

Basic Optics: What You Need To Know

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Disclaimer

• Please prepare for certification testing with materials from the organization in which you want your certification granted i.e.:

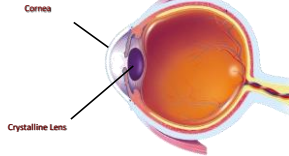
- ADA
- JCAHPO
- ABO
- NCLE
- OT

Outline

- The Visual System
 - Physiology
 - Anisotropias
- Ophthalmic Lenses
 - Properties of Light
 - UV, Visible, and Infrared Spectrums
 - Reflection, Refraction, & Absorption
 - Aberrations
- Lens Designs
 - Fitting
- Basic Optical Formulas

The Visual System

There are two main refractive bodies in the human eye...



The Visual System

Cornea

The cornea is the primary refractive element in the eye...

... with a power of around +42-44 diopters



The Visual System

Cornea

The tear film maintains both the health and optics of the cornea...

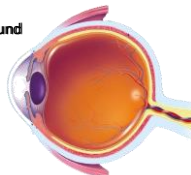


The Visual System

Crystalline Lens

The crystalline lens has a power of around +12-18 diopters...

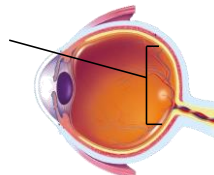
...it is primarily responsible for changing the eye's focal point...a term referred to as accommodation



The Visual System

The retina is the "film" or sensory body...

Retina

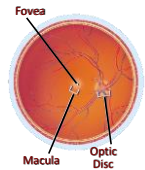


The Visual System

Retina

Light is converted to electrical impulses which are sent through the optic nerve...

...the "blind spot" is the point at which the optic nerve connects



The Visual System

Eye Movement or ocular motility

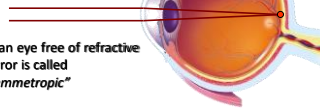
The eye is connected to the orbit by several muscles which control movement...



Visual Anomalies

Ametropias

In a "normal" eye, parallel light is brought to a focus on the retina...

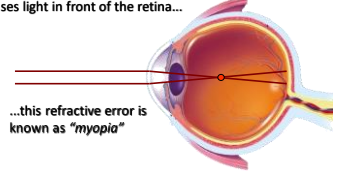


...an eye free of refractive error is called "emmetropic"

Visual Anomalies

Ametropias

An eye with excessive focal power for its length focuses light in front of the retina...

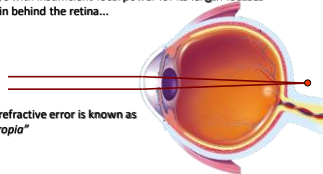


...this refractive error is known as "myopia"

Visual Anomalies

Ametropias

An eye with insufficient focal power for its length focuses light in behind the retina...

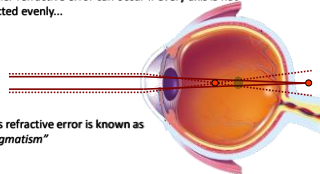


...this refractive error is known as "hyperopia"

Visual Anomalies

Ametropias

Another refractive error can occur if every axis is not refracted evenly...



...this refractive error is known as "astigmatism"

Visual Anomalies

Ametropias

As the eye ages, the crystalline lens loses flexibility...

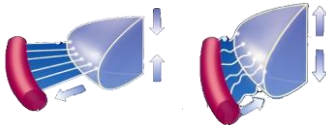


...this results in a condition known as "presbyopia"

Visual Anomalies

Presbyopia

The inability to focus on near objects becomes noticeable around age 40 and steadily worsens thereafter...



Ophthalmic Lenses



•Ophthalmic Lenses

- Properties of Light
 - UV, Visible, and Infrared Spectrums
 - Reflection, Refraction, & Absorption
- Lens Designs
- Lens Materials

Ophthalmic Lenses

Properties of Light

Like the artist's paint, the eye requires light to see...



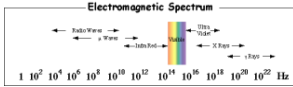
...what is "light," and how does it work?

Ophthalmic Lenses

Properties of Light

So what is light?

