2.
3.

Review for Exam

VERGENCES (convergence / divergence) - a few important points

- In our ray diagrams, light travels from left to right
- Distances regarding focal lengths are expressed in meters (m)
- Vergences are expressed in diopters (D)
- Diverging rays = virtual image
- Converging rays = real image

• Virtual images are usually created from minus lenses, and real images are always a result of a plus lens (page 8 & 9 of workbook)

And a few more important points to remember

- In ray diagrams, any distance to the left of the lens is a negative value
- Distances to the right of the lens are positive values

Vergence powers and focal lengths

• The vergence power of light approaching a lens is added to the power of the lens, to result in the vergence power leaving the lens

L + F = L' i.e. -2.00 + (+6.00) = +4.00

• In all of the above powers, the focal lengths are determined easily by simply taking the inverse of the power. If you have only the focal length and want to determine the power, again simply take the inverse of the focal length.

An object is 600 mm from .a +8.00 lens. How far from the lens will the light come to a focus (form an image)

Magnification formula

- Typically used with in conjunction with vergence questions for our purposes

• Uses information from vergence qLiestion, such as image and object distances (Le. I and I' or v and u)

The formula

$$\frac{I}{O} = \frac{v}{u}$$

- Where I is the image size (m), and O is the object size (m)

- v isthe image distance (m), and u is the object distance (m)

An example

• An object is 5 cm in diameter, and is 500mm from a converging lense of 6.00 diopters. Where will the image form and what size will the image be?

First determine the vergence scenario using L +F=L'

Second use the magnification formula to determine the size of the image If I is a positive value, it means that the image is upright. .

If I is a negative value, it means that the image is inverted.

If v is a positive value, the image is formed to the right of the lens and is therefore considered a real image
If v is a negative value, the image is formed to the left of the lens and is therefore a virtual image

Effective and Compensated Powers

• Vertex distance is that distance between the cornea and the back surface of the lens.
• Vertex distance is considered in higher spectacle prescriptions, and conversion from a spectacle prescription to contact lens prescription in certain powers
• Effective power is the power that the lens would become at an increased **/** decreased distance
• Compensated power is the power that is used to correct the changed effective power, thus keeping the focal point in check.

Vertex distance changes and effective powers

• For plus lenses, as the vertex distance increases, the effective power increases. To compensate for this, you would use a weaker power at the increased vertex distance.
• The opposite holds true for a decrease in vertex distance. The plus powered lens loses power with a decrease in vertex distance.
To compensate for this decrease in power, you would use a stronger powered lens at a decreased vertex distance
Methods of measurement

- Oistometer
- Rule'r
- Pupillometer

RX: : :-9.00 O.U. BVO = 14 mm If FVO = 11 mm, what is the effective powers? What would be the compensated powers?

Rx: +12.00 O.U. BVO = 12 mm If FVO = 9 mm, what would the compensated power be?

Styles and designs of Multifocal Lenses

TYPES OF CONSTRUCTION
-Fused
-One-piece
-Cemented

OCCUPATIONAL SEGMENT STYLES

-CRT **/** Datalite (14 mm intermediate)
-double O
-double round
-ED Trifocal
-Quadrafocal
-Rede Rite

BIFOCAL SEGMENTS STYLESJbased on shape) page 446 of Systems For Ophthalmic Dispensing
-round (kryptok)
-flat top (straight top, D)

-curved top (Euro.)
-panoptik (N.S.C)
-ribbon (N.S.C)
-Franklin (executive)

Near and Intermediate powers

Intermediate add usually 50%, but can be altered depending on near add and manufacturer

Example
Rx info:

oo +0.25-0.25x170
as +0.25-0.25x010
Add +2.50
Patient requires intermediate and near only What type of lens would you consider? What prescription would you order from the lab?

Image jump in segments

Occurs due to the sudden change in prismatic effect when the eye 'looks from distance to near portion of lens (over segment line)

The farther the eye looks from the o.e., the greater the prismatic effect (any lens)
Depending on the style of segment, the N.O.e. distance'will vary from the topcCif the seg.

