

A Lens Is A Transform

Review of Joseph W. Goodman, *Introduction to Fourier Optics* (457 pp.)

TLDR / 80-20

Stop treating an optical system as glass and treat it as a linear system.

Once you do, every tool built for signals — impulse response, transfer function, convolution — applies to light without modification.

The Keys

- **The reframe is the whole book.** An optical system takes an input field and returns an output field. That is a linear operator, and linear operators have standard machinery.
- **The impulse response has a physical meaning.** For an imaging system it is the image of a point source — which is why it is called the point spread function.
- **Describe the system by its response to points.** Lenses, stops and apertures are fully specified by what they do to point sources across the object field.
- **Invariance buys simplicity.** If the response does not change across the field, the system is described by a convolution — and convolution becomes multiplication after transforming.
- **The transfer function is that multiplication.** The Fourier transform of the impulse response tells you what the system does to each spatial frequency.
- **Coherent and incoherent systems are linear in different quantities.** Coherent imaging is linear in complex amplitude; incoherent imaging is linear in intensity. Mixing them is the classic error.
- **A coherent system is therefore nonlinear in intensity.** Which means frequency analysis must be applied to amplitude, not to what a detector measures.
- **Decomposition is the method.** Break a complicated input into simple pieces, find the response to each, and add. That is superposition doing work.

AI's Take

- **This is the hinge book.** It converts optics into signal processing, which is why the same mathematics later appears in image processing and machine vision.
- **The insight generalises past optics.** Any linear, shift-invariant system is fully described by its response to a single impulse. That is a very large class of systems.
- **It demands more mathematics than the other optics texts.** Transforms, convolution and complex amplitude are assumed, not taught, which narrows who can start here.
- **The coherent-versus-incoherent distinction is the practical trap.** Most confusion in applied imaging traces back to applying one system's rules to the other.
- **Read Chapter 2 and Chapter 6.** Two-dimensional linear systems, then frequency analysis of imaging systems. Those two carry the argument.