EyeFlyMD

The Eye Guide

The Eye Exam

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Table of Contents

Proofread, fact-checked, and edited by Rachel Conlee and Ariess Gharabagi.

Disclaimer: This writing is my own and based on knowledge I've accumulated through various resources thus far in my ophthalmology training. I encourage every reader to consult the relevant literature/texts for their program and/or training level. Don't take my word for it. The purpose of this work is to provide a concise summary of critical topics. This work contains no medical advice and is in no way a substitute for formal medical training. I use examples of one way to perform or document these exams and they are by no means universal or comprehensive. I also don't cover *every* component of the exam in total detail either but attempted to summarize what would be reasonable for a new resident to know and would be applicable the majority of the time. Please submit errors to matt@eyeflymd.com. All figures/photographs are original.

Visual Acuity

The physical exam for ophthalmology is rarely taught to any degree of detail in medical school. If anything, students may be shown a direct ophthalmoscope which is rarely used in an ophthalmology practice. This means it's difficult for students or new residents to fully participate in the physical exam. Hopefully, this short guide will help explain the method behind a typical exam in ophthalmology. To keep the scope concise, my goal is to focus on how to perform a physical exam and the reasoning/science behind it without getting too deep into the pathology behind specific exam findings. Some discussion of specific pathology will be inevitable.

Most of the work-up for a patient is done by ophthalmic technicians although every ophthalmologist knows how to work patients up and must be proficient at it themselves. The work-up usually involves the ophthalmology equivalent of "vital signs" which are vision, pupils, and pressure. Some clinics (e.g., pediatrics) have a more involved or unique workup. Many components of the workup are typically obtained before the ophthalmologist/optometrist walks in the room.

Visual Acuity (VA)

Visual Acuity (VA) is essentially a measure of visual clarity. It is tested one eye at a time. There are different ways to measure visual acuity and the most common way in clinic is with a chart such as the Snellen (pictured here). There are different types of visual acuity tests, and *minimum legible threshold* is the most common. Minimum legible threshold describes the point at which a patient cannot distinguish progressively smaller optotypes (letters or numbers) from one another. Reading a chart like the Snellen is a form of minimum legible threshold. There are other types of visual acuity tests, but these are rarer compared to minimum legible threshold testing.

Minimum separable threshold measures the smallest distinguishable separation between two objects.

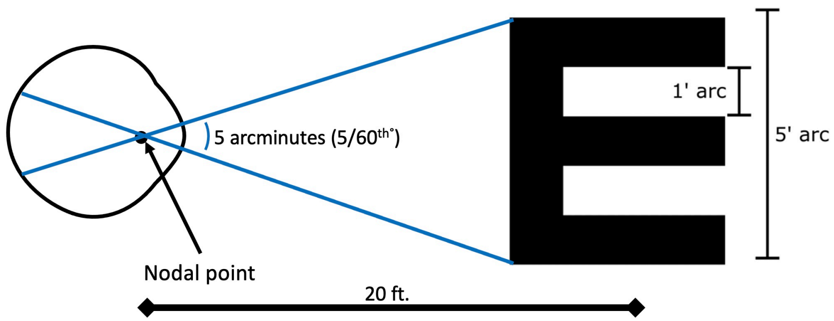
Vernier acuity measures the smallest perceivable break between in a line (the space between line segments).

There are also more modern analogs to the Snellen chart including the Sloan or Tumbling "E" chart. Chart preference varies substantially by clinic.

Minimum legible threshold is reported as the distance a patient could read a line of optotypes divided by the distance a person with normal vision could read the same line. Patients are asked (one eye at a time) to read smaller and smaller lines until they're unable to read the optotypes.

So, 20/60 means the patient can see at 20 feet what a "normal" eye can see at 60. 20/15 means the patient can see at 20 feet what a normal eye can see at 15. Vision can be more specifically reported as well. For example, if there are 5 optotypes on the 20/20 line and a patient reads 3 of them, it can be reported as 20/20-2. If they read 2, it's 20/25+2.

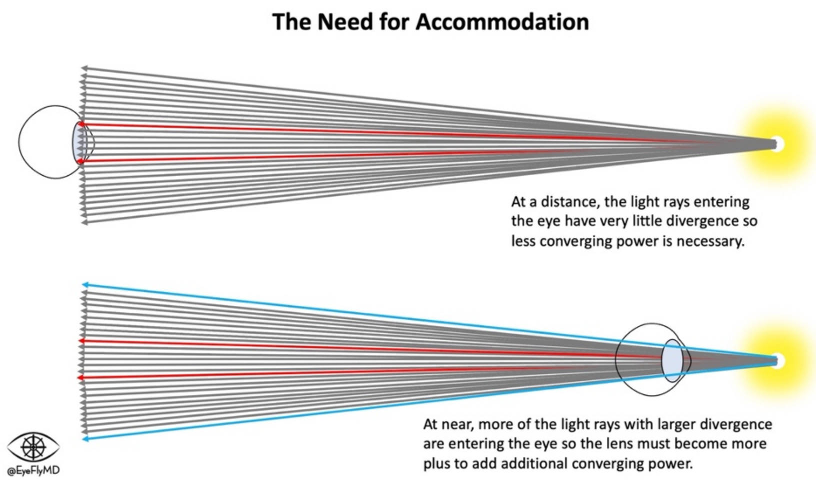
The technical definition of 20/20 vision is the ability to resolve a separation of one minute of arc on the retina which is the spatial resolution of the human eye. An arcminute is 1/60th of a degree. The angle refers to the angle formed as it relates to the "nodal point" of the (model) eye.



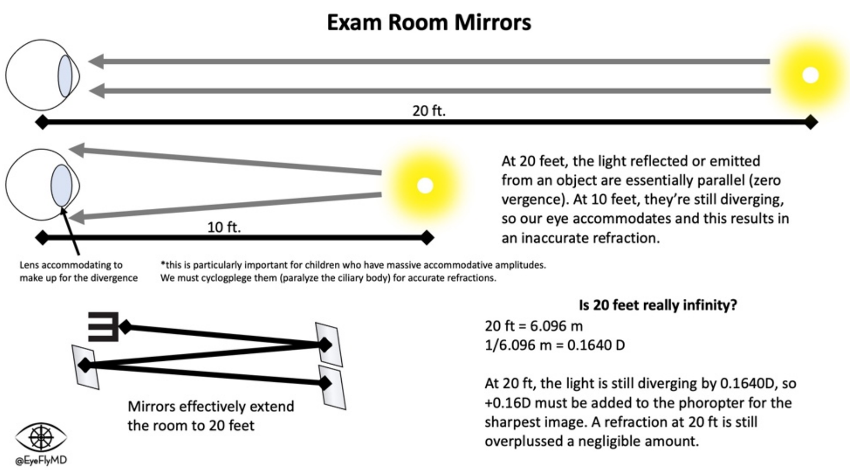
The optotypes are designed carefully with this in mind. On the 20/20 line, the letter "E" is constructed such that the spaces between the arms are 1' of arc. To distinguish the letter as "E" vs. "P", the eye must be able to resolve to 1' – the spatial resolution of the retina. The entire letter is 5' of arc tall.

20/20 is “normal” vision, around 20/60 driving becomes difficult and 20/200 is legal blindness. 20/800 (aka 5/200) makes ambulating a challenge. Once a patient can’t identify the largest optotypes on the charts, we move to counting fingers (CF). This reports the patient’s ability to count fingers and how far away from the eye. For example, CF 3’ means the patient can accurately count fingers 3 feet from the eye. Beyond the ability to count to fingers is “Hand Motions” (HM). This is assessed by moving the hand back and forth and up and down over the eye. If the patient can accurately report which direction the hand is moving, the vision can be reported as HM in that eye. If the patient cannot accurately report which direction a hand is moving, the eye is checked for its ability to perceive light (LP for “light perception”). This is typically accomplished by shining a bright light (like a muscle light pictured here) in the patient’s eye while asking the patient if the light is on or not. If they can accurately tell when the light is shining in their eye and when it is not their vision can be reported as LP for that eye. Sometimes BLP is recorded for “bare light perception”. If they definitely cannot detect the light, their vision is reported as “NLP” for “no light perception”. Always report vision for each eye separately.

While on the topic of “20/20” and visual acuity, why 20 feet? 20 feet (or 6 meters) is close to "optical infinity" where light rays entering the eye are parallel and the eye doesn’t need to *accommodate*. The eye in an unaccommodated state allows for an accurate refraction. Remember, a diopter (D) is an inverse meter so 1/6 m = 0.167 D. That is less than can be ground into glasses.



20-foot rooms are expensive, so most eye clinics use mirrors to simulate this distance.



Visual acuity can be recorded with or without corrective lenses or contacts. With corrective glasses is recorded as "cc" for *con correction*. Without glasses is "sc" for *sans correction*. "Sans" means "without". Contact lenses are abbreviated as CL so "cCL" means "with contact lenses".

Pinhole

A pinhole is a small (1.2 mm) hole in an occluder that can screen for uncorrected refractive error. They use the *stenopeic* principle and eliminate diverging rays from entering the optical system. This makes the blur circle of the light much smaller on the retina by only allowing light to pass through the very center of the cornea and lens, eliminating any refractive errors of the eye. This is why patients shouldn't squint when testing visual acuity. Pinhole visual acuity can be recorded separately. It is a good measure of visual potential with corrective lenses. This is a very similar principle to pinhole cameras.

Pinhole is abbreviated "ph" in the exam. "NI" is the abbreviation for "no improvement" with pinhole occlusion.

LogMAR

For purposes of research or tracking visual acuity over time, *logMAR* visual acuity is commonly used. This measures the minimum angle of resolution using a base-10 logarithm. Specific logMAR charts include the Bailey-Lovie chart or ETDRS which was designed for the famous "Early Treatment Diabetic Retinopathy Study" study. Here are some quick conversions:

Feet (Snellen)	logMAR	Meters
20/200	1.00	6/60
20/20	0.00	6/6
20/15	-0.12	6/4.5

While Snellen or Sloan charts dominate the adult world, other types of minimum legible threshold are used for different age groups. The "HOTV" chart consists of just those four letters and is used for children 2-5 who might not know every letter yet and can come with a key card of the four letters so children can match by pointing. "LEA" symbols are also popular in this age group. They consist of a simple image of a house, an apple, and a square and can also come with a key.

Pediatric Visual Acuity

What about children (or anyone) who can't talk? Under two years of age, vision is assessed on if it is "central", "steady", and "maintained". This is abbreviated CSM.

Central: Tested monocularly (covering one eye). The corneal reflex from a muscle light should be in the center of each pupil; documented "C". If it is not, this might suggest strabismus and would be documented as "UC".

Steady: Tested monocularly. When moving the muscle light around, the eyes should be able to easily follow it. "S" represents "steady" and "US" represents "unsteady".

Maintained: This is a binocular test. Fixation should be maintained when each eye is intermittently covered. An eye that doesn't maintain fixation might have a lower VA than the other eye. "M" represents "maintained" and "UM" represents "unmainatained".

This can be reported as any combination. For example, if vision is central and steady but not maintained in the right eye:

OD: CSUM

OS: CSM

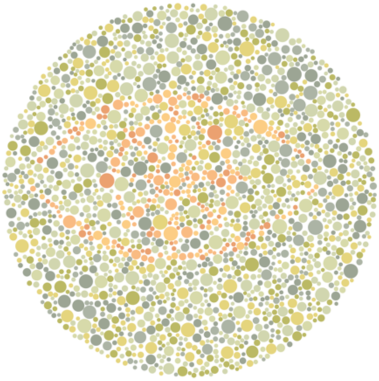
Young infants (around 3 months) should have ability to fixate on and follow a target (in each eye separately) which can be documented as "Fixes and Follows".

Crowding

Something that comes up often in the pediatric clinic is the idea of crowding. Visual acuity can be overestimated when using a single optotype on a big white screen, especially in amblyopia. There are competing theories about the exact mechanism. This is overcome by using "boxed" letters in "crowding bars". They're officially called *contour interaction bars* and can improve the accuracy of visual acuity.

Color Vision

Color vision testing can be a sensitive screening tool for optic nerve pathology. There are many types of color vision tools including color plate tests (like Ishihara) or more complicated hue tests. The exact test is scored based on the patient correctly identifying the number (or squiggly line). Each test has its own criteria and interpretation system.



Normal Visual Acuity Exam

Some other important terminology for ophthalmology in general is the names used for the eyes.

- **OD** – "Oculus Dexter" or "Right Eye"; note this does not apply to lids (i.e., Say "Right Upper Lid" not "Upper Lid OD".
- **OS** – "Oculus Sinister" or "Left Eye"
- **OU** – "Oculus Uterque" or "Both Eyes"

I will provide examples for a "normal" exam at the end of each section. There are *many* ways to perform and document these exams so you will see *many* variations. Here is an example of a normal adult visual acuity exam:

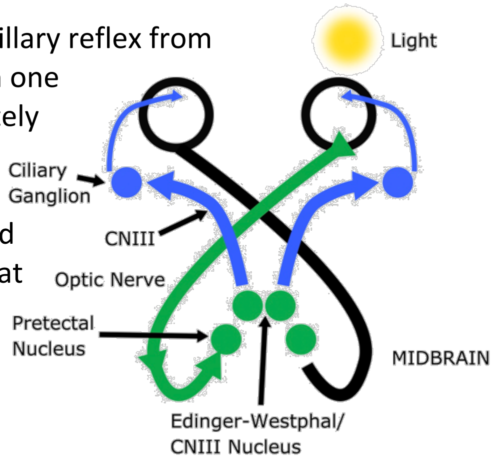
	sc	cc	cCL	Ph
OD	20/30-2	20/20		NI
OS	20/30+1	20/20		NI

Color Vision: 14/14 OU (Ishihara)

Pupils

The Pupillary Reflex

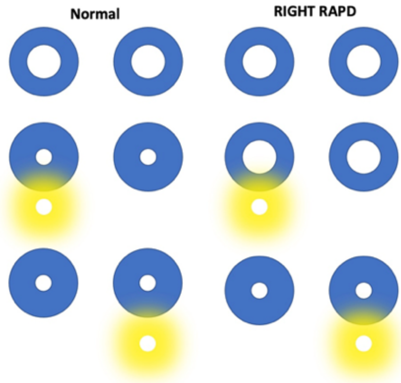
You may recall the pupillary reflex from medical school. Shining light in one pupil should cause approximately equal constriction of both pupils at the same time. Additionally, both pupils should constrict when viewing things at near as part of the *near triad*: miosis, convergence, and accommodation.



The Pupil Exam

The pupils are constricted by the iris sphincter which is innervated by the parasympathetic nervous system in the oculomotor nerve (cranial nerve III). The pupils are dilated by the iris dilator which is innervated by the sympathetic nervous system. Using standardized cards or rulers, measure the pupils in light and dark. They should be equal to each other in both the light and dark. A penlight/muscle light is then shone in each pupil individual to evaluate appropriate constriction.

The light is then swung back and forth (swinging flashlight test, pictured here) to ensure both the illuminated and fellow pupil constrict which is referred to as the consensual light reflex. If shining light in one eye produces no constriction in either pupil, this can be a sign of unilateral/ asymmetrical retina or optic nerve disease.



Optic neuritis, severe retinal disease, or even advanced glaucoma can feature a relative afferent pupillary defect (RAPD). Some conditions like posterior synechiae (adherence of the iris to the lens capsule), traumatic mydriasis, or certain iris pathology can make the pupils irregular by nature of the disease and thus complicate the pupillary exam.

Patients can be asked to look at a near target (finger or light) to ensure miosis with the near triad.

Anisocoria

Pupil sizes can differ between eyes (called *anisocoria*) by 1 mm physiologically (i.e., physiologic anisocoria). Anything more than this must be evaluated in both light and dark.

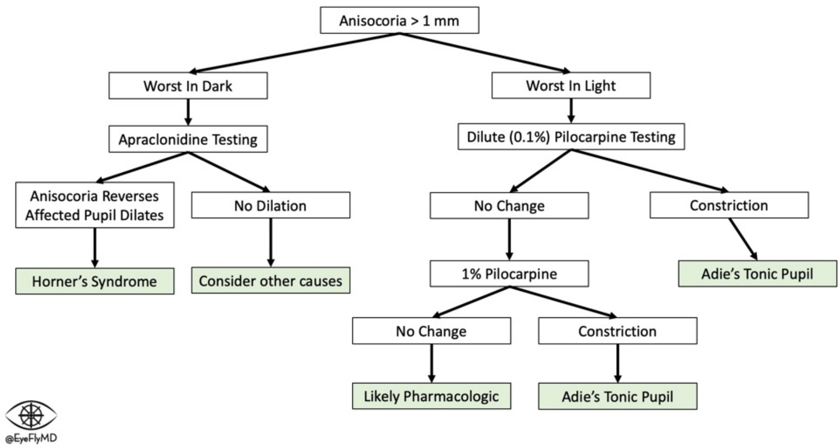
Anisocoria worst in the *dark* implies one pupil is not *dilating* appropriately, and there may be pathology in the sympathetic pathway, like Horner Syndrome. This is typically evaluated using the apraclonidine test. Apraclonidine is a nonselective α adrenergic receptor agonist. In addition to inhibiting aqueous production in glaucoma, it's also a sympathomimetic. Horner Syndrome can cause hypersensitivity of the sympathetic pathway due to denervation and apraclonidine can reverse anisocoria in these cases. Reversal of the anisocoria and resolution of the ptosis after administration of apraclonidine is a sensitive test for Horner's Syndrome.

Traditionally, Horner syndrome was tested using a combination of cocaine and hydroxyamphetamine, but obviously these are now difficult to obtain and store.

Anisocoria that is worst in the *light* implies one pupil is not *constricting* appropriately and there may be pathology in the parasympathetic pathway. Common causes of dilated pupils include Adie's Tonic Pupil and pharmacologic dilation. Dilute pilocarpine (0.1%) can be used to distinguish these. If the pupil does not constrict, 1% pilocarpine can be instilled. If either of these solutions constrict the pupil, Adie's is likely. If the eye does not dilate to even full-strength pilocarpine, pharmacologic dilation must be considered.

Pharmacologic dilation can come from sources other than eyedrops. Scopolamine patches are used for seasickness or nausea associated with anesthesia. If a patient touches the patch and then touches their eye this can induce pharmacologic dilation.

Here is a flow chart that summarizes anisocoria. This is NOT comprehensive and is extremely simplified. Additional findings like ocular motility deficits could be suggestive of CNIII palsies. This is just a summary of common anisocoria clinic drop testing.



Again, the slit lamp exam is a good time to determine if the anisocoria is due to something like posterior synechiae.

Normal Pupil Exam

Here is an example of a normal pupillary exam:

Pupils:
Round, equal, and reactive to light; no RAPD
Light: 2.0 mm OU
Dark: 4.0 mm OU

Intraocular Pressure (IOP)

IOP is measured in millimeters of mercury (mmHg). Normal IOP is between 10-21 mmHg with a right skew (so the average is closer to 15 mmHg). IOP is one of the most important modifiable risk factors for glaucoma.