The amount of image jump is independent of the distance power

-Determine distance from top of seg. to NOe

-Apply Prentice Rule to the above distance and add power to determine the, amount of prismatic effect

-Amount of prismatic effect caused by the image jump will be in reference to the seg. Line, therefore, base down prism in most cases

Determine image jump for following lenses given an add power +2.00 O :

Round 24
Flat top 28
Executive
Rodenstock Life 2

Lenses

1. A flat top segment of 28mm width and 19mm depth has an addition power of + 2.75. The seg. drop is 4mm and the lens has an index of refraction of 1.523. What is the image jump?
4. How do you determine N.O.C distance in flat top segments?
3. The near Rx is +2.50-0.25x180 and the add power is +1.75, what is the distance Rx?
4. What does the designation 8x35 mean?
5. List the six types of bifocal lenses based upon the SHAPE of the segment (not

size).
6. What type of lens construction would you expect a Flat top 7x25 Photogrey trifocal to be?

-Consider difference between segment drop, segment depth and segment height
-Minimum fitting heights
-Prism thinning

Abberations

Whenever a correctly powered lens delivers less than a perfect image, it is said to be abberated .

. A glass or plastic lens does not have only one index of refraction, instead, a slightly different index of refraction for each wavelength. The listedn value for a lens is that of the yellow wavelength.

The Abbe value indicates the dispersive value of a lens. (the higher the abbe value, the less dispersion)

The two major types of abbe rations are Chromatic abberation and Monochromatic abberation.

Chromatic abberation
Two types of chromatic abberation are Longitudinal (Axial) and Lateral chromatic abberation

Longitudinal involves a series of point images along the optical axis. This is because each color or wavelength undergoes a slightly different degree of refraction at the lens surface

Lateral chromatic abberation is due to the image magnification differences, or the differences in the prismatic effect.

<u>Considerations with lenses of low Abbe values</u> Mono p.d.'s
Measure MRP height, considering o.c. height and pantoscopic tilt
Shorten vertex distance as possible
Not more than 10 degrees of pantoscopic tilt
Attention to o.C.' s that need to be above or below the datum, and the resultant thickness that will occur

Monochromatic abberations

Spherical abberation - parallel light strikes a large area of a spherical lens surface. The peripheral rays focus at different points on the optical axis than do the central (paraxial) rays. Luckily, due to the small aperature of the pupil the effects of spherical abberation are almost non -existant

Coma - occurs due to a difference in magnification from rays passing through different zones of a lens. Instead of forming single point images, they form comet or cone shaped images with the point of the comet pointed towards the optic axis. Similar to spherical abberation, the pupil size restricts the effects of coma as well.

Oblique astigmatism - bundle of light striking at an angle, resulting in two line images a certain distance from one another.

Curvature of field (power error) - another peripheral abberation that causes a different power to be present at the lens periphery. Again, following manufacturer's base curve recommendations are a good way to keep power error to a minimum.

Distortion - another peripheral abberationas there is differing magnification in peripheral areas of the lens, compared to that of the O.C.

tn the case of high plus lenses, a pin cushion effect occurs with the image.
In the case of high minus lenses, a barrel shaped image is present.

Aspheric design

A spherical lens has the same radius of curvature for the entire surface, whereas an aspheric surface has differing radii of curvature. The purposes of asphericity are:

-correct abberations
-flatter lens, less magnification
-thinner, lightweight
-progressive lens designs
If a regular spherical lens was flattened, the result would be power error(curvature offield) and oblique astigmatism. This is one popular example of the benefits of aspherics.

Decentration of aspherics - not an option to decenter an aspheric lens for prism, the result will be a displaced aspheric region in comparison to the line of sight for the patient

Fitting High Myopia (considered -6.00 or more)
Lens power_- determine if there is any change due to vertex compensation. (Communicate with refractionist)
MRPposition_- horizontal and vertical
Correct measurement

<u>Lens type and treatment_</u>
full field lenses when less than -14.00 O Myodisc / lenticular when greater than -14.00
Other considerations are mid to high index, glass v.s. plastic, lens weight, edge thickness and aspheric designs.
SRC (non-tintable only?) and ARC in multicoat

Tints

Frame Selection
Minimum vertex distance (8-9mm provides wide field), watch for thickness and frame problems (explain) Thicker rims

Fitting High Hyperopia (+5.00 or greater)
Lens power_ - vertex
MRP position - horizontal and vertical

Lens type and treatments
full field lenses in most cases, but lenticular is recommended for +15.000 and higher
Other considerations are index, surfacing, aspherics,
SRC (sometimes only non tintable) and ARC (multi) tints

