


**ABBE VALUE & REFRACTIVE INDEX**

*THE ONGOING BATTLE*

**PHERNELL WALKER, MBA, ABOM, LDO**  
1 HOUR CE CREDIT




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**Phernell Walker, MBA, ABOM, LDO, NCLEC**



- ❖ Principle | Pure Optics LLC
- ❖ Author | Pure Optics textbook
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- ❖ Pacific University College of Optometry | Past Adjunct Professor
- ❖ Master in Business Administration (MBA)
- ❖ Master in Ophthalmic Optics (ABOM)
- ❖ Associate in Science Ophthalmic Optics (AS)
- ❖ Licensed Dispensing Optician (WA-LDO)
- ❖ National Contact Lens Examiners Certified (NCLEC)

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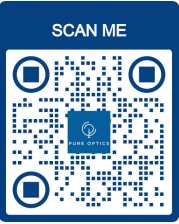
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**SCAN ME**



**Phernell Walker, MBA, ABOM, LDO**

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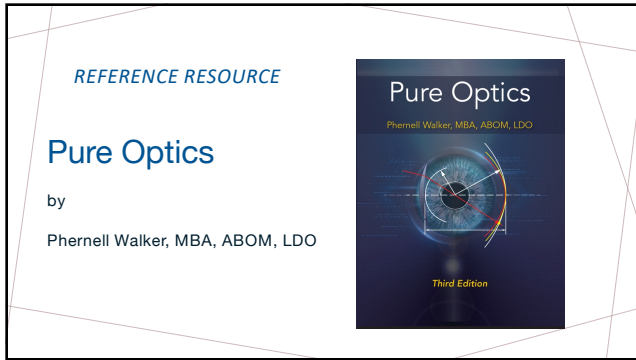
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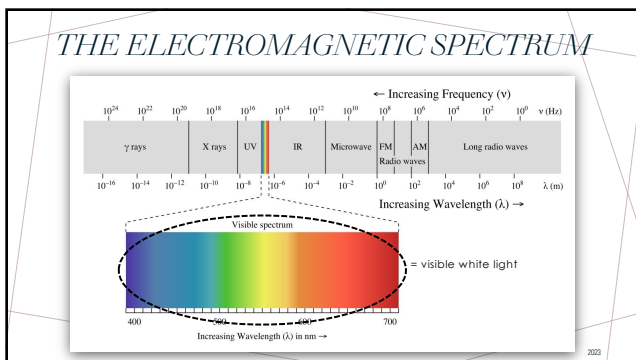
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*WAVE THEORY OF LIGHT*

**Huygen's Principle**  
Light wave vibrates up and down, while traveling side to side

Labels in diagram: Crest, Wavelength, Amplitude, Trough, Midline.

Analogous To Wavefronts

"Light is thought of as traveling away from a point, in the form of wavefronts, analogous to ripples in a pond"

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*WAVEFRONTS, LIGHT RAYS, AND VERGENCE*

Fig. 1 Diverging wavefronts  
Point source, Ray, Wavefront

Fig. 2 Plane wavefronts  
Ray

Fig. 3 Plus Lens - Converging wavefronts  
Point focus

Light Ray    Wavefront    Optical System with Curvature / Vergence Properties

Light travels away from a point source or object as diverging wavefronts

Hypothetical, perpendicular rays indicate direction of travel

Curvature of a wavefront or optical system indicates its vergence properties

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*REFRACTIVE INDEX, ABBE VALUE, AND DISPERSION*

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### REFRACTIVE INDEX

Refractive Index,  $n = \frac{\text{Speed of light in a vacuum, } c}{\text{Speed of light in second medium, } v}$

LENS MATERIAL	REFRACTIVE INDEX
CR39	1.498
Crown Glass	1.530
Polycarbonate	1.586
Trivex	1.53
MR-8™	1.60
MR-10™	1.67
MR-174™	1.74

**Refractive Index:** Ratio between speed of light in air to speed of light in a second medium (in U.S. 587.56nm)

- Refractive index is a measure of its refractive properties
- Higher refractive indices = thinner lens (all else considered equal)

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### HOW THIN WILL MY LENSES BE? *Curve Variation Factor*

$$CVF = (n_1 - 1) / (n_2 - 1)$$

$n_1$  = index of initial material     $n_2$  = index of compared material

Lens Material	Percentage Thinner Compared to CR39 (RI 1.498)
Trivex	6% Thinner
Polycarbonate	15% Thinner
MR-8™/MR-95™ (1.60)	17% Thinner
MR-10™ (1.67)	26% Thinner
MR-174™ (1.74)	33% Thinner

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### GEOMETRY OF LIGHT

“Opticians seek to control light. We can slow it down, redirect it, capture it, disperse it, and even compress it. But only temporarily”

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### REFRACTIVE INDEX DEFINED & IMPLICATIONS

- **Refractive index** - the ratio between lights velocity in air, compared to lights velocity in another transparent substrate
- **Relevance** - determines the materials efficiency at refracting light
- **Implication** - higher values equals greater efficiency and thinner lenses

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### REFRACTIVE INDEX FORMULA

