NON–LINEAR AND DIGITAL CONTROL SYSTEMS
(Elective Course)

Course Code:	14B1WEC734	**Semester:**	7th Semester
Credits:	3	**Contact Hours:**	L-3, T-0, P-0

Course Objectives

The objectives are to study

1. The ability to understand the characteristics of various types of nonlinearities present in physical systems.
2. The ability to carry out the stability analysis of non-linear control systems.
3. The ability to carry out the analysis and design of digital control systems.
4. The ability to design compensators for digital control system to achieve desired specifications.
5. The ability to represent digital control systems using state space models.
6. The ability to analyze the effect sampling on stability, controllability and observability.
7. The ability to design digital controllers for industrial applications.

Course Outcomes

After studying this course the students would gain enough knowledge

1. The ability to understand the characteristics of various types of nonlinearities present in physical systems.
2. The ability to carry out the stability analysis of non-linear control systems.
3. The ability to carry out the analysis and design of digital control systems.
4. The ability to design compensators for digital control system to achieve desired specifications.
5. The ability to represent digital control systems using state space models.
6. The ability to analyze the effect sampling on stability, controllability and observability.
7. The ability to design digital controllers for industrial applications.

Course Contents

Unit	**Topics**	**References (chapter number, page no. etc)**	**Lectures**
1.	**Non-Linear Systems** Introduction to nonlinear systems, mathematical modeling, common physical nonlinearities in control systems: saturation, dead zone, backlash, Columb friction and on-off nonlinearity, concept of linearization of non-linear mathematical models, multivalued responses, describing function fundamentals, derivation of describing functions of nonlinearities and their applications to system analysis, unique characteristics of non-linear systems, jump resonance and limit cycle behavior, nonlinear state variable equations, nonlinear state variable models.	Text4/15	7
2.	**Stability Analysis of Non-Linear Systems**	Text 1/8, Text	10

	Stability analysis by describing function method, Phase plane analysis, types of phase portraits, singular points, analytical method, method of isoclines. Lyapunov functions for linear and non-linear systems, statement of various stability terms in sense of Lyapunov, stability analysis by Lyapunov's first and second methods, Methods of constructing Lyapunov's functions for non-linear systems, Krasovskii's and variable gradient methods, Popouv's stability theorem for non-linear systems.	1/10, Text 4/13, Text 4/15	
3	**Design of Digital Control System** Configuration of basic digital control scheme, sampleand- hold elements, Mapping from s-Plane to z-plane, various representations of sampled data feed-back systems, Pulse transfer function, Stability and controller design uses z transform and difference equations, Jury stability criterion, bilinear transformation, z-domain specifications of control system design, Root locus of digital control systems, design of digital controllers, design of digital compensators.	Text 1/3, Text 1/4	10
4	**State Variable Analysis of Digital Control Systems** State descriptors for digital processors, conversion of state variable models to transfer functions, conversion of transfer functions to canonical state variable models, state description of sampled continuous time plants, state description of systems with dead-time, solution of state difference equations, controllability and observability, effect of sampling on stability, controllability and observability.	Text 1/6	8
5	**Applications of Digital Control Systems** Digital temperature control system, Digital position control system, Building blocks of a PLC, Ladder diagram programming instructions, case studies of automatic control applications.	Text 1/3	9
		Total Number of Lectures	42

Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
    - 10 Marks : Class performance, Tutorials & Assignments
    - 10 Marks : Quizzes
    - 5 marks : Attendance

Text Books

1. Text 1 Gopal M., Digital Control and State Variable Methods TMH Publishers
2. Text 2 Ogata, K., Discrete-time Control Systems, Pearson Education.
3. Text 3 Kuo B.C, Digital Control Systems, Wiley Publications.
4. Text 4 Nagrath I.J, Gopal M, Control System Engineering, New age International.

Reference Books

1. Hassan K. Khalil, Non Linear Systems, 3rd Edition, Prentice Hall.
2. Horacio J. Marquez, Nonlinear Control Systems Analysis and Design, Wiley Publications.