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 and Holography
   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