Optical Aberrations and Best Form Lenses Cheat Sheet

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Optical Aberrations and Best Form Lenses

Lens Form - Types	Curved Lenses
Curved surface determines whether plus or minus	Meniscus lenses are convex-concave lenses they have one outward faced curved and one inward
Flat surfaces are plano and have 0 power	Outward curve shaper than inward curve? Lens has a positive focal length and acts as a magnifier. Forms either real or virtual image.
Lenses are determined by their surface curvatures, can be flat or curved	Toric lenses are curved surfaces. One surface spherical, the other toroidal. Used when cylinder in prescription.

Curved surfaces are either meniscus or toric lenses

F1 + F2 = F Total is the nominal power of a lens

Aberrations

Lens aberrations can reduce image quality as the wearer gazes away or looks obliquely from the optical axis.

There are 6 different lens aberrations that impact quality of peripheral vision through a lens:

Oblique Astigmatism, Power Error, Spherical Aberrations, Coma, Distortion. These are monochromatic and occur independently of colour.

Aberrations (cont)

Chromatic Aberrations are the consequence of the dispersive properties of the actual lens material.

As the eye rotates behind the lens, the far point moves with the eye at a fixed distance from the Centre of rotation. This movement is known as the far point sphere.
The far point sphere is a spherical surface that represents the ideal focal points for a lens as the eye rotates to look through it.
Lens aberrations arise when light refracted by a lens fail to focus on the far point sphere.

Distortion

Distortion is an optical aberration that deforms and bends straight lines and makes them appear curvy in images.

There are 3 types of optical distortion:

Oblique Astigmatism

An abberation that occurs when lightrays from an object in the periphery strike the lens obliquely and are then refracted by the tangential and sagittal meridians differently.

Oblique astigmatism can also be induced by tilting the lens, as this places the line of sight at a significant angle to the optical axis.

Oblique Astigmatism (cont)

The Tangential meridian (T) refracts more incident lightrays than the Sagittal meridian (S). Consequently, incident light from an off-axis object are brought to a focus at 2 different points.

OA due to lens tilt can be minimised by ensuring that the optical axis of the lens passes through the centre of rotation in the eye.

The image of the object point is no longer focused at a single point, but is separated at 2 different foci, the Tangential Focus and the Sagittal Focus.

This can be achieved by manipulating the relationship between the pantoscopic tilt.

Oblique astigmatism occurs when the wearer looks at an angle (obliquely) through the lens or through the lens periphery.

The pantoscopic tilt is the lens tilt towards the cheeks and the height (H) of the wearer's pupil centre above the optical centre (OC)

1mm of Optical Centre Drop (H) for Every 2 Degrees of Pantoscopic Tilt

Oblique astigmatism is an astigmatic focusing error, and has a similar effect to unwanted cyl power in a prescription.

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Curvature of Field - Aspherical Lens

Any surface that isn't spherical is aspheric	Conic sections are the sections when a plane intersects a cone
Toroidal surfaces are aspheric	If a plane intersects a cone at right angles exactly to a vertical line passing through the apex the cut face would be a circle
Aspheric surfaces are from concoids: a family of curves	Various curves that represent a section of the cone for aspheric lenses are: Cone, Ellipse, Parabola, Hyperbola

Eccentricity is the slight variation of angle that the plane has from the circular section, moving into the Ellipse section

If the plane of intersection is exactly parallel to one side of the cone, it is the parabola section

The eccentricity for the conic sections are:	e = 0 for Circle, 0 <e < 1 for Ellipse, e = 1 for Parabola, e > 1 for Hyperbola

Aspherical lenses are astigmatic.
As you move away from the central vertex to the periphery of the lens, it results in negative surface astigmatism.
The negative surface astigmatism is used to neutralise the positive oblique astigmatism.
Positive oblique astigmatism arises off the axis gaze.

Power Error

When no OA is present, a lens brings light to a focus on the Petzval Surface - a curved image plane.	Power error is a result of the fact that the focal plane of the lens for off-axis object points departs from the FPS of the eye.
Curvature of Field is an aberration that arises from the difference in focus between a flat focal plane and the Petzval surface	PE occurs even when there is no OA
Curvature of Field is a concern for flat image planes, such as a camera. However the FPS (ideal plane of the eye) is also curved.	In PE, the Tangential and Sagittal meridians may refract incident light to a single point focus, however this is not on the FPS
The Petzval surface is flatter than the FPS.	The FPS is the desired point of focus
Power Error arises as the difference in focus between the Petzval surface and the FPS.	The dioptric difference between the actual focus and the desired focus results in a PE

Unlike oblique astigmatism, power error is a spherical-like focusing error and is similar to unwanted spherical power in a prescription

Coma

Off-axis points of light appear comet shaped

As lightrays from the edges pass through a lens they vary in magnification and create a series of asymmetrical circular shapes

Reducing the lens down to a smaller aperture can reduce coma

Corneal conditions like Keracotonus, corneal injuries or abrasians can result in coma

Transverse Chromatic Aberrations

Off axis blur occurs under low contrast conditions. Wearer may notice colour fringes. Transverse Chromatic Aberrations reduce visual acuity.

Transverse Chromatism can be eliminated by an Achromatic Lens (a pair of lenses bonded together). Chromatism of one component neutralises the chromatism of the second.

Power is given by selecting a material with the highest V-value.

Wollaston Lens reduce chromatism. The lens is bent into a steep curve. However Woollaston lenses are expensive and very bulbous

Ideal Best Form Lens

Significant aberrations are: Transverse Chromatic Aberration, Distortion, Oblique Astigmatism, Curvature of Field

In practice, best form lenses usually eliminate: Oblique Astigmatism, Distortion, Curvature of Field

Spherical Aberration and Coma are both aberrations of wide aperture systems such as photography. A spectacle lens may be quite large but it is not a common issue.

Aspheric Lens are the most common Best Form Lens