- particles in the form of a wave
- electromagnetic radiation with **wavelengths between 400 and 700 nanometers** (a nanometer is 1/1,000,000th mm) is considered the **visible spectrum**
- white light is composed of all wavelengths

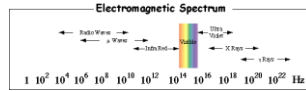


Ophthalmic Lenses

Properties of Light

So what is light?

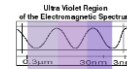
- visible light is a small portion of the overall spectrum of light
- EM surrounding the visible spectrum is hazardous
 - Ultra-Violet is <390nm
 - Infrared is >720nm



Ophthalmic Lenses

Properties of Light

Ultra-Violet Radiation

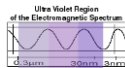


UVA is less photobiologically active than UVB and consists of light just beyond the blue end of the visible spectrum...

Ophthalmic Lenses

Properties of Light

Ultra-Violet Radiation

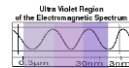


UVB falls farther from the visible spectrum, is the most significant UV most of us experience, and is variably absorbed by ozone...

Ophthalmic Lenses

Properties of Light

Ultra-Violet Radiation

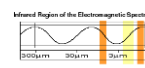


UVC light is farthest from the visible spectrum, and is almost completely absorbed by ozone (except at very high altitudes)....

Ophthalmic Lenses

Properties of Light

Infrared



Infrared is >720nm- the most common source is blown glass...

Ophthalmic Lenses

Properties of Light

Movement of Light

Light moves in wave form along a straight line...



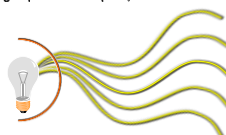
...the distance between peaks determines wavelength

Ophthalmic Lenses

Properties of Light

Movement of Light

As light spreads from a point, it forms a wavefront...



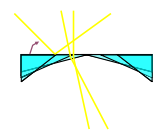
Ophthalmic Lenses

Properties of Light

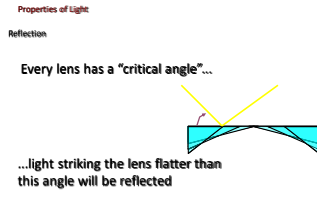
Movement of Light

Wavefronts interact with lenses in 3 ways

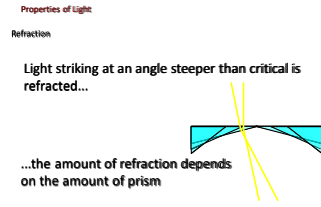
- Reflection
- Refraction
 - prism
 - dispersion
- Absorption