Frame. selection
Minimal vertex distance (8 to 9 mm)
Little or no decentration
Small uniform shape
Thin frame with adjustable pads (larger)
Lightweight though durable

Fitting for Aphakia
Lens power _- vertex
MRP - horizontal and vertical

Lens style and treatments
full field design up to +15.00 0
lenticular when above +16.00 0
between +15.00 to +16.00 0, consider eyesize, larger decentration & weight sensitivity
fit segment higher than normal
UV treatment and tint (at least TL#1)

Frame section - same as for the high hyperopia

MULTIFOCAL LENSES

Presbyopia - (ll$_o$ld eyes") A gradual loss of accommodation (the ability of the eye to focus at near) due to increased inelasticity of the crystalline lens. An age-related condition that usually occurs in the mid-forties, it is corrected through the use of additional lens power (the "add") for near vision.

BIFOCAL LENSES:

The type of construction is dependant upon the material used; glass

lenses are *fused,* plastic lenses are *moulded.*
Various styles and sizes are available; those most commonly used today include round-tops (22mm, 38mm), straight-tops or flat-tops (25, 28,35mm) curved-top (aspherics, ex. "Cosmolit") and executives.
Measurement is taken at the lower limbus; round segs are set slightly higher. Working distance is usually 40cm.

TRIFOCAL LENSES:

Similar construction to a bifocal. but containing an intermediate section of *a.specific lens power;* usually 50% of the add power. Depending of the working distance required, trifocals may have intermediate powers of 40, 60 and 70%; and can be easily calculated. Trifocals are normally used for (mature) presbyopes who requireV.A. at near, arms length, and distance, and have a moderate to high near addition.
Measurements are taken relative to the pupil; usually 1-2mm below. Segment height must be at least 20mm to accommodate intermediate seg, which is usually 7mm high.

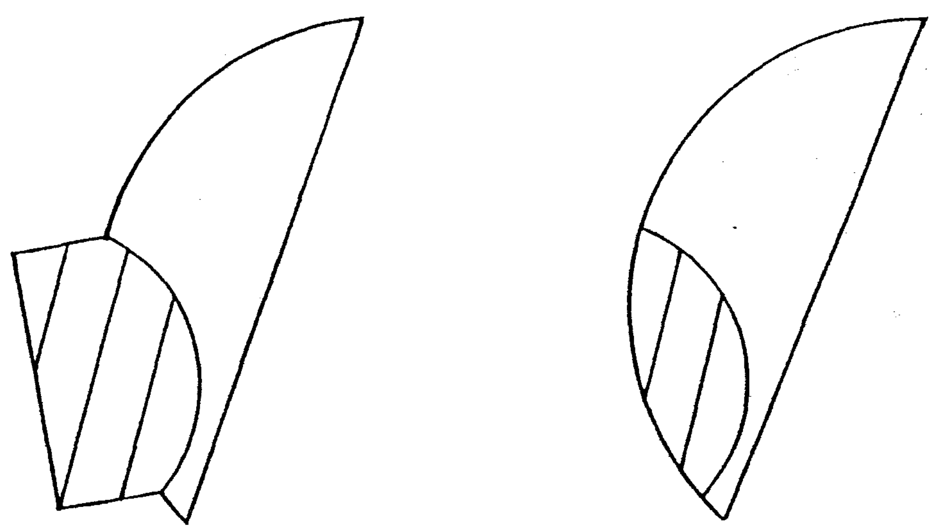
VOCATIONAl OCCUPATIONAl lENSES:

These lenses are designed for specialized tasks, and have near or intermediate segments in both top and bottom portions of the lens (plumbers, mechanics, etc.) The segs have a separation of 13·14 mm~ with the upper seg being at least9mm deep - frame selection and measurement is critic all
Measurement is taken relative to the lower limbus - frames must be deep enough to accommodate this type of lens.

Bifocal Construction:

Glass bifocals may be either a fused, or one-piece (moulded) construction. Fused-glass bifocals are manufactured in minus cylinder form with the segment fused on the front surface. The lens blank is crown glass (index of refraction = 1.523), while the segment is mad.e from_a material with a higher index of re-fraction. such as barium. or barium"-flint.--' This type of design allows increased magnification at near. while maintaining a "smooth" front surface. Special care must be taken in the manufacture of these lenses to minimize chromatic aberration.

