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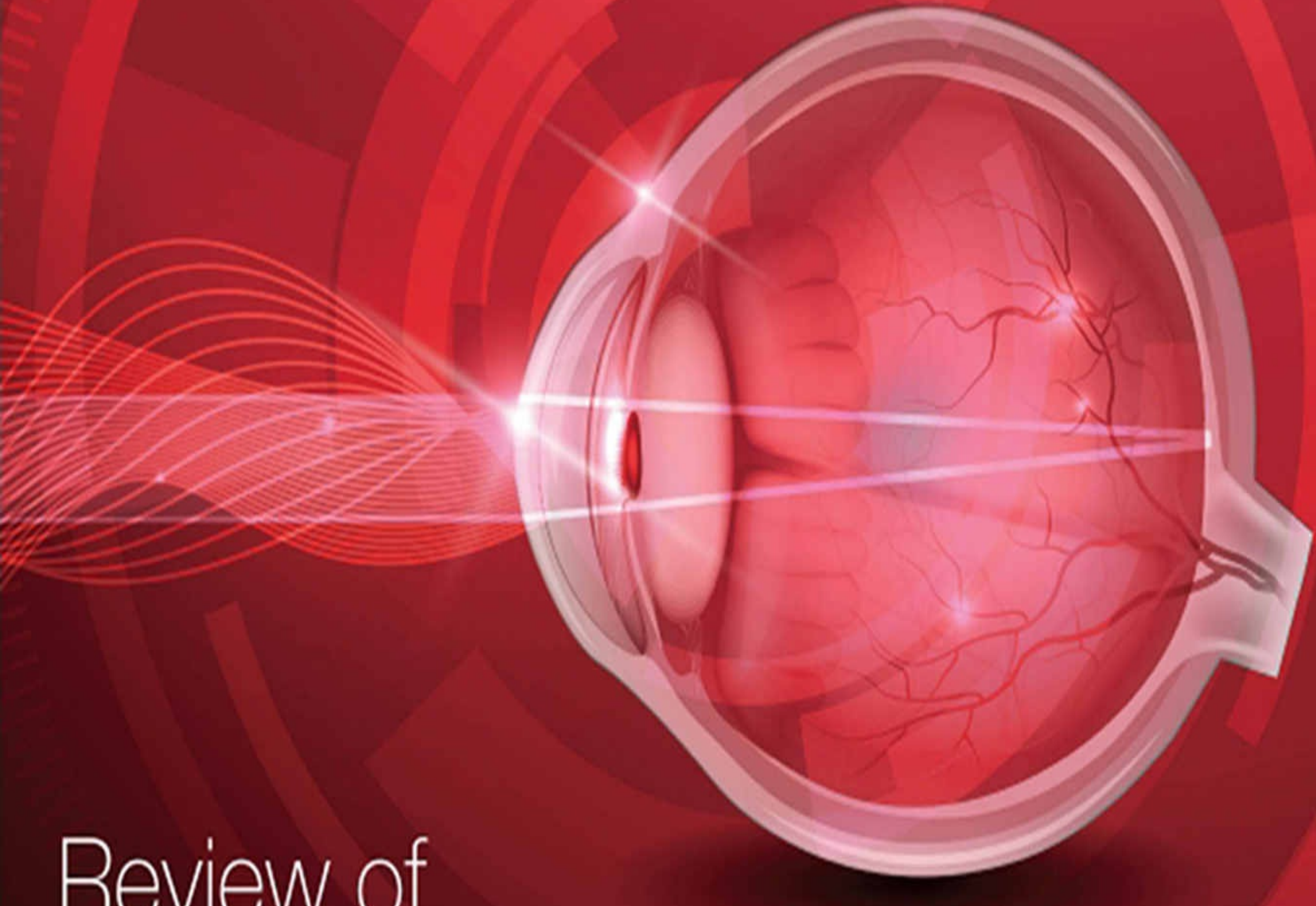

Review of Ophthalmology

Third Edition

ELSEVIER

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THIRD EDITION

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Preface

Neil J. Friedman, MD; Peter K. Kaiser, MD; William B. Trattler, MD

We are pleased to present the third edition of Review of Ophthalmology. The basic organization of the book, with its outline format and multiple choice questions divided into chapters based on familiar written exam sections, is unchanged. What we have changed is the content: we have added new topics, rewritten entire sections, updated treatments, and incorporated over 100 new questions many of which represent the style of questions encountered on recertification type exams (ie, clinical scenarios rather than esoteric facts). Although standardized test questions are slow to change, we believe it is important to stay current. We feel that the material in the new edition provides this essential information in the most concise and easy to use manner. We hope that you agree and will find this book helpful in your review process.

