show that  $x = 0$  is globally asymptotically stable equilibrium point.

(b) Consider scalar differential equation—

$$\dot{x}(t) = 1 + x^2(t); \quad x(0) = 0$$

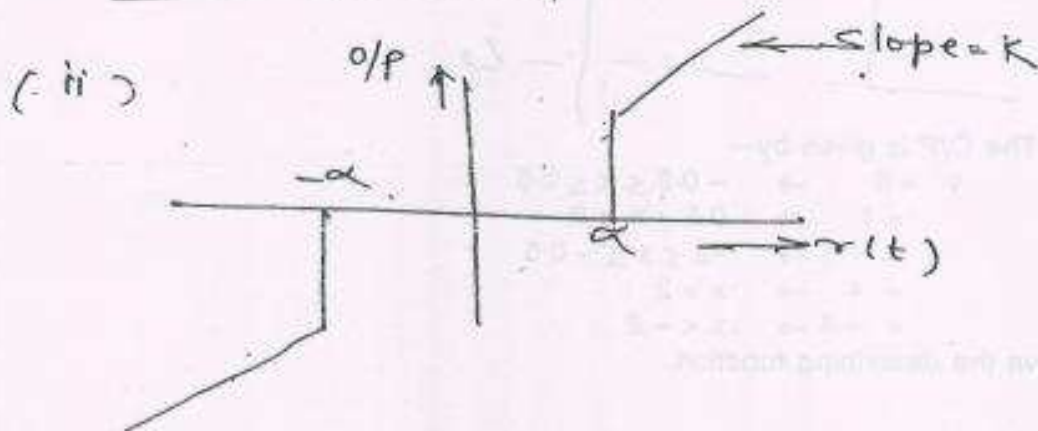
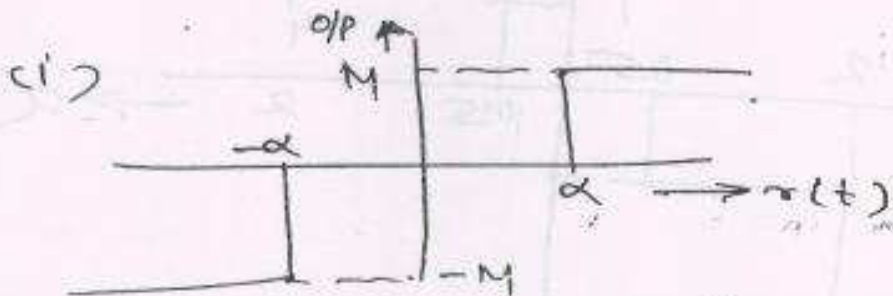
Show that  $x(t) = \tan(t)$  is a solution what happens as  $t \rightarrow \pi/2$ .

(c) Explain jump response for soft spring with characteristics.

(d) On what factors Robustness of the system depends.

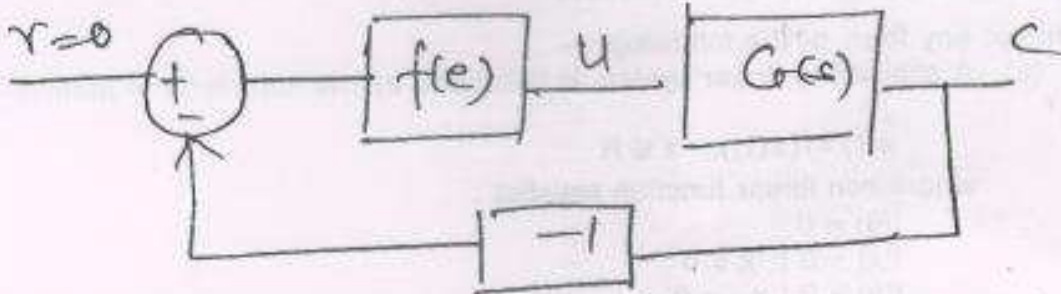
(e) Discuss gradient update law.

(f) For sinusoidal input and given non-linearity draw the possible output.



