Normal Lens:

a normal lens is a lens a lens that reproduces a field of view that appears "natural" to a human observer

Lenses work in a very similar way to the human eye. However, not all lenses have an angle of view that is similar to the human eye. The normal lens aims to capture a shot in a way that is most similar to how we see the world.

What is a normal lens?

A **normal lens**, also called a standard lens, is a lens with a focal length between 35mm to 50mm. The focal length of standard lenses are most similar to how the human eye sees the world. Cinematographers often use normal lenses for more grounded, naturalistic cinematography. Normal lenses can vary depending on what format is being used. Normal lenses are generally equal to the length of the diagonal of a digital camera's sensor or the film format.

A test of what is a normal lens then, is to find one that renders a printed (or otherwise displayed) photograph of a scene that when held at 'normal' viewing distance (usually arm's length) in front of the original scene and viewed with one eye, matches the real-world and the rendered perspective

Perspective effects of short or long focal-length lenses

Lenses with longer or shorter focal lengths produce an expanded or contracted field of view that appears to distort the perspective when viewed from a normal viewing distance. Lenses of shorter focal length are called *wide-angle lenses*, while longer-focal-length lenses are referred to as long-focus lenses (with the most common of that type being the *telephoto lenses*). Superimposing a wide-angle image print against the original scene would require holding it closer to the eye, while the telephoto image would need to be placed well into the depth of the photographed scene, or a tiny print to be held at arm's length, to match their perspectives.

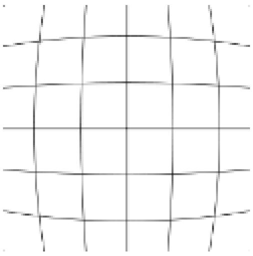
Normal lenses vary for different formats

For still photography, a lens with a focal length about equal to the diagonal size of the film or sensor format is considered to be a normal lens; its angle of view is similar to the angle subtended by a large-enough print viewed at a typical viewing distance equal to the print diagonal; this angle of view is about 53° diagonally. For cinematography, where the image is larger relative to viewing distance, a wider lens with a focal length of roughly a quarter of the film or sensor diagonal is considered 'normal'. The term **normal lens** can also be used as a synonym for rectilinear lens. This is a completely different use of the term.

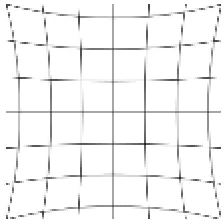
a photographic lens that yields images where straight features, such as the edges of walls of buildings, appear with straight lines, as opposed to being curved.

Curvilinear (above) and rectilinear (below) image.

Curvilinear barrel distortion



Curvilinear pincushion distortion



What is normal lens is used for?

- Less stylized cinematography
- To give a shot a naturalistic look
- Matching the perspective of the human eye

  Standard lenses have a narrower angle of view that can restrict what you fit within a frame.

Objective Lens

An objective lens is the most important optical unit that determines the basic performance/function of an optical microscope To provide an optical performance/function optimal for various needs and applications

Objective lenses are roughly classified basically according to the intended purpose, microscopy method, magnification, and performance (aberration correction). Classification according to the concept of aberration correction among those items is a characteristic way of classification of microscope objectives.

Classification According to Microscopy Method

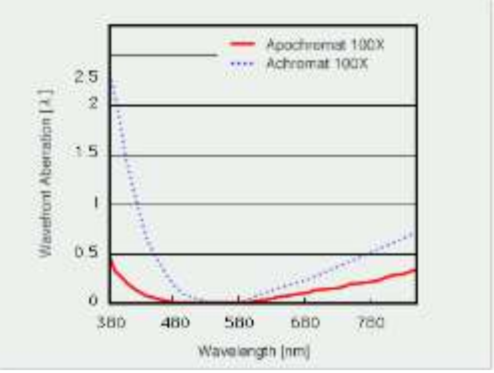
A variety of microscopy methods have been developed for optical microscopes according to intended purposes. The dedicated objective lenses to each microscopy method have been developed and are classified according to such a method. For example, "reflected darkfield objective (a circular-zone light path is applied to the periphery of an inner lens)", "Differential Interference Contrast (DIC) objective (the combination of optical properties with a DIC) prism is optimized by reducing lens distortions)", "fluorescence objective (the transmittance in the near-ultraviolet region is improved)", "polarization objective (lens distortions are drastically reduced)", and "phase difference objective (a phase plate is built in) are available.