Types of Tonometry

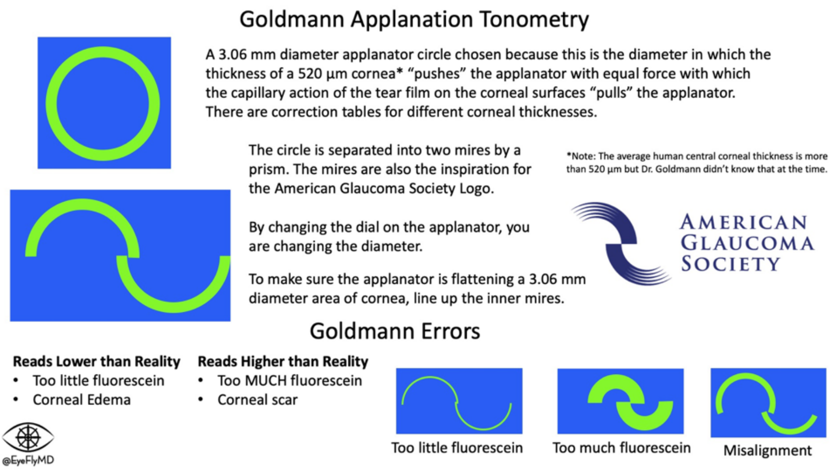
There are several ways to measure intraocular pressure. The most common ways in routine clinic work-up include the Tono-Pen® and iCare. The eye is typically numbed with Proparacaine (which lasts around 20 minutes) for the Tono-Pen® and it takes ~10 readings to make an average. Patients should look to the distance and the Tono-Pen® should be gently tapped perpendicular to the cornea in the very center. Avoid scraping motions since it can be easy to cause epithelial defects. Both of these handheld methods have limited accuracy and are not sufficient for monitoring IOP in conditions such as glaucoma. Some examples of handheld tonometry devices are pictured.

The gold standard for measuring IOP is Goldmann Applanation. This is a device, usually connected to the slit lamp, with a 3.06 mm disc. They utilize the Imbert-Fick law: P=F/A. That is, pressure is equal to the force required to flatten an area of cornea divided by the area of cornea flattened.

The 3.06 mm diameter was chosen very intentionally. The Imbert-Fick law assumes the cornea is infinitely thin and dry. It's neither and IOP is influenced by the fact that corneal tissue is pushing back on the applanator and artificially increasing IOP, and the capillary action of the tear film pulls the applanator forward and artificially lowers IOP. In Dr. Goldmann's time, the central cornea was thought to be an average of 520 µm so 3.06 mm was chosen because that is the diameter that a 520 µm cornea pushes with equal force that the capillary action is pulling so those two variables are essentially cancelled. An average cornea is actually closer to 550 µm. There are tables for correction (but their use is variable).

Fluorescein must be applied to the eye first to make the mires of the applanator visible. You may recall fluorescein from biochemistry. Fluorescein is an orange dye that… fluoresces. It absorbs light of one wavelength (the 475-490 nm Cobalt Blue light of the slit lamp) and emits a different color wavelength (510-520 nm green).

A summary of Goldmann Applanation Tonometry is below. In cases of high astigmatism, the applanator can be used once at 90° and once at 180° and subsequently averaged.



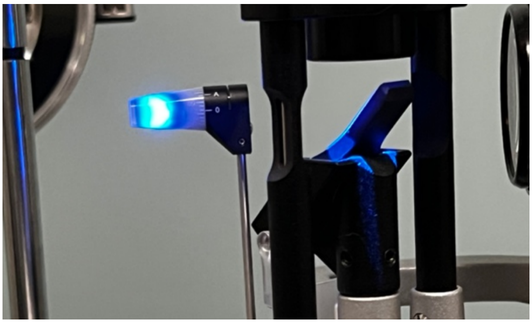
If IOP needs careful monitoring (e.g., as in glaucoma), it's common to see tables of IOP so trends can be observed over time. It's also a good idea to record the time the IOP was obtained as there are diurnal fluctuations in IOP. Some glaucoma specialists will also record which drops patients are on in this same location.

For workflow purposes, it's important to avoid actually touching the eye too much before the patient has any cornea imaging. For example, if the patient is going to have their surface measured (e.g., tomography/topography) or biometry for cataract surgery, it's better to wait until after these measurements for things like Goldmann applanation because it can distort the cornea and reduce accuracy of the cornea measurements.

This is what a typical Goldmann tonometer looks like. Notice the dial on the bottom for adjusting IOP. These can vary in appearance.

Illuminating it with the Cobalt blue light from the side allows visualization of the Fluorescein tear film mires.

Lastly, things like refractive surgery, corneal transplants, or scars can influence tonometry. Be very cautious with tonometry (pushing the globe) in the setting of trauma. Air-puffs or the iCare may be preferred for corneal transplants. Pushing anything on the eye can cause an abrasion so always be gentle.



Normal IOP Exam

Here is an example of a normal IOP portion of an exam.

IOP: 15/15 (tp)

"tp" for "Tono-Pen®"; also can use "GA" for "Goldmann Applanation

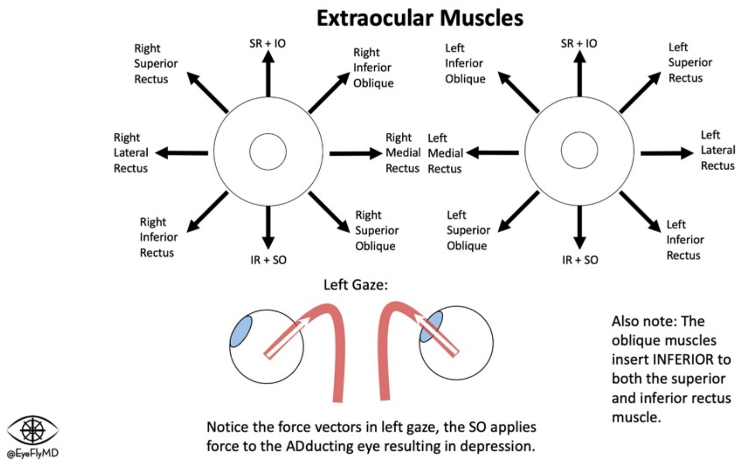
OR

Date	OD	OS	Drops
10/05/2021; 1034	24	22	latanoprost
11/12/2021; 0934	19	18	latanoprost, timolol
01/14/2022; 1332	17	16	latanoprost, timolol

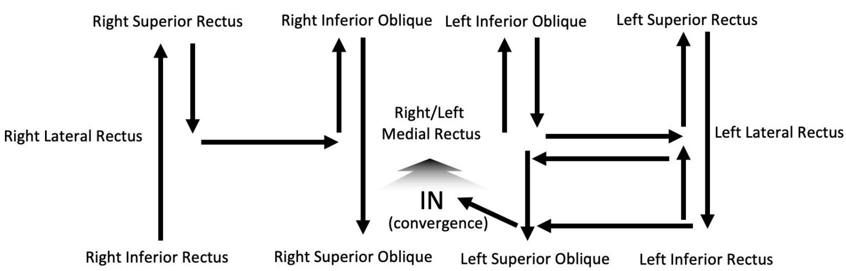
Motility and Strabismus

Extraocular Motility

Recall that there are 6 extraocular muscles responsible for movement of the globe. They each control a *cardinal field of gaze*. That is, a direction of eye movement where only one muscle is controlling the movement. Because of this, the muscle functions can be isolated. It's important to realize that "up" and "down" are not cardinal positions. The extraocular muscles can be best assessed by moving a target (finger or light) in an "H" pattern. See how this isolates each muscle. At the end of the "H", move in towards the nose to ensure *convergence* is normal.



Here is an example of how that translates clinically:



Check "up" and "down" too even though these motions are due to two muscles.

If any of the motions are incomplete (including up and down), they can be graded and scored in accordance with the table below based on the "H" plus "up" and "down":

RSR	"UP"	RIO	LIO	"UP"	LSR
RLR		RMR	LML		LLR
RIR	"DOWN"	RSO	LSO	"DOWN"	LIR

Numbers are assigned to reflect the relative ability of the eye to complete a gaze in that position. A normal exam looks like this:

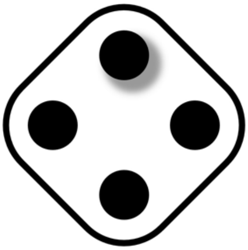
0	0	0	0	0	0
0		0	0		0
0	0	0	0	0	0

The grading is based on the ability of the eye to normally gaze in that position by quarters:

No limitation:	0
75% of movement:	-1
50% of movement:	-2
25% of movement:	-3
No movement past midline:	-4

Stereo Vision

When the eyes are working together (including moving normally together) the subtle difference in perspective between eyes creates stereo (3D) vision. Stereo vision can be tested in a variety of ways. They usually involve wearing polarized 3D glasses (like in a movie theatre). These allow each eye to see a different image and create the illusion of 3D. Children might be asked to grab a fly or identify 3D animals. Adults might be asked to identify 3D circles. Lack of stereo vision may be an indicator of strabismus.



Strabismus

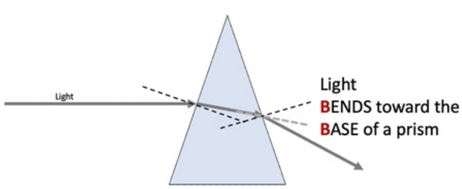
Strabismus refers to misalignment between the eyes. It can also be called “cross-eye” or “lazy-eye”. In England, strabismus is also called “squint”. Symptoms of strabismus can be obvious based on appearance (e.g., parents noticing eye misalignment in their children) or based on symptoms including diplopia (double vision) or reduced stereo vision. The types of strabismus are beyond the scope of this reference guide, so we’ll focus on the general evaluation of strabismus.

Strabismus can present as exotropia (eyes out), esotropia (eyes in), hypertropia (vertical eye misalignment, usually just represented as one eye above the other), or cyclotropia (torsional strabismus). Strabismus can also be constant or intermittent.

A tropia describes strabismus, but a *phoria* is a deviation when the eyes are not under binocular vision. For example, when one eye is covered, the other may deviate slightly without a fixation target but binocular function will resume when the eyes are both uncovered and allowed to fixate. A phoria is generally normal and nondisruptive.

Strabismus can be evaluated at near, distance, and in all fields of gaze with head turn and tilt. The strabismus exam can become quite complicated.

Frist, recall the optical principles of prisms. Light bends towards the base of a prism and the image actually moves towards the apex. Prisms are used to determine the amount of misalignment between the eyes with the unit of *prism diopter* (PD, or Δ). The definition of a prism diopter is a prism that would displace light by 1 cm at the distance of 1 m.



Prism Cover Test

When the eyes are aligned, it is reported in the physical exam as “alignment: ortho”. When they’re not, it’s important to determine the amount of deviation. This is commonly accomplished by covering one eye with an occluder and then moving the occluder between the eyes. Alternating which eye is covered will cause the image to “jump” from the perspective of the patient and the eyes to move as the misaligned eye re-fixates on the object (usually a dot on the wall or projector). Prisms are then introduced (with the apex in the direction of the deviation, so apex OUT for EXOtropia and apex IN for ESOtropia) until the image doesn’t appear to jump anymore from the patient’s perspective. At this point, the eyes won’t appear to move anymore from the examiner’s perspective. There are 3 main variations of this test:

The *Monocular Cover-Uncover* test involves viewing a fixation target and covering one eye while observing the fellow eye for movement. Once the eye is uncovered, it is again observed for movement. If the covered eye re-aligns, this can indicate a phoria. Again, phorias typically are harmless and the eyes will appear ortho before and after the test, only “breaking down” when one is occluded. In a patient with a tropia, the eyes will *start* and *end* deviated.

The *Alternate Cover Test* involves moving an occluder between eyes to detect latent phoria and manifest tropias. “Latent” means the misalignment is only present when fixation is interrupted while “manifest” deviations is present under binocular conditions.

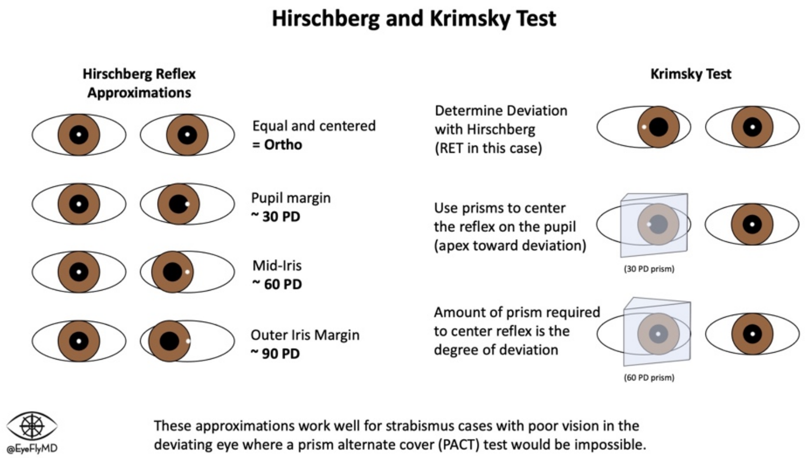
The *Prism Alternate Cover Test (PACT)* is the same as the alternate cover test except prisms are held over one eye until the deviation is neutralized and movement is no longer seen when the occluder is moved back and forth. This is the magnitude of the deviation. This can be used for both horizontal and vertical deviations. The test measures *total deviation* which is the tropia plus phoria (i.e., manifest plus latent deviation).

The *Simultaneous Prism Cover Test (SPCT)* measures *manifest deviation* under binocular conditions (so only the tropia is measured; remember, a phoria is only present when fixation is interrupted). In this test, a prism is placed in front of the deviating eye at the same time the fixating eye is covered. Like before, the strength of the prism is increased until the eye movement is neutralized. This is mostly used for monofixation syndrome which we'll talk about in a moment.

As mentioned previously, strabismus can be measured in all fields of gaze and with head turn or tilt.

Remember that measuring strabismus these ways requires fixating on a target (finding a target when the occluder is moved). What about cases where the vision is too poor to fixate on a target?

The amount of deviation can still be measured using the pupillary light reflex (Hirschberg). The pupillary light reflex can even be neutralized to the center of the pupil using prisms while the other eye fixates on a target to precisely measure deviation (Krimsky). These are outlined below:



There is a special circumstance where an eye experiences a deviation when it is not being used and the fellow eye is fixating but when both eyes are fixating again (when the deviating eye is uncovered) the deviated eye returns to primary position *without* associated motion in the fellow eye. Remember, strabismus typically features the eyes moving together so this situation is unique. This is called dissociated strabismus complex and is unique from hypertropia, exotropia, or esotropia. "Dissociated" because the movement is in one eye. When the motion is vertical, it's called Dissociated Vertical Deviation (DVD). When it's horizontal, it's called Dissociated Horizontal Deviation (DHD). It can also be torsional (DTD).

Parks-Bielschowsky

Another special maneuver worth mentioning is the "Parks-Bielschowsky three-step test" for determining the paretic muscle in hypertropia. It boils down to these three questions:

1. Which eye is hypertropic in primary gaze?
2. Is the hypertropia worse in right or left gaze?
3. Is the hypertropia worse in right or left head tilt?

Just try to remember if everything is worse in the same direction it's the opposite inferior oblique that is paretic. For example, if the RIGHT hypertopia is worst in RIGHT gaze and RIGHT head tilt then the paretic muscle is the LEFT inferior oblique. That gets you a third of the way there.

You can also remember if the tilt is the only thing that's different it's the opposite inferior recuts from the worse tilt. For example, RIGHT hypertropia that is worse in RIGHT gaze and LEFT head tilt is a RIGHT inferior rectus palsy. If it doesn't fit one of those two scenarios, it's an opposite side superior rectus palsy.

I know, that's complicated and a lot. Here is a summary.

Inferior Oblique Palsy
- Opposite side HT
- Opposite gaze worst
- Opposite tilt worst

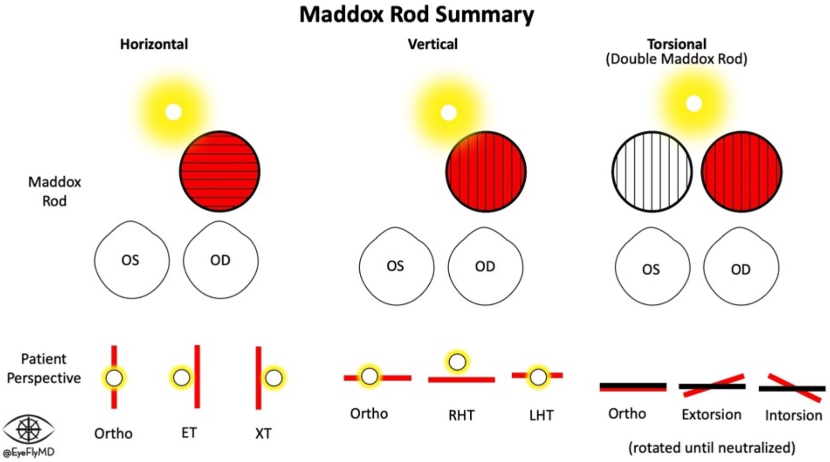
Inferior Rectus Muscle Palsy
- Same side HT
- Same side gaze worst
- Opposite tilt worst

Superior Rectus Muscle Palsy
- Opposite side HT
- Same side worse gaze
- Opposite side tilt worst

The Maddox Rod

A Maddox rod is a lens with parallel cylinders that convert a point light source into a streak/line perpendicular to the cylinders. They are helpful for strabismus screening and especially evaluating the torsional component of strabismus. They can come either free or in trial frames so the axis can be carefully determined.

Always remember e**X**o deviations result in **X**'d (crossed) diplopia (OD image to the left of OS image and vice versa).



Strabismus Notation

After obtaining these measurements, it's important to record them correctly. Like most things in ophthalmology, strabismus has special notation. Here are some of the symbols and phrases used:

O	Orthophoria/Orthotropia
E	Esophoria (distance)
E'	Esophoria at near (the ' symbol indicates "near")
X	Exophoria (distance)
X'	Exophoria at near
RH/LH	Right/Left Hyperphoria
ET	Exotropia (constant), ET' for near
XT	Exotropia (constant) XT' for near
RHT/LHT	Right/Left Hypertropia (constant), RHT'/LHT' for near
E(T)	Intermittent Esotropia, E(T)' for near
X(T)	Intermittent Exotropia, X(T)' for near
R/LHoT	The addition of "o" can indicate hyp**O**tropia
OEAd	Overelevation in adduction
IOOA	Inferior Oblqiue Overactivation
ODAd	Overdepression in adduction
SOOA	Superior oblique overactivation
UDAd	Underdepression in adduction
SOUA	Superior obluqe underactivation
UEAd	Underelevation in adduction
IOUA	Inferior oblique underaction
DVD	Dissociated vertical deviation
DHD	Dissociated horizontal deviation

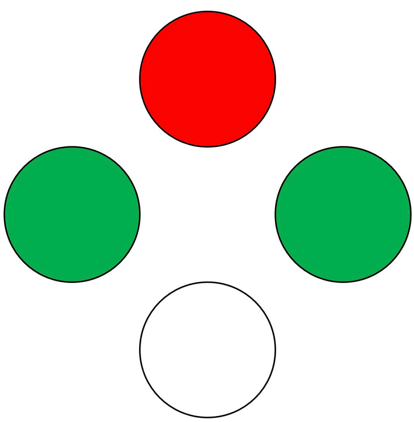
For example; 5 ET', means there is 5 prism diopters of constant esotropia at near.

Strabismus can be recorded along with the extraocular muscle exam in all the fields of gaze if necessary. See the example at the end of the chapter.

