ECE/MATH 430: Fourier and Wavelet Analysis with Apps

Concepts:
- Elementary signals and systems
- Periodic and trigonometric signals
- Fourier series for periodic signals
- Pointwise representation and convergence
- Expanding a function in an orthogonal basis
- Discrete Fourier transform
- Fast Fourier transform
- Lebesgue integration and measurable functions
- Function spaces, $C^k$, $L_1$, $L_2$, and Hilbert spaces
- Fourier transform on $L_1$ and $L_2$
- Convolution and Fourier transform
- Tempered distributions and generalized functions
- Fourier transform of distributions
- Sampling
- Uncertainty principle
- Poisson formula and aliasing
- Limitations of Fourier transform for time-frequency analysis
- The continuous wavelet transform and its inverses
- Multiresolution analysis
- The discrete wavelet transform and its inverse

Applications:
- Communication
- Signal Processing
- Control
- Circuits
- Optics

Tools:
- MATLAB

Real and Functional Analysis
- Understand metric spaces, Cauchy sequences, limits, and convergence
- Understand functional spaces including $L_1$ and $L_2$
- Understand functions as vectors
- Understand Hilbert spaces, inner products, and orthogonality
- Understand the basics of distribution theory

Time-Frequency Analysis
- Use Fourier methods to analyze frequency content of signals
- Understand spectra and frequency harmonics
- Understand convergence results for Fourier series and transform
- Understand Fourier transform of distributions
- Understand the uncertainty principle and its consequences
- Use MATLAB for time-frequency analysis with FFT and iFFT

Multi-Resolution Analysis
- Understand limitations of Fourier transform for time-frequency analysis and the need for wavelets
- Understand continuous wavelet transform and multi-resolution analysis
- Understand discrete wavelet transform and multi-resolution analysis
- Use MATLAB for wavelet transform

Calculus
- Understand limits and continuity
- Integrate and differentiate
- Determine sums of basic series
- Understand and apply trigonometric identities

Complex Arithmetic
- Understand fundamentals of complex numbers
- Express complex numbers in Cartesian and polar coordinates

Differential Equations
- Solve linear ordinary differential equations
- Identify homogenous and particular solutions to an ODE

Pre-requisites
- MATH 340 or MATH 345

Reviewed 1/2020