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ECE 601 - 101 - LINEAR SYSTEMS

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1. **Introduction To Linear System Analysis**
    - Definition of a System
    - Simple Examples
    - The General Problem
    - Basic Concepts, Terms and Definitions
        - Input-Output Relations
        - Linearity
        - Time-Invariance
        - Causality
    - Linear function
        - Matrix Multiplication representation
        - Engineering examples of linear systems and linear functions

2. Time-Domain Analysis of Input-Output Representation

A. Continuous-Time Systems

- Elementary Functions
- Distribution Theory
- Resolution of Arbitrary Signals
- Impulse and Step Response
- Convolution Integrals

B. Discrete-Time Systems

- Discrete-Time Impulse Function (Kronecker Delta Function)
- Discrete-Time Impulse Response
- Discrete-Time Convolution Sum and Solution

3. Frequency Domain Analysis of Continuous-Time Systems

- Fourier Series (for obtaining properties of signals)
    - Properties of Fourier Series
    - Signal Spectra
- Fourier Transforms (for obtaining properties of systems)
    - Properties of Fourier Transforms
    - System Response Function and its Spectra
    - Fourier Series Coefficients From Fourier Transform
- Laplace Transforms

    - Easier to Use Than Fourier Transforms
    - Limitations of Laplace Transforms
    - Properties of Laplace Transforms
    - Relationship to Fourier Transforms
- Applications of Fourier Series, Fourier Transform, and Laplace Transform
- Discrete-time Frequency response

4. Least Square Approximation

- Linear Algebra: Norms, Cauchy-Schwartz Inequality, Basis, Rank of Matrix, Matrix norm
- Underdetermined and Overdetermined system
- Least square solution: Formulation and methods
- Estimation of Signal
- Practical Applications and Design of Systems

5. State Variable Representation of Continuous-Time Systems

- Definition of State Vector
- Review of Matrix Algebra
- Representation in State-Variable form: Practical Examples
    - Companion Forms
    - Jordan Form
    - Similarity Transformations
    - Use of Software (MATLAB)

6. Solution of the Continuous-Time State Equations

- The State Transition matrix
    - Properties

    Method of Finding
- The Complete Solution

7. Solution of the Discrete-Time State Equations

- The Discrete-Time Transition matrix
    - Properties
- The Complete Solution

8. Higher Dimensional solution of Linear Dynamical Systems

- Matrix Exponential

- Characteristic Polynomial
- System Design
- Linear Dynamical Systems: Examples (Aircraft, Robotics)

9. Controllability and Observability of Linear Systems

- Definitions
- Examples of How Unwanted Uncontrollable and Unobservable Systems Can Arise
- The General Controllability Theorem (difficult to use)
- The Algebraic Controllability Theorem for time-invariant systems (easier to use)
- The General Observability Theorem (difficult to use)
- The Algebraic Observability Theorem for time-invariant systems (easier to use)

10. Stability of Linear Systems

- Continuous-Time Systems
    - Definitions
    - Bounded-Input-Bounded-Output (BIBO) Stability
    - Internal Stability

- Discrete-Time Systems
    - Definitions
    - Bounded-Input-Bounded-Output (BIBO) Stability
    - Internal Stability