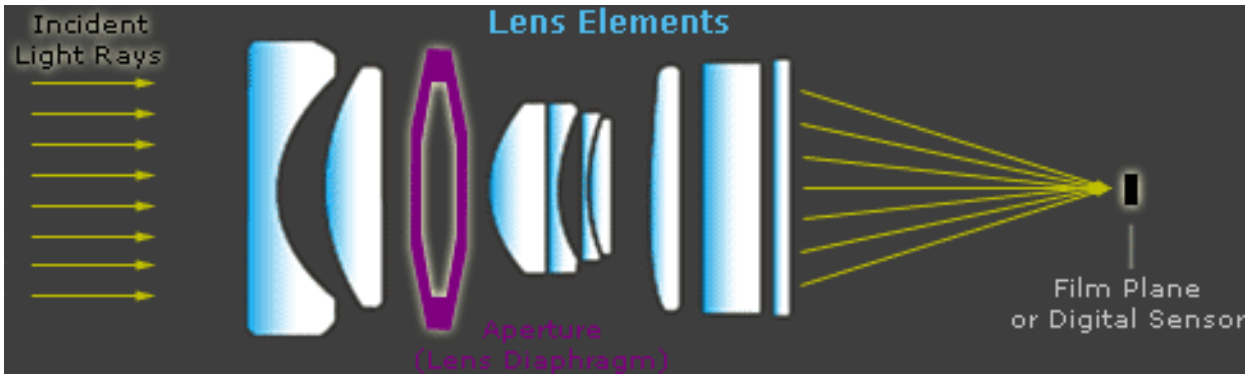
Camera Lens

Preamble:

For optical imaging, such that transforming the object profile to the detector (CCDs or photographic films), it involves lens. However, optical aberrations occur when points of the image do not translate back onto single points after passing through the lens, causing image blurring, reduced contrast or misalignment of colors (chromatic aberration). Lenses may also suffer from uneven, radially decreasing image brightness (vignetting) or distortion.

Choosing the right lens for the task can become a complex trade-off between cost, size, weight, lens speed and image quality. Understanding camera lenses can thus help you to make the best choice that meets your specific requirements. Here we provide an introductory overview of concepts relating to image quality, focal length, perspective, prime vs. zoom lenses and aperture or f-number.

All but the simplest cameras contain complicated lens system that comprises of several “lens elements”. The goal is to minimize aberrations, maximize brightness (intensity), and eliminate distortion while still utilizing the fewest and least expensive elements.



f-number and aperture

In camera technology the term f-number is often called “*f*-stop”. It is related to the “aperture” or “iris diaphragm” size D (diameter) and the lens focal length f via the relationship: $f-number = \frac{f}{D}$. The diagram below shows a typical camera diaphragm (光圈) discrete setting, which is arranged in steps of $\sqrt{2}$. The aperture area, i.e. the amount of light going through, is doubled in every step.

Suppose we have a 50mm focal length lens. If we have a big size hole - a big aperture, it might measure 25mm. So 50 divided by 25 gives us 2: the *f*/number is 2, which we write as *f*/2. (Don’t get confused. Note that the smaller the aperture no. (f-number), the more light can be collected!)

For a 50 mm camera lens:

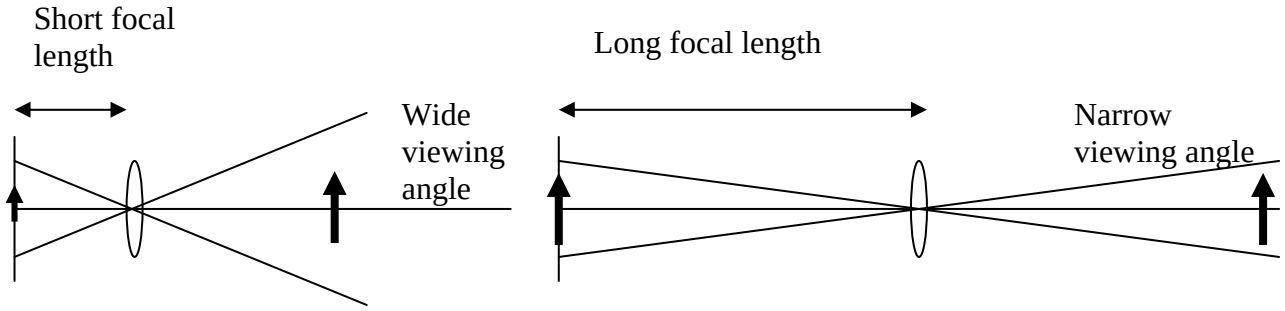
f-number	1.2*	1.4	2	2.8	4	5	8	11	16
Aperture D (mm)	41.7	35.7	25.0	17.9	12.5	8.9	6.3	4.5	3.1
Area (mm^2)	1364	1002	491	250	123	63	31	16	8

