1. ECE 502: Advanced Fourier Optics

2. 3 credits: 2-75 minute lecture sessions/week

3. Randy Bartels

4. Fourier Optics and Computational Imaging. K. Khare. 2016.

5. Course Information
    a. Introduction to optical systems for signal and information processing with emphasis on Fourier optics. Engineering design principles, models, and computational techniques for forward optical imaging and optical image reconstruction
    b. Prerequisites: ECE 311 with a C or higher; ECE 342 with a C or higher; MATH340 with a C or higher
    c. Selected Elective: Electrical Engineering; Computer Engineering

6. Goals for the Course
    a. Course Learning Objectives
        i. Describe the principles of Fourier analysis and linear systems theory to the behavior of light and the design of optical imaging systems
        ii. Apply engineering design principles of optical measurement in linear system and optical imaging
        iii. Design and evaluate optical system using the principles of Fourier Optics
        iv. Evaluate and interpret data from optical imaging experiments and measurements
        v. Design optical imaging systems and reconstruction algorithms for computation imaging
        vi. Describe the behaviors and important experiments and practical issues for inverse computational imaging
        vii. Evaluate the capabilities of computational imaging strategies for application to a wide range of microscopy applications
    b. Student Outcomes
        1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
        3. An ability to communicate effectively with a range of audiences
        4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
        6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

7. Topics Covered

    Motivation for Fourier optics and computation imaging and open challenges
    Linear systems theory and Fourier transforms; electromagnetics
    Inverse problems and computational imaging

Inverse problems and regularization
Wave propagation and diffraction
Iterative phase retrieval and ptychography
Monochromatic filed propagation through a lens; coherent image deconvolution
Three dimensional imaging with monochromatic light; coherent image deconvolution (3D)
Imaging with speckle
Computational speckle imaging
Light scattering theory; holography and quantitative phase microscopy; beam probation methods (QPM)
Transport of intensity equation for computational QPM; computed tomography; diffraction tomography
Light coherence theory; phase imaging with incoherent light
3D imaging properties of incoherent light
3D incoherent imaging deconvolution; computational phase imaging
Imaging with projections; coded aperture imaging
Multi-camera computational imaging
Structured light imaging; light field imaging