x298-CLA: Complex linear algebra for ECE

Three math courses merged into 1: DiffEq, Linear Alg, Complex Functions

Jont B Allen
UIUC Urbana IL, USA

November 15, 2022

Circuit theory applies to many areas

ECE-298 CLA is engineering mathematics for engineering students

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- Half-semester course (Part B)
- Simplified version of ECE-498/Math-487
- Designed for those taking ECE 210 or 310
- Three or Four math courses, pack into one half semester (really!)
  - Differential equations, Math 285
  - Linear algebra with computations, Math 257
  - Applied linear algebra
  - Complex analysis
- Reorgization of Math courses
- Math online may be the future

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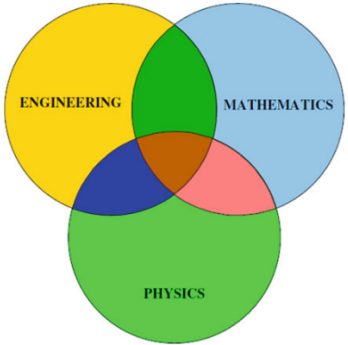

Fig. 1 There is a natural symbiotic relationship among mathematics, engineering, and physics

Unifies many areas of Engineering, Physics & Math

- Properties of impedance in various fields: Class text

3.8 Transmission (ABCD) Matrix Composition Method 147

Table 3.2 The *generalized impedance* is defined as the ratio of a force to a flow, a concept that also holds in mechanics and acoustics. In mechanics, the force is the mechanical force on an element (e.g., a mass, dashpot, or spring) and the flow is the velocity. In acoustics, the force is the gradient of the pressure, and the flow is the volume velocity or particle velocity of air molecules

Case	Potential	Flow	Impedance	Units *ohms* [Ω]
Electrical	Voltage (V)	Current (I)	$Z = -\nabla V/I$	[Ω]
Mechanics	Force (F)	Velocity (U)	$Z = -\nabla F/U$	Mechanical [Ω]
Acoustics	Pressure (P)	Particle velocity (V)	$Z = -\nabla P/V$	Specific [Ω]
Acoustics	Mean pressure ($\mathcal{P}$)	Volume velocity ($\mathcal{V}$)	$Z = -\nabla \mathcal{P}/\mathcal{V}$	Acoustic [Ω]
Thermal	Temperature (T)	Entropy ($\mathcal{S}$)	$Z = -\nabla T/\mathcal{S}$	Thermal [Ω]

- Breadth of topics taught in ECE-298-CLA using *impedance = Force/Flow*

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ECE 298 Website

ECE-298-S22

- Part I: Introduction to 2x2 complex matricies (9 Lectures)
  - Companion matrix to find eigen-values and eigen-matricies
  - Fourier (signals) vs. Laplace transforms (causal functions)
  - Cauchy-Riemann (CR) conditions and differentiation wrt the Laplace Frequency $s = \sigma + j\omega$
  - Review Laplace's equation
  - Integration complex analytic functions (the key to the inverse Laplace Transform)
- Part II: Complex analytic analysis (6 Lectures)
  - Visualizing complex valued functions
  - Example: impedance and system transfer functions
  - Cauchy's integration

Students who take this course find ECE-298 fills in the gaps in

- ECE 210 (networks) and
- 310 (digital signal processing)

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Publications

https://auditorymodels.org

Allen WebPage