*Refractive Index* - The ratio between the velocity of light through air compared to that of the new medium.

$$n = 186,000 / \text{velocity of light in a medium}$$

**Example:**  
The speed of light through water is 139,849 miles per second  
What is the refractive index of water?

$n = 186,000 / 139,849$   
 $n = 1.33$

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### REFRACTIVE INDEX OF WATER

Light's velocity in air  
186,000 mps

Impedes to  
139,849 mps

Water

Velocity of Light

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# ERNEST ABBE

- Lived (1840 – 1905)
- German physicist
- Microscope magnification limits
- Formulated the Abbe sine condition
- Measured chromatism



Source: Cambridge  
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# ABERRATION

Aberration is the failure of lens system to bring light rays to a single focal point

- Imperfect image
- Chromatic vs. monochromatic
- substrate material
- lens index
- lens geometry
- mirror
- human eye

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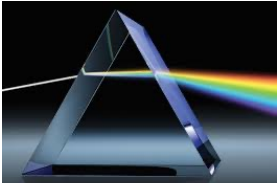
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# ABBE VALUE & DISPERSION



- What is dispersion, why does it take place?
- Dispersion: "Breaking up of white light into it's component, or spectral colors": BAD!
- A material's Abbe value determines its dispersion properties
- Abbe Value: "The relationship of material indices at specific reference wavelengths"
- Dispersive properties are inversely related to Abbe Value
- High abbe value = low dispersion: GOOD!
- High dispersion presents as increased chromatic aberration

Abbe Value & Refractive Index  
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### CHROMATIC ABERRATION

**Definition**

- An optical system focusing error
- Spectral components focused different distances from the lens

**Cause**

- Low Abbe value

**Result**

- Color fringes around images seen through lens periphery
- Visually distracting

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### ABBE VALUE & REFRACTIVE INDEX

LENS MATERIAL	REFRACTIVE INDEX	ABBE VALUE
CR39	1.498	58
Crown Glass	1.530	59
Polycarbonate	1.586	30
Trivex	1.53	45
MR-8™	1.60	41
MR-10™	1.67	31
MR-174™	1.74	32

How are Abbe value and refractive index related?

Generally, increasing refractive index results in a decreased Abbe Value

Increased potential for chromatic aberration

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### LONGITUDINAL CHROMATIC ABERRATION

**Longitudinal = FF (blue light) - FC (red light)**

- Dioptric Difference

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### LONGITUDINAL CHROMATIC ABERRATION

$$\text{Longitudinal} = D / v$$

- D = lens dioptric power
- v = Abbe value

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### TRANSVERSE CHROMATIC ABERRATION (TCA)

- TCA - components of light refract at different distances through the same lens
- Chromatic aberration (chromatism)
  - results in a noticeable color shift towards the edges of objects

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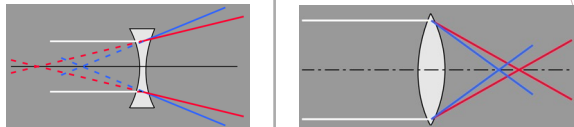
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### BLUE LIGHT SHORTER WAVELENGTH



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**TRANSVERSE CHROMATIC ABERRATION (TCA)**

$$TCA = (n_{\text{yellow}} - 1) / (n_{\text{blue}} - n_{\text{red}})$$

- TCA = Transverse Chromatic Aberration
- $n_{\text{yellow}} = 589.3 \text{ nm}$
- $n_{\text{blue}} = 486.1 \text{ nm}$
- $n_{\text{red}} = 656.3 \text{ nm}$

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**ABBE VALUE**

- Abbe Value (nu) - reciprocal value measuring Transverse Chromatic Aberration (TCA)
- Measures the optical properties of a substrate vs. its mechanical attributes

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**TRANSVERSE / LATERAL CHROMATIC ABERRATION**

- **TCA** - measures the optical properties of a substrate vs. its mechanical attributes. TCA measures chromatism
- **LCA** - measures the amount of chroma in prism diopters in the periphery

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**LATERAL CHROMATIC ABERRATION (LCA)**

**LCA = P / Abbe**

- ◊ LCA = Lateral Chromatic Aberration
- ◊ P = (hcm) (D) @ given meridian
- ◊ Abbe = Material's V value

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**CALCULATE LCA**

**LCA = P / Abbe**

- ◊ Calculate the LCA of 1.74<sub>n</sub> @ 23mm
- ◊ Rx: -8.00 DS
- ◊ Abbe: 32

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**CALCULATE LCA**

**LCA = 18.4 / 32**

- ◊ Substrate = 1.74<sub>n</sub> @ 23 mm
- ◊ P = -8.00 x 2.3 cm
- ◊ Abbe = 32
- ◊ LCA = 0.58<sup>^</sup> D

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**CALCULATE LCA**

**$LCA = P / Abbe$**

- Calculate the LCA of 1.586<sub>n</sub> @ 23mm
- Rx: -8.00 DS
- Abbe

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**CALCULATE LCA**

**$LCA = 18.4 / 30$**

- Substrate = 1.586<sub>n</sub> @ 23 mm
- P = -8.00 x 2.3 cm
- Abbe = 30
- LCA = 0.61<sup>▲</sup> D