Good luck on your exams and in your future careers!

Acknowledgments

Neil J. Friedman, MD

Peter K. Kaiser, MD

William B. Trattler, MD

We owe thanks to many individuals who have assisted us with this third edition of Review of Ophthalmology. Our colleagues, family and friends never failed to support us in this endeavor, and we are forever grateful to you.

A number of ophthalmologists deserve a special thank you for donating countless hours to reviewing individual chapters and the question and answer sections: Drs. Talmadge Cooper, Blair Armstrong, Daniel Choi, Andrew Kao, and Yohko Murakami.

We have been extremely fortunate to continue to work with a fantastic group of professionals at Elsevier: thank you Russell Gabbedy, Nani Clansey and Srividhya Vidhyashankar and your wonderful staff for always doing such an outstanding job on this book.

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1

Optics

Properties of Light

Light behaves both as waves and as particles (photons)

Its **speed** (velocity) (v) is directly proportional to wavelength (λ) and frequency (ν): $v = \lambda\nu$

In any given medium, speed of light is constant ($v_{\text{vacuum}} = c = 3.0 \times 10^{10}$ cm/s); therefore, wavelength and frequency are inversely proportional

Light slows down in any substance other than air or vacuum;

amount of slowing depends on medium; frequency of light remains unchanged, but wavelength changes (becomes shorter) (Fig. 1-1)