For the 50 mm lens mentioned above, there are a total of 8 full steps in the f-stops: f/1.4, 2, 2.8, 4, 5.6, 8, 11, and 16, with half-steps (and third steps) in between every pairs but 1.4 and 2 (i.e. f/1.7, f/6.7, and f/9.5 are half steps, and f/1.8, f/3.5, and f/6.3 are third steps found in most modern lenses). The very exception f/1.2 has a lens area that is one-third bigger than that of f/1.4 ones. For each full step down in f-number, the aperture area is double; so is the amount of light collected.

Large aperture generally gives small f-number. However you have to bear in mind that small f-number can also be achieved by using short focal length lens. Lenses with larger apertures are also described as being "*faster*," because for a given ISO speed, the shutter speed can be made faster for the same exposure. Additionally, a smaller aperture means that objects can be in focus over a wider range of distance, a concept also termed the *depth of field.*

f/3 f/14

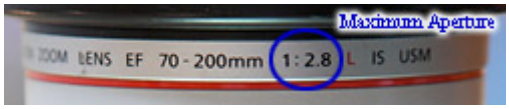

Wide angle and zoom lenses



The focal length of a lens determines its angle of view, and thus also how much the subject is magnified. Wide angle lenses have small focal lengths, while telephoto (zoom) lenses have larger focal lengths. Additionally, *digital zoom is not the same as optical zoom, as the former only enlarges the image through interpolation.*

Camera Terminology	**Lens Focal Length**
Extreme Wide Angle	Less than 20 mm
Wide Angle	20-35 mm
Normal	35-70 mm
Medium Telephoto (Medium Zoom)	70-130 mm
Super Telephoto (Super Zoom)	130-300 mm

How to choose a camera (lens):
In considering of purchasing a camera, the choice of the camera lens (apart from the cost, of course) is the most important issue. Very often the manufacturer would label the f-number as 1:X. For the examples shown below the Canon 70-200mm f/2.8 lens is present as 70-200mm 1:2.8.



Also note that just because the maximum aperture of a lens may not be used, this does not necessarily mean that this lens is not necessary. **Lenses typically have fewer aberrations when they perform the exposure stopped down one or two f-stops from their maximum aperture** (such as using a setting of f/4.0 on a lens with a maximum aperture of f/2.0). This *may* therefore mean that if one wanted the best quality f/2.8 photograph, a f/2.0 or f/1.4 lens may yield higher quality than a lens with a maximum aperture of f/2.8.

f-number for exposure and field of depth control

This parameter controls the aperture size of the virtual camera. Lowering the **f-number** value increases the aperture size and so makes the image brighter, since more light enters the camera. In reverse, increasing the **f-number** makes the image darker, but the field of depth is better.

f-number is ***8.0***

f-number is ***6.0***

f-number is ***4.0***

Zoom Factor

This parameter determines the zooming (In and Out) of the final image.