Classification of Objectives According to Aberration Correction

Classification According to Chromatic Aberration Correction (Level)

Axial chromatic aberration correction is divided into three levels of achromat, semi apochromat (fluorite), and apochromat according to the degree of correction. The objective line-up is divided into the popular class to high class with a gradual difference in price. An objective lens for which axial chromatic aberration correction for two colours of C ray (red: 656,3nm) and Fray (blue: 486.1nm) has been made is known as Achromat or achromatic objective. In the case of Achromat, a ray except for the above two colours (generally violet g-ray: 435.8nm) comes into focus on a plane away from the focal plane. This g ray is called a secondary spectrum. An objective lens for which chromatic aberration up to this secondary spectrum has satisfactorily been corrected is known as Apochromat or apochromatic objective. In other words, Apochromat is an objective for which the axial chromatic aberration of three colours (C, F, and g rays) has been corrected. The following figure shows the difference in chromatic aberration correction between Achromat and Apochromat by using the wavefront aberration. This figure proves that Apochromat is corrected for chromatic aberration in wider wavelength range than Achromat is.

Comparison of Chromatic Aberration Correction (Between Achromat and Apochromat)



Meanwhile, an objective lens for which the degree of chromatic aberration correction to the secondary spectrum (g ray) is set to medium between Achromat and Apochromat is known as Semi apochromat (or Flulorite).

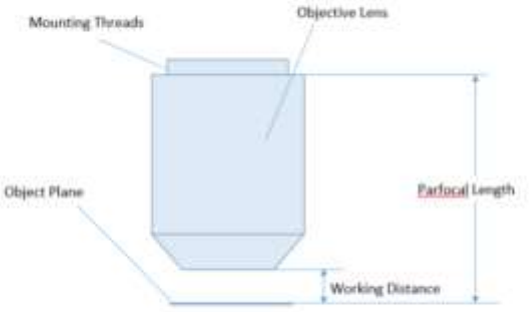


Fig1. Objective Lens

- ### Magnification

Magnification is one important parameter. Magnification is usually denoted by an X next to a numeric value. Objectives are available in a range of magnifications from 2X to 200X.

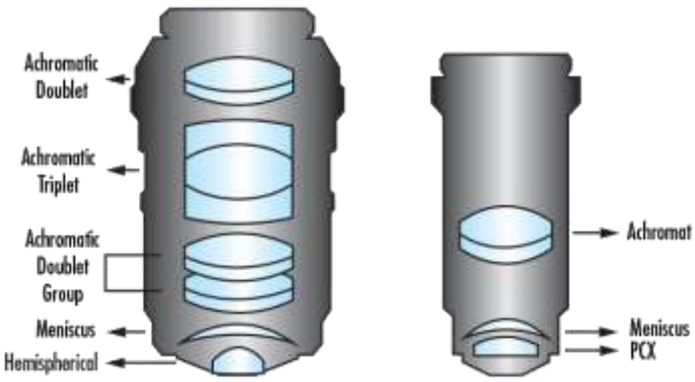
- ### Numerical Aperture (NA)

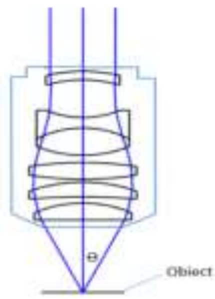
NA is a critical value that indicates the light acceptance angle. It is commonly expressed as

NA = n × sinθ

where ϑ is the maximum 1/2 acceptance ray angle of the objective, and *n* is the index of refraction of the immersion medium. Figure 2 shows the ray angl e ϑ of an infinity-corrected objective.

Numerical aperture (NA) is defined as being equal to n sinθ, where n is the refractive index of the medium between the objective lens and the object (n=1 for air) and θ is half the angular aperture angle of image-forming rays) of the objective lens.





