

# Course Title: Linear System Theory

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**Credit Hours:** 3+0

**Prerequisite:** Feedback Control Systems and Linear Algebra.

## **Course Objectives:**

The aim of the course is to provide the students an understanding of Linear System Models and its application in different engineering domains.

## **Contents:**

### **1. Mathematical Description of the System**

- 1.1. Linear Models
- 1.2. Properties of Linear Systems
- 1.3. Linear Time Invariant (LTI) Systems
- 1.4. Linearization

### **2. State space representation of dynamic system.**

- 2.1. The concept of state
- 2.2. Obtaining the state equations
- 2.3. Interconnections of subsystems and simplification using Signal Flow Graph.
- 2.4. Structure of State Space Model
- 2.5. Mathematical model of electrical circuits and mechanical systems using state space approach

### **3. Solution of State space equations**

- 3.1. Solution of continuous time equations
- 3.2. Free Response, Forced Response, Weighting Sequence, Complete Response of LTI system.
- 3.3. Continuous time Impulse Response, Continuous time convolution.
- 3.4. Discretization, Solution of discrete time equations

### **4. Vector and vector spaces**

- 4.1. Definition of linear vector space
- 4.2. Linear dependence and independence
- 4.3. Spanning a space and Basis vectors
- 4.4. Orthogonal vectors and their construction

- 4.5. Similarity Transformation
- 4.6. Diagonal Form and Jordan form
- 4.7. SVD, Norms of a matrix

**5. Least Squares solution to Linear Systems**

- 5.1. Over-determined and Under-determined system
- 5.2. Existence and Uniqueness of a solution
- 5.3. Geometric Interpretation of Least Square
- 5.4. Polynomial Fitting
- 5.5. Psuedo-inverse and the Least Square problem

**Recommended Books:**

**Text Book(s):**

The Essential of Linear State Space System by J. Dwight Aplevich

**Reference Book(s):**

- 1. "Linear System Theory and Design" by Chi-Tsong Chen
- 2. "Modern Control theory" by William .L.Brogan
- 3. "A First Course in Linear Algebra" by Robert A