Plastic bifocals are always of a one-piece design. Also manufactured in minus cylinder form, the bifocal segment is "moulded" on the front surface of the lens, resulting in a "ridge" which can be felt as you move your finger over the lens. The increased power of the bifocal is generated ,through this change in curvature.



6.

"Bifocal Basics"

Segment (seg) - An area of a spectacle lens having power differing from that of the main portion.

Segment Depth - The longest vertical dimension of the lens segment.

Segment Drop - The vertical distance from the major reference point to the top of the seg.

Segment Heigth-The vertically measured distance from the lowest point on the lens to the level of the top of the seg.

Segment Inset -The distance the center of the near segment is moved laterally from the M.R.P.

Segment Width -The size of the seg; measured horizontally across its widest section.

Distance Optical Center -The point on the distance portion of the lens which coincides with the position of the wearer's eye when looking toward infinity. There is no prism at this point.

Near Optical Center - The point on the segment portion of a bifocal lens Which coincides with the position of the wearer's eye when looking at a reading point. There is no prism at this point.

Near Vision Point - The actual position in which most people's eyes fall wh~n looking down to read. The near vision point will not always coincide with the vertical position of the near optical center, due to the geometry of various bifocal styles.

Major Reference Point - The point on a lens where the prism equals the amount prescribed; the point (on a decentered lens) at which prism is measured.

Bifocal Designs:

There are five basic types of bifocal design; these types are determined by the shape of the bifocal segment:

1. Round-top bifocals
2. Straight-top bifocals
3. Curved-top bifocals
4. Straight-across bifocals
5. 5. "Invisible" bifocal

1. Round Top

Lens material - glass (fused), plastic (one-piece, or moulded)

Construction - forms a perfect circle, although when edged into a lens, usually only semi-circle remains visible

Optical Center - exact middle of circle (half the lens diameter)

Sizes available - 22 mm is most common, 38 mm is rarely used

Fitting height - measured I reference to limbus, add 1 - 2 mm to height

The round-top bifocal is less "noticeable" than other bifocals due to the knifeedge of the circle. In some types of glass lenses, chromatic aberrations are a problem, as they create a "blur fringe" around the periphery of the circle (especially prevalent in higher adds). Because of the low optical centers of these lenses, they must be fit slightly higher than normal, in order to reduce the distance the eye must travel to reach the near vision point. The low optical centers also produce a large amount of image jump. The larger round-tops, such as the Ultex A 38mm, were originally designed as vocational lenses, due to their large reading area; however, they are seldom in use today, because of the large amount of image jump they produce. Hyperopes tend to adapt more easily to round-tops than myopes, due to the base down effect of the low optical center.

2. STRAIGHT-TOP (flat-top, monostep, "0" style segs)

Lens material- glass(fused) plastic (one-piece) polycarb., high index

Construction - semi-circle with a straight dividing line on top

(line becomes more noticeable as add power increases) 25 x 17.5, 28 x 19, 35 x 23.5,40 x 20 (plastic only) 25mm, 28mm -5 below seg line, 35mm - 3, 40-on line measured using limbus or lower lid as

The straight-top is by far the most widely-prescribed bifocal, as it affords clear near vision with a minimum of image jump. The 28mm is used for bicentric grinding (to help hide the slab-off line) and the 35 and 40 mmsizes are used as vocational bifocals, for those needing larger reading areas.

3. Curved Top (Kryptok,Panoptik)

Lens material - glass (fused) plastic (one-piece), high index Construction - similar to S. T. 25, but having a curved top and rounded corners - usually used in aspheric lens design (Cosmolit)
Size - 25 x 17mm ,28 x 18.5mm
Optical center - 4.5 mm below dividing line
Fitting height - same as S.T., slightly higher for. high plus Rx's

Originally designed with widths of 20, 22 and 24mm, this type of bifocal is no longer in common use. The optics are similar to that of the S.T. 25, although it is considered to be less cosmetically pleasing. Most curved-top bifocals available today are of a "European" design, ex. Cosmolit Bifo 28.