Zoom factor is ***1.0***

Zoom factor is ***2.0***

Zoom factor is ***0.5***

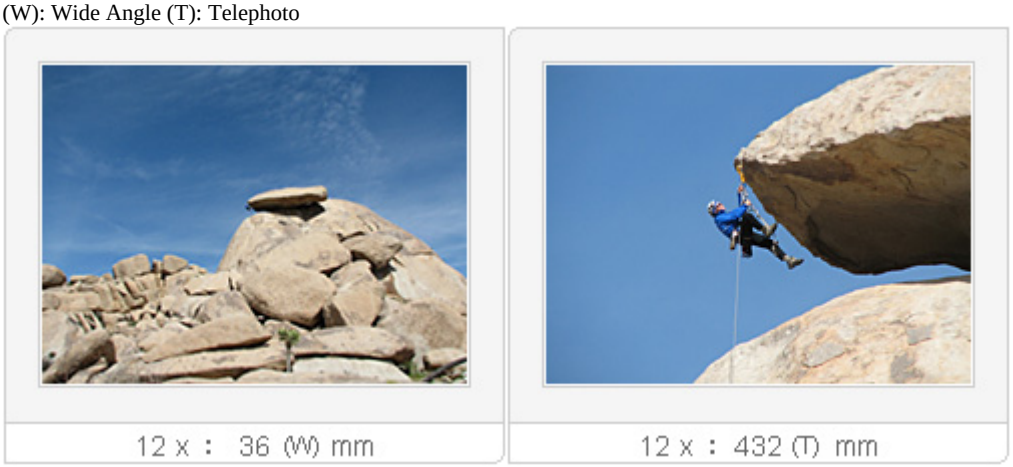
Distortion

This is particularly important in wide angle optics.

Examples:

With all of the options on digital cameras today it is hard to know which is right for you. Below are examples of all the most popular zooms - 12x and 4x- along with quick specifications on Canon's most popular PowerShot cameras.

(W): Wide Angle (T): Telephoto



PowerShot S3 IS

- 12x optical zoom
- Focal Length
  36 (W)–432 (T) mm equiv
- Aperture Value
  f/2.7 (W)–f/3.5 (T)

PowerShot G7

- 6x optical zoom
- Focal Length
  35 (W)–210 (T) mm equiv
- Aperture Value
  f/2.8 (W)–f/4.8 (T)

PowerShot SD700 IS | DIGITAL IXUS 800 IS

- 4x optical zoom
- Focal Length
  35 (W)–140 (T) mm equiv
- Aperture Value
  f/2.8 (W)–f/5.5 (T)

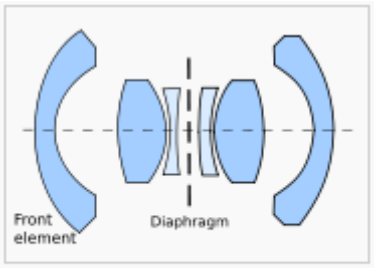
Wide angle lens

the problem posed by the design of wide angle lenses is to bring an accurate focus light from a wide area without causing internal flare. Wide angle lenses therefore tend to have more elements to help refract the light sufficiently and still minimise aberrations whilst adding light-trapping baffles between each lens element.

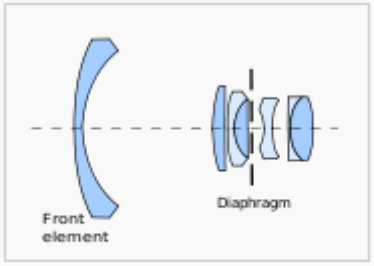
There are two different varieties of wide-angle lens: short-focus lenses and retrofocus lenses.

Short-focus lenses are generally made up of multiple glass elements whose shapes are more or less symmetrical in front of and behind the diaphragm. As the focal length decreases, the distance of the rear element of the lens from the film plane or digital sensor also decreases. This makes short-focus wide-angle lenses undesirable for single-lens reflex cameras unless they are used with the reflex mirrors locked up. Short-focus lenses are widely used on large format view cameras.

The retrofocus lens solves this proximity problem through an asymmetrical design that allows the rear element to be further away from the film plane than its effective focal length would suggest.



Cross-section of a typical short-focus wide-angle lens.



Cross-section of a typical retrofocus wide-angle lens.

