

Optics — The Terms You Actually Need

33 terms, beginner to early intermediate · the 80/20 of Hecht, Fourier Optics, Modern Optics and Foundations of Computer Vision

Learn five first: wavelength, phase, superposition, interference, aperture.

Nearly everything else on this page is those five combined. Phase in particular does more work than any other term here.

What light is

- **Electromagnetic wave** — light is an oscillating electric and magnetic field travelling through space. The fields are perpendicular to each other and to the direction of travel.
- **Wavelength (λ)** — the distance between one wave peak and the next. It sets colour in visible light, and it is the yardstick everything optical is measured against.
- **Frequency** — how many wave cycles pass a point per second. Frequency stays fixed when light enters glass; wavelength is what changes.
- **Amplitude** — the height of the wave. Intensity, which is what your eye and a camera actually measure, goes as amplitude squared.
- **Phase** — where a wave is in its cycle at a given place and moment. Two waves with the same wavelength can still differ in phase, and that difference is where optical structure comes from.

How it travels

- **Wavefront** — a surface joining all the points of a wave that share the same phase. Plane wavefronts mean a distant source; spherical ones mean a nearby point source.
- **Ray** — a line drawn perpendicular to the wavefront, showing the direction of travel. A convenient fiction that works when wavelength is small compared with everything else.
- **Refractive index (n)** — how much slower light travels in a material than in vacuum. Glass is about 1.5, water about 1.33.
- **Refraction** — the bending of light when it crosses into a material with a different refractive index. The cause of lenses working at all.
- **Reflection** — light bouncing off a surface, leaving at the same angle it arrived. The basis of mirrors and of every unwanted glare.
- **Dispersion** — refractive index varying with wavelength, so different colours bend by different amounts. This is why a prism makes a spectrum.

Waves overlapping

- **Superposition** — when two waves occupy the same place, the fields simply add. This holds because the governing equations are linear, and it underpins everything below.
- **Interference** — the visible result of superposition: a pattern of bright and dark where waves reinforce or cancel each other.

- **Constructive and destructive interference** — in phase means peaks align and add; out of phase by half a wavelength means they cancel.
- **Diffraction** — the spreading of light as it passes an edge or through an opening. The smaller the opening relative to wavelength, the more it spreads.
- **Coherence** — how well a wave keeps a predictable phase relationship with itself or with another wave. Without it, interference patterns wash out.
- **Coherence length** — the distance over which a wave stays phase-predictable. Ordinary light manages very little; a laser manages a great deal.
- **Polarization** — the orientation of the wave's electric field. Unpolarized light contains all orientations; a polarizer passes one.

Lenses and images

- **Focal length** — the distance from a lens to where parallel incoming rays converge. Short focal length means strong bending and a wide view.
- **Aperture** — the opening that limits how much light enters a system. It sets both brightness and, through diffraction, the finest detail possible.
- **f-number** — focal length divided by aperture diameter. Lower numbers mean a wider opening, more light, and shallower focus.
- **Real and virtual image** — a real image forms where light actually converges and can land on a sensor. A virtual image only appears to be there, as in a flat mirror.
- **Point spread function (PSF)** — the image a system makes of a single point of light. A perfect system would give a point; every real one gives a blur.
- **Resolution** — the smallest separation at which two points are still distinguishable. Limited by the PSF, so ultimately by the aperture.
- **Diffraction limit** — the resolution ceiling set by physics rather than by manufacturing. No amount of lens quality gets past it.

Optics as signal processing

- **Spatial frequency** — how rapidly brightness varies across space. Fine detail is high spatial frequency; broad gradients are low.
- **Fourier transform** — the operation that rewrites a pattern as a sum of spatial frequencies. It converts a picture into a recipe of stripes.
- **Convolution** — sliding one function across another and combining as you go. It is what a lens does to a scene, and what a filter does to an image.
- **Impulse response** — how a system responds to a single sharp input. In optics this is the point spread function, under a different name.
- **Transfer function** — the Fourier transform of the impulse response. It states plainly which spatial frequencies a system passes and which it loses.

Where vision picks it up

- **Pixel** — a sample of the image at one location on a grid. It has a position as well as a value, which is what makes neighbourhoods meaningful.
- **Filter kernel** — a small array of weights slid across an image, combining each pixel with its neighbours. The software version of an optical impulse response.
- **Edge detection** — finding where brightness changes sharply, because object boundaries live at discontinuities rather than in flat regions.