

Lecture 1 – Introduction to Aberrometry & Visual Optics Review

DR SALMON INTRODUCTION

COURSE SYLLABUS

COURSE SCHEDULE

INTRODUCTION TO ABERROMETRY

As former dean Dr. George Foster used to say, “Next to life itself, God’s most precious gift is the gift of sight.” As optometric physicians, one of our missions in life is to protect, restore and enhance the vision of our patients. What are some of the causes of poor vision?

- Eye diseases such as glaucoma or cataracts
- Systemic diseases such as a brain tumor that impinges on the visual pathways
- Eye injuries such as blunt trauma to the eye during a basketball game
- Developmental anomalies such as amblyopia.
- Refractive errors

By far, the most common cause of poor vision is an uncorrected refractive error. One of the most important things optometrists do is to evaluate and correct the eye’s optics. Knowledge of optics makes optometric physicians the best-qualified professionals to care for the visual needs of patients. Dr. West provided you with an excellent education in optics. In this course, we’ll continue where Dr. West left off by discussing one of the most exciting developments in the field of visual optics—aberrometry.

Q. What is aberrometry?

A. Aberrometry is also known as wavefront sensing. It is a technique used to measure refractive errors in much greater detail than is possible with traditional clinical refraction methods such as subjective refraction using a phoropter or autorefractor.

Aberrometry takes a different approach to measuring refractive errors. It measures the shape of a wavefront of light that has passed through the optical elements of the eye. By analyzing the wavefront’s shape, we can determine the amount and kinds of refractive errors present in the eye, including

- Spherical defocus (myopia, hyperopia)
- Astigmatic errors
- Higher-order aberrations (coma, spherical aberrations and others)

We’ll be using an aberrometer in Lab 1 to measure each other’s eyes, and in the next lecture we’ll discuss this topic in more detail. In preparation for lab, please bring a copy of your current refractive error and come to lab without contact lenses.

VISUAL OPTICS REVIEW

Similarities between the eye and a camera

The human eye is often likened to a camera. Both are optical instruments that have been designed to form images. Other similarities are summarized in Table 1.

Schematic eyes

The camera illustration can help us understand the eye, and schematic eyes have also been useful for this purpose. Examples include the

- Gullstrand’s No. 1 schematic eye. Two-surface cornea and four-surface lens, all with spherical, rotationally symmetric surfaces.

- Gullstrand-Emsley reduced eye. One-surface cornea and two-surface lens with spherical, rotationally symmetric surfaces. (Fig. 1.)
- Indiana Eye. One-surface aspheric cornea with a pupil. See the article at the following web site: (<http://research.opt.indiana.edu/Library/INEye/IndianaEye.html>) or in Thibos LN, Ye M, Zhang X, Bradley A. Spherical Aberration of the Reduced Schematic Eye with Elliptical Refracting Surface. *Optom Vis Sci* 1997;74:458-556.

Table 1. Similarities between the eye and a camera

Eye	Camera	Function
Cornea + lens	Lens elements	Refract, focus light, form an optical image
Retina	CMOD sensor (video/digital camera)	Receive image, convert photons to an electrical signal
Pupil	Aperture	Control image brightness, depth of focus, diffraction, aberrations
Black RPE layer	Blackened interior	Reduce internal light scatter
Accommodation	Auto-focus mechanism	Focus for different distances

Figure 1 illustrates the location of the eye's **entrance pupil** and exit pupil.

Q. What is the definition of the entrance pupil?

A. It is the image of the real pupil formed by the cornea. That is, if the anatomic pupil/iris is the object, after refraction by the cornea, the entrance pupil is the image. When we look at a person's eye and see the pupil or iris, we are not seeing the real pupil but an image of the pupil, that is, the entrance pupil.

The entrance pupil is particularly important in aberrometry because it is the normal reference plane for measuring aberrations of the eye.

The COAS aberrometer allows you to specify the aberrations in the spectacle or corneal plane, but the basic measurement is normally made in the entrance pupil plane.

Axes of the eye

In visual optics you learned about several theoretical axes of the eye and important angles between those axes. For the purposes of aberrometry, the most important axis of the eye is the **line of sight**.

The line of sight is the line segment connecting the fixation point and the center of the entrance pupil. If a ray of light enters the eye on the line of sight, it will continue inside the eye from the exit pupil to the fovea. (Fig. 1)

The line of sight is important in aberrometry, because measurements of the eye's aberrations should be centered on the line of sight.

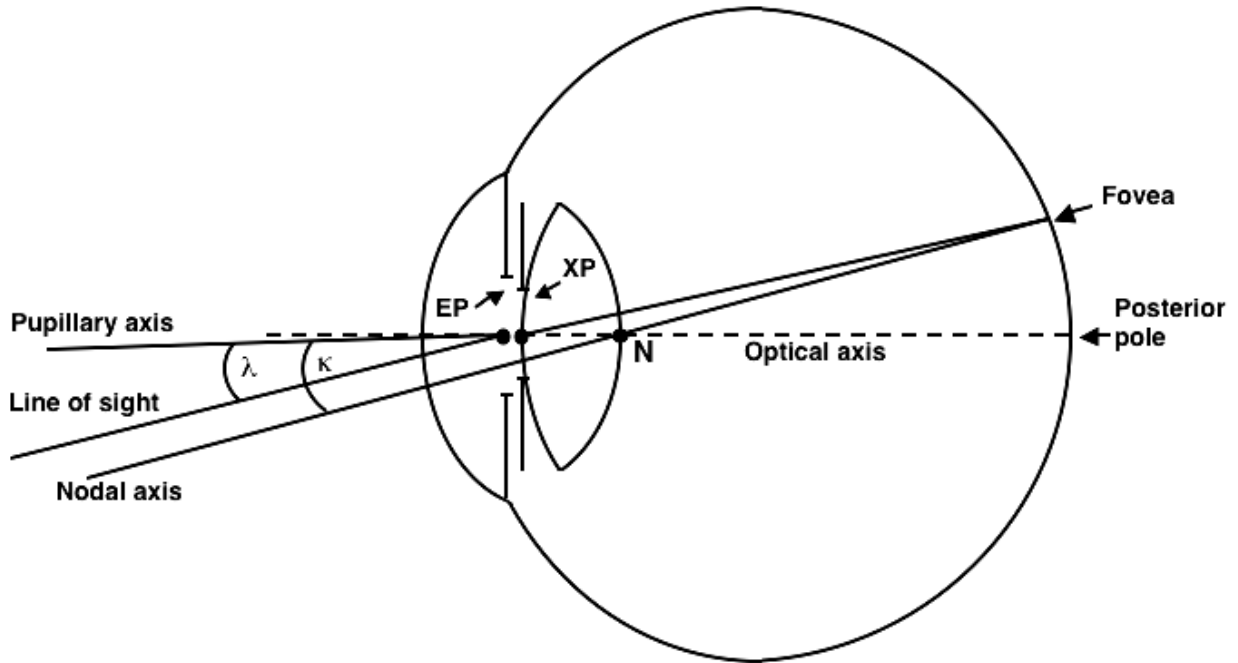


Figure 1. Figure based on the Gullstrand-Emsley reduced eye showing some of the important axes and angles, as well as the location of the entrance and exit pupils.

American National Standard ANSI Z80.28-2004 summarizes many of the basic principles of aberrometry and standardizes the system of measuring and recording aberrations.