Objective
What is this course about?

Motivation
Why are we learning this course?

Methodology
How do we plan to learn this course?

Signals, Systems and Networks

- What is a signal?
- Measuring signals using Energy/Power
- Classification of signals
- Useful signals:
  - Unit step: $u(t)$
  - Unit impulse: $\delta(t)$
    - $\frac{du}{dt} = \delta(t)$
  - Complex exponential: e^{st}
- Signal Operations:
  - Shifting
  - Inversion
  - Scaling
  - Separating even and odd part

- What is a system? How is it represented and characterized?
- Two goals of learning systems: Analysis and Design
- Classification of systems:
  - Linear vs Non linear
  - Time invariant vs Variant
  - Causal vs Non causal
  - Invertible vs Non invertible
  - BIBO stable vs BIBO unstable
- Time domain analysis of LTIC systems:
  - Representing LTIC systems using linear DEs: $Q(D)y = P(D)x$
  - $m \leq n$ for practical systems
  - Total system response = Zero-input (y_{zi}) + Zero-state (y_{zs})
  - Zero-input response:
    - Solve $Q(D)y = 0$
    - Distinct roots, repeated roots, and complex roots
  - Zero-state response:
    - Understanding the impulse response $h(t)$
    - Deriving $y_{zs}(t) = \int_{-\infty}^{\infty} x(t-\tau)\,h(t)\,d\tau$
    - Convolution integral $x_1(t) * x_2(t)$ and its properties
    - Computing convolution properly
  - Total system response = Natural + Forced
  - System Stability:
    - Asymptotic/Internal/ZI: Characteristic roots → A.S. / M.S. / U.S.
    - BIBO/External/ZS: Is $h(t)$ absolutely integrable? → BIBO-S / BIBO-US
- Fourier Series Representation:
  - Helps us split $x(t)$ into simpler functions, which makes computing $y_{zs}(t) = x(t) * h(t)$ easier
  - Generalized Fourier Series using a set of orthogonal signals
  - Trigonometric Fourier Series:
    - Set of Harmonic sinusoids and cosines
    - Trigonometric Fourier Series expansion and computing the coefficients
    - $x(t)$ and the Fourier series expansion have the same T_0
    - Dirichlet Conditions
  - Compact Trigonometric Fourier Series
  - Exponential Fourier Series expansion and computing the coefficients
  - Converting Fourier Series expansions from one form to another
  - Parseval's Theorem
  - Properties of Fourier Series
  - Limitations of Fourier Series
- Fourier Transform:
  - Motivation and deriving the Fourier Transform/Integral and its Inverse
  - Properties of Fourier Transform
  - Using Fourier Transform to find the LTIC System response
  - Parseval's Theorem
  - Application of Fourier Transform in modulation and demodulation
- Laplace Transform:
  - Laplace Transform as an extension of Fourier Transform
  - Properties of Laplace Transform
  - Using Laplace Transform to find the LTIC System response
  - Applications of Laplace Transform in solving Differential Equations and Electrical Circuits

- What is Network Analysis?
- Kirchhoff's Current Law & Generalized Nodal Analysis
- Kirchhoff's Voltage Law & Generalized Mesh Analysis
- Supernode and Supermesh
- Network Theorems:
  - Superposition
  - Thevenin's
  - Norton's
  - Maximum Power Transfer
  - Millman's
  - Reciprocity
  - Substitution
  - Compensation
  - Tellegen's
- Network Functions:
  - Transform (driving-point) Impedance & Admittance
  - Transfer Impedance & Admittance
  - Voltage transfer function
  - Current transfer function
  - Poles and Zeros
    - ↳ Stability criterion?
- Two-Port Networks:
  - Impedance Parameters
  - Admittance Parameters
  - Transmission Parameters
  - Hybrid Parameters
  - Interrelationship between parameters
  - Interconnection of Two-port networks
    - Cascade
    - Series
    - Parallel
- Passive and Active Filters
  - Low-Pass
  - High-Pass
  - Band-Pass
  - Band-Stop