Objective Ray Angle θ

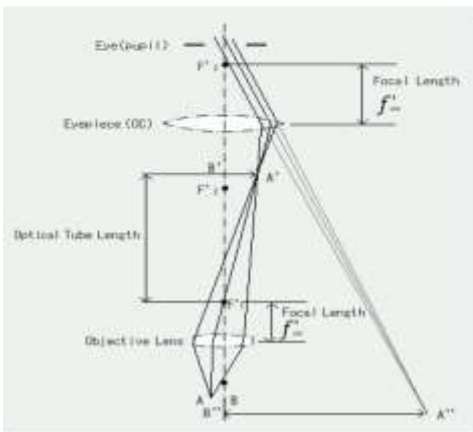
A microscope enlarges the view of an object by enlarging it twice using the objective and oculus lenses.

It happens in the following way:

1. Light from below a specimen illuminates it.
2. An objective lens placed very close to the specimen produces a 'real image' of the specimen.
3. This image is created somewhere between the two lenses.
4. The oculus lens looks at that real image, already magnified, and creates a 'virtual image' of it that is many times magnified.
5. This image is created far away, behind the actual objective.
6. This final image is inverted to the original object, remember that.
7. The light passes through the specimen and the two lenses to reach your eye. In the process, the loss of light can be negligible.

   Since the light comes through the image, this type of microscope is called a bright-field microscope. Indeed, the final image is sometimes so bright that there is a dedicated control to reduce the amount of light that pours into the specimen.

Application of Objective lens:



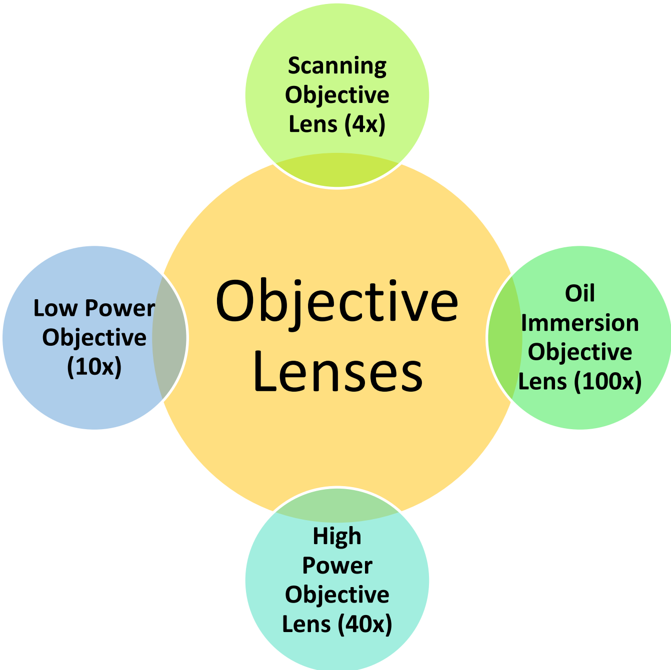
Uses of objective lenses in the microscope:

1. **A convex lens is a converging lens, which means that as light waves travel through all of it, they converged at a position.**

2. **As a result, they are utilized as the microscope's objective lens in situations where a precise focus on the object is necessary.**
3. **The objective lens is made up of many lenses that work together to magnify an item and produce a bigger picture. Objective lenses could be utilized for a variety of purposes, including extreme magnification and spatial filtering.**

What Are the Different Magnifications of Objective Lenses?

Most compound microscopes come with interchangeable lenses known as **objective lenses.** Objective lenses come in various magnification powers, with the most common being 4x, 10x, 40x, and 100x, also known as **scanning, low power, high power,** and (typically) **oil immersion** objectives, respectively.



Scanning Objective Lens (4x)

4x is a common magnification for scanning objectives and, when combined with the magnification power of a 10x eyepiece lens, a 4x scanning objective lens gives a total magnification of 40x. The name "scanning" objective lens comes from the fact that they provide observers with about enough magnification for a good overview of the slide, essentially a "scan" of the slide.

Low Power Objective (10x)

The total magnification of a low power objective lens combined with a 10x eyepiece lens is 100x magnification, giving you a closer view of the slide than a scanning objective lens without getting too close for general viewing purposes.

Figure 1. Sample objective magnifications.

