Correction with Single Vision Spectacle Lenses

Lecture for Residents

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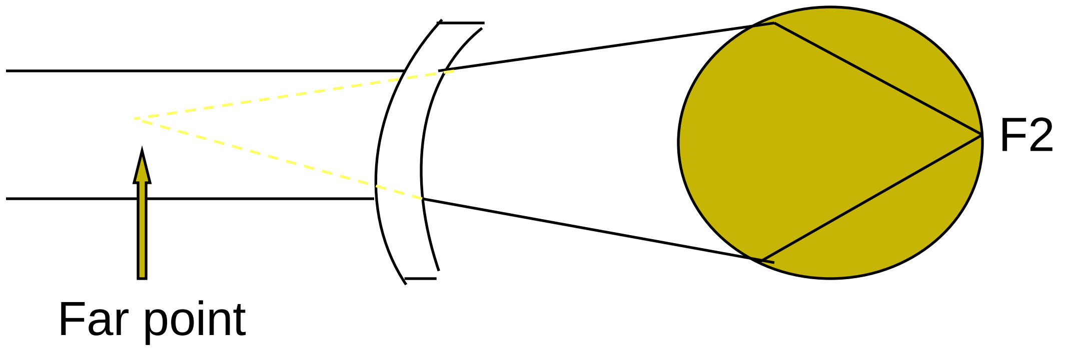
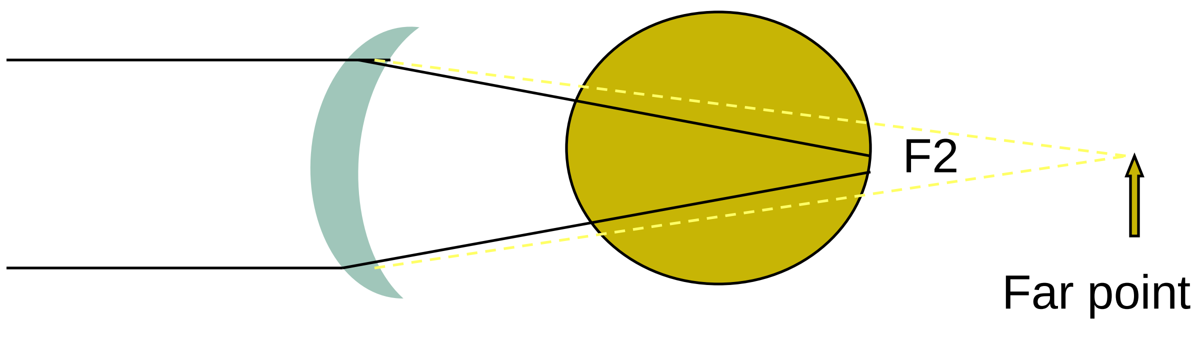
Lens Shape and Power

A lens corrects a refractive error if the secondary focal point coincides with the far point (punctum remotum) of the eye with accommodation relaxed.