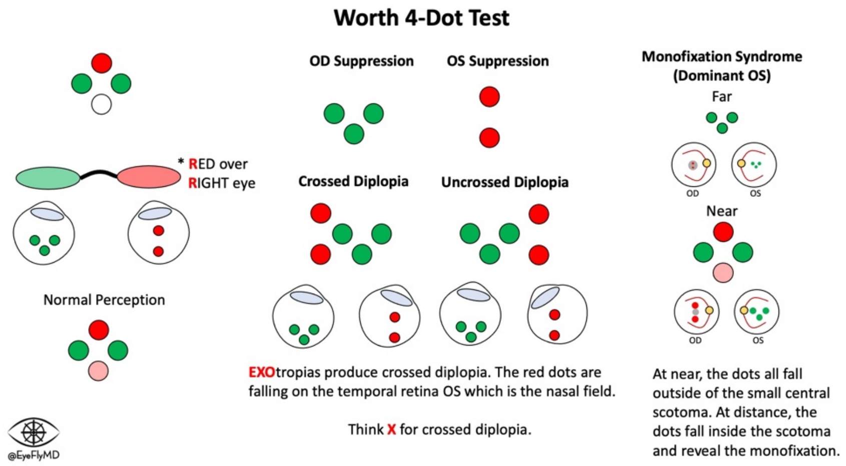
Worth Four Dot Test

Either hanging in the back of every exam room, sitting in the drawers, or some combination thereof is the Worth Four-Dot Test. This is useful for examining fusion, strabismus, suppression, and monofixation syndrome. It is composed of a diamond shape with a red dot on top, two green dots on the sides, and a white dot on the bottom. The patient wears red-green glasses, **R**ed lens over **R**ight eye. The right eye then should see two dots (the top red one and the bottom white one seen as red) and the left eye should see three green dots (the two green and the bottom white one seen as green).

Monofixation syndrome describes a small-angle strabismus resulting in a small (< 3°) unilateral scotoma. Essentially, for some reason (small angle strabismus, anisometropia, macular pathology, etc.) a small central scotoma develops but binocular fusion is maintained through the peripheral fields which have a larger tolerance for image discrepancy than the high acuity fovea. The eyes will usually not look grossly misaligned. Picture the four dots up close, they are occupying a large portion of the visual field and it is likely the dots will all fall outside of the small central scotoma. Now picture the four dots far away. They are occupying a small central portion of the visual field and now they will fall within the central scotoma so there will be a discrepancy in what the patient sees with the four dots at near and at a distance.



The following is a more concise summary than can be conveyed in words of Worth dot test interpretation.



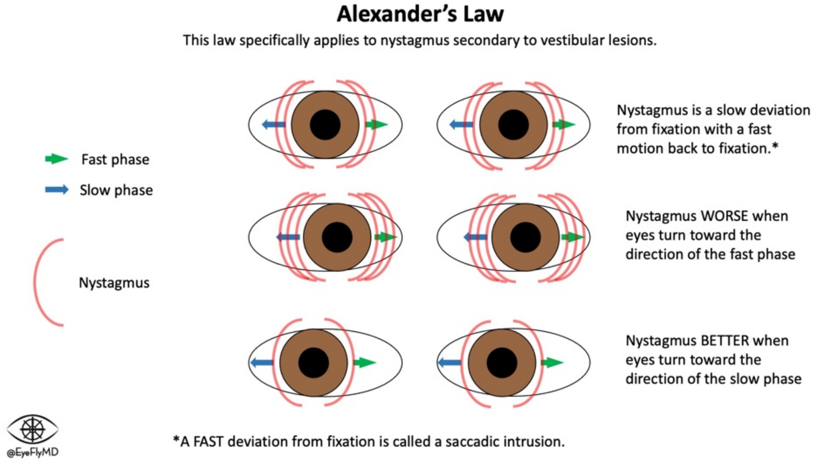
Nystagmus and Optokinetic Drum

Nystagmus is a repetitive and involuntary motion of the eye characterized by a “slow” phase that takes the eye off fixation with a fast phase to bring it back. It is often described as “jerk” or “pendular” and is usually worsened or improved by certain directions of gaze (see the following graphic on Alexander’s Law). Nystagmus can also be torsional (the eyes appear to rotate). Nystagmus is distinct from saccadic intrusions which are rapid eye movement off and then back on the target.

Physiologic (end-gaze) nystagmus can occur at the extremes of lateral gaze and is a normal finding.

An exam for nystagmus involves closely observing the eyes in all fields of gaze for any sign of nystagmus. If present, it’s important to determine where it’s most and least prominent.

A “charismatic” instrument in the ophthalmology clinic is the optokinetic drum. It’s a striped cylinder that spins and looks like a Halloween Decoration. The spinning motion induces nystagmus. They specifically can evaluate optokinetic nystagmus (tracking objects in motion with a stationary head). The eyes will follow the spinning target and then saccade back. Its most practical use is to evaluate the afferent and efferent visual pathway. If a patient claims to be NLP (and denies the ability to see light at all) then their eyes shouldn’t move when looking at the drum. It can also be used in children to get a sense of visual acuity (their eyes should follow the drum). For the efferent pathway it essentially evaluates the ability to form symmetric eye movements and can inform the examiner on the overall health of the pursuit system in the parietal lobe. Lastly, spinning downward (and causing an upward saccade), it can bring out convergence retraction nystagmus characteristic of Parinaud’s Syndrome.



Head position is also important to record due to posturing patients may prefer if they have strabismus or nystagmus. Based on Alexander’s law above, nystagmus can have a “null point” or a direction of gaze where the nystagmus is minimized or eliminated. Obviously, patients will prefer this gaze and adjust their posture accordingly. For example, if their nystagmus is minimized in right gaze, they may turn their head to the left so they’re always looking to the right.

Normal Exam

Here is an example of a normal extraocular muscle and strabismus exam.

Alignment: Ortho
Method: Cover-Uncover
Correction: sc
Fixing Eye: N/A (the fixing eye would go here if applicable)
Distance: Ortho
Near: Ortho

	0 0 0		0 0 0	
	0 0	Ortho Ortho’	0 0	
	0 0 0		0 0 0	

Head posture: Straight
Nystagmus: None

The empty boxes can be filled with strabismus measurements in the different gazes. For example, strabismus might be worst in upgaze (the middle upper box) and least in downgaze (the middle lower box) which would be called “V-Pattern strabismus. If the strabismus was worst in downgaze and best in upgaze it is called “A-Pattern strabismus”.

Refraction

Overview

The art of refraction measures the refractive error of the eye for purposes of prescribing glasses. Whether it's for a pediatric strabismus exam or for a cataract evaluation, knowing the refractive state of the eye is extremely important.

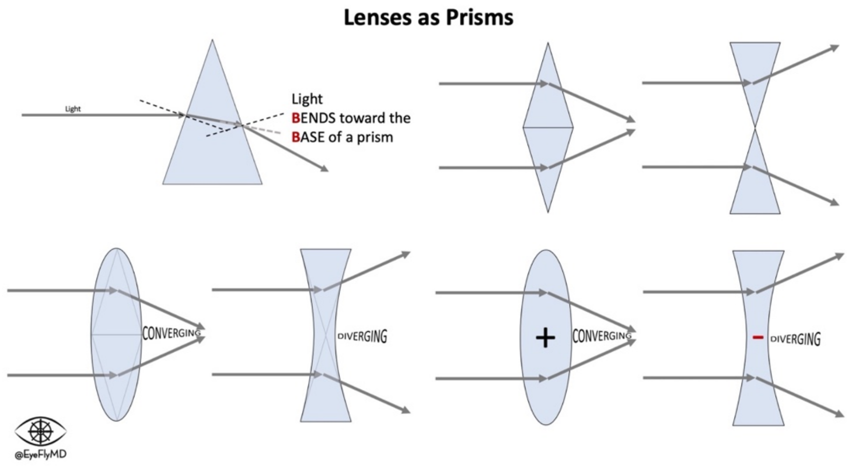
Before discussing *how* to refract, it's important to understand how glasses correct vision and the basics of a glasses prescription. Some of this discussion will be familiar from *The Eye Guide: Anatomy and Optics*.

Lens Basics

If you can remember what a prism does to light, you will never forget **PLUS, CONVEX, CONVERGING** or **MINUS, CONCAVE, DIVERGING** lenses ever again. Remember from the strabismus discussion, due to Snell's law light **b**ends towards the **b**ase of a prism. The dotted lines on the following illustrated prism represent the *normal*, the imaginary line perpendicular to the optical surface. When light enters a substance with a greater refractive index (*n*) it bends towards the normal. When light enters a substance with a lesser refractive index it bends away from the normal. The *n* of air is 1.00. Other important *n*s include the cornea (1.376), aqueous (1.336), vitreous (1.337), water (1.333), and crown glass (1.517).

Spherical lenses can be thought of as two prisms either apex to apex or base to base. Light has 3 options, it can either converge, diverge, or have zero vergence (be parallel). **PLUS, CONVEX, CONVERGING** lenses (two prisms base to base) are converging lenses and **MINUS, CONCAVE, DIVERGING** lenses (two prisms apex to apex) are diverging lenses.

PLUS, CONVEX, CONVERGING lenses are denoted by **BLACK** numbers. **MINUS, CONCAVE, DIVERGING** lenses are denoted by **NEGATIVE** numbers.



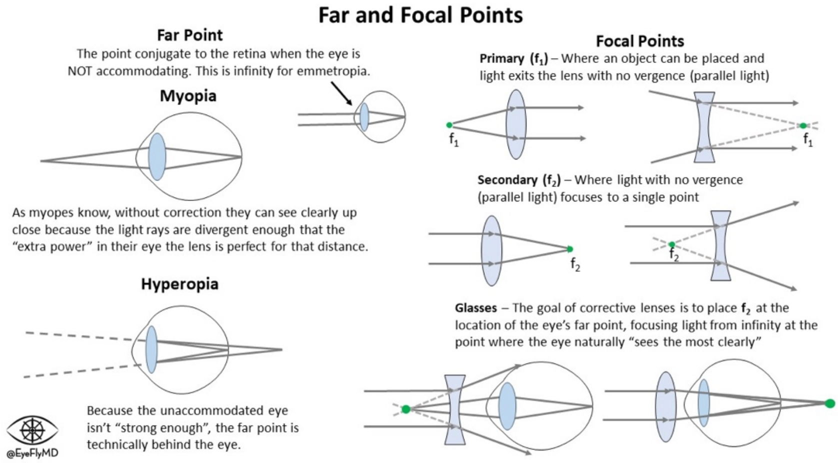
Far and Focal Points

The eye must take light with no vergence (remember, parallel light from infinity) and focus it to a single point on the retina over a distance of ~24 mm (the average length of an eye). This requires quite a bit of refracting power and the average eye is ~ +60 D. The eye must be **PLUS, CONVEX, CONVERGING** naturally because natural light must be focused onto the retina. The cornea (especially the air-tear interface where the biggest refractive index change occurs) contributes ~74% of this refractive power and the lens does the rest.

Eyes have a **Far Point**. This is the point conjugate to the retina when the eye is not accommodating. Put another way, this is the point where an object could be placed and the emitted/reflected light rays would focus onto the fovea after passing through the eye's optical system. For myopes, either the lens is "too powerful", or the axial length is too long and light rays with no vergence will focus in the vitreous. For hyperopes, the lens is either "too weak" or the eye is too short, and the incoming light would focus behind the retina but strikes the retina as a blurry circle.

Lenses have **Focal Points**. A primary focal point (f_1) is a point where an object could be placed and the light rays coming from that object would exit the lens with zero vergence. A secondary focal point (f_2) is where light with zero vergence would focus on a single point after passing through the lens. For minus, concave lenses, the focal points are the locations where the light rays “appear” to be going or coming from because the light rays in a concave system may never actually cross to form a single point. This is indicated with dotted lines below.

The goal of corrective lenses in a pair of glasses then is to take the light coming from a distance with zero vergence and focus it to the conjugate point of the unaccommodated eye, the **Far Point**. Remember, the far point is where light will focus on the retina after passing through the unaccommodated optical system of the eye. You can think of a corrective lens then as taking light from infinity and focusing it to the point where the eye sees most clearly. As far as the eye is concerned, it is seeing that “image” of infinity since all the light is focused there and the result is clear distance vision.



Refractive Error

Emmetropia describes an eye without refractive error. Light with zero vergence from a distance will pass through the optical system of the *unaccommodated* eye and focus on the retina. Unaccommodated is an important modifier because the lens can accommodate and become more **PLUS**.

Myopia, or "nearsightedness", is a refractive error of the eye characterized by light focusing IN FRONT OF the retina after passing through the optical system of the unaccommodated eye. Uncorrected myopes can see at near but not at a distance.

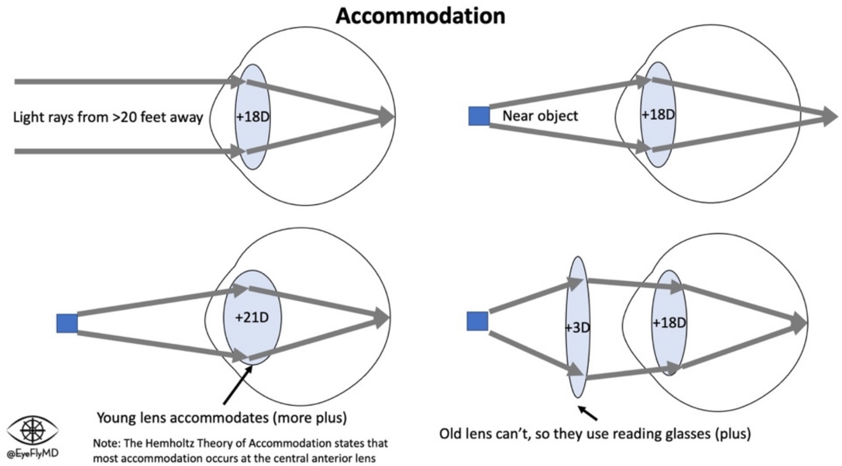
- Correction: **Concave** lenses that diverge the light (denoted by a **-**, **MINUS** prescription)
  - One way to think of it is that a concave lens will "spread" the light rays or "push" the image back, so it comes to a point on the retina.
  - Another way to think about it is that the concave lens will focus light with zero vergence to f_2 which is powered to align with the far point of the eye (close in front of the eye in myopes).

Hyperopia, or "farsightedness", is a refractive error of the eye characterized by light focusing BEHIND the retina after passing through the optical system of the unaccommodated eye. Technically for the *unaccommodated* hyperopic eye, no distance (near or far) will result in clear vision but (especially young) hyperopes can simply accommodate, make their lens more **CONVEX** (**PLUS**), and see well at distance.

- Correction: **Convex** lenses that converge the light (denoted by a **+**, **PLUS** prescription)
  - One way to think of it is that a convex lens will more "sharply" focus the light rays or "pull" the image forward, so it comes to a point on the retina.
  - Another way to think about it is that the convex lens will focus light with zero vergence to f_2 which is powered to align with the far point of the eye (behind the eye in hyperopes).

Recall from earlier that accommodation is necessary because as objects become nearer to the eye, more divergent rays are allowed to enter the eye. The eye must **accommodate** to allow the light to keep focus on the retina. The result of this process is the lens bulging and becoming more convex (positive) to increase the refractive power of the lens and increase its converging power. The process (according to the *Hemholtz* theory) is:

- The ciliary muscles contract
- This loosens the zonular fibers supporting the lens
- The lens bulges becoming more **CONVEX (+)** and increases converging power



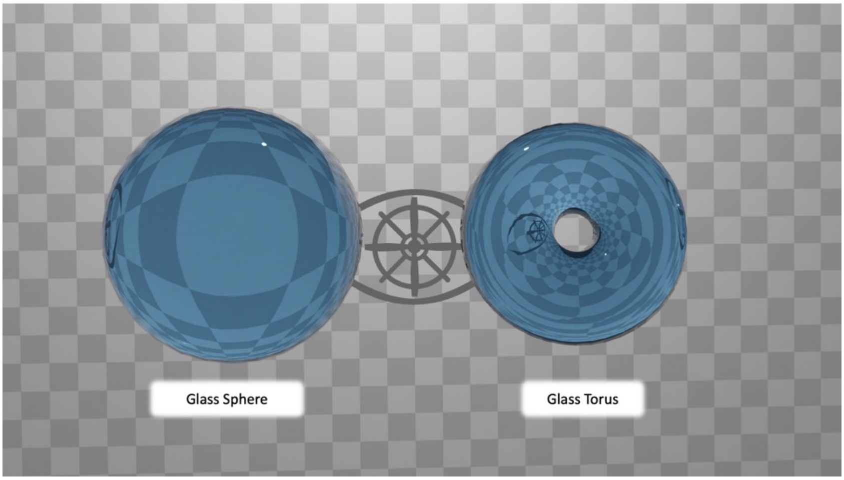
This becomes particularly important when refracting children as we'll discuss later.

The *Goldberg* theory of accommodation postulates that coordinated ciliary body, zonule, and anterior hyaloid movements changes the posterior lens curvature. During ciliary contraction in accommodation, the ciliary muscle annular ring moves forward and relaxes tension on the zonules which rounds the lens and increases refractive power.

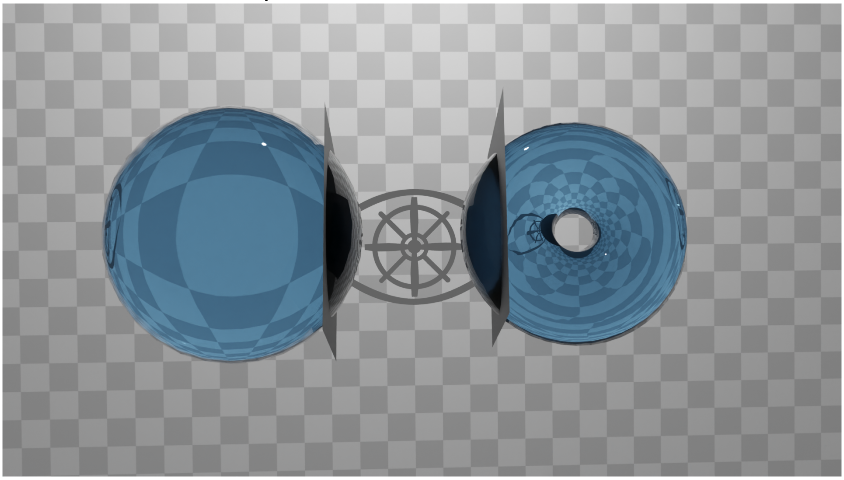
Astigmatism

Before discussing the basics of a spectacle prescription, it's important to have a solid understanding of astigmatism (which can be confusing at first so let's really break it down).