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*WHICH LENS MATERIAL IS BEST?*

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### FACTORS TO CONSIDER

*Why Not Default to The Thinnest Material Every Time?*

Prescription Complexity/ Prism

Base Curve

Frame Style

Frame Dimensions vs. Patient Anatomy

Material's Effect on Acuity

"Cost" vs. "Benefit"

Juggling Act

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### LENS MATERIAL SELECTION

Power Range	Suggested Materials
+2.00D to -2.00D	Low Index Option
+/-2.25D to +/-5.00D	MR-8™ (1.60)
+/-5.25D and Up	MR-7™/ MR-10™ (1.67) • MR-174™ (1.74)

Purpose	Suggested Materials
Industrial Safety/ Sports/ Children	Polycarbonate or Trivex
Monocular Patient	Polycarbonate or Trivex
Drill Mount/ Semi-Rimless	MR-8™ (1.60) • MR-7™/ MR-10™ (1.67)
Tinted Sunglasses	MR-8™ (1.60) • MR-7™/ MR-10™ (1.67)

*Guidelines only – Frame type and size can create the need for alternatives* 2023

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### WHO IS MITSUI CHEMICALS?

*A Japanese Company with a Global Presence*

● Mitsui Chemicals, Inc.  
● SDC Technologies, Inc.  
● Acornon AG  
● KOC Solution Co., Ltd.

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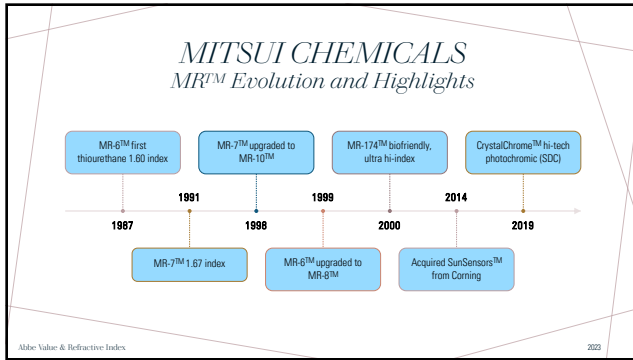
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	Premium High Index MR Materials				Alternative Materials					
	MR-8™	MR-7™	MR-10™	MR-174™	Poly	Acrylic 1.60	CR39	Crown Glass	Trivex	
Refractive Index	1.60	1.67	1.67	1.74	1.59	1.60	1.50	1.52	1.53	
Abbe Value	41	31	31	32	30	32	58	59	45	
Specific Gravity	1.30	1.35	1.37	1.47	1.20	1.38	1.32	2.54	1.11	
Heat Distortion Index (CJ)	118	85	100	78	142-148	89	55-65	>450	>260	
Tintability	Good	Exc.	Good	OK	Poor	Good	Good	Poor	Exc.	
Impact Resistance	Good	Good	Good	Good	Exc.	Poor	OK	Bad	Exc.	
Static Load Resistance	Good	Good	Good	OK	Good	Poor	Good	Good	Exc.	
Rimless Eyewear	Good	OK	Good	Poor	Exc.	OK	Poor	Bad	Exc.	
UV Attenuation	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	

*LENS MATERIAL COMPARISON*

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### PREMIUM HIGH INDEX BENEFITS

- Enhanced optical performance
- Superior impact resistance
- Excellent UV protection
- Easy to tint
- Excellent scratch resistance
- Enhanced durability for all frame types
- Index-matched hard coat

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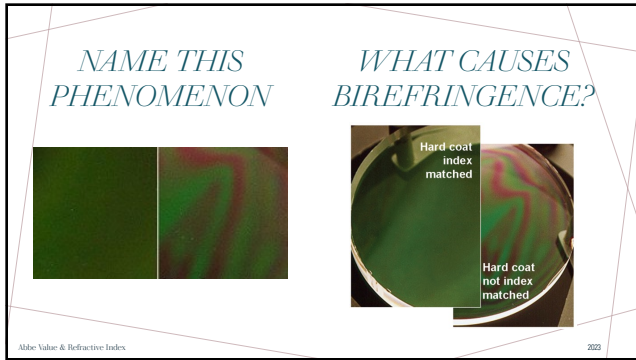
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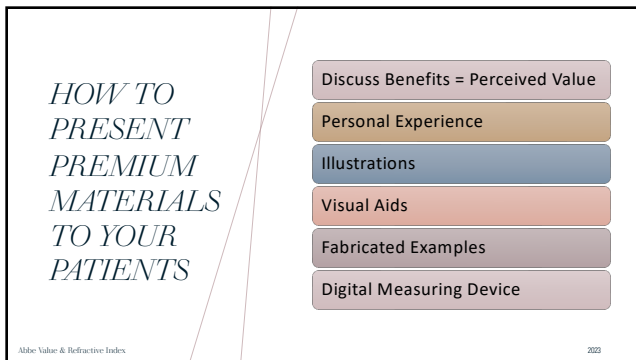
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