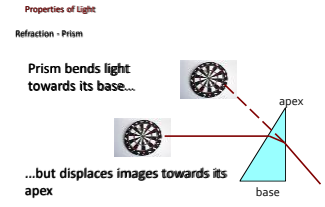
Ophthalmic Lenses



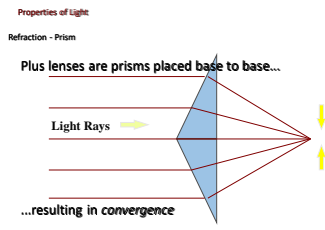
Ophthalmic Lenses



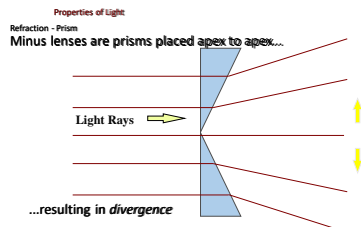
Ophthalmic Lenses



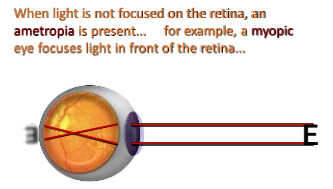
Ophthalmic Lenses



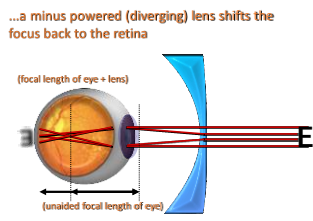
Ophthalmic Lenses



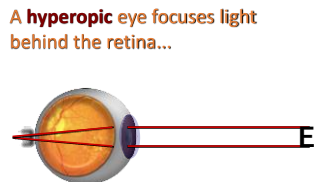
Vision & Ametropias



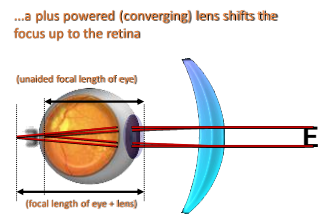
Vision & Ametropias



Vision & Ametropias

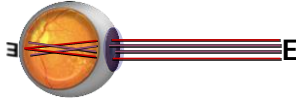


Vision & Ametropias



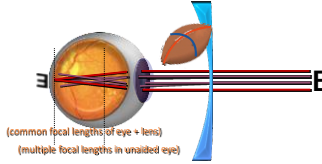
Vision & Ametropias

Astigmatism causes light along different axes to focus at different planes...



Vision & Ametropias

...a cylindrical lens is prescribed to compensate for astigmatism in the eye- creating a common focal point on the retina...



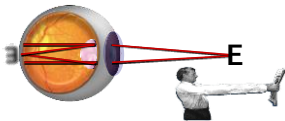
Vision & Ametropias

As previously mentioned, the crystalline lens enables the eye to focus on near objects...



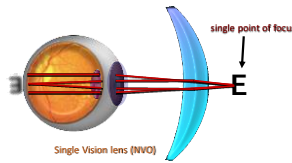
Vision & Ametropias

...as the crystalline lens ages, it loses its flexibility- and its ability to adjust focus... this condition is called **presbyopia** and typically becomes noticeable around age 40



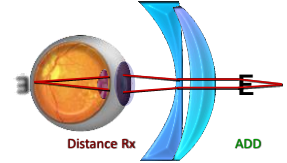
Vision & Ametropias

To restore near vision, the required convergence is supplied by a plus powered lens...



Vision & Ametropias

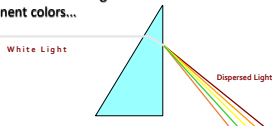
...this plus lens may stand alone (NVO) or may work with distance correction (ADD)



Ophthalmic Lenses

Properties of Light
Refraction - Dispersion

All prisms break white light into its component colors...



...this is called dispersion and results in chromatic aberration

Ophthalmic Lenses

Properties of Light
Refraction - Dispersion

Abbe value is used to describe the amount of dispersion a material will create...

...ranges are from 59 (CR-39) to 30 (polycarbonate)



Chromatic Aberration

Ophthalmic Lenses

Properties of Light
Absorption

A dark lens absorbs light...



Ophthalmic Lenses

Properties of Light

Absorption

White light is composed of all colors in the rainbow- but all colors can be formed using a combination of three "primary colors:"

- Red
- Yellow
- Blue

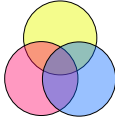


Ophthalmic Lenses

Properties of Light

Absorption

Filters absorb light. Chemical compounds are used to selectively filter single colors.



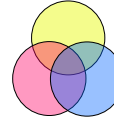
To create a green filter, only red light must be absorbed. The appropriate chemicals are applied, and a green filter is created.

Ophthalmic Lenses

Properties of Light

Absorption

To create a perfectly neutral- or gray- filter, energy from all three primary points in the spectrum must be absorbed to the same degree.



When creating a filter by absorbing dye into resin, this process is further complicated by the inconsistent nature of the chemicals involved.

Ophthalmic Lenses

Properties of Light

Aberrations

The most common aberrations found in ophthalmic lenses are:

- Power Error
- Material Distortion
- Marginal Astigmatism
- Chromatic Aberration
- Unwanted Prism*

Ophthalmic Lenses

Properties of Light

Aberrations

Aberrations occur due to various factors:

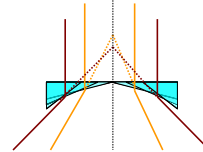
- Refractive power
- Off-axis viewing of objects
 - lens tilt
 - peripheral objects
- Vertex distance
- Lens material

Ophthalmic Lenses

Properties of Light

Aberrations – Power Error

Spherical lenses are stronger in the periphery...

