OPTICAL IMAGE FORMATION
SIMG-738, Quarter 20083

TTh, 2:00PM – 3:50PM, 76-1235

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Office Hours: TBD, and by appointment

Text: *Introduction to Fourier Optics*, Third Edition, by J.W. Goodman, Roberts and Company, Englewood CO, 2005, ISBN 0-9747077-2-4

Course notes will be distributed

Other Useful Readings:
Linear Systems, Fourier Transforms, and Optics, by J.D. Gaskill, John Wiley and Sons, 1978, ISBN 0-471-29288-5
Introduction to Optics and Optical Imaging, by Craig Scott, IEEE, 1997, ISBN: 078033440X.*The New Physical Optics Notebook*, Reynolds, DeVelis, Parrent, Thompson, SPIE, 1989.
Engineering Optics, K. Iizuka, Springer-Verlag, 2^{nd} Edition, 1987.
Optical Signal Processing, A. VanderLugt, John Wiley & Sons, 1992.
Systems and Transforms with Applications in Optics, A. Papoulis, Krieger, 1986 (reprint of 1968 edition)

RIT Course Catalog Description:

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. (nominal prerequisite is 1051-737, 1051-733 is also sufficient) Class 4, Credit 4 (alternate years, S)

Actual Description:

This course develops a mathematical description of optical image formation via mathematical modeling of light propagation through the imaging system by application of the principles of linear systems. The model is based on approximations of Huygens' principle that light propagates via spherical wavelets. The propagation of light from plane to plane is modeled as a convolution with the impulse response appropriate to the model. The action of the optical element is a multiplication of the complex amplitude by the appropriate phase function. The mathematical description is based on the so-called "chirp Fourier transform."

The course will develop the model for the single-wavelength case ("coherent" light) and will be generalized to the "incoherent" case, including a description of appropriate metrics for the optical system. Holographic imaging will also be considered.

Homework:

Problem sets will be handed out
Assignments due as scheduled, typically (but not necessarily) one week later
There may be some computer homework, with a two-week deadline.
I encourage you to work together on problems, but you must hand in your own answers.

Final Examination:

Take-home open-book problem set.

COURSE OUTLINE: OPTICAL IMAGE FORMATION - SIMG-738-20083

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1. Review of the Wave Equation and Systems Analysis of Light Propagation
    - i. Huygens' principle, diffraction integrals
    - ii. Measurable electromagnetic quantities: power
    - iii. Quadratic phase factors
2. Review of the 2-D Fourier transform
    - i. Approximations to the Fourier transform
        1. Moments
        2. 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
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
    - i. Temporal coherence
    - ii. Spatial coherence
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