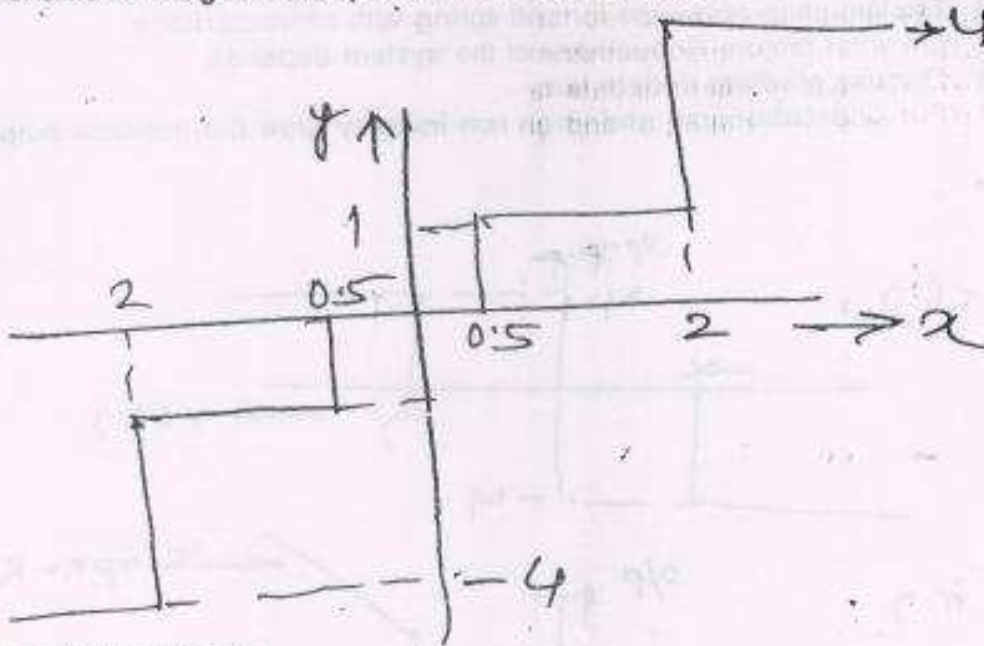
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2. (a) Consider the feedback loop in figure the linear system  $G(s) = \frac{1}{(s+1)^4}$  is connected to a static nonlinearity  $u(t) = f(e(t))$  where  $f(0)$  has describing function  $N(X, j\omega) = X + 3X^2 \angle \sigma$



What is the amplitude and frequency of the limit cycle? Comment on stability of limit cycle.

- (b) Consider the logarithmic quantizer with two levels.



The O/P is given by—

- $y = 0 \rightarrow -0.5 \leq x \leq 0.5$
- $= 1 \rightarrow 0.5 < x \leq 2$
- $= -1 \rightarrow -2 \leq x < -0.5$
- $= 4 \rightarrow x > 2$
- $= -4 \rightarrow x < -2$

Derive the describing function.

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3. (a) Consider the nonlinear system described by the equations—

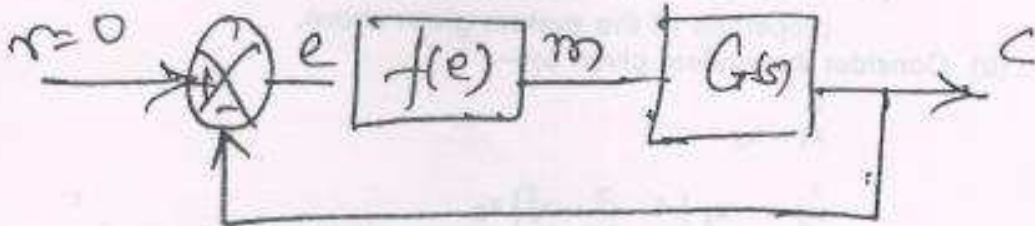
10

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

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

Using Krasovskii's Method construct a Liapunov's function for the given system.

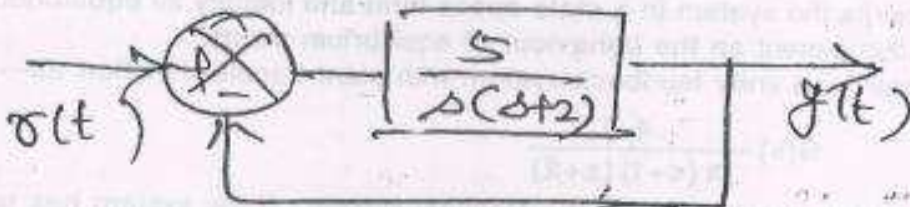
(b) For the control system shown in figure, use variable gradient method to investigate stability of the system. 10



$$f(e) = e^3$$

$$G(s) = \frac{1}{s(s+1)}$$

4. (a) For the block diagram shown in figure, use method of isocline to draw the phase trajectory. 10



$$r(t) = 24(t) \text{ and initial conditions } y(0) = -1 ; \dot{y}(0) = 0$$

(b) For a system given by the differential equation—

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$$\ddot{x} + 3\dot{x} + x = 0$$

Use delta method to plot the phase trajectory using initial conditions as (1, 0).

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5. (a) Consider the system :

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

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

(i) Is the system asymptotically stable ?

(ii) Use Liapunov function  $V(x) = 3x_1^2 - 2x_1x_2 + x_2^2$  to investigate the stability properties of the system given above.

(b) Consider the system given by—

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$$\dot{x}_1 = x_2$$

$$\dot{x}_2 = -x_1(1-x_1^2-x_2^2)$$

Find the only equilibrium points show that the unit circle is a limit cycle for the system.

6. (a) Discuss different Adaptive control schemes.

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(b) Explain methods for improving Robustness of the system.

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7. (a) Consider the second order system—

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$$\ddot{x} + 2\alpha\dot{x} - \alpha x + x^3 = 0$$

where ' $\alpha$ ' is a constant parameter.

Rewrite the system in a state space form and identify all equilibrium points and comment on the behaviour of equilibrium points.

(b) Consider a unity feedback system with plant transfer function as—

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$$G(s) = \frac{4.5}{s(s+1)(s+2)}$$

Ascertain the stability of the Nominal system. If the system has uncertain coefficients.

$$4 \leq a_0 \leq 5$$

$$1 \leq a_1 \leq 3$$

$$2 \leq a_2 \leq 4.$$