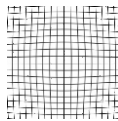


Ophthalmic Lenses

Properties of Light

Aberrations – Distortion

The minus lens result is barrel distortion...



...the periphery of an object will be minimized to a greater degree than the center

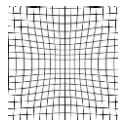
Ophthalmic Lenses

Properties of Light

Aberrations – Distortion

Plus lenses create the opposite effect...pincushion effect

Aspheric lenses reduce distortion



...the periphery of an object will be magnified to a greater degree than the center

Ophthalmic Lenses

Properties of Light

Aberrations – Distortion

Compare a spherical lens to an aspheric lens of equal power...



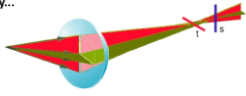
...notice the central curve & thickness

Ophthalmic Lenses

Properties of Light

Aberrations – Marginal Astigmatism

Light striking the lens at an oblique axis do not refract evenly...




...unwanted astigmatism occurs

Ophthalmic Lenses

Properties of Light

Aberrations – Chromatic Aberration



As previously discussed, chromatic aberration is the dispersion of white light into its component colors...


...large amounts of prism are necessary for chromatic aberration to affect vision

Ophthalmic Lenses

Properties of Light

Prism

Although prism is not technically an aberration, unwanted prism does affect quality of vision...




...the optical center of a lens usually has no prism

Ophthalmic Lenses

Properties of Light

Prism

The eye does not always view objects through the optical center...



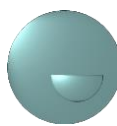
...what will the eye perceive?

Ophthalmic Lenses

Lens Types

There are many types of lenses designed to meet specific patient needs...

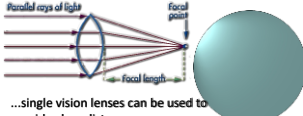
- Single Vision
 - Distance Vision
 - Near & Intermediate Vision
- Bifocals
 - Flat Tops
 - Executive
- Trifocals
- Progressive Addition Lenses



Ophthalmic Lenses

Lens Types – Single Vision

Single Vision lenses have only one focal length...

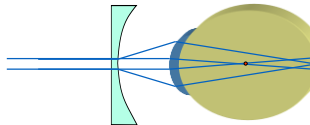


...single vision lenses can be used to provide clear distance, intermediate, or near vision for presbyopes

Ophthalmic Lenses

Lens Types – Single Vision

The myopic eye focuses light in front of the retina...

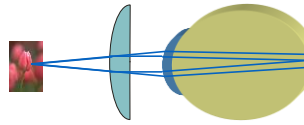


...using a minus powered single vision lens, light is focused on the retina

Ophthalmic Lenses

Lens Types – Single Vision

“Reading glasses” are also single vision lenses...

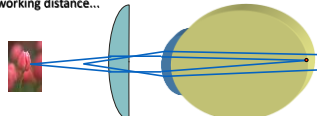


...a plus powered single vision lens restores near vision

Ophthalmic Lenses

Lens Types – Single Vision

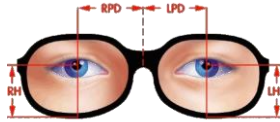
Single vision readers only provide clear vision at one working distance...



Ophthalmic Lenses

Lens Types – Single Vision

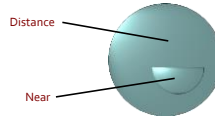
Single vision lenses require measurement of pupillary distance, and occasionally fitting height...



Ophthalmic Lenses

Lens Types – Bifocals

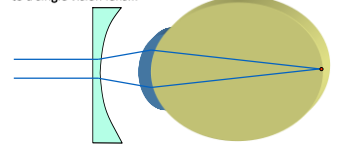
Bifocal lenses have two focal lengths...



Ophthalmic Lenses

Lens Types – Bifocals

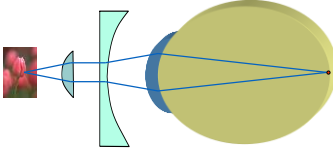
For distance vision, the lens contains a "carrier" similar to a single vision lens...



Ophthalmic Lenses

Lens Types – Bifocals

For near vision, an extra "reading" segment is added...



