NIRMA UNIVERSITY

Institute:	**Institute of Technology**
Name of Programme:	**M. Tech. in Electrical Engineering (Electric Vehicular Technology)**
Semester:	**II**
Course Code:	**6EE167**
Course Title:	**Advanced Control Systems**
Course Type:	(□ Core/ □ Value Added Course / √ **Department Elective** / □ Institute Elective/ □ University Elective/ □ Open Elective / □ Any other)
Year of Introduction:	**2022 – 23**

L	T	Practical component				C
		LPW	PW	W	S	
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Course Learning Outcomes (CLOs):

At the end of the course, the students will be able to-

1. represent different dynamical systems in state space form and understand the concept of controllability and observability **(BL4)**
2. gain familiarity with sample theory, z-transform, and to decide system stability in a discrete domain **(BL5)**
3. use system identification methods to design adaptive controllers and use input-output experimental data for identification of mathematical dynamical models **(BL4)**
4. control a dynamical system over a period of time such that an objective function is optimized **(BL6)**

Syllabus: **Teaching Hours: 30**

UNIT-1: State-Space Analysis **08**

State-space approach to linear system theory, State space representation of different dynamical system, State space modelling of electric vehicle control system, Representing transfer function in different canonical forms such as controllable and observable canonical forms, Jordan form, Solutions of state equations using different methods (time invariant and time varying systems) System Analysis: Controllability, Observability.

UNIT-2: Digital Control **05**

z Transform. z Plane Analysis of Discrete-Time Systems Stability of discrete systems: location of poles, Jury's stability criterion, stability analysis through bilinear transforms, Lyapunov stability analysis. Design of Digital Controller: Pole Placement and observer design

UNIT-3: System Identification and Adaptive Control **09**

Introduction and overview of Systems Identification, Adaptive Control and applications. Parameter Estimation: Least Square, Generalized and Recursive Least Square, Estimator properties including error bounds and convergence. Model Structures and Predictors. Recursive Identification of Linear dynamic systems: RLS, ELS, IV, RML, Stochastic Approximation, Extended Kalman Filter, generalized prediction error framework and its application to ARMA and state models, convergence analysis. Use of robust estimation methods in MRAS. The basic idea. Indirect self-tuning regulators. Direct Self-tuning regulators. Linear Quadratic STR. Adaptive Predictive control. Prior knowledge in STR.

UNIT-4: Introduction to Optimal Control **08**

Static Optimization: unconstrained and constrained cases, Lagrange multiplier Dynamic programming Hamilton-Jacobi-Bellman equation Lagrange, Mayer and Bolza formulations for optimal control problems. Matrix Riccati equation and its solution. Pontryagin's principle and control problems

Self-Study:

The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Laboratory Experiments:

This shall consist of at least 08 experiments / simulations based on the above syllabus.

Suggested Readings:

1. S.H. Zak, Systems and Control, Oxford Univ. Press
2. Katsuhiko Ogata, Modern Control Engineering, Pearson
3. M. Gopal, Digital Control and State Variable Methods, Tata McGraw-Hill
4. K.J. Astrom and B. Wittenmark, Adaptive Control, Pearson
5. L. Ljung, System Identification Theory for the user, Prentice-Hall
6. K.S. Narendra and A.M. Annaswamy, Stable Adaptive Systems,, Prentice-Hall
7. Donald E Kirk, Optimal Control Theory: An Introduction, Dover
8. M. Athans and P.L. Falb, Optimal Control, McGraw Hill

Suggested List of Experiments (not restricted to the following):
(Only for Information)(04 hours each)

1. Development of state space model of physical and electrical system using simulation package
2. Design and simulation of controller using pole placement technique
3. Design and simulate a control system to emulate zero order hold compensation
4. Stability analysis of a digital control system using Jury's stability criteria
5. Design and simulation of Recursive Least Square (RLS) method-based controller
6. Design and simulation of a Kalman filter based controller
7. Design and simulation of Linear Quadratic Regulator (LQR)
8. Design of a controller using solution of algebraic Riccati equation

L = Lecture, T = Tutorial, P = Practical, C = Credit

w.e.f. academic year 2022-23 and onwards