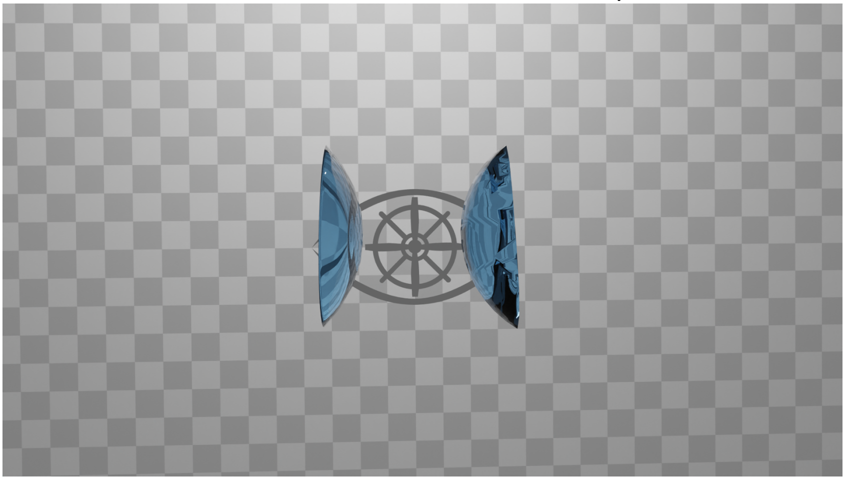
First, consider two shapes. A sphere and a torus. A torus is the geometry term for a donut shape. This might sound familiar because toric intraocular lenses are derived from toruses.



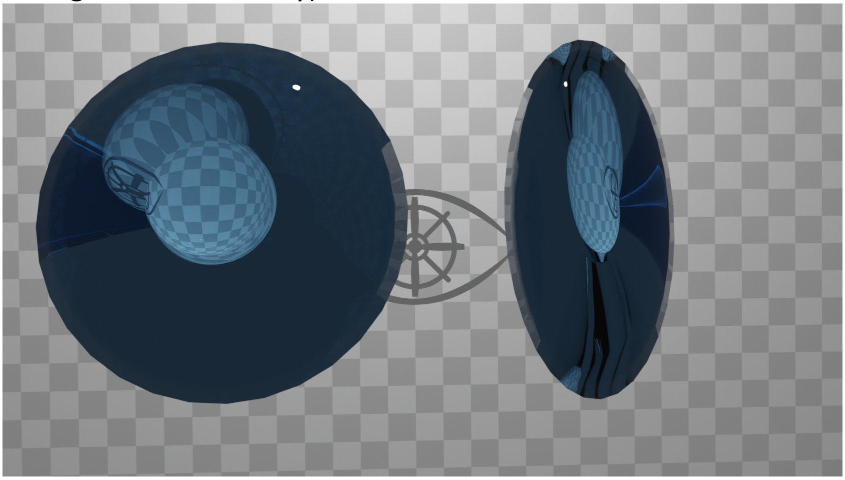
Now imagine taking a sharp blade and cutting a slice off of each of these shapes.



We’re left with these two lenticular endcaps.



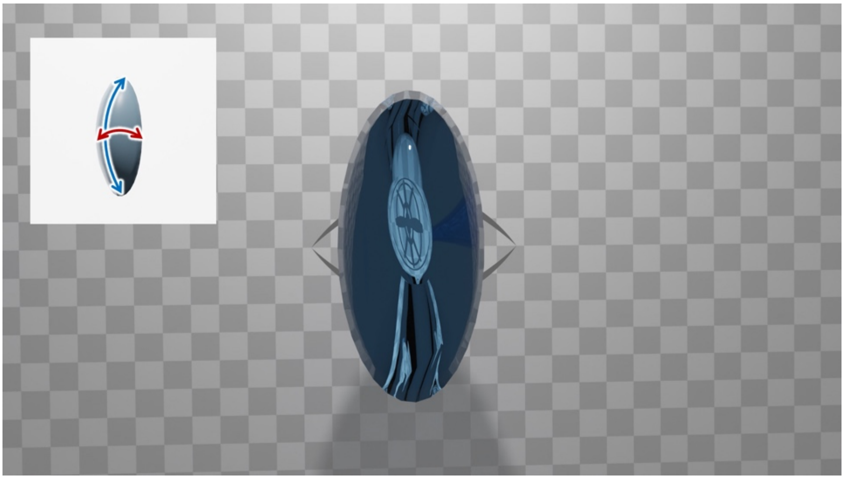
Now, let’s turn them so the round part is facing you (and enlarge them for clarity).



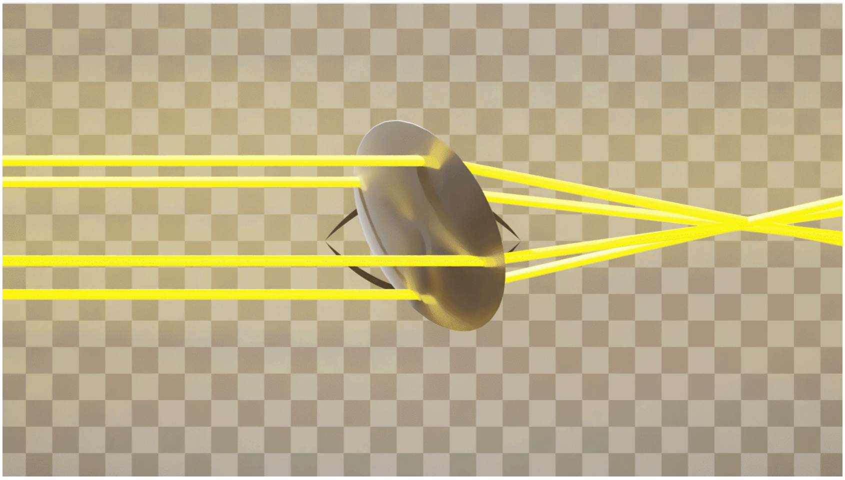
The spherical lens has the same radius of curvature no matter which direction light enters it. I.e., a pair of light rays entering the top and bottom of the lens will focus in the same area as a pair of light rays entering the horizontal sides of the lens. These are also called the ***meridians of power***.

So, the horizontal vertical meridian and horizontal meridian have the same refracting power (two black lines)

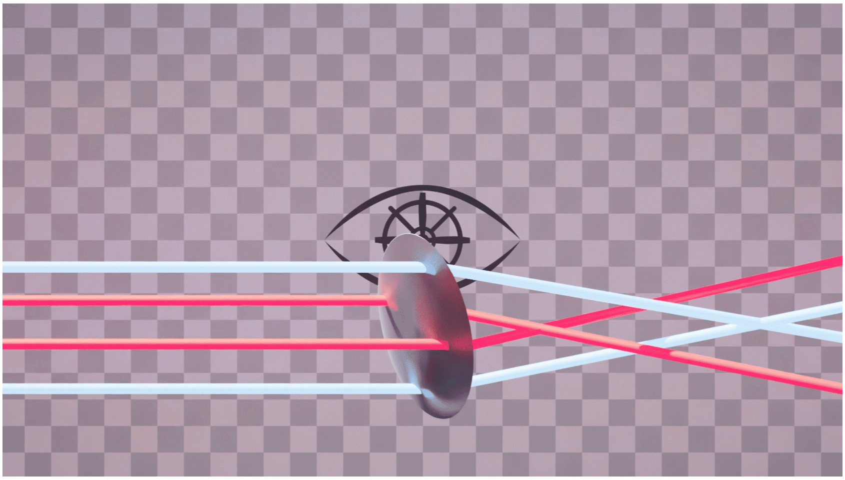
The toric lens has TWO radii of curvature. In the following example, the vertical meridian (**blue**) is less steep with less refracting power while the horizonal (**red**) meridian is more steep with more refracting power. When people liken astigmatism to having a football shaped cornea this is exactly what they mean.



The final consequence of this is that light entering a spherical lens (or cornea) will (essentially) focus to a single point.



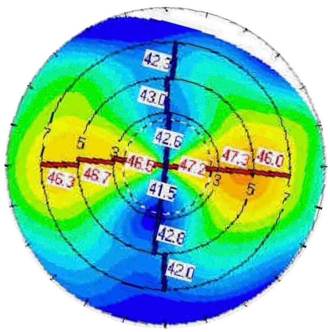
For the toric lens (or cornea) though, the steeper meridian (again, **red**) will will focus its rays in front of the less steep (**blue**) meridian.



Therefore, if corneas (or crystalline lenses) are shaped this way with astigmatism, it means we need to be able to correct both meridians separately. We accomplish this with ***cylindrical*** lenses.

Lastly, you've probably seen the topography of a state park. The red areas are higher than the flat green or blue areas. We can image the cornea this way too, either through tomography or topography.

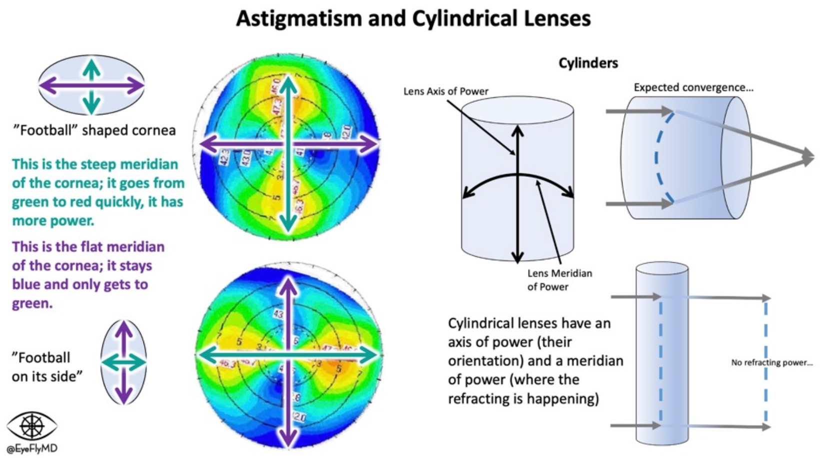
If the previous astigmatic cornea was a state park, it's topography would probably look like this. Notice that vertical meridian stays essentially blue the whole time because it's not very steep while the horizontal meridian goes from green to yellow to orange very quickly because it is steep.



Now, let's think about a cylinder. A cylinder has a curved surface that is capable of refracting light. We already know this is called the meridian of power. A cylinder also has a long portion, along which there is technically no refracting power because it's flat. This is called the ***axis of power***. Immediately notice the meridian and axis are 90° away from each other.

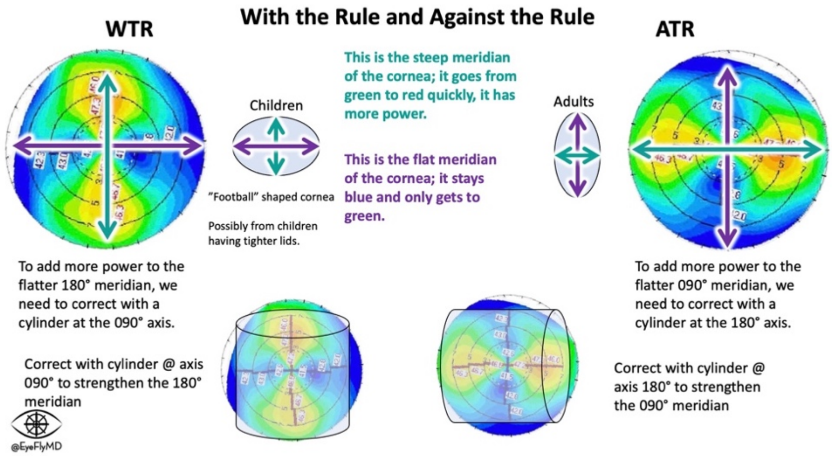
We can think of using cylinders to correct astigmatic vision by imagining "catching up" the power of the weak meridian using a cylinder so the light rays from each meridian land on the same spot. In the 3D example from before, we said the horizontal meridian (**red**) was weaker than the vertical meridian (**blue**) so we essentially need to place a cylinder so it exerts its refracting power of the weaker (**blue**) meridian. To accomplish this, we'd need a cylinder "on its side" so the power is exerted over that weak 90° meridian. That means the axis would be at 180° because remember, an axis of power has no refracting power itself but dictates the orientation of the cylinder and will contribute nothing to that meridian.

Here is a review of cylindrical lenses and astigmatism.



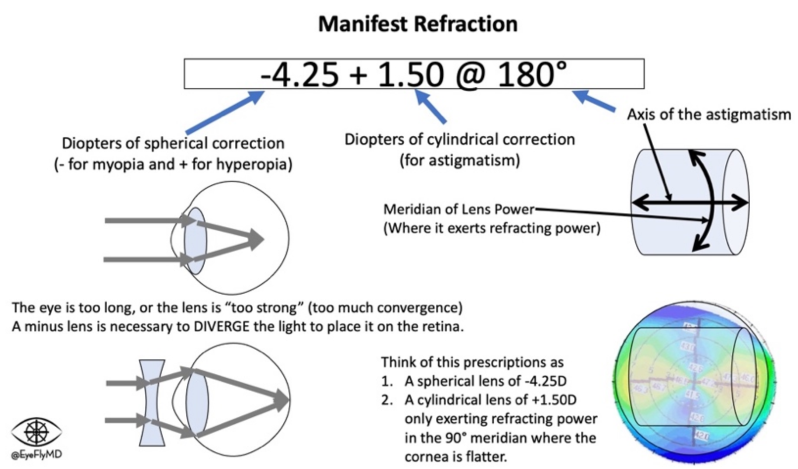
One last complicating factor is that fact that ophthalmologists work in **PLUS CYLINDER**. That means, we essentially imagine literal glass cylinders that exert **PLUS** refracting power (for many reasons including that toric intraocular lenses are labeled in plus cylinder). Optometry typically works in **MINUS CYLINDER**. This imagines a long concave, **MINUS** lens that only exerts power on one meridian. The **MINUS** cylinder system is probably better because this is how the lenses for glasses are actually made. This can create confusion though because the axes are different depending on **PLUS** or **MINUS** cylinder. It's easy to see because instead of "strengthening the weak meridian" optometry thinks of "weakening the strong meridian". To facilitate communication, we use "WITH THE RULE" (WTR) and "AGAINST THE RULE" (ATR) terminology.

To an ophthalmologist, WTR astigmatism requires correction (with a **PLUS** cylinder) at 90°. To our optometry friends though, WTR astigmatism requires correction (with a **MINUS** cylinder) at 180°. Either way, we know what refractive state the eye is in based on common WTR/ATR terminology.



Anatomy of a Glasses Prescription

Now that we have a solid foundation in astigmatism, we can talk about how a glasses prescription is written. A typical prescription has 3 numbers. The amount of spherical correction in diopters, the amount of cylindrical correction in diopters, and the axis of the cylinder in degrees. The sphere number can be thought of as the correction necessary to put the light rays from the strongest meridian on the retina. The cylindrical component can be thought of as the power required to then independently "pull" the weakest meridian onto the retina also. Again, keep in mind this is fiction because glasses are actually ground with **MINUS** cylinder but it's still helpful to conceptualize.



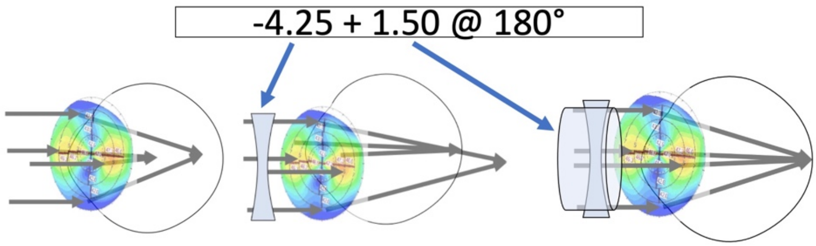
Remember that optometry typically works in **MINUS** cylinder, so you will see many refractions in this notation. Here is how to convert between **PLUS** and **MINUS** cylinder:

1. ADD sphere and cylinder
2. REVERSE the sign of the cylinder
3. FLIP the axis by 90°

For example, a prescription of -4.00 + 2.00 x 090° is equivalent to -2.00 - 2.00 x 180°. We only use 0° - 180° for simplicity. 270° is the same as 90°.

Even though it is entirely fictitious, it is helpful to think of glasses as a base spherical lens with a positive cylinder on top of it. Again, this is the opposite of reality but it's how ophthalmology refracts and conceptualizes cylinder. The following example considers a cornea with astigmatism belonging to a hyperope. This astigmatic cornea has two different radii of curvature that require two different powers to place an image on the retina because one is "further back" than the other. Picture using a normal convex, **PLUS**, spherical lens to put the farther forward picture on the retina. We're halfway there but we need to individually move the other axis to put it on the retina as well. We need a little more converging power only on that axis so we can use a cylindrical lens to "help out" where the cornea is flatter and contributing less converging power.

Manifest Refraction



Uncorrected, notice the "red bowtie" meridian has more refracting power so there are two focal points.

Spherical diverging correction added, we have pushed the whole refractive system back but there is still two focal points.

Cylindrical correction added, we have ADDED more converging (plus) power only to the flatter meridian of the cornea. We have only moved one focal point so now all the light focuses to one spot.

@EyeFlyMD

Note: This is oversimplified for two reasons. Cylinders don't make focal points; they make focal planes along the length of their axis. Also, glasses are ground with minus cylinder, but this is one easy way to think through a refraction.

Not all eyes have astigmatism though. The notation for only sphere is “DS” for “diopters sphere”. This is usually written in place of astigmatism for additional clarity. So, “-2.00 DS” represents a prescription of -2.00 spherical lens without any astigmatism correction. Axis should also have 3 numbers to eliminate confusion. Instead of writing “90” it’s better to write “090”.

Not all eyes even have refractive error. Emmetropic eyes with no astigmatism have no prescription and this is denoted by “Plano”, which simply means a prescription of +0.00 DS.

Spherical Equivalent

A final important consideration for prescriptions is the idea of “spherical equivalent” (SE). The technical definition of SE is the point where the “Circle of Least Confusion” lies between the two focal planes in an astigmatic optical system. The practical definition is SE represents the spherical lens that would provide the best possible vision in an eye with astigmatism. It is calculated by the following formula:

SE = SPHERE + ½ CYLIDNER

In our example of -4.00 + 2.00 x 090°, the spherical equivalent would be:

-4.00 + ½ (+2.00) = **-3.00**

A -3.00 spherical lens would give the best vision when using spherical lenses alone. Pay attention to the minus sign in minus cylinder. Remember that same prescription in minus sylinder is -2.00 - 2.00. The SE is:

-2.00 + ½ (-2.00) = **-3.00**

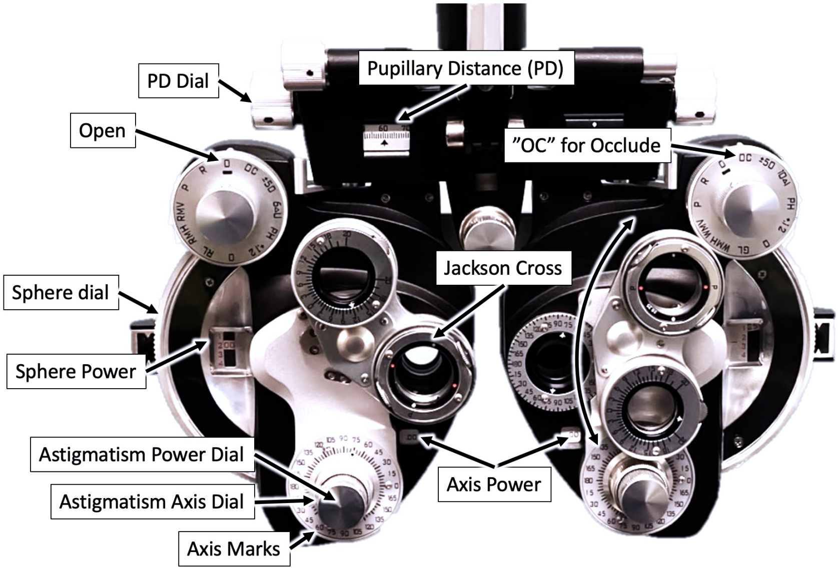
The spherical equivalent is the same because the minus sign from the cylinder led to a subtraction from sphere.