4. Straight Across (Executive, President)

Lens material - glass, plastic; polycarbonate
Construction - always a one-piece construction; the dividing line forms an inverted "shelf extending entire width of lens
Size - dependent on frame size
Optical center - one optical center, located on dividing line
Fitting height - measured from limbus or lower lid, usually set slightly lower depending on power and thickness of "shelf

This lens is a modem version of the original "Franklin Bifocal" designed in 1784. It is unique as it is of one-piece construction, and has only one opncal center for the entire lens; as this center is located on the dividing line, there is no image jump produced. Although this is an advantage, the lens is cosmetically the most unappealing due to the heavy "shelf effect of the dividing line. This also results in a much heavier lens, and although the near area is the largest available, the eye (with normal convergence) is unable to make use of the temporal areas. Due to weight and thickness, this lens type is not suitable for larger frame styles.

5. INVISIBLE BIFOCALS (Younger Seamless, Blended Bifocals)

Lens material - glass (fused) plastic (one-piece), high-index glass 1.7 Construction - similar to the round-top 22, but having the demarcation line polished out to present "no line"

Size - 22mm, 28mm round

- 11 or 14 mm from top of seg
Fitting height - as per round-tap-may be fit higher to avoid "blur fringe"

This "invisible" bifocal (not to be confused with a P.A.L. lthough cosmetically pleasing, has a large amount of image jump, as well as a "blur fringe" which extends3mm from the seg causing chromatic a,berration. ~

Procedure for MeasureMeasurement of Bifocal Height

1. Place the selected frame on the patient's face, in the correct position (complete with any necessary adjustments)

2. Maintaining eye level, place the ophthalmic ruler vertically on the right lens with the zero point positioned as though it were the top of the B.F.

3. Repeat procedure for left eye

4. Record readings. If the frame shape is irregular (ex. aviator shape) the total measurement must be taken to the lowest part of the eyewire (boxed measurement)

5. Make a visual representation of the reading (using china marker) and obselVe the patient's eye position and posture relative to this measurement.

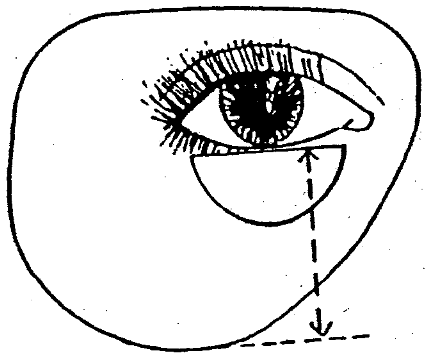
6 .. If frame sample is the exact size to be ordered, and is a metal or rimless frame, record the final measurement. If frame is plastic, add .5 - 1 mm forbevel.(depending on thickness of eyewire)

7. If frame sample used is the incorrect size, add 1 mm segment height for every 2mms in size difference. Ex: a 52mm eyesize sample is used, but a 54mm size is ordered; add 1 mm to the seg height.

8. If the patient has one eye higher than the other, note the difference and compensate for half of this difference: the frame adjustment will compensate for the rest. Ex: 0.0. 18 mm, 0.8. 20 mm -order 0.0. 18.5, 0.8.19.5

Segment height determination is based on several factors: patient's height, posture, occupation, special interests and needs, previous bifocals, and any physical or health problems/limitations. Always communicate with the patient to completely assess their needs, make comparisons with present glasses, and make recommendations based on their wants, needs and expectations that will not only.satisfy the patient,

but meet the requirements of their prescription.



Trifocals:

The mature presbyope may eventually reach a point where the bifocal segment does not provide adequate focusing ability for both near and intermediate vision - usually when the add reaches +1.75. Clear vision at near, intermediate and distance may be obtained by adding an intermediate power to the lens, which is less than the add power, but stronger than the distance. Such a lens is the trifocal, meaning it has three distinct focusing distances. Most trifocals are manufactured with a standard intermediate power of 50% of the add, although lens powers of 40, 60 and 70% of the add are also available.

STRAIGHT-TOP TRIFOCAL 7-25

lens Material- glass (fused) plastic (one-piece) polycarbonate,high index
Construction - similar to S.T.B.F. with intermediate segment (7x25) on top
Sizes available- STT 7-25, STT 7-28, STT 7-35 (plastic only) STT 10-35
Optical center - 7 mm below bifocal line (STT 7-25)
Fitting height - the trifocal area (including the add) should be at least 20mm high. Measurement is taken at bottom edge of pupil

like its bifocal counterpart, the S.T. 25, this is the most popular and widely-used type of trifocal. The variation in widths and trifocal depth make this lens ideal for those needing a large viewing area at this distance. The dividing lines become more prominent as power and segment size are increased; care must be taken not to fit this lens too high, as the lines could interfere with distance vision.