High Power Objective Lens (40x)

The high-powered objective lens (also called “high dry” lens) is ideal for observing fine details within a specimen sample. The total magnification of a high-power objective lens combined with a 10x eyepiece is equal to 400x magnification, giving you a very detailed picture of the specimen in your slide.

Oil Immersion Objective Lens (100x)

The oil immersion objective lens provides the most powerful magnification, with a whopping magnification total of 1000x when combined with a 10x eyepiece. But the refractive index of air and your glass slide are slightly different, so a special immersion oil must be used to help bridge the gap. Without adding a drop of immersion oil, the oil immersion objective lens will not function correctly, the specimen will appear blurry, and you will not achieve an ideal magnification or resolution. Oil immersion lenses are also available from some manufacturers in lower magnifications, and provide higher resolution.

Immersion Media and Objective Lenses

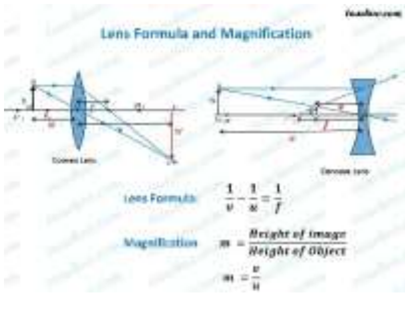
It is important to always use the correct immersion media (e.g., air, water, oil, etc.) that is specified by your objective lens. The image produced by the wrong immersion media will be blurry. In general, objectives are engineered to "look" through an immersion medium with a particular refractive index (a topic for another article). For example, air has a refractive index of close to 1.0, whereas standard immersion oil has a refractive index of ~1.51, You can damage the objective if you use the wrong immersion oil.

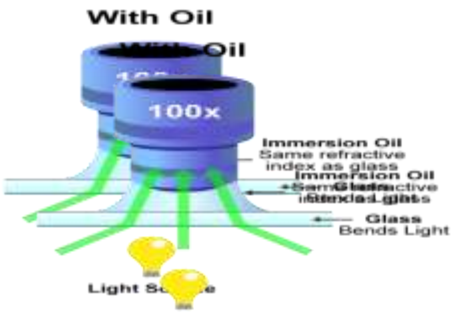
Oil immersion:

In light microscopy, **oil immersion** is a technique used to increase the resolving power of a microscope. This is achieved by immersing both the objective lens and the specimen in a transparent oil of high refractive index, thereby increasing the numerical aperture of the objective lens. 4x is a common magnification for scanning objectives and, when combined with the magnification power of a 10x eyepiece lens, a 4x scanning objective lens gives a total magnification of 40x. The name “scanning” objective lens comes from the fact that they provide observers with about enough magnification for a good overview of the slide, essentially a “scan” of the slide.

Magnification:

The mag nification of a lens is defined as the ratio of the height of an image to the height of an object.it is also given in terms of image distance and object distance . it is equal to the ratio of image distance to that of object distance.





Without oil, light waves reflect off the slide specimen through the glass cover slip, through the air, and into the microscope lens (see the coloured figure to the right). Unless a wave comes out at a 90-degree angle, it bends when it hits a new substance, the amount of bend depending on the angle. This distorts the image. Air has a very different index of refraction from glass, making for a larger bend compared to oil, which has an index more similar to glass. Specially manufactured oil can have nearly exactly the same refractive index as glass, making an oil immersed lens nearly as effective as having entirely glass to the sample (which would be impractical).

LENS ABERRATION

In optics, aberration is a property of optical systems such as lenses that results in light being spread out over some region of space rather than being focused to a point. An image-forming optical system with aberration will produce an image that is not sharp. Aberration can be caused due to a variety of reasons such as lens size, material, thickness and position of the object.

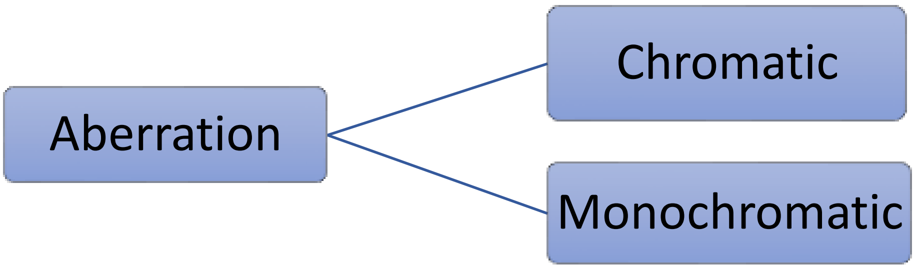
Ideal lens: Perfect lens means free of aberration and focuses light onto a single point.