This is a good time to discuss the concept of the Jackson Cross. A Jackson Cross is a lens that has cylinder but an SE of 0. Examples include -1.00 + 2.00 x 090, -0.50 + 1.00 x 180, and -1.50 + 3.00 x 045. Calculate the SE of those lenses and see how they’re all Plano. They’re useful because they can help guide the prescription of cylinder as we’ll see shortly.

Refracting

Now we can finally talk about how to refract. There are autorefractors that can give a pretty good estimate of the refractive status of the eye, and these can be a good place to start.

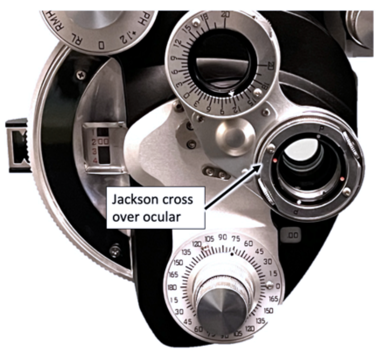
Manifest Refraction is the classic "Better one? Better two?" exam in the phoropter (pictured below). It's always easier to start from an autorefractor reading or from a previous pair of glasses. Put this in the phoropter. Sphere is adjusted by the large dials on the side and cylinder by the small dials surrounded by the axis markings. It's also important to know what kind of phoropter your clinic uses. They can be plus or minus cylinder. How do you think you can tell? The color of the cylinder window will tell you. If it's **BLACK** text, it's **PLUS** cylinder. If it's **RED** text, it's **MINUS** cylinder.



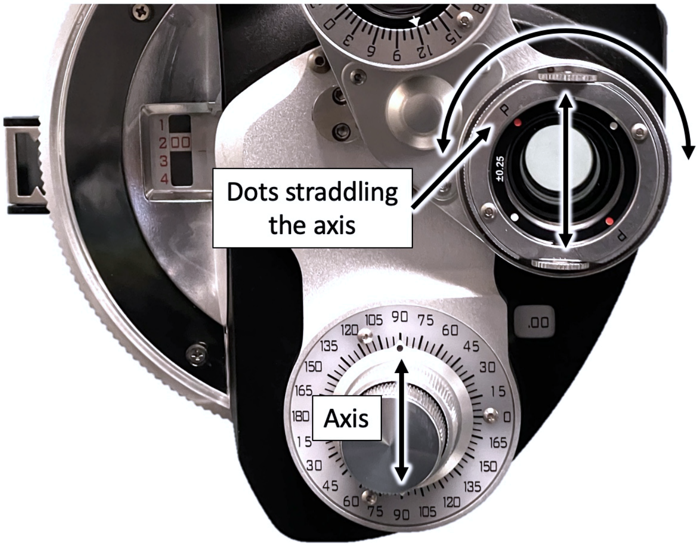
Here is an overview of how to perform a very routine refraction starting from an autorefraction or previous glasses prescription. You will find many ways to refract and many different preferences. This is just one method. I want to give special thanks to Kelli Shaon OD for teaching me refraction.

Summary of Refraction

1. Put the autorefraction or current glasses prescription in the phoropter.
2. Occlude one eye by turning it to “OC”, keep the other eye open on the “O” setting as in the diagram.
3. Have the patient read down the chart until they reach the smallest legible line. Go up by 1 line.
4. Blur their vision by adding +0.75 D of sphere (3 clicks on the big dial). This should make the line illegible.
5. Start progressively adding minus back in by asking “Better 1? Better 2?”. Patients need to “earn” minus. You’ll hear phrases like “eating minus” because it’s preferable for patients to be a little more minus than they need. Think about it, if you push the focal point behind the retina, you still can accommodate and pull the image forward with the natural crystalline lens. This means a constant state of accommodation and eye strain though, so it’s not preferable for eye doctors. “Push plus” is the rally cry. Another way to tell is to ask if the image is clearer or just darker and smaller. The Duochrome test (discussed later) also helps with this.
6. After landing in a good place with sphere, rotate the Jackson cross in front of the ocular. In the image, the right eye has the Jackson Cross engaged and the left eye doesn’t. The Jackson Cross also has two dots, a white dot and a red dot.



7. Twist the Jackson Cross over the ocular such that a red and white dot straddle the axis. For example, if the axis is set to 90°, the red and white dots should be sitting around 45° and 135°. This will help us find the axis of cylinder.



8. Flip the axis of the Jackson Cross back and forth using the little spin dial while asking "Better 1? Better 2?". The red and white dots will switch places. What you're doing is changing the axis that the cylinder is exerting its refracting effect. Whichever orientation patients prefer, turn the axis (outer dial) of the astigmatism knob in the direction of the WHITE dot. In **PLUS** CYLINDER notation, you'll hear about "chasing the WHITE dot". Turn it by 5°-15°. Once they start going back and forth or saying they look the same you've found the axis of power for the cylinder.

Better 1? **Better 2?**

9. Next, twist the Jackson cross such that a red/white dot (and "P") are ALIGNED with the axis. Now we're looking for power.

10. Flip the axis of the Jackson Cross back and forth using the little spin dial while asking "Better 1? Better 2?". The dots will change between red and white. What you're doing now with the Cross in this orientation is changing the amount of cylinder exerted on that axis. If the patient says the option with the WHITE dot aligned with the axis is better, increase the power. Again, chase the WHITE dot. If they prefer the **red** dot, decrease cylinder. Once they start going back and forth or saying they look the same you've found the amount of cylinder correction.
    a. For every +0.50 D (2 clicks) that astigmatism increases, decrease the sphere (large dial) by -0.25 D (1 click). This is to preserve the spherical equivalent.

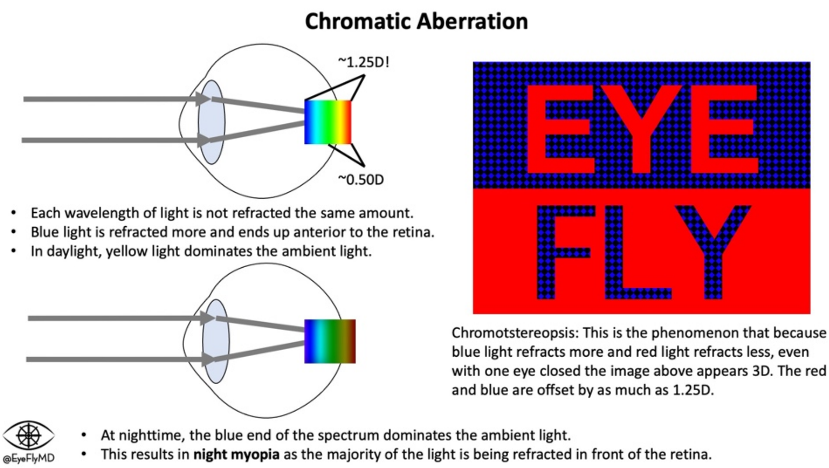
11. Lastly, fine tune the cylinder with one more round of "Better 1? Better 2?" keeping in mind to go as PLUS with the prescription as possible where they can still read 20/20 (or as good as they can).
12. Repeat for the fellow eye.

Lastly, "ADD" power for bifocals or transition lenses can be carefully determined using a prince rule (a small reading chart on a stick) but in reality, most patients do well with +2.50 D and this is the go-to for many clinicians.

Prism can also be prescribed to be built into lenses. The orientation of prism is set by base: up, down, in, or out.

The Duochrome Test

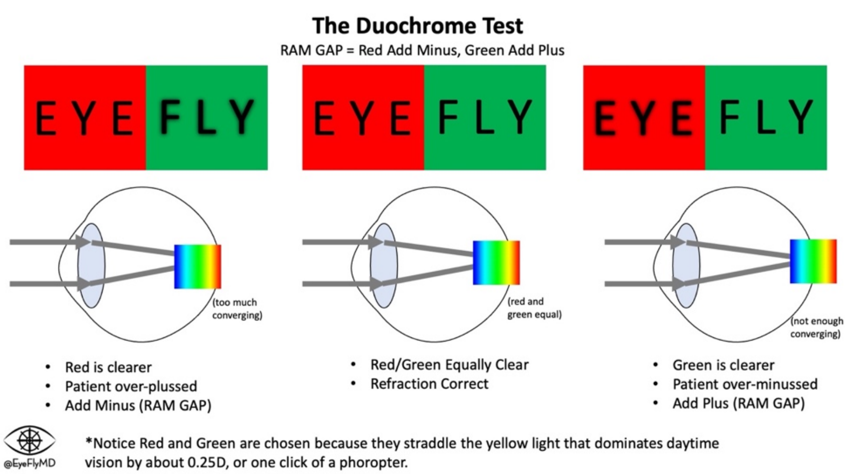
We mentioned earlier than the Duochrome Test can be used to ensure patients are not over minused. This is the Red and Green split background for the acuity charts. The basis is **chromatic aberration**. Not all light is refracted through a lens by the same amount. Shorter wavelengths are slowed more by optically dense substances. The visible color spectrum ranges from ~400-700 nm and there is about a 1.25 D difference between the blue (~400 nm) and red (~700 nm) range of the spectrum. If you look at the BLUE/RED image below, even with one eye closed it will look 3D because the blue is focusing slightly anterior relative to the red so the red appears closer.



Chromotstereopsis: This is the phenomenon that because blue light refracts more and red light refracts less, even with one eye closed the image above appears 3D. The red and blue are offset by as much as 1.25D.

If you had to pick one color to precisely fall on your retina, which would you choose? During the day, yellow light dominates the ambient spectrum, so this is the color for which we try to optimize vision. How positive are we, though, that the yellow spectrum is the one falling on the retina? Remember earlier we said that people will generally prefer a little more **MINUS** than **PLUS** because (especially young) eyes can dial in their own accommodation and pull the image forward onto the retina. To avoid allowing someone to "eat minus" we can perform the **Duochrome Test**. This involves overlaying the Snellen (or other) chart on a red and green background. Why red and green though? Well, we just said yellow light dominates the daytime atmosphere and red and green tend to straddle the yellow spectrum by about 0.25 D on either side.

The mnemonic **RAM GAP** can help us remember what to do depending on what the patient reports seeing. If the **red** side is clear but the **green** side is blurry then this means the **red** part of the spectrum is falling on the retina and there is too much converging power (**PLUS**) so we need to "add **MINUS**." In the opposite circumstance where the **green** side is clearer than the **red** side then there is too much diverging power (**MINUS**) so we need to "add **PLUS**." Hence, **RAM GAP** = **Red** Add **Minus**, **Green** Add **Plus**. Visual acuity needs to be at least 20/30 in each eye for this test to be effective.

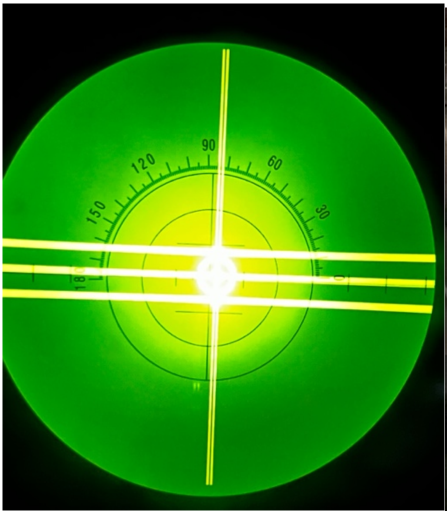


Lensometers/Lensmeters

We mentioned one way to start an MRx is to see what a patient's current prescription is. There are automated ways to read a glasses prescription, but the TOP-CON Lensmeter is one of the most common ways to do this manually.

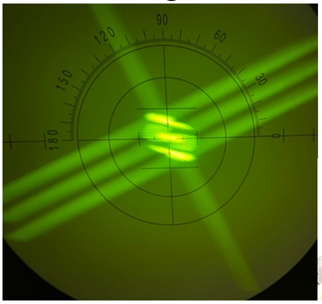
Basic Steps of Using a Manual Lensmeter

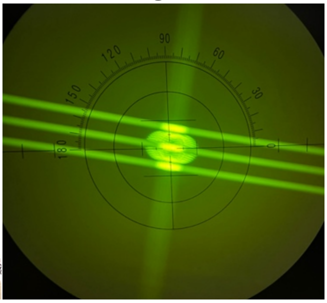
1. Place the pair of spectacles on the table (arms back) and secure them with the holder. The device should look through the optical center of the lens.
2. Turn the light on (usually a button).
3. Look through the ocular. The power knob is rotated until the cross (both large and small focusing bars) are clear (as pictured; it's really difficult to photograph this by the way). The large and small focusing bars will only be in focus at the same time if the lens is purely spherical.
4. The power knob indicates the prescription of the lens.



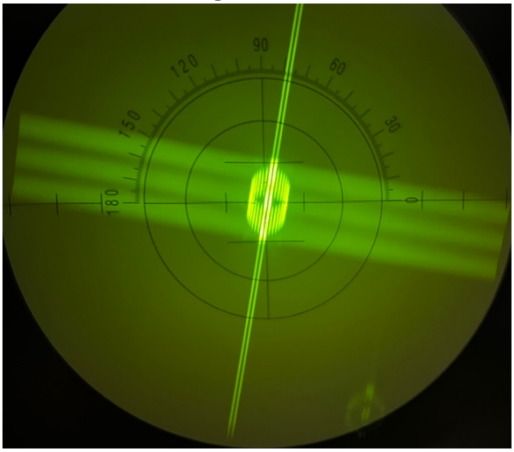
5. If there is any astigmatism, remember **F**ocus **F**at **F**irst. That means (for **PLUS** cylinder), focus the large bars first and the small bars second. The axis w
6. Once the large bars are in focus (and thin bars are out of focus), take note of the power, this is the sphere. The axis wheel will need to be rotated until the center circles appears aligned with the large bars for maximum focus.

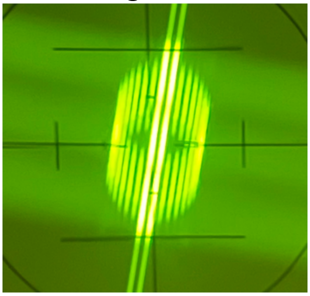
Not aligned **Adjust Axis** **Aligned**





7. Lastly increase power until the small bars are in focus. The difference in power between the large bars being in focus and the thin bars being in focus is the amount of astigmatism. The axis of astigmatism is the lower power in which the large bars were in focus and circles aligned.





This is a good picture of what alignment of the axis circles looks like.

For example, if the large bars were in focus and the circles aligned at -2.50 x 170° and the thin bars in focus at -1.50, then the prescription is -2.50 +1.00 x 170°.

Add power can also be measured by a lensmeter. It is possible to discern prism as well but that is beyond this this scope.

To determine the add power on progressive lenses, a special machine with green lights and a magnifier is used. The add power stamped on the lens becomes illuminated by the green light.

For completeness, here is an image of an autorefractor and an automatic lensmeter. The autorefractor is a great way to to get pupillary distance (PD) which helps lensmakers craft glasses.

Autorefractor

Automatic Lensmeter

Streak Retinoscopy

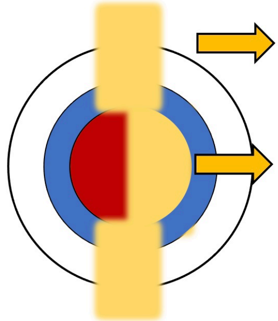
Lastly, we have to consider cases where the patient can't answer "Better 1? Better 2?". This is especially useful in pediatric clinic using free lenses (or paddles with lenses on them) but can also be done using the phoropter.

The essence of streak retinoscopy is to sweep a light back and forth from a retinoscope until the reflex is neutralized. A big pupil makes this easier on anyone, but children especially should be cyclopleged (have their ciliary body paralyzed) so they can't accommodate. Children can accommodate a *lot*, as in over 10 diopters. If they're increasing the prescription of their eye during refraction by accommodating, then the refraction will be more minus to cancel the accommodation as a result. Over minusing children is especially bad as it can lead to myopia progression. A cycloplegic refraction is sometimes called a "wet refraction."

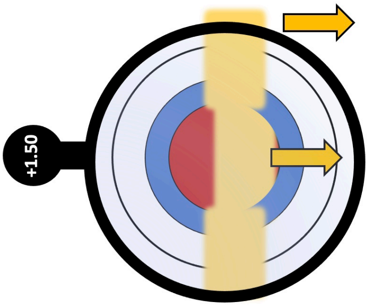
Here is the retinoscope. It emits a beam shape of light. There is a plastic collar underneath the head that is adjustable by both rotating it (which changes the axis of the beam) and moving it up and down. The collar should always be kept at the bottom of its range.

Basic Steps of Streak Retinoscopy

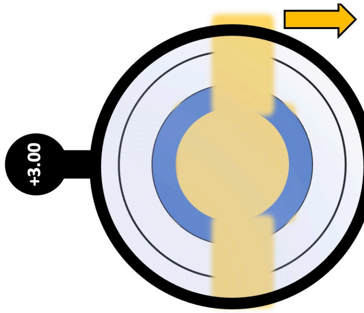
1. Make sure you have "with" motion or try minus lenses until you have with motion of the streak in the eye.



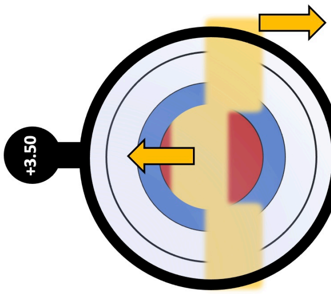
2. Go more "plus" until the streak is totally neutralized.



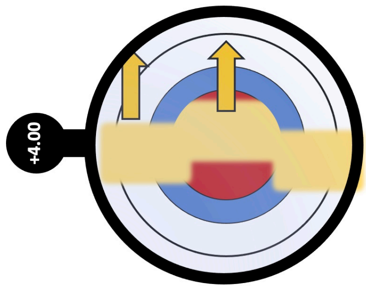
3. The reflex is neutralized when there is no apparent motion with movement of the streak.



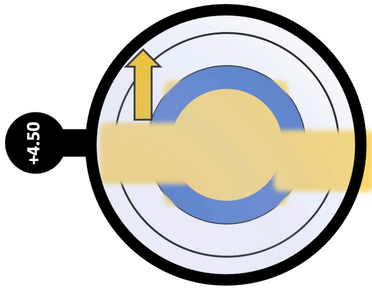
4. Too much plus results in “against” motion of the streak.



5. Check 90° away, if the streak isn’t neutralized then there is astigmatism.



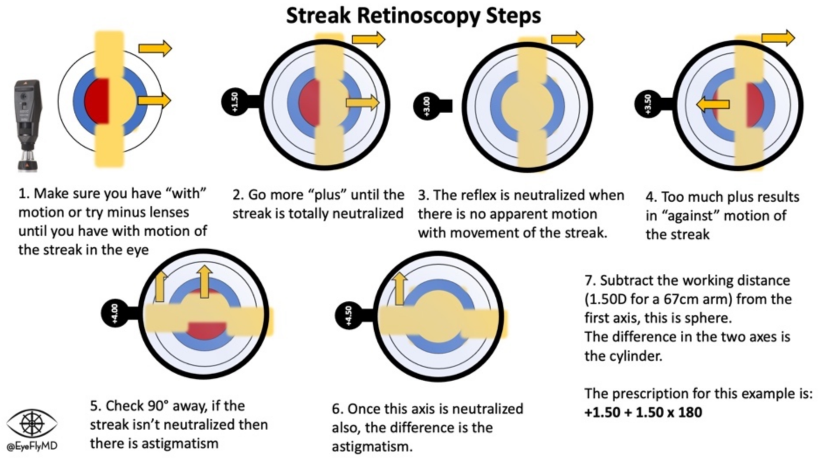
6. Once this axis is neutralized also, the difference is the astigmatism.