ED TRIFOCAL (Sola) "Executive - D-style)

lens material ... Plastic (one-piece)
Construction - Executive-style bifocal extending the width of the lens containing the intermediate power, which surrounds a a S. T. 25 bifocal segment
Size - dependent on frame size; near seg is always 25mm
Optical center - 5mm below near segment line
Fitting height - measurement is taken at 1 mm below lower pupil edge

This type of bifocal provides the wearer with a very large intermediate viewing area; however, due to the unsightly "ledge" it is not a popular lens choice, and it rarely used.

lens material ... Plastic (one-piece)
Construction - Executive-style bifocal extending the width of the lens containing the intermediate power, which surrounds a a S. T. 25 bifocal segment
Size - dependent on frame size; near seg is always 25mm
Optical center - 5mm below near segment line
Fitting height - measurement is taken at 1 mm below lower pupil edge

This type of bifocal provides the wearer with a very large intermediate viewing area; however, due to the unsightly "ledge" it is not a popular lens choice, and it rarely used.

__Image Jump__ - *phenomenon that occurs as the eye passes through the distance portion to the reading portion of a bifocal lens; Images viewed seem to suddenly "jump" due to the abrupt change In magnification*

Image jump is dependant on two factors: the power of the BF seg, and the distance from the top of the seg to Its near optical center. The amount of Image jump In a given lens may be calculated by using Prentice's Rule: Prism = cF

Different types of Bifocals produce varying amounts of Image jump according to the distance the eye must travel through (the Increased power of) the seg; In other words, how far away the near optical center of the lens Is from the top of the seg. This distance Is calculated by subtracting the depth of the seg from half Its width. For example, a S. T. 25 lens has a depth of 17.5mm (17.5 - 12.5 = 5mm), therefore, the eye must travel 5mm through the seg to reach Its center.

In the case of a round-top segment, In which the depth and width are the same, the formula for calculation is half the width of the seg; for example, in a round-top 22mm seg, the distance from the top of the seg to the N.O.C.ls 11mm.

O.C. Is generated on the dividing line (the top of *the seg and N.O.C. are co-Incident) and therefore* no *Image jump occurs.*

QUESTION: Calculate the amount of *Image jump found In* a S. T. 25 *lens with* an *add* of *+2.50*
SOLUTION: Prism = *cF therefore .5mm* X *2.50* = 1.25 *Prism Dlopters*

QUESTION: Calculate the amount of *Image Jump found In* a *round-top* 22 *lens with* an *add* of *+2.50*
SOLUTION: Prism = *cF therefore 1.1mm* X *2.50* = 2.75 *Prism Dlopters*

As Is evident from these examples, Image jump may be reduced through use of *bifocal segs with hlghopt/cal centers* (S. T. 25, S. T. 35) *as opposed to segs with low optical centers (round-top* 22, 38, *etc.)*

Progressive Powered Lenses

Progressive Powered Lenses (a.k.a. PALS, t!.nvlslble blfocals'}etc.) are specially-designed mu/lifoca/lenses that provide distance, Intermediate and near vIsion without a *"dividing line". These lenses are aspheric In desIgn; this allows for* a *gradual increase in lens power from distance* to *near, while maintaining* a *smooth surface.*

There are many progressives available today; all fall into two basic types of construction:
HARD STRUCTURE: In hard structure design, the areas of peripheral distortion are highly concentrated around the Intermediate and near areas of the lens (ex. Rodenstock Progressive R, Selko P6).

SOFT STRUCTURE: In soft structure design, the areas of peripheral distortion are spread out over a *much larger portion of the lens, with some distortion above the . 0-180 line (ex. Essilor Varllux* 11, *AO Omnl Pro)*

FITTING PROGRESSIVE POWER LENSES:

Fitting and measuring this type of lens must be done PRECISEL Y; *height measurement Is taken relative* to *the pupil and varies according to lens type. Monocular Pds are necessary to permit accurate eye movement through progressive zones. Most manufacturers provide lens charts to aid in proper centering and lens blank size determination.*

Frames must be adjusted as *accurately as possible, with* a *close-fitting vertex, and* a 12-15 *degree pantoscopic tilt* to *Insure easy access to near addition.*

Extra consideration and explalnatlon should be given to *1st time wearers, In terms of usage and adaptation.*

(Kryptok, Achromat, Ultex A)