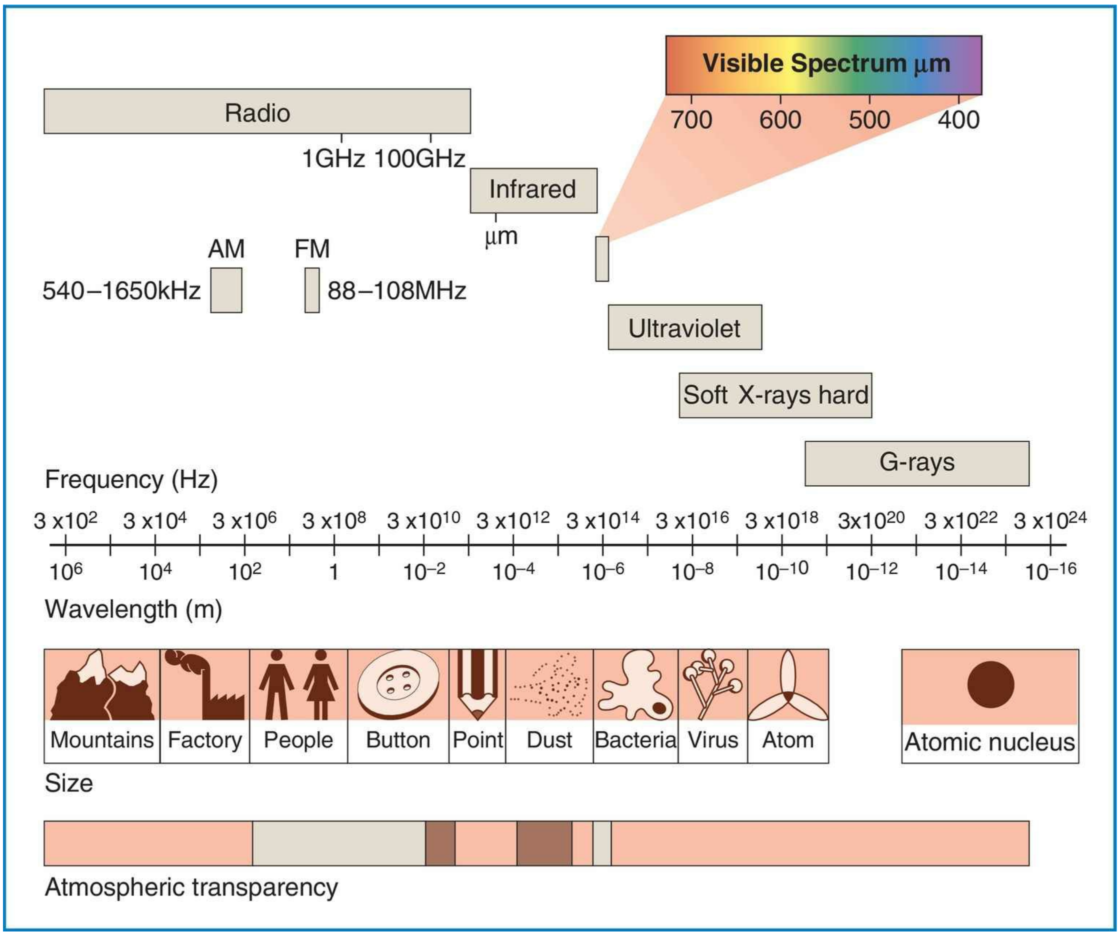

FIGURE 1-1 The electromagnetic spectrum. The pictures of mountains, people, buttons, viruses, and so forth, are used to produce a real (i.e., visceral) feeling of the size of some of the wavelengths. (With permission from Miller D, Burns SK: Visible light. In: Yanoff M, Duker JS (eds): *Ophthalmology*, ed 2, St Louis, 2004, Mosby.)

Its **energy** is directly proportional to frequency and inversely proportional to wavelength: $E = h\nu = h(c/\lambda)$

Index of refraction (n):

ratio of speed of light in a vacuum to speed of light in specific material ($n = c/v$)

Air = 1.00, water = 1.33, aqueous and vitreous = 1.34, cornea = 1.37, crystalline lens = 1.42, intraocular lens (IOL) (silicone = 1.41; polymethyl methacrylate 1.49; acrylic = 1.55), glass = 1.52, high index lenses = 1.6-1.8

Interference:

overlapping of light waves; may be constructive or destructive

Constructive:

peaks of two waves overlap, resulting in maximum intensity at that wavelength

Destructive:

peak of one wave overlaps with trough of another, obliterating both waves

Example:

antireflective coatings (destructive interference, one fourth wavelength apart); interference filters (allow only green light out of the eye during fluorescein angiography); laser interferometry (retinal function test; optical coherence tomography [OCT])

Coherence:

ability of two light beams to cause interference (large white source has a coherence close to zero)

Example:

OCT

Polarization:

each light wave has an electrical field with a particular orientation

Nonpolarized light:

electrical field of each wave has a random orientation

Polarized light:

all electrical fields have same orientation

Example:

Haidinger brushes (polarizing filter rotated in front of blue background produces rotating image like a double-ended brush or propeller; type of entopic phenomenon; test of macular function), Titmus stereo testing, polarized microscopy, polarizing sunglasses

Diffraction:

bending of light waves around edges; change in direction of light wave is related to wavelength (the shorter the wavelength, the less the change in direction); amount of diffraction is related to size of aperture (the smaller the aperture, the greater the diffraction); interference of new waves with original rays forms a diffraction pattern

Example:

Airy disc (diffraction pattern produced by a small, circular aperture; occurs when pupil size is < 2.5 mm; diameter of central disc increases as pupil size decreases); pinhole (reduces refractive error and improves vision by increasing depth of focus, but limited by diffraction; optimal size is 1.2 mm; may correct for as much as 3 D; smaller aperture limits visual acuity; squinting is method of creating a natural pinhole to improve vision; pinhole can also improve vision in eyes with corneal or lenticular irregularities; pinhole can reduce vision in eyes with retinal disorders)

Scattering:

disruption of light by irregularities in light path; shorter wavelengths scatter to a greater extent

Example:

Opacity (corneal scar or cataract) scatters light, causing glare and image degradation; in atmosphere, scattering involves particles (Rayleigh scattering) and blue light (scattered to the greatest extent; therefore, sky appears blue)

Reflection:

bouncing of light off optical interfaces; the greater the refractive index difference between the two media, the greater is the reflection; also varies with angle of incidence

Example:

Asteroid hyalosis (asteroids reflect light back into examiner's eye, creating glare; patient is asymptomatic)

Transmission:

percentage of light penetrating a substance (%T); can vary with wavelength

Absorption:

expressed as optical density (OD) ≡ log 1/T

Illumination:

measure of incident light

Luminance:

measure of reflected or emitted light (lumen/m^2);
apostilb ≡ diffusing surface with luminance of 1 lumen/m^2 (used in Humphrey and Goldmann visual field testing)

Example:

contrast sensitivity is the ability to detect small changes in luminance

Laser:

light **a**mplification by **s**timulated **e**mission of **r**adiation; excited material releases photons of same wavelength and frequency; process is amplified so that released photons are in phase (constructive interference); produces monochromatic, coherent, high-intensity polarized light; power can be increased by increasing energy or decreasing time ($P \equiv E/t$); Q switching and mode locking (types of shutters that synchronize light phase) are methods of increasing laser power by compressing output in time

Refraction

Light changes direction when it travels from one material to another of different refractive index (e.g., across an optical interface); direction of refraction is toward the normal when light passes from a medium with a lower index of refraction to a medium with a higher one, and away from the normal when light passes from a more dense to a less dense medium (higher refractive index materials are more difficult for light to travel through, so light takes a shorter path [closer to the normal]); light does not deviate if it is perpendicular to interface (parallel to the normal)

Snell's law:

$n \sin(i) = n' \sin(r)$; n = refractive index of material; i = angle of incidence (measured from the normal); r = angle of refraction (measured from the normal) (Fig. 1-2)

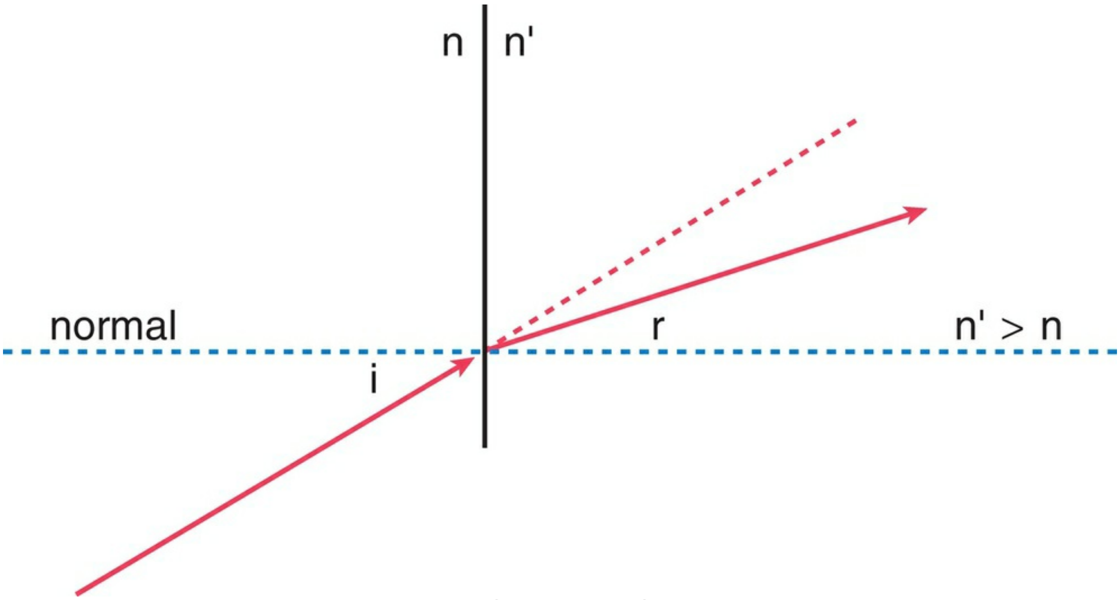

FIGURE 1-2 Refraction of light ray.