7. Subtract the working distance (1.50D for a 67cm arm) from the first axis, this is sphere. The difference in the two axes is the cylinder.

The prescription for this example is: **+1.50 + 1.50 x 180.**

Remember, streak retinoscopy can be done using the phoropter as well for patients who have no glasses to base a prescription off of or if an autorefractor is not available.



Contact Lenses

Fitting contact lenses is a complex topic. Contact lenses have a diameter and base curve that must be carefully fit to each patient. Additionally, there isn't a one-to-one relationship between the spectacle prescription and contact prescription. Contact lenses have a smaller *vertex distance* than glasses. That is the location of the refracting element with respect to the nodal point. Contact lenses sit much closer to the eye, so a correction is necessary. There are also many types of contact lenses including soft, daily, rigid, scleral, and even toric contacts that are weighted to maintain their orientation on the eye.

Normal Exam

Here is an example of normal prescription.

Eye	Sphere	Cylinder	Axis	ADD	Prism	Base
OD	-2.25	+1.25	095	+2.50		
OS	-2.00	+1.50	080	+2.50		
PD	62					

External Exam

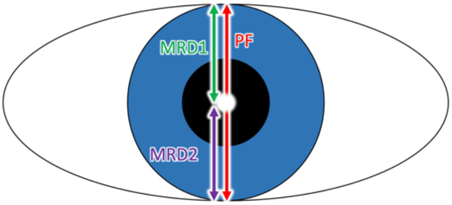
Ptosis

The ptosis exam involves taking several eyelid measurements, many with respect to the pupillary light reflex. Time to get the muscle light out again.

Palpebral Fissure (PF) is a measure between eyelids at the axis of the pupil. A normal measurement is 9 to 12 mm.

Margin to Reflex Distance 1 (MRD1) is the distance between the *upper* eyelid and the pupillary light reflex.

Margin to Reflex Distance 2 (MRD2) is the distance between the *lower* eyelid and the pupillary light reflex. MRD1 + MRD2 should equal palpebral fissure height.



Levator Function (LF) is the distance the upper eyelid travels from downgaze to upgaze. It's sometimes necessary to hold the brow down while measuring this to prevent the patient from using the frontalis muscle. > 10 mm is normal.

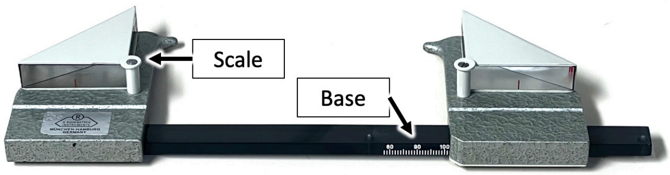
Bell's Phenomenon refers to the upward movement of the globe when the eyelids are forcefully closed. It's important to record if this reflex is intact since it can be a protective mechanism for the cornea.

Another crucial piece of a ptosis evaluation is photographs before and after administering phenylephrine. A picture is always worth a thousand words.

Cogan's lid twitch refers to the overshooting of the upper lid when a patient goes from downgaze to upgaze and can be suggestive of myasthenia gravis.

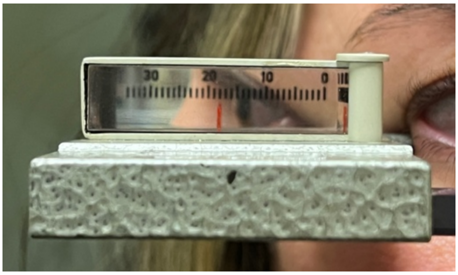
Hertel

The most common cause of unilateral or bilateral proptosis (bulging eyes) is thyroid eye disease (TED). Proptosis can be measured by use of a Hertel Exophthalmometer.



Overview of Hertel Exophthalmometry

1. The notches are set against the patient's orbial rim.
2. The base measurement is taken.
3. The examiner should look with the same eye (examiner's right eye to patient's right eye) through the portion with the mirrors, aligning the red lines. The patient looks into the examiner's open eye.
4. Measure the most anterior portion of the cornea.
5. Repeat for the fellow eye.



Von Graefe's Sign refers to lagging of the upper eyelid on downgaze (i.e., when looking down it takes a second for the upper lid to cover the globe) and can be a sign of TED.

Normal Exam

Here is an example of a normal external eye exam.

Eyelid Measurements

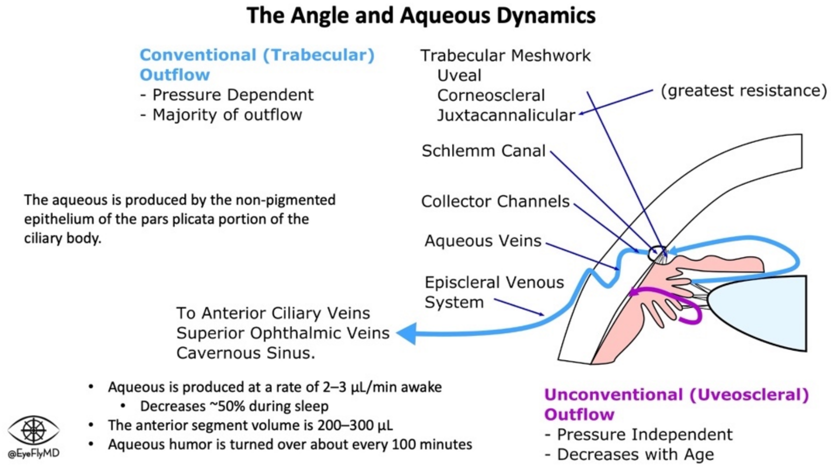
	Right	Left
PF	10 mm	10 mm
MRD1	4 mm	4 mm
MRD2	6 mm	6 mm
LF	15 mm	15 mm
Bell's	Present	Present

Hertel Exam
Base: 97 mm
OD: 18 mm
OS: 18 mm

Dilation and Gonioscopy

Dilation

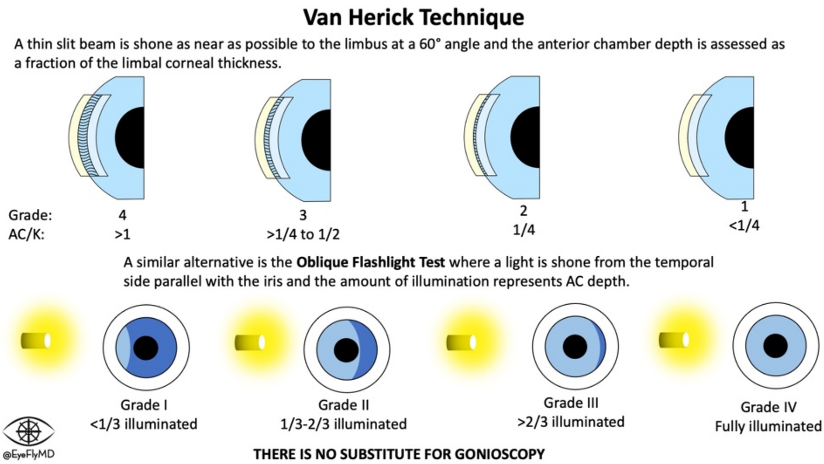
Before dilating, we need to be confident that this won't induce angle closure. Recall the anatomy of the angle below.



If the angle is too narrow, a dilated iris could obstruct the trabecular meshwork and cause an abrupt rise in IOP.

Two quick screening tools for anterior chamber depth are the Van Herick and Oblique flashlight test. The Van Herick Technique involves shining a slit beam from the slit lamp at an angle of 60° near the limbus. The distance between the corneal endothelium and iris is compared to the limbal corneal thickness (based on the slit beam passing through it). If there is a full "limbal corneal thickness" or more of space near the angle, then the anterior chamber is usually sufficiently deep.

An even simpler screening test is the oblique flashlight test. A light source (hello again muscle light) is held temporally parallel to the iris. There should be no obstruction and the light should easily illuminate the entire iris/anterior chamber. If the iris is casting a shadow, this could indicate a shallow anterior chamber.



When it comes to dilating, this varies by clinic but typically **Proparicaine** (a sodium channel blocker) is administered first to provide anesthesia for both tonometry and subsequent drops that can sting or burn.

Tropicamide (a non-selective muscarinic antagonist) is an anti-cholinergic drop that inhibits parasympathetic drive to the pupillary sphincter. The result is pupillary dilation. It also binds to muscarinic receptors of the ciliary body to prevent accommodation. On average, onset begins in 20 minutes and effect last for 6 hours. Other medications in this class are cyclopentolate and atropine. **Cyclopentolate** has a stronger cycloplegic affect in children which is essential for obtaining an accurate refraction. For this reason, cyclopentoalate is often used to dilate children. On average, onset begins in 30 minutes and the effects last for 24 hours. **Atropine** is much longer acting and is more common in other applications (like dilation to prevent synechiae in uveitis) than routine dilated exams. On average, onset begins in 1 hour and effect lasts 7 days.

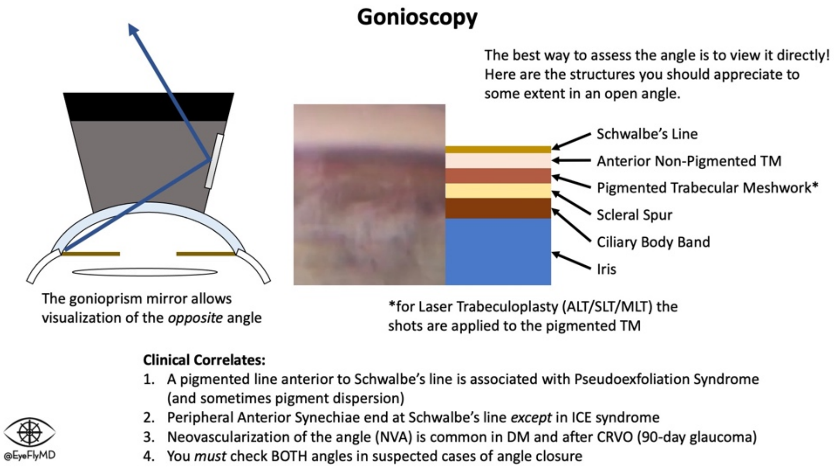
Phenylephrine (an alpha-1 receptor agonist) acts as a sympathomimetic to directly contract the pupillary dilator muscle. A common formulation is 1%. Higher concentrations like 10% may affect blood pressure.

It’s important to remind consultants that the effects of even tropicamide may cause pupil irregularities for 24 hours.

Gonioscopy

There is NO substitute for gonioscopy when evaluating the angle. Neither van Herick, the oblique flashlight test, anterior segment ocular coherence tomography, or ultrasound biomicroscopy are adequate substitutes for visualizing the angle. A question that comes up frequently is why we can't simply see the angle by moving the slit lamp in the right place. The answer is because of total internal reflection of the air-tear film interface. Gonioscopy involves using a lens or prism to visualize the angle. The lens is called a gonioprism. There are different types of gonioprisms including Koeppe, Barkman, Zeiss, Possner, and Sussman. Koppe and Barkman lenses allow direct visualization of the angle while the rest use mirrors.

Dynamic gonioscopy (aka compression gonioscopy or indentation gonioscopy) involves applying pressure with the gonio lens to see if the angle can deepen. If applying pressure doesn't deepen the anterior chamber and allow more angle structures to be visualized then there may be peripheral anterior synechia (PAS). PAS are adherences of the iris to the angle structures. Only Zeiss, Possner, and Sussman style lenses can perform dynamic gonioscopy.



Gonioscopy Grading

The **Shaffer System** is based on the angular width of the angle.

Shaffer Gonioscopic Grading System	
Grade 4	45°-35°; wide open
Grade 3	35°-20°; wide open
Grade 2	20°; narrow
Grade 1	$\leq$ 10°; extremely narrow
Slit	0°; slit

The **Sheie System** is based on the most posterior visible structure.

Scheie Gonioscopic Grading System	
Wide Open	All structures visible
Grade 1	Iris Root
Grade 2	Ciliary Body Band
Grade 3	Trabecular Meshwork
Grade 4	Schwalbe's Line

The **Spaeth System** is extremely complex and uses several metrics including iris insertion, peripheral iris appearance, and trabecular meshwork (TM) appearance.

Spaeth Gonioscopic Grading System			
Iris Insertion	**Angle**	**Peripheral Iris**	**TM Pigment**
A: Anterior to Schwalbe's	0°-50°	**r: r**egular	0 – no pigment
		s: steep	1+ – minimal
B: Behind Schwalbe's		**q: q**ueer	2+ – mild
		f: flat	3+ – moderate
C: S**C**leral Spur		**b: b**owed	4+ – intense
D: Ciliary Body (**D**eep)		**p: p**lateau	
		c: concave	
E: Extremely Deep			

Lastly, the Becker Goniogram is a standardized drawing of gonioscopic findings.

Immediately notice that some of these systems are the inverse of each other. For example, a “Grade 4” Shaffer angle is wide open while a “Grade 4” Scheie angle is very narrow. My unsolicited opinion on these is that while they may facilitate quick communication between glaucoma specialists, they’re complex and confusing and it may be better to just describe what you’re seeing. For example:

Open to CB 360, 2+ TM

contains essentially the same information as

E45r2+

but is easily understandable to any ophthalmologist.

One of the most common gonio lenses is the G-4 Gonio (pictured here). A gonio with 4 mirrors makes the most sense since it’s common to report findings in quadrants, always remember with mirror lenses you’re actually looking at the opposite angle (e.g., the top mirror visualizes the inferior angle). This is a Sussman style lens.

Dilation is generally considered safe if two quadrants of trabecular meshwork are visible.

Normal Exam

Here is an example of a normal gonioscopy exam.

<u>Gonioscopy:</u> With a Sussmann Style 4-mirror lens
OD: Open to CB 360, 2+ TM, no PAS
OS: Open to CB 360, 2+ TM, no PAS
Impression: Open OU

Dilated with Tropicamide 1% and Phenylephrine 1% at 0945 01/22/23

The Slit Lamp Exam

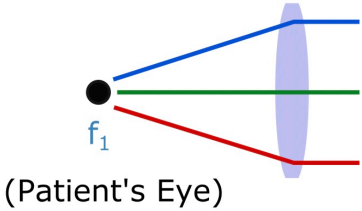
The Slit Lamp

After all that, we've finally made it to the quintessential ophthalmology tool: the Slit Lamp Biomicroscope. It is literally a microscope for examining the eye and produces a stereoscopic view and a slit shaped beam (that can be widened to a circle). Slit lamps date to the early 1900s.

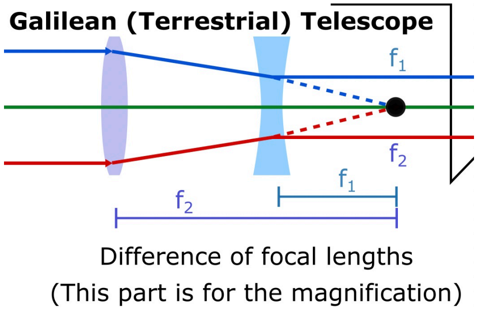
Slit Lamp Optics

The optics of the slit lamp have very little clinical utility but do appear in board questions.

First, the patient's eye must be placed at the ***primary focal point (f_1)*** of the slit lamp's objective lens. This means the light rays will exit the lens with zero vergence (all parallel to each other) and upright. For a review of focal points, please see Page 29 or *The Eye Guide: Anatomy and Optics.*

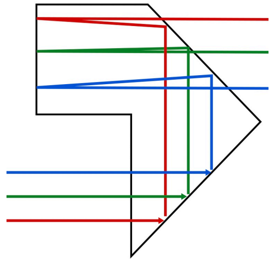


The magnification portion of the slit lamp uses principles of a Galilean (terrestrial) telescope. The low plus objective lens and high minus eyepiece are separated by the difference in their focal lengths. The light rays again leave with zero vergence and upright.



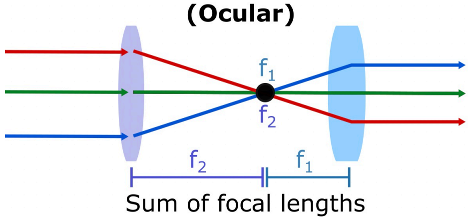
The light rays are then inverted using a Porro-Abbe prism. They exit the prism with zero vergence but inverted which is equivalent to a 180° rotation.

Porro-Abbe Prism



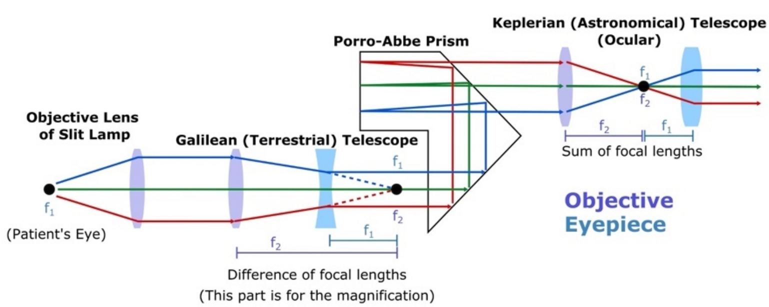
The ocular (eyepiece of the slit lamp) uses principals of a Keplerian (astronomical) telescope. The low plus objective lens and high plus eye piece are separated by the sum of their focal length. The light rays leave the eyepiece portion inverted but since the light rays entered inverted they are now upright.

Keplerian (Astronomical) Telescope (Ocular)



Here is a summary of slit lamp optics.

