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

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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!)
  - (1) Differential equations: Math 285
  - (2) Linear algebra with computations: Math 257
  - (3) Applied linear algebra
  - (4) Complex analysis
- Reorganization of Math courses
- Math online may be the future

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- Reorganization of Math courses Math Dept's Mission Statement
- Math online may be the future The Future is Now

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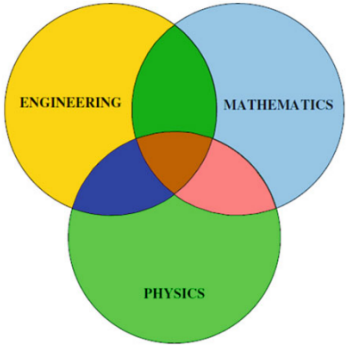

Fig. 1 There is a natural symbiotic relationship among mathematics, engineering, and physics

Unifies many areas of Engineering, Physics & Math

- Properties of impedance in various fields: Class text

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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3.8 Transmission (ABCD) Matrix Composition Method 147

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ECE 298 Website

Website for ECE-298-S22

- Part I: Introduction to 2x2 complex matrices (9 Lectures)
  - Companion matrix to find eigen-values and eigen-matrices
  - Fourier (signals) vs. Laplace transforms (causal functions, or *systems*)
  - Cauchy-Riemann (CR) conditions (differentiation wrt the Laplace Frequency $s = \sigma + \jmath\omega$)
  - Review Laplace's equation
  - Integration complex analytic functions (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

Slides for this presentation: ▸ pdf of my talk

`https://jontalle.web.engr.illinois.edu/Public/talk.298.11_16_5PM.pdf`

▸ Alternative: 1) click on Allen Webpage; 2) then **Public**, then scroll to bottom