Duration: 3 Hours   **Total Marks: 80**

Note:
  1. Question one is compulsory.
  2. Solve any three from remaining and assume suitable data

Q1.   Solve any four   20
  a.   Explain in details Jump resonance for nonlinear system.
  b.   Explain types of stability in details.
  c.   Differentiate linear and nonlinear system in detail
  d.   Explain Lyapnov theorem in details
  e.   Derive classical control "c" from the IMC controller 'q'

Q2. a   Determine stability of system described by the following equation. Use   10
        Lyapunov direct method

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

Q2. b   Formulate the describing function for relay.   10

Q3.a   Derive the Lyapunov function using Variable Gradient method for the   10

       system given , $x_1 = -9x_2 , x_2 = -x_1^2 - x_2$

Q3.b.   Design IMC- PI controller for the following plant model in order to achieve   10

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

       the response with time constant of 1.5 Sec.

Q4.a.   Investigate Stability using Describing function of following system which   10
        has unity saturation signal as a nonlinearity and find out frequency and
        magnitude where system has limit cycle
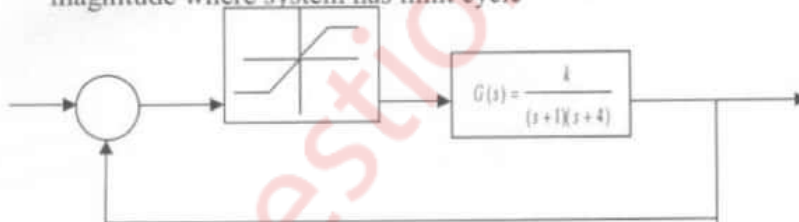
Q4.b.   Investigate stability using singular point and its type   10

$$\ddot{Y} - (0.1 - \frac{10}{3} y) \dot{y} + y + y^2 = 0$$

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Q5.a. Explain in details IMC based PID controller Design/tuning. 10

Q5.b. Investigate stability using variable gradient method so that system becomes stable at equilibrium point 10

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

Q6a. How would you classify the following physical nonlinearities and sketch their input-output characteristics? 04

    a. Saturation b. Dead-zone c. Relay d. Friction

Q6b Demonstrate the following: 06

    1. Phase plane
    2. Phase portrait
    3. Singular point
    4. Phase trajectories

Q6c What is limit cycle? Explain in details contrast between stable and unstable limit cycles using Van der Pol equation 10

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