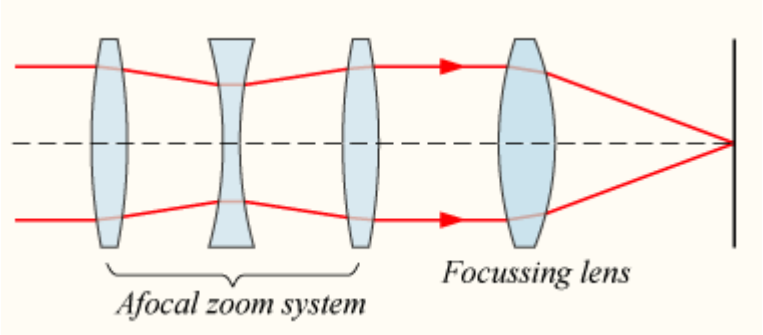
Digital Wide Zooms

Nikon 12 - 24 mm f/4, Tokina 12 - 24 mm f/4, Sigma 10 - 20 mm f/4 - 5.6, Tamron 11 - 18 mm f/4.5 - 5.6.

Sigma 10-20mm F3.5 EX DC HSM

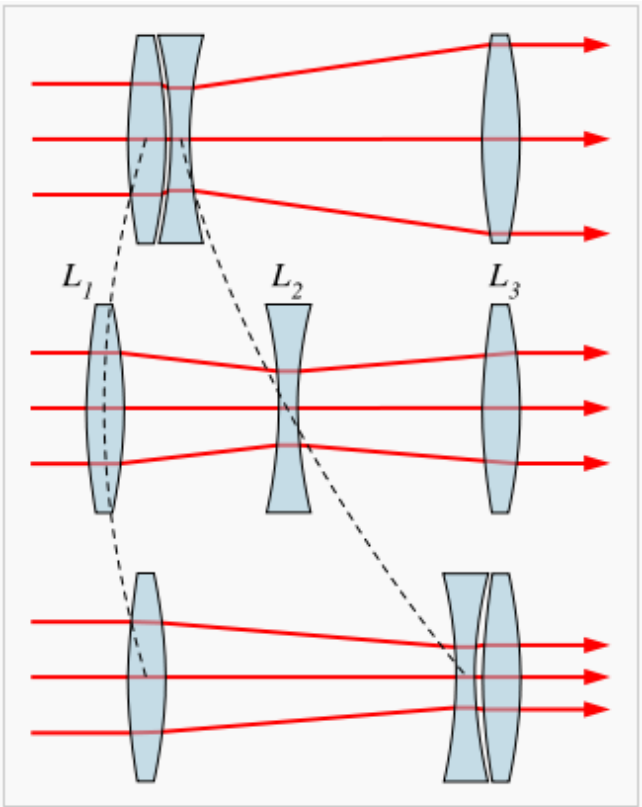
With its wide angle view from 102.4 degrees it can produce striking images with exaggerated perspective. The maximum aperture of F3.5 is ideal for indoor shooting and it enables photographers to emphasize the subject. The lens system consists of 13 Elements in 10 Groups. Two ELD (Extraordinary Low Dispersion) glass elements and a SLD (Special Low Dispersion) glass element provide excellent correction of color aberration. Four aspherical lenses provide correction for distortion and allow compact and lightweight construction.

Zoon Lens Design



A simple zoom lens system

There are numerous possible zoom lens designs. Some complex ones consist of tens of individual lens elements. Generally they are constructed with a number of individual lenses that may be either fixed, or slide axially along the body of the lens. A simple scheme for a zoom lens divides the assembly into two parts: a focussing lens similar to a standard, fixed-focal-length photographic lens, preceded by an *afocal zoom system*, an arrangement of fixed and movable lens elements that does not focus the light, but alters the size of a beam of light travelling through it, and thus the overall magnification of the lens system.



Movement of lenses in an afocal zoom system

The Latest and the Best (2008)

TAMRON AF18-270MM Di II VC
ULTRA HIGH POWER ZOOM LENS

With its vast zoom-range, the Tamron AF18-270mm F/3.5-6.3 Di II VC lens enables the user to cover virtually any photographic subject from wide angle to ultra telephoto simply by turning the zoom control.