1/d0 + 1/di = 1/f .... (d0 is object distance & di id image distance from principle axis).

Real in lenses: The image is real and inverted.

What is Optical Aberration?

aberration, in optical systems, such as lenses and curved mirrors, the deviation of light rays through lenses, causing images of objects to be blurred. Reduces the intensity of image, due to different focal lengths.so that there will many images of object.



Ideal image is a point image of point object, the point which are at same distance at object have an image in the same plane and at same distance. The colour of the image is same as the object so called as ideal image.

In case of aberration – "The departures of real images from the Ideal Images, in respect of the actual size, and position, are called Aberration."

The light ray which is incident on the lens near to principal axis called paraxial ray and the one which incident on lens away from the principal axis called marginal ray. (Deviation of paraxial rays is less than marginal ray)

Monochromatic Aberration:

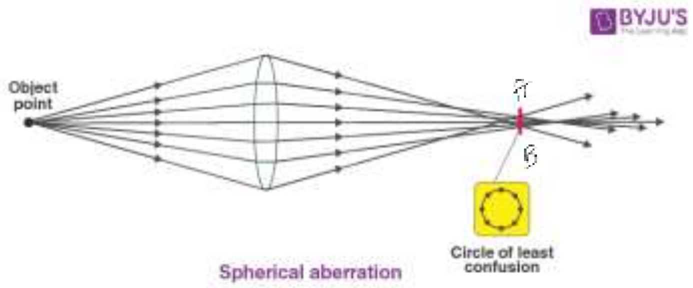
The defects which occur even with the Monochromatic (single colour light-mean single wave length)

Types of Monochromatic Aberration

- Spherical aberration
- Coma
- Astigmatism

Spherical aberration

In spherical aberration, rays of light from a point on the optical axis of a [spherical lens] do not all meet at the same image point. Rays passing closer to the centre are focussed farther away than the rays passing through a circular zone near its rim. A circular cross-section is formed whenever a plane held perpendicular to the optical axis is made to intersect a cone. The area of the cross-section varies with the distance along the optical axis. The smallest size is known as the circle of least confusion. The most spherical aberration-free image is found at this distance.

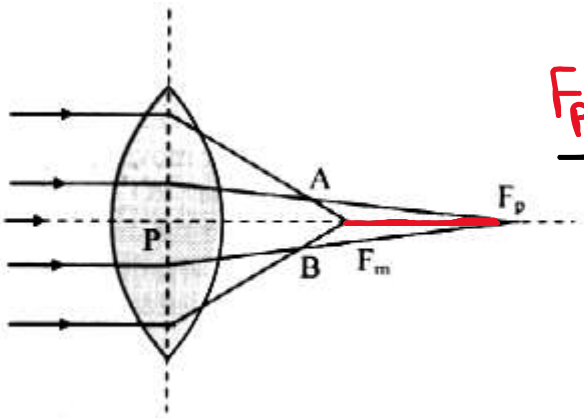


Here it is the point object image

If the screen is placed perpendicular to the axis of AB, then the image appears to be a circular patch of diameter AB. This patch of diameter AB is called Least of confusion.

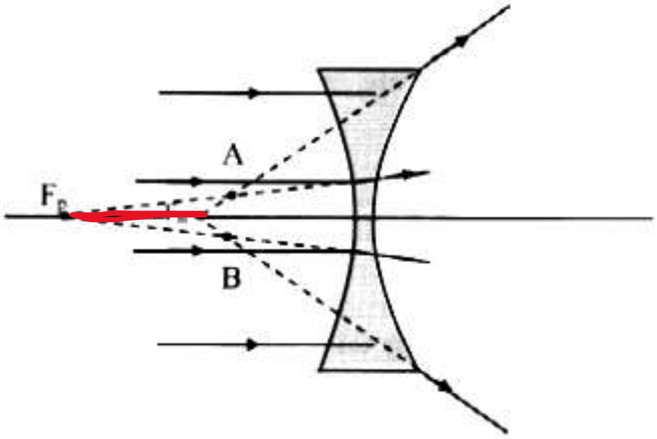
Here the focal points are different due to marginal and axial rays so the focal points are on axis therefore it called as axial spherical aberration.in both concave and convex we can see the focal points and the difference between

Fp-Fm is called Axial Spherical Aberration.



