

OPTI 604- Mathematical Methods for Optics

Course Description:

Complex variables. Fourier theory and applications to imaging. Coherent and incoherent imaging. Other integral transforms. Special functions and orthogonal polynomials. Linear algebra. Integral equations. Green's functions. Prerequisites: MATH 223, PHYS 142 and PHYS 241.

Textbooks:

- Barrett, H.H. and Myers, K.J. (2004), Foundations of Image Science. Wiley.

Recommended

- Abramowitz & Stegun. (1965). Handbook of Mathematical Functions: with Formulas, Graphs, and Mathematical Tables. Dover.

Outline

Linear Algebra

1. Linear vector spaces - general theory.
2. Linear operators and imaging.
3. Eigenanalysis of Hermitian operators.
4. Singular-value decomposition; null functions.
5. Solutions of linear equations; pseudoinverses.
6. Least-squares solutions.

Dirac Delta Function

7. Motivation and elementary properties. Limiting representations.
8. Functionals and distributions.
9. Multidimensional delta functions.
10. Linear shift-invariant (LSIV) systems. Convolutions and eigenfunctions.

Fourier Theory

11. Fourier series; convergence issues.
12. Introduction to Fourier transforms; the inverse
13. 1D Fourier transforms - properties and examples.
14. Application to LSIV systems; transfer function and impulse response.
15. 2D Fourier transforms. Cartesian and polar coordinates.
16. 2D linear systems.

17. Sampling theory.
18. Discrete Fourier transforms.

Series Expansions and Integral Transforms

19. Orthogonal polynomials; generalized Fourier analysis.
20. Classical integral transforms.
21. Fresnel integrals and chirps; application to diffraction.

Mixed Representations

22. Local Fourier transforms.
23. Wigner distribution functions.
24. Wavelets: general theory.
25. Wavelets: applications.

Group Theory

26. Definition of a group.
27. Classes and representation.
28. Irreducible representations.
29. Continuous groups.
30. Groups of operators on a Hilbert space.
31. Group theory in quantum mechanics and image science.
32. Functions and transforms on groups.

Take-home final exam.