Optics of a Slit Lamp

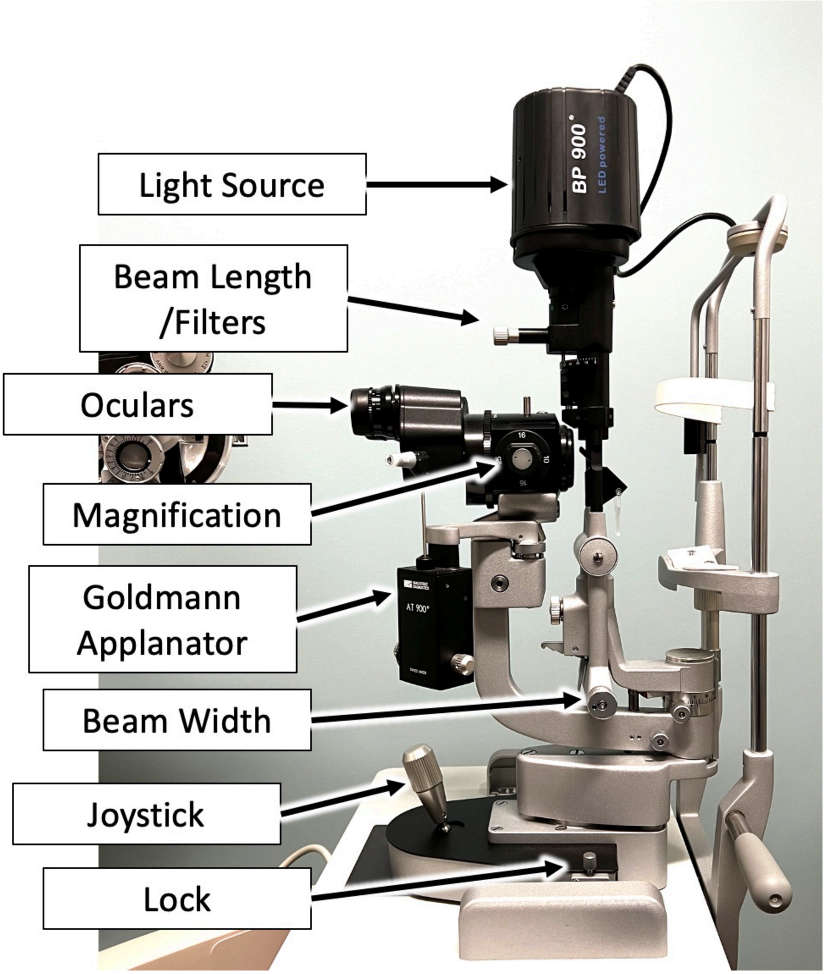


@EyeFlyMD

Anatomy of a Slit Lamp

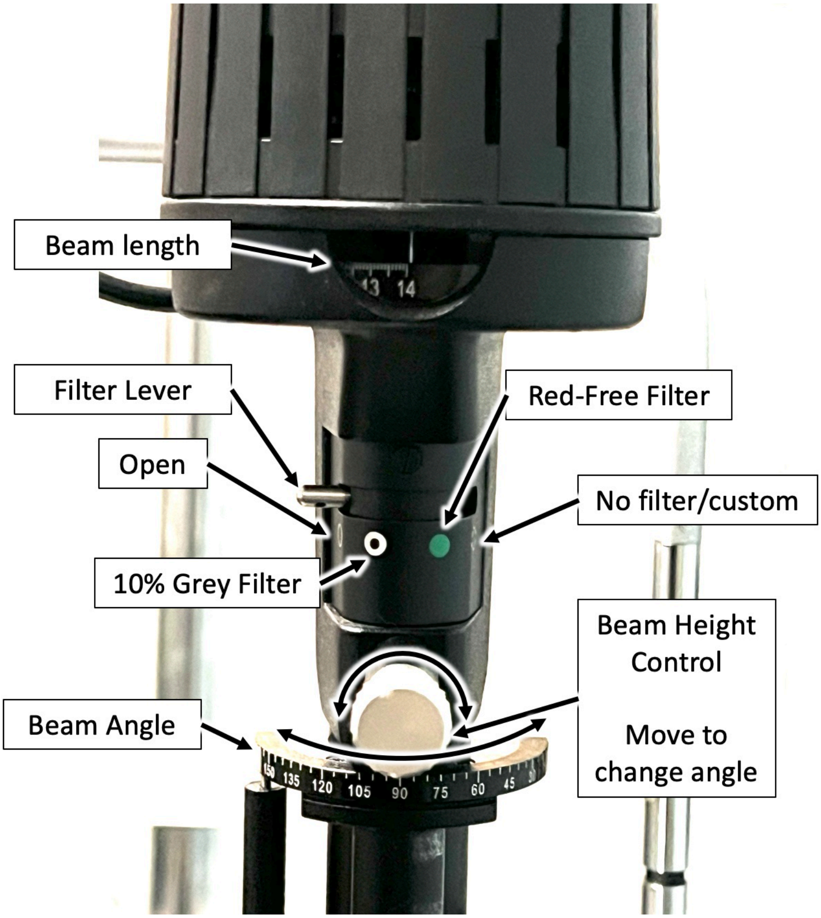
Like everything we've discussed so far, slit lamps vary wildly in appearance and design. I use a Haag-Streit slit lamp in this example because it's very common but there are many different types.

Here is an overview of the entire device.

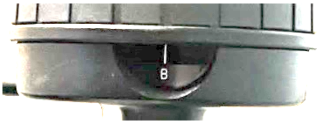


The light source can either be an incandescent bulb or LED.

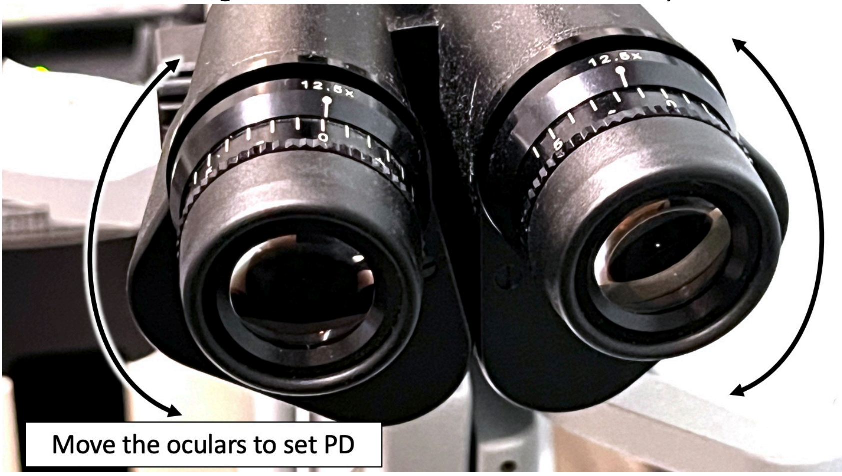
The light source has many levers that control the nature of the slit beam. You can control the length of the slit beam, filters, and angle of the beam. The scale for the height of the beam is in millimeters and combining this with the ability to rotate the entire beam makes it easy to take measurements of lesions. The red-free filter is great for visualizing veins, arteries, and the nerve fibers.



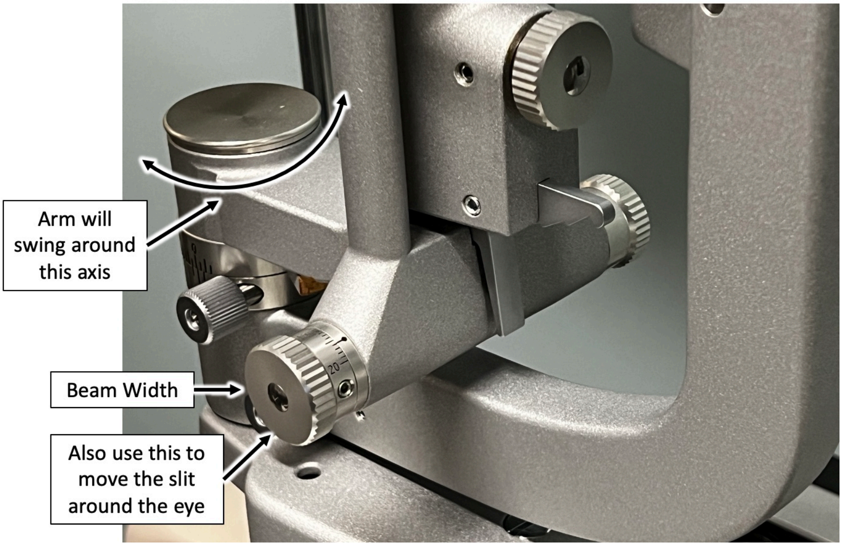
Rotating the length past 14 mm engages the **Cobalt Blue** filter for the fluorescein exam.



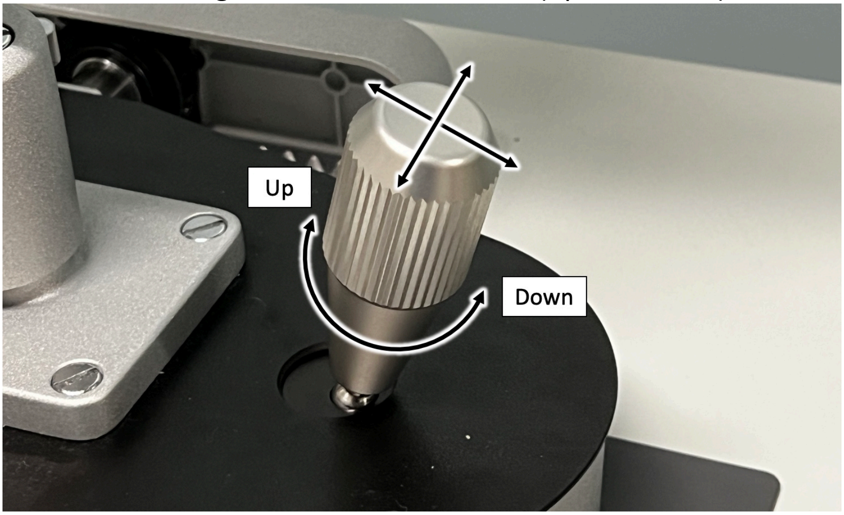
The oculars should produce a clear stereoscopic view. Make sure the pupillary distance is comfortable to you. The little dials at the end of the oculars are for setting the refraction of the examiner but assuming you wear correction for distance vision then the light should be set to "0" for both eyes.



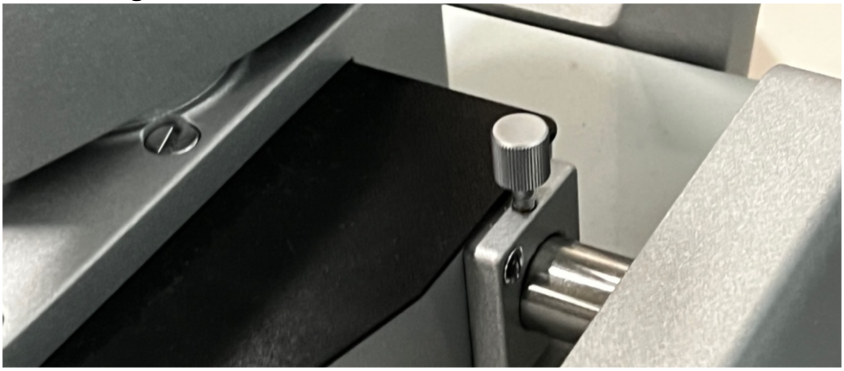
The width of the beam is set by the dial. The dial is also used to swing the arm of the slit beam around. The maximum with and length is 14 mm.



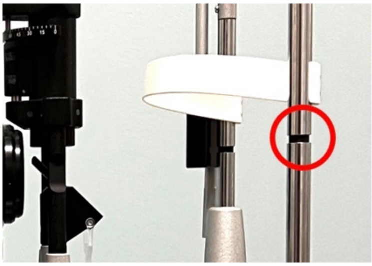
The slit beam is focused and moved around using the joystick. Moving the joystick around controls the “X-Axis” and “Z-Axis”. Twisting it controls the “Y-Axis” (up and down).



Don’t forget to lock and unlock the slit lamp by twisting the locking screw.



A final helpful tip is to make sure the patient’s lateral canthus is in line with this black mark so the eye is well within the slit beam’s excursion.



Slit Lamp Exam

General

Some of the internal medicine exam still applies. In fact for billing purposes a general medical exam is often required, so take note of orientation, breathing, mood/affect, etc.

Adnexa/External

Then, observe around the eye for any lesions or swelling. Many eye diseases present *around* the eye such as herpes zoster ophthalmicus. Even allergic reactions to eyedrops can cause periorbital dermatitis. Make note of any abnormality on the face or around the orbits.

Lids/Lashes

Next, carefully examine the eyelids and eyelashes. Make note of any lesions, edema, ecchymosis, blepharitis, meibomian gland dysfunction, or any other abnormality.

Conjunctiva/Sclera

The sclera should be white and conjunctiva free of any follicles and papillae. Note any unusual injection, hemorrhages, concerning findings, pterygia, etc.

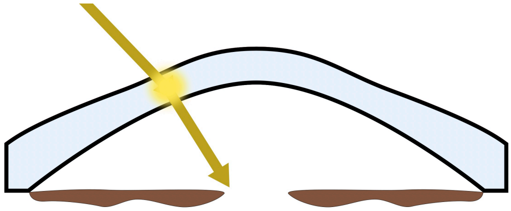
Cornea

This is a good time to carefully examine the tear film. Take note of Tear Breakup Time (TBUT). This is easier to see with fluorescein instilled but this is essentially how long it takes for dry spots on the cornea to develop. Fluorescein can also reveal punctate epithelial erosions and other surface disease.

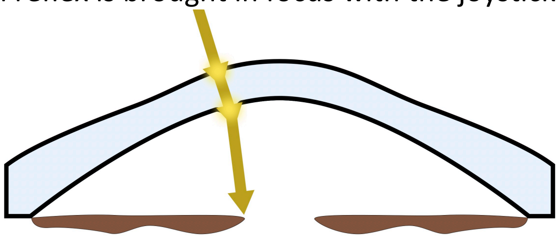
There are 4 reflections of the slit beam when examining the eye: the anterior surface of the cornea, the posterior surface of the cornea, the anterior surface of the lens, and the posterior surface of the lens. These are called Purkinje reflexes.

There are several methods for examining the cornea.

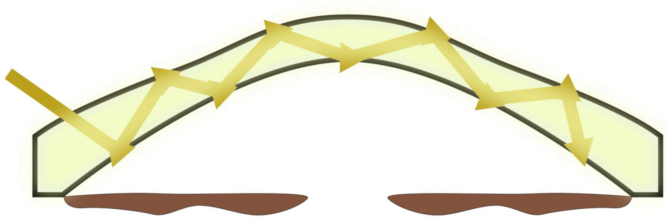
Direct (Focal) Illumination involves moving from a broad to narrow beam (~1 mm). This is helpful for evaluating cornea edema, thinning, infiltrates, or endothelial pathology (e.g., guttae).



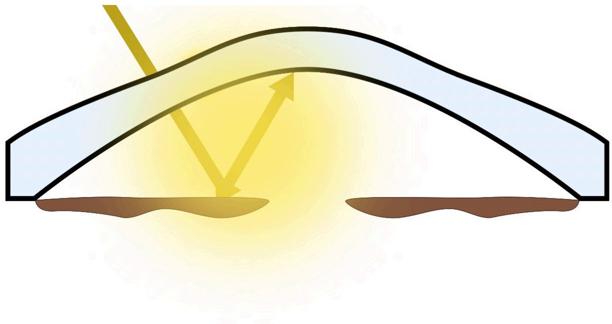
Specular Reflection involves using the light reflex on the corneal surface to detect any abnormalities in the tear film or underlying cornea. This applies to the posterior cornea and endothelium as well. The arm of the slit lamp is set to ~60° and the beam is set to a short, small slit. Next, look for the reflection of the light source and its Purkinje light reflex on the anterior and posterior cornea. The endothelial Purkinje reflex is overlaid on the light source mirror image to produce a glare and then the endothelial reflex is brought in focus with the joystick.



Sclerotic Scatter is a form of indirect illumination using total internal reflection (the same reason we can't directly visualize the angle by just using the slit lamp). A bright beam is shone near the limbus, scatters off the sclera, and causes the cornea to glow. This highlights opacities, edema, and verticillata among other things. It's also great for viewing the endothelium.



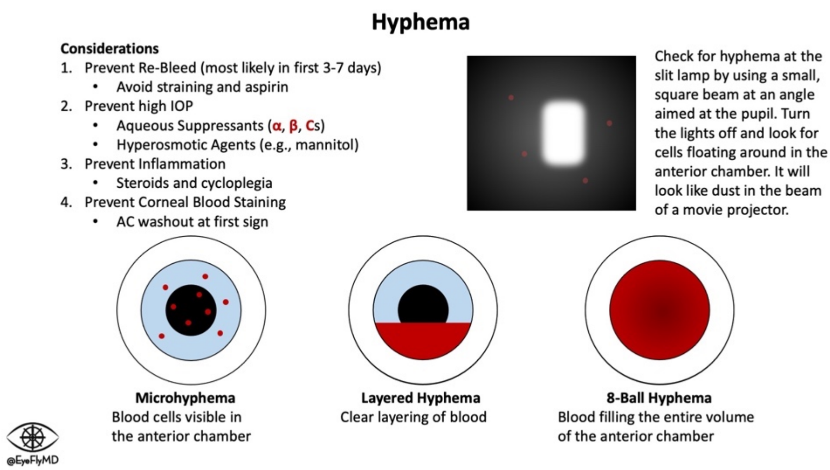
Retroillumination is commonly used to help visualize the lens but can also help visualize the cornea (especially opacities). A tangential beam is directed on the iris while observing the cornea.



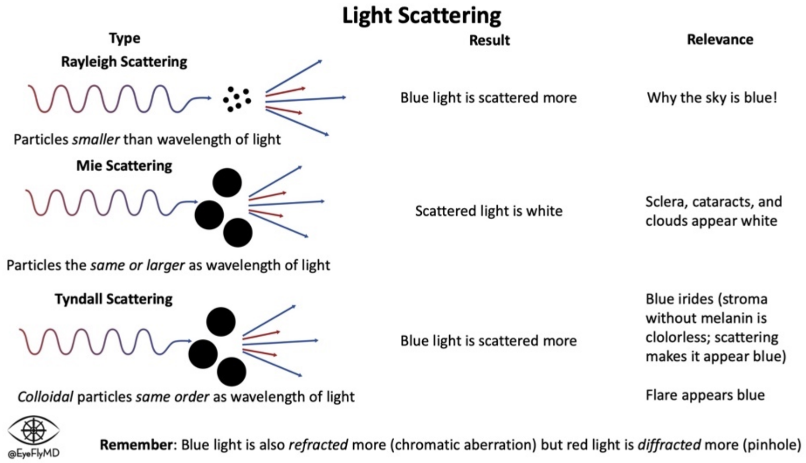
The cornea portion of the exam can be very extensive. It's important to note tear film health and any signs of abnormality or pathology including scars, limbus neovascularization (especially for contact lens users), pterygia, edema, or endothelial guttae.

Anterior Chamber (AC)

The anterior chamber should be assessed for overall architecture (e.g., depth). To evaluate for any cell or flare, make a very small (1 mm x 1 mm) square with the slit lamp beam. It's analogous to looking at dust in the beam of a projector. A microhyphema presents as red blood cells in the AC.

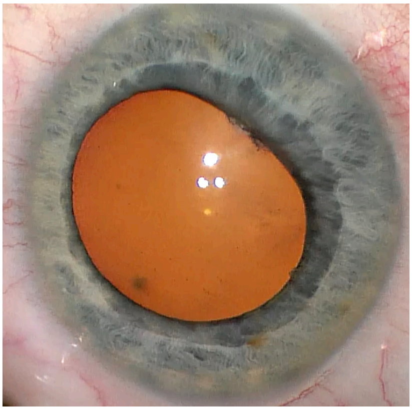


Flare refers to proteins in the AC which scatters light and spreads it in multiple directions.

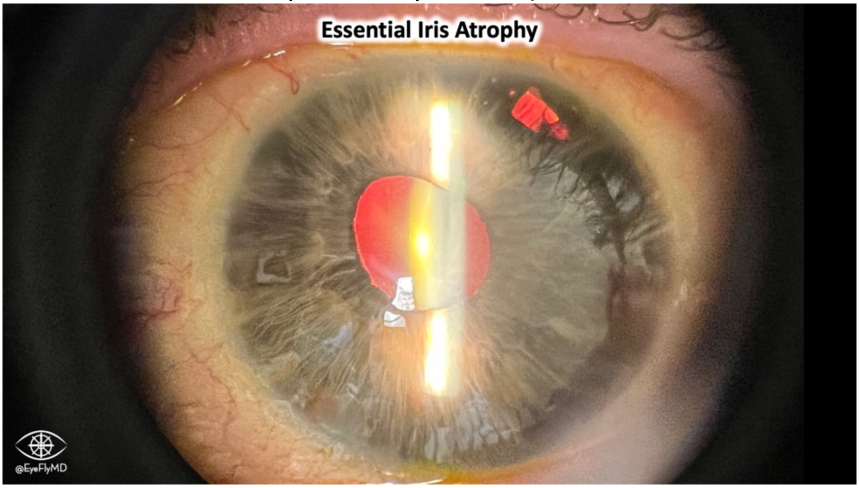


Iris

The iris should be evaluated for overall architecture (e.g., two humps in the iris can be a sign of plateau iris syndrome). Make note of any posterior synechia or TIDs (transillumination defects). Posterior synechia are adhesions between the iris and anterior lens capsule. Here’s an example in a surgical setting.

