OPTI503 Syllabus

Optical Design and Instrumentation II (3). Aberrations of Optical Systems: wave fans and ray fans, spot diagrams, wavefront expansion, effects of aberrations on image quality, image quality criteria, aberration balancing, principle of lens design; Color: colorimetry, chromaticity, color gamut, additive and subtractive colors; Digital Imaging Systems: resolution and aliasing, color filter arrays, aliasing suppression, image displays and projectors.

P, Opti 502, Recommended Opti512.

Aberrations and image quality
1. Coordinate systems, tangential and sagittal rays, ray tracing.
2. Transverse and longitudinal ray aberrations, wave aberrations.
3. Demonstration of system analysis with design software, ray fans, wave fans, spot diagrams, RMS spot size.
4. Defocus; wavefront tilt.
5. Spherical aberration, spherical aberration balance with defocus.
6. Coma
7. Field curvature, Petzval surface, astigmatism.
8. Distortion
9. Chromatic aberration
10. Seidel aberration coefficients
11. Stop-shift effects, aspherical surfaces
12. Image quality metrics, Rayleigh criterion, wavefront variance.
13. Airy disk; calculation of PSFs with wavefront errors, influence of aberrations on PSFs; Strehl ratio.
14. Modulation transfer functions, test targets, influence of aberrations on MTFs, contrast reversal.
15. Other measures of image quality, encircled and ensquared energy, image simulation; isoplanatic patches, geometric calibration, instantaneous field of view, Johnson criterion.

Optical design
1. System specifications, system design process.
2. Principle of optical design
3. Optimization, merit function, optimization examples and demonstration.
4. Design for manufacturability, tolerancing
5. Optomechanical design
6. Non-sequential raytracing, stray light, ghost images, veiling glare.

Color
1. Visual color perception, basic color concepts (spectrally pure, hue, saturation).
2. Colorimetry, sources and color temperature, trichromatic theory of color, color matching functions.
3. CIE RGB and XYZ chromaticity values, x-y chromaticity diagram.
4. Dominant and complementary wavelengths, color addition, additive color, color gamut, sRGB color system for digital images.
5. Subtractive color, other color systems, gamma correction, calibration.

Digital Imaging Systems

1. Imaging chain modeling
2. Sampled imaging systems, resolution, aliasing.
3. Optical low-pass filters, sharpness-aliasing tradeoff, display MTF, interpolation.
4. Two-dimensional sampling and Nyquist domains, color filter arrays, reciprocal sampling grids.
5. Birefringent blur filters, lens design issues.
6. Selected optical instruments