Critical angle:

angle at which incident light is bent exactly 90° away from the normal (when going from medium of higher to lower n) and after which all light is reflected

Example:

Glass/air interface has a critical angle of 41°; critical angle of cornea = 46.5°

Total internal reflection:

angle of incidence exceeds critical angle, so light is reflected back into material with higher index of refraction; $n \sin(i_c) = n' \sin(90°)$; $\sin(i_c) = (n'/n) \times 1$

Example:

Gonioscopy lens is necessary to view angle structures because of total internal reflection of the cornea

Prisms

Prisms displace and deviate light (because their surfaces are nonparallel); light rays are deviated toward the base; image is displaced toward the apex (Fig. 1-3)

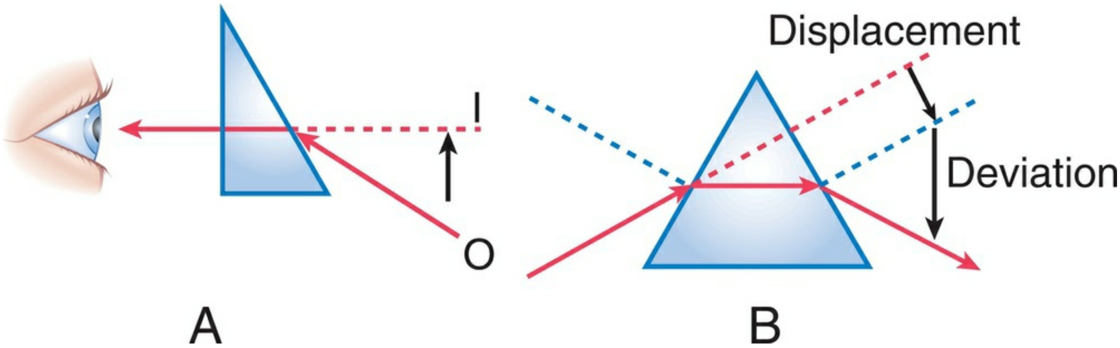

FIGURE 1-3 **A,** Displacement of image toward apex. **B,** Displacement and deviation of light by prism.

Prism diopter (PD, Δ):

displacement (in cm) of light ray passing through a prism, measured 100 cm (1 m) from prism

Example:

15 Δ = ray displaced 15 cm at a distance of 1 m (1 Δ = 1 cm displacement/1 m); 1° ≈ 2 Δ (this approximation is useful for angles smaller than 45°)

Angle of minimum deviation:

total angle of deviation is least when there is equal bending at both surfaces of prism

Plastic prisms are calibrated by angle of minimum deviation: back surface parallel to frontal plane

Glass prisms are calibrated in **Prentice position**: back surface perpendicular to visual axis

Prism placed in front of the eye creates a phoria in the direction of the base

Example:

Base-out (BO) prism induces exophoria; to correct, use prism with apex in the opposite direction

Apex is always pointed in direction of deviation: base-out for esotropia, base-in for exotropia, base-down (BD) for hypertropia

Stacking prisms is not additive; 1 prism in front of each eye is additive

Risley prism:

two right-angle prisms positioned back to back, which can be rotated to yield variable prism diopters from 0 to 30 Δ; used to measure prismatic correction for tropias

Fresnel prisms:

composed of side-by-side strips of small prisms; prism power is related to apex angle, not the size of the prism; available as lightweight, thin press-on prism to reduce base thickness of the spectacle prism; disadvantage is reflection and scatter at prism interface, causing decreased visual acuity

Prismatic effect of lenses (Fig. 1-4):

spectacles induce prism; all off-axis rays are bent toward or away from axis, depending on lens vergence