$F_p - F_m = \text{Axial SA}$

Spherical aberration in convex lens



Spherical aberration in concave lens

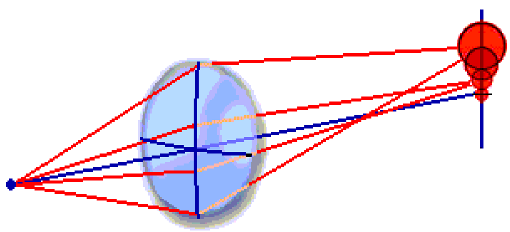
Coma:

Here the point object is not situated on the axis, it may be above or below the axis. So that the focal point is not on the axis. if we place a plane perpendicular to the axis, we get the focal point at different position which are perpendicular to the axis and the images are aligned like comet. So that we named this as Coma.

The aberration known as coma, occurs for rays which comes from object points that lie off the Lens axis. (Below or above)

Comatic aberration is similar to spherical aberration because in both cases lens failed to bring all the rays from an object to focus at the same point.

The image is comet shaped and hence the name coma.



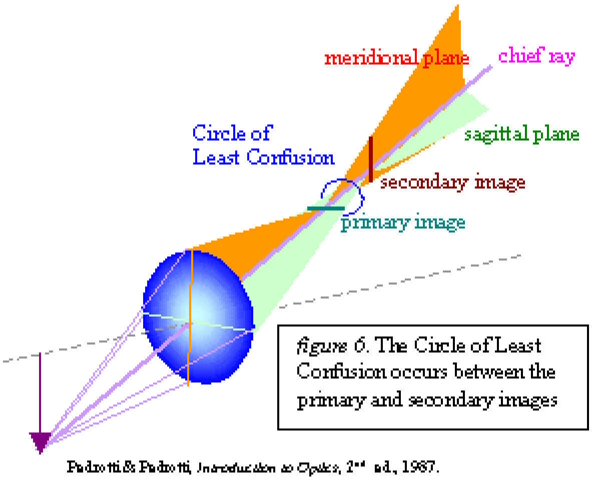
Coma can be reduced by using Abbe's sin condition i.e,

$n1\ h1\ \sin\theta1 = n2\ h2\ \sin\theta2$

Astigmatism:

This is same as comatic aberration because in both aberration object lies off the principal axis.

Here the spreading of image take place along (parallel) to the axis.

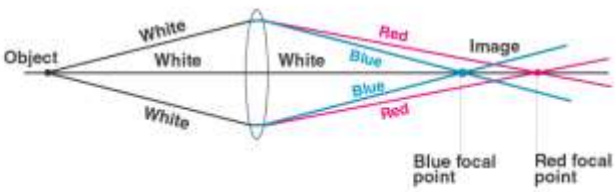


Tangential plane-meridional, radial plane-sagittal

Astigmatism is the result of the failure of a single zone of the lens to focus the image of an off-axis point at a single point. In the figure, we see two planes perpendicular to each other passing through the optical axis. These planes are known as the meridian plane and the sagittal plane, the meridian plane being the one containing the off-axis object point. Skew rays, rays not in the meridian plane are focused farther away from the lens than those lying in the plane. In either case, the rays do not meet in a point focus but as lines perpendicular to each other. Intermediate between these two positions, the images are elliptical in shape.

Chromatic Aberration:

The failure of a lens to focus all colours in the same plane is known as chromatic aberration. The refractive index for red is least at the red end of the spectrum, hence the focal length of a lens in the air will be greater for red and green than it would be for blue and violet. Chromatic aberration affects magnification along the optical axis and the axis perpendicular to it. The former is known as longitudinal chromatic aberration and the latter is known as lateral chromatic aberration.



Chromatic Aberration