# THEROY AND APPLICATIONS OF CONTROL SYSTEMS

**(Core Subject)**

| **Course Code:** | 10B1WEC515 | **Semester:** | 5th Semester, B. Tech (ECE) |
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| **Credits:** | 4 | **Contact Hours:** | L-3, T-1, P-0 |

## Course Objectives

The objectives are to study

1. To understand procedures for developing mathematical models of physical systems, and related analytical and numerical methods for predicting their behavior.
2. To develop the skill of designing compensating networks according to the desired design specifications.
3. Use computational tools in the modelling, simulation and analysis of linear control systems.
4. Understanding of stability of state space models and their controllability and observability in modern automation and control.
5. Ability to understand and design advance control schemes for industrial applications.

## Course Outcomes

After studying this course the students would gain enough knowledge

1. The ability to analyze any physical system using mathematical model.
2. The ability to formulate reduced models for complex systems.
3. The skill to analyze the response of any LTI system.
4. The ability to design any system with desired specifications both in time and frequency domain.
5. The ability to derive, interpret and solve problems using modern state space control methods for continuous time and discrete time systems.
6. The skill to apply advance control schemes for various applications.

## Course Contents

| **Unit** | **Topics** | **References (chapter number, page no. etc)** | **Lectures** |
|---|---|---|---|
| **1.** | Introduction to Systems and Control: Open loop and closed loop control systems, components of control system: sensors, actuators, controllers, process, modeling principles of physical systems: electrical, mechanical, thermal and pneumatic systems, effect of feedback on gain, stability, sensitivity and noise, characteristics of transfer function models: poles, zeros, stability and minimal realization, block diagram algebra, signal flow graphs, Mason's gain formula, conversion between block diagram and signal | BC. Kuo : Chapter 1, 3, 4<br>M. Gopal: Chapter 4 | 6 |

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| | flow graph. | | |
| **2.** | Response Analysis: Standard test input signals, transient and steady state response: first, second and higher order systems, system design specifications, error analysis: static and dynamic error coefficients, Effect of adding poles and zeroes, Correlation-ship between time and frequency domain specifications. | BC. Kuo : Chapter 7, 9<br>M. Gopal: Chapter 5 | 8 |
| **3** | Stability Analysis: Absolute stability, relative stability, routh-hurwitz, root locus, bode plot, polar plot and Nyquist plot techniques, gain margin and phase margin, constant magnitude loci: M-circles, constant phase Loci: N-circles, nichol's chart. system identification: inverse bode plots. Effect of adding zero to the forward path, effect of adding pole to the forward path. | BC. Kuo : Chapter 6, 8, 9 | 10 |
| **4** | Compensator Design: System design specifications, design of compensating networks (Lead, Lag, Lag-Lead) for specified control system performance using root locus and bode plot, concepts and applications of P, PD, PI and PID controllers. | BC. Kuo : Chapter 10 | 6 |
| **5** | Linear State Variable Models: Concept of state, state space modeling: SISO and MIMO systems, useful transformations in state–space analysis and design, various forms: physical variable form, phase variable form, Jordan canonical form, solution of state equations, computation of state transition matrix: Laplace method, power series method and Cayley Hamilton method, derivation of transfer function from State variable model, decomposition of transfer function: direct decomposition, cascade decomposition, parallel decomposition, characteristics of linear state variable models, natural and forced responses, determination of controllability and observability of a control system using Kalman and Gilbert tests. | BC. Kuo : Chapter 5<br>M. Gopal: Chapter 12 | 8 |
| **6** | Advanced Control Schemes: Control systems with multiple loops- cascade control, selective control systems: override control, split range | Stephanopoulos- Chapter 20, 21, 22 | 6 |

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| | control, feed-forward and ratio control, adaptive and inferential control systems. | | |
| | | **Total Number of Lectures** | 44 |

## 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. Benjamin C. Kuo, "Automatic Control Systems", Prentice Hall of India.
2. Nagrath & Gopal, "Control System Engineering", New age International.
3. Stephanopoulos, G., Chemical Process Control, Prentice Hall of India.


## Reference Books


1. K. Ogata, "Modern Control Engineering", Prentice Hall of India.
2. Norman S. Mise, "Control System Engineering", Wiley Publishing Co.
3. Richard C Dorf, Robert H Bishop, "Modern Control Systems", Pearson Edu.


**Web Resources:** http://nptel.ac.in/courses/108102043/