

COURSE OUTLINE: OPTICAL IMAGE FORMATION - SIMG-738

This course presents a unified view of the formation of images and image quality of an optical system from an applications viewpoint, but with a strict mathematical development. Topics covered are: ray and wave theory of imaging, image quality measurements, image formation with coherent and incoherent light, and optical information processing.

1. Review of the Wave Equation and Systems Analysis of Light Propagation
 - i. Huygens' principle, diffraction integrals
 - ii. Maxwell's equations
 - iii. Measurable electromagnetic quantities: power
 - iv. Quadratic phase factors
2. Review of the 2-D Fourier transform
 - i. Approximations of the Fourier transform
 - a. Moments
 - b. Method of Stationary Phase
 - ii. Impulse response and transfer function of light propagation
 - iii. Asymptotic evaluation of the diffraction integral in the Fresnel and Fraunhofer regions
 - iv. Stationary phase method
3. Fresnel transform
 - i. Effect of apertures and lenses on plane wave spectra: Abbé's theory
 - ii. Uncertainty in fields and transforms
4. Coherence of light
5. Imaging Properties of Lenses from the Viewpoint of the Plane Wave Spectrum
 - i. Plane wave spectrum analysis
 - ii. Transfer function in coherent light
 - iii. Transfer function in incoherent light
 - iv. Modulation transfer function (MTF) of a perfect lens
 - v. Sampling of fields and transforms, relation to information theory
6. Imaging Properties of Lenses from Viewpoint of Diffraction Integral
 - i. Thin lens as "quadratic phase plate"
 - ii. Fourier transforming property of lenses, shift-variant systems
 - iii. Action of lens for plane waves and spherical waves
7. Metrics of Optical Image Quality
 - i. Optical transfer function and point spread functions in coherent and incoherent light
 - ii. Modulation Transfer Function
8. Optical Information Processing
 - i. 4f correlator
 - ii. Optical Transfer Function Synthesis
 - iii. Incoherent processing by geometrical optics
 - iv. Holography and computer-generated holography
 - v. Optical matched filtering
 - vi. Spatial carrier techniques