

M.E. ELECTRICAL ENGINEERING, 1st YEAR 2nd SEMESTER EXAMINATION– 2019**NON-LINEAR AND ADAPTIVE CONTROL (CS)**

Time : 3 hours

Full Marks : 100

Answer any FIVE questions.*Answer all parts of a question in the sequential order.*

1. a) State the advantages of nonlinear control techniques over linear control techniques.
- b) Explain with neat diagrams, the frequency response of a mass-spring-damper system where the spring has nonlinear characteristics. Hence, comment on it.
- c) Describe, with suitable sketches, the various forms of nonlinearities commonly found in electro-mechanical systems.

[4+6+10=20]

2. a) Explain the basic concept of Phase Plane Analysis.
- b) Explain the various properties of Phase Plane Portraits.
- c) Explain how the dynamics of a second order linear system can be analyzed using Phase Plane Method for under-damped, critically damped, over-damped and undamped cases.

[4+4+12=20]

3. a) Explain the following:

- i) Equilibrium state
- ii) Stability in the sense of Lyapunov
- iii) Asymptotic stability
- iv) Exponential stability
- v) Region of attraction

- b) State and explain the Lyapunov's Indirect Method of Stability theorem. What is the significance of this method in the perspective of nonlinear control theory.

[2x5+10=20]

4. a) Explain the basic concept of Describing Function method for analyzing nonlinear systems.
 b) Derive the describing function for a nonlinear system containing a typical electromechanical relay.

[7+13=20]

5. a) Explain the basic concept of feedback linearization. Hence, explain its shortcomings.
 b) Derive the feedback control law for the following system employing Integrator Backstepping:

$$\dot{\eta} = f(\eta) + g(\eta)\xi$$

$$\dot{\xi} = u$$

Where η and ξ are the system states and u is the control input.

[10+10=20]

6. a) Explain, with suitable schematic diagrams, the various adaptive control schemes.
 b) Derive a Model Reference Adaptive Control law for a first order system containing model uncertainties. Then analyze the tracking convergence of the chosen control law.

[10+10=20]

7. a) Explain the concept of Variable Structure Systems. How does it help us?
 b) Describe the design steps to derive the control input for a typical nonlinear system employing Sliding Mode Control technique. The control input should ensure stability and robustness in closed-loop operation.

[5+15=20]

8. Write short note on **any two** from the following:

- a) Derivation of Lyapunov candidate function.
 b) Linear Parametric Modelling.
 c) Lyapunov's Direct Method.

[10x2=20]