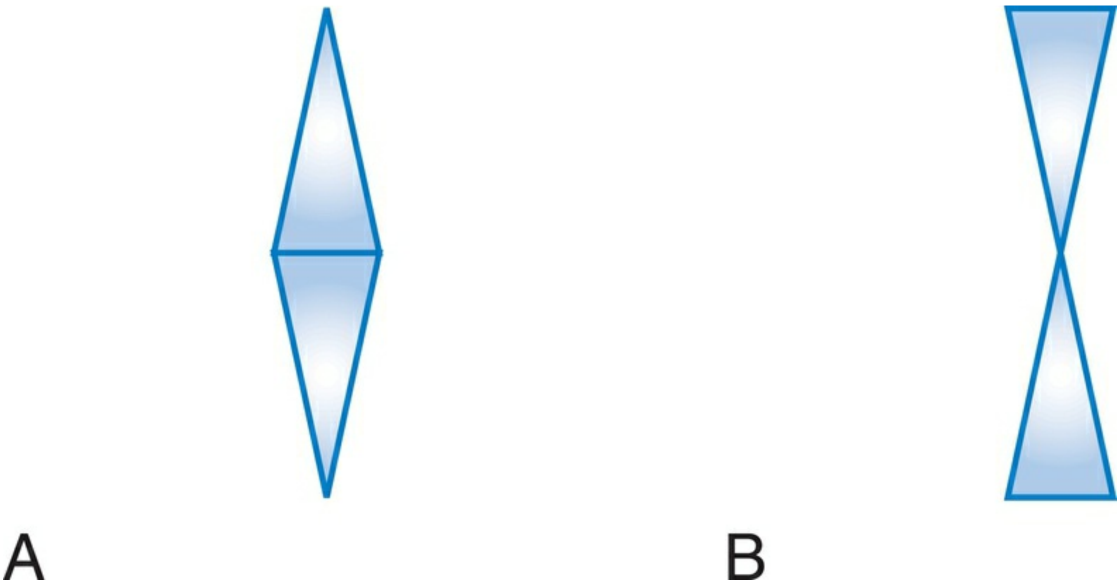

FIGURE 1-4 **A,** Plus lenses act like two prisms base to base. **B,** Minus lenses act like two prisms apex to apex.

Perceived movement of fixation target when lens moves in front of the eye:

Plus lenses:

produce ″against″ motion (target moves in opposite direction from lens)

Minus lenses:

produce ″with″ motion (target moves in same direction as lens)

Amount of motion is proportional to the power of the lens

Prismatic effect of glasses on strabismic deviations: 2.5 × D = percent difference; minus lenses make deviation appear larger (″minus measures more″); plus lenses decrease measured deviation

Prentice’s rule:

prismatic power of lens = $\Delta = hD$ (h = distance from optical axis of lens [cm], D = power of lens [D])

Prismatic power of a lens increases as one moves farther away from optical center (vs. power of prism, which is constant)

Example:

Reading 1 cm below optical center: OD − 3.00; OS + 1.00 + 3.00 × 90
OD (*Oculus Dexter* – right eye): prism power = 1 cm × 3 D = 3 Δ BD
OS (*Oculus Sinister* – left eye): prism power vertical meridian:
1 cm + 1 D = 1 Δ BU (base-up) (Note: power of cylinder in 90° meridian is zero)
Net prismatic effect = 4 Δ (either BD over OD, or BU over OS)

Treatment of vertical prismatic effect of anisometropia:

1. Contact lenses (CL) (optical center moves with eyes)
2. Lower optical centers of lenses (reduce amount of induced prism)
3. Prescribe slab-off prism (technique of grinding lens [done to the more minus of the 2 lenses] to remove BD prism [to reduce amount of induced prism])
4. Single vision reading glasses

Prismatic effect of bifocal glasses:

Image jump:

produced by sudden prismatic power at top of bifocal segment; not influenced by type of underlying lens; as line of sight crosses from optical center of lens to bifocal segment, image position suddenly shifts up owing to base-down prismatic effect of bifocal segment (more bothersome than image displacement; therefore, choose segment type to minimize image jump)

Image displacement:

displacement of image by total prismatic effect of lens and bifocal segment; minimized when prismatic effect of bifocal segment and distance lens are in opposite directions

Prismatic effect of underlying lens:

Hyperopic lenses induce BU prism, causing image to move progressively downward in downgaze