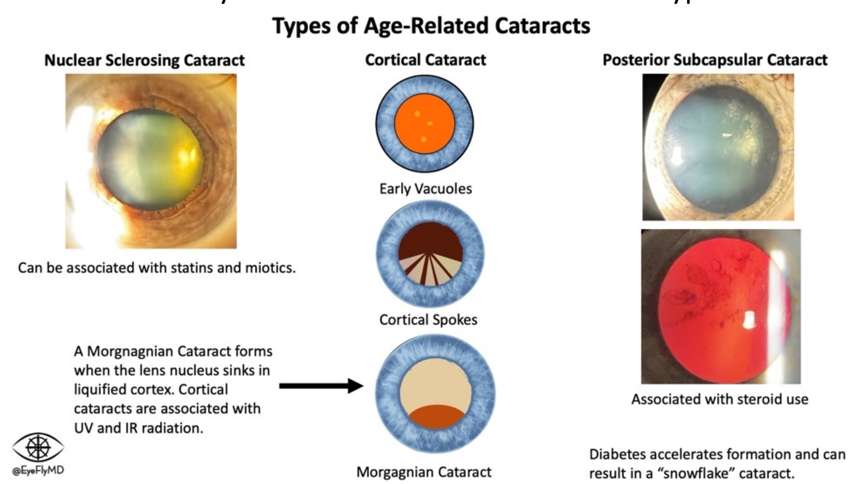


Transillumination defects are best seen by using retroillumination again. Align the slit beam straight through the pupil to elicit the red reflex. This makes it easy to see thin spots in the iris. Here’s an example of TIDs in Essential Iris Atrophy (a form of iridocorneal epithelial syndrome).



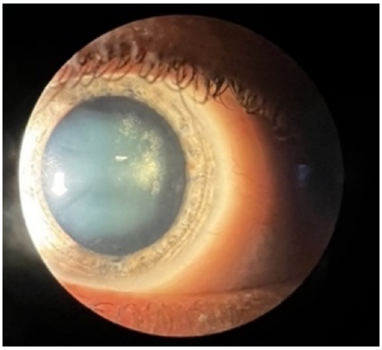
Lens

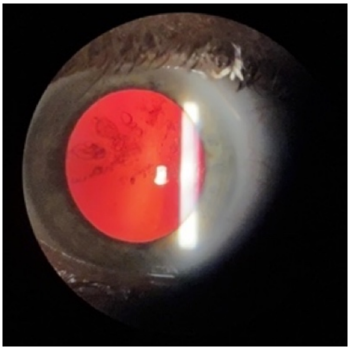
The lens has the other two Purkinje reflexes. The slit beam should be visible on the anterior and posterior portion of the lens. Always note if the patient is phakic (natural lens), pseudophakic (an IOL), or aphakic (no lens). Describe the lens and if there is any cataract. Here is a review of the types.



Retroillumination is essential for examining the lens because it allows any subtle opacities (e.g., cortical vacuoles, posterior capsular opacification) to become more visible.

Without Retroillumination **With Retroillumination**





Cataracts and posterior capsular opacifications can be graded on a scale of 1-4 but this can be quite subjective. Sometimes it's better to just describe what you see, e.g.:
Trace NSC with dense cortical spokes to visual axis.

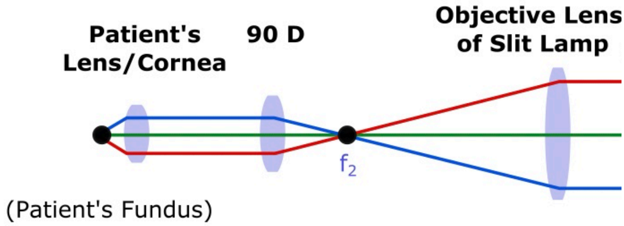
Vitreous

Focusing the slit beam posterior to the posterior capsule allows visualization of the anterior vitreous. The vitreous should be clear and visible floaters are typical. Using a similar technique as visualizing cell in the anterior chamber, evaluate for the presence of cell in the vitreous. Pigmented cell in the anterior vitreous is call *Shaffer's Sign* (aka tobacco dust) and is associated with retinal detachment. The vitreous can also appear hazy if there is a hemorrhage. Make note if the media to the back of the eye is not clear.

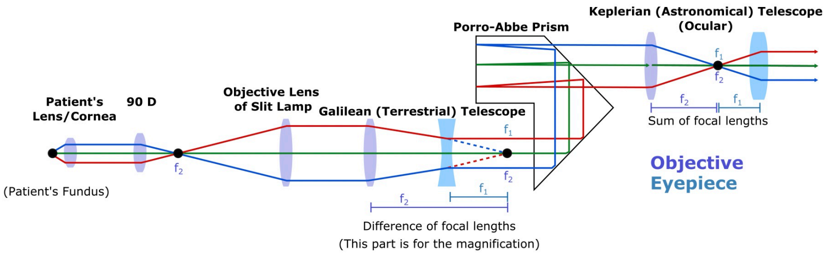
Fundus Exam

The anterior vitreous is the extent of what can normally be evaluated with the slit lamp alone. Lenses are needed to see the posterior pole. This can be accomplished by using high diopter plus lenses (usually between 60 D - 90 D). An example of a slit lamp lens is pictured here.

It's important to consider the consequence of adding this additional, high power plus lens to the slit lamp's optical system because it does have an important clinical correlation. Don't forget, we're now looking through the patient's optical system as well.



You might immediately notice a major difference with this optical set up so let's zoom out.



The image is now inverted from the perspective of the examiner. The fundus is essentially 180° rotated from reality.

Overview of Fundus Exam

1. Align the slit beam with the pupil.
2. Place the lens between the eye in the path of the slit beam.
3. Move the slit lamp backwards to focus on the retina.

It takes time to master this and to get a feel for "working distance" which is how close to hold the lens to the eye.

Here is a brief review of the anatomy of the fundus.

Anatomy of the Macula

Macula	Between the Arcades	5.5 mm	GCL ≥ 2 cells
Perifovea	Farthest from center	1.5 mm ring	
Parafovea	Rim around fovea	0.5 mm ring	Thickest retina
Fovea	Center of Macula	~ 1 DD (1.5 mm)	All Cones
Foveola	Just within FAZ*	~ 1 cup (.35 mm)	GCL/INL Absent
Umbo	Center of Fovea		

The **PERI**fovea is the furthest from the center because if forms a **PERI**meter.

The fovea contains 10% of the total cone population.

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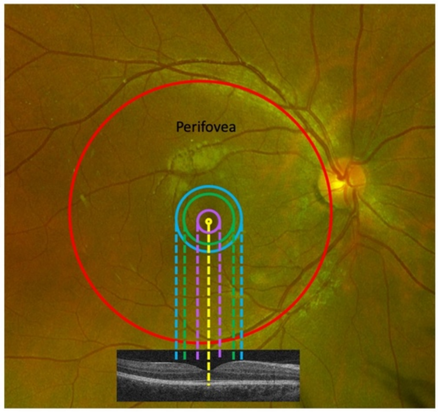
*Foveal avascular Zone, where the inner retina blood supply (from central retinal artery) disappears

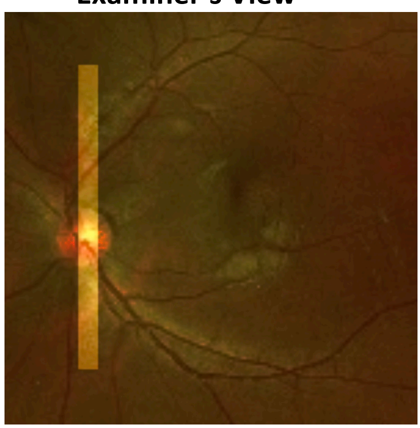


Additionally, the measurement of beam length is now inaccurate. It's no longer a 1:1 relationship when using a lens. There are special lenses that maintain the 1:1 ratio but a conversion factor must be used if taking measurements of the fundus. It's common just to measure lesions in "Disc Diameters" (DD) as this is always ~ 1.5 mm.

Putting it all together, remember if a lesion appears on the superior arcade, it's actually on the inferior arcade.

Reality (OD)

Examiner's View



Nerve

To examine the nerve, ensure that the margins are sharp and no vessels are obscured (this could be a sign of disc edema). Measure the optic cup in relation to the optic disc, it should be ~ 0.3 of the optic disc. A larger than normal cup/disc ratio is characteristic of glaucoma. Examine the rim for notching or thin spots. Note any hemorrhages or irregularities including peripapillary atrophy or abnormal disc insertions.

Macula

The macula should be flat. Changes in contour of the slit beam might indicate elevation from edema. Take note of any drusen or irregularities. Remember, as you saw in the pictures on the previous page, younger patients will have a sheen on their internal limiting membrane (ILM). This ILM sheen is normal but can trick new examiners. Look for any diabetic changes in the macula including dot-blot hemorrhages, cotton wool spots, or exudative changes. Note any irregularities in the retinal pigment epithelium. Describe what you see that isn’t typical and where you see it.

Vessels

The vessels should not be too tortuous and there should be no irregularities when they cross each other (which may indicate hypertensive changes). It’s hard to see, but diabetes can appear in the vessels as microaneurysms.

Some lenses (e.g., the Volk Super Field®) allow visualization of the periphery of the retina by asking the patient to look up, down, left, and right. To fully visualize the entire retina out to the ora serrata, binocular indirect ophthalmoscopy must be used.

Normal Exam

Here is an example of a normal slit lamp exam.

General: Patient Alert and Oriented, nonlabored breathing, mood and affect appropriate.

Slit Lamp Exam:	OD	OS
Adnexa/External:	no edema/lesions	no edema/lesions
Lids/Lashes:	no lesions	no lesions
Conjunctiva/Sclera:	white and quiet	white and quiet
Cornea:	Clear	clear
AC:	deep and quiet	deep and quiet
Iris:	Round	round
Lens:	phakic, clear	phakic, clear
Vitreous	Clear	clear

Fundus Exam:	OD	OS
Nerve:	0.3, sharp, flat,	0.3, sharp, flat,
Macula:	flat, dry	flat, dry
Vessels:	Normal	normal

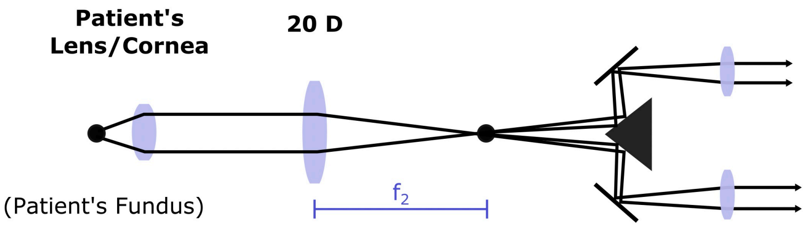
Indirect Ophthalmoscopy

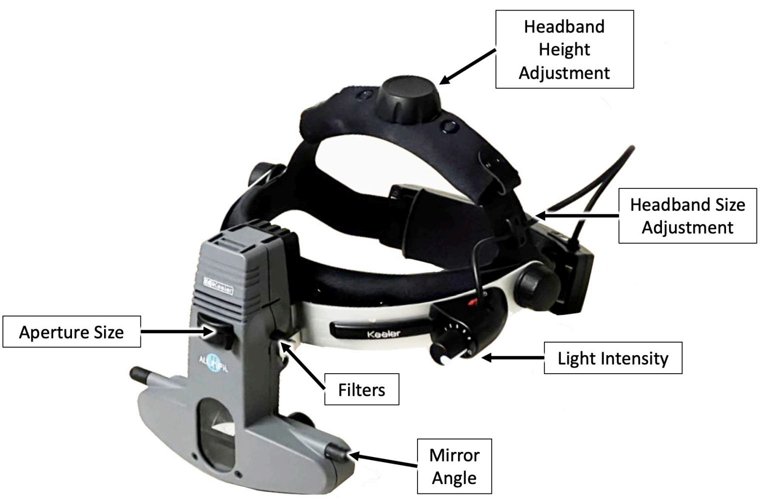
Overview

Binocular indirect ophthalmoscopy uses a lower power lens (usually 10 D – 30 d) and a headlamp. Headlamps can have many appearances. Some examples of indirect lenses are pictured.

Like everything else, this involves sophisticated optics. The condensing lens forms an image of the retina in the air. This image is adjusted for pupillary distance by using mirrors and a low plus lens is used in the ocular portion of the headlamp (like a pair of reading glasses).

This image is also *inverted*, so think of everything as rotated 180°.





The amount of magnification can be simplified to 60 divided by lens power. For example, a 20 D indirect lens has a magnification of 60/20 = 3X.

Different lenses have different advantages. The 20 D provides excellent magnification while the 28 D provides an excellent field of view.

Because of the lack of magnification relative to viewing the fundus at the slit lamp, determining C/D might be difficult.

Overview of Indirect Ophthalmoscopy

1. First, position the headlamp comfortably. Look at your hand and adjust the PD so that both eyes are centered on the same spot.
2. Next, elicit the red reflex by looking into the patient's eye and place the lens over the eye at the correct working distance (distance between the eye and lens).
3. Ask the patient to look up, down, left, and right to visualize the entire retina.

Here's an example. You can tell this is a left eye so you'd think the nerve would be inserting on the left (nasally) but remember the image is essentially flipped 180°. This disc is edematous.

The indirect exam takes time to master. Remember to check the published manufacturers' working distances for their lenses. There will be a light reflex from the headlamp on the anterior and posterior surface of the lens. Align these reflexes to ensure you're looking through the center of the optic and the lens isn't tilted.

Scleral Depression

To fully observe the retina out to the ora serrata, scleral depression is often required. This is the use of a blunt instrument (usually a metal stick as pictured below) to press the globe from the outside to bring the far periphery into view. There are many different methods to accomplish this.

This definitely takes time to learn and probably shouldn't be attempted until very comfortable with the rest of the exam.

Normal Exam

The peripheral exam can be lumped in with the rest of the fundus exam. Again, there's a lot of ways to do this depending on preference.

General: Patient Alert and Oriented, nonlabored breathing, mood and affect appropriate.

Slit Lamp Exam:	OD	OS
Adnexa/External:	no edema/lesions	no edema/lesions
Lids/Lashes:	no lesions	no lesions
Conjunctiva/Sclera:	white and quiet	white and quiet
Cornea:	clear	Clear
AC:	deep and quiet	deep and quiet
Iris:	round	Round
Lens:	phakic, clear	phakic, clear
Vitreous	clear	Clear

Dilated with Tropicamide 1% and Phenylephrine 1% at 0945 01/22/23

Fundus Exam (90D):	OD	OS
Nerve:	0.3, sharp, flat,	0.3, sharp, flat,
Macula:	flat, dry	flat, dry
Vessels:	normal	normal
Periphery (20D):	no holes/tears	no holes/tears

Summary

As we've seen, the eye exam can be quite extensive. It is usually not necessary to do every exam maneuver on every single patient every single time. For example, patients rarely require gonioscopy every single visit. Not every patient requires the IOP accuracy of Goldmann applanation. A scleral depression might not always be indicated. The exam ultimately is usually tailored to the purpose of the visit and symptoms. Just to have it all together in one place, here is an example of a (very comprehensive) normal eye exam.

Visual Acuity

	sc	cc	cCL	Ph
OD	20/30-2	20/20		NI
OS	20/30+1	20/20		NI

Current Rx:

Eye	Sphere	Cylinder	Axis	ADD	Prism	Base
OD	-2.00	+1.0	100			
OS	-2.25	+1.25	075			

Manifest Rx:

Eye	Sphere	Cylinder	Axis	ADD	Prism	Base
OD	-2.25	+1.25	095	+2.50		
OS	-2.00	+1.50	080	+2.50		
PD	62					

Color Vision: 14/14 OU (Ishihara)

Pupils:
Round, equal, and reactive to light; no RAPD
Light: 2.0 mm OU
Dark: 4.0 mm OU

IOP: 15/15 (tp)

Stereo
Fly: Yes
Circles: 9/9

Alignment: Ortho
Method: Cover-Uncover
Correction: sc

	0 0 0		0 0 0	
	0 0	Ortho Ortho’	0 0	
	0 0 0		0 0 0	

Head posture: Straight
Nystagmus: None

<u>Gonioscopy:</u> With a Sussmann Style 4-mirror lens
OD: Open to CB 360, 2+ TM, no PAS
OS: Open to CB 360, 2+ TM, no PAS
Impression: Open OU

Dilated with Tropicamide 1% and Phenylephrine 1% at 0945 01/22/23

<u>General</u>: Patient Alert and Oriented, nonlabored breathing, mood and affect appropriate.

<u>Slit Lamp Exam:</u>	<u>OD</u>	<u>OS</u>
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Vitreous	Clear	clear

Dilated with Tropicamide 1% and Phenylephrine 1% at 0945 01/22/23

<u>Fundus Exam (90D):</u>	<u>OD</u>	<u>OS</u>
Nerve:	0.3, sharp, flat,	0.3, sharp, flat,
Macula:	flat, dry	flat, dry
Vessels:	normal	normal
Periphery (20D):	no holes/tears	no holes/tears

Conclusion

I know what it was like as a student/new resident and how intimidating the eye exam initially was. It takes time to learn. It's much easier to report "lung sounds are coarse" on Internal Medicine wards than to report "myopic discs with some lattice at 6 o'clock OS" in the ophthalmology clinic. To even have the skill set to examine an eye takes time and dedication to develop. Repetition and practice are critical for anything in life. Examine a lot of eyes and it gets a lot easier. A thorough examination is crucial for every ophthalmologist. For example, corneal scars may interfere with LASIK flaps and certain TID patterns can be indicative of weak zonules in preparation for cataract surgery. Dedicate yourself to perfecting the exam and it will make everything else, including surgery, easier.

If there are any other common exam techniques that I'm missing here and you feel should be included, please let me know and I will add them.

I also want to thank everyone who taught me and continues to teach me the eye exam. I wish I had something like this when I was a student/new resident so I hope you have found it helpful.

Notes:

This book series is dedicated to my first teachers:
Raymond & Helen Holderle

Thank you for reading! Please submit any errors, feedback, questions, or inquiries to matt@eyeflymd.com.

The Eye Guide: The Eye Exam

This short book is a summary of high-yield topics in performing a typical eye exam. It covers subjects including the scientific basis for visual acuity, pupils, intraocular pressure, external exam and strabismus, gonioscopy, IOP, dilation, refracting, reading prescription lenses, and the optics and method of the slit lamp and dilated fundus exam. The eye exam can be intimidating and the details are rarely taught in medical school. Hopefully this guide demystifies the ophthalmic physical exam.

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: @eyeflymd