Ophthalmic Lenses

Lens Types – Bifocals

Flat-top bifocals are usually fit:

- to lower limbus (seg line @ lower lid)
- decentered 1.5mm in from Far PD

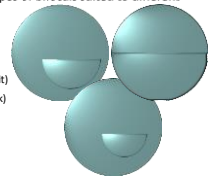


Ophthalmic Lenses

Lens Types – Bifocals

There are several types of bifocals suited to different needs...

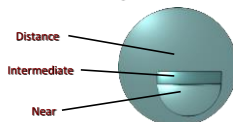
- Flat Tops
 - FT28
 - FT35
 - FT45
- Simas Seg*
- Curve Top (Cosmolit)
- Executive (E-Line)
- Round Seg (Kryptok)
- Blended



Ophthalmic Lenses

Lens Types – Trifocals

Trifocal lenses have three focal lengths...

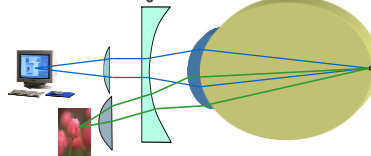


...generally, the intermediate ADD is 50% of the near ADD

Ophthalmic Lenses

Lens Types – Trifocals

Objects at the focal length of either the near or intermediate segments are focused on the retina...



Ophthalmic Lenses

Lens Types – Trifocals

Flat-top trifocals are usually fit:

- to lower edge of the pupil
- decentered 1.5mm in from Far PD



Ophthalmic Lenses

Lens Types – Trifocals

There are several types of trifocals suited to different needs...

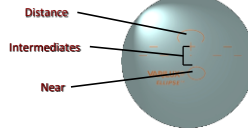
- Flat Tops
- FTT 7/28
- FTT 8/35
- Smart Seg*
- Executive (E-Line)
- Occupational*



Ophthalmic Lenses

Lens Types – Progressives

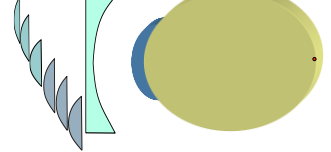
Progressive Addition Lenses (PALs) have an infinite number of focal lengths across a range...



Ophthalmic Lenses

Lens Types – Progressives

PALs contain a reading ADD that progressively gets stronger- providing many, many focal lengths...



Ophthalmic Lenses

Lens Types – Progressives

Progressives are usually fit:

- at pupil center



Ophthalmic Lenses

Lens Types – Progressives

PALs require precise fitting if the lens is to perform to its potential, this necessitates:

- Monocular pupillary distances
- Verification of fitting height
- Proper frame adjustment

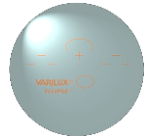


Ophthalmic Lenses

Lens Types – Progressives

There are literally hundreds of PAL designs available- each with unique characteristics...

- Traditional
 - hard design
 - soft design
 - monodesign
 - multidesign
- Short Corridor
- Customized
- Task Specific



Basic Formulas

Calculations

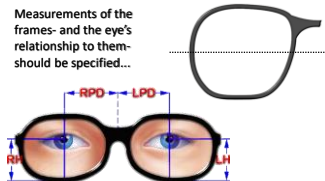
There are perhaps two calculations every person who works with eyewear MUST know...

- Prentice's Rule
- Box Measurements

Basic Formulas

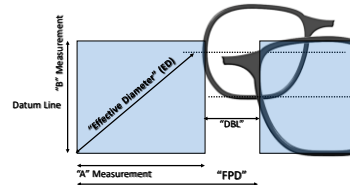
Box Measurements

Measurements of the frames- and the eye's relationship to them- should be specified...



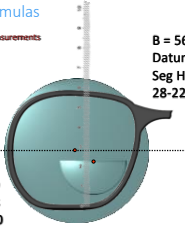
Basic Formulas

Box Measurements



Basic Formulas

Box Measurements



A = 58
DBL = 20
FPD = 78
NPD = 60
 $(78-60)/2 = 9$ in

B = 56
Datum $(56/2) = 28$
Seg Ht = 22
 $28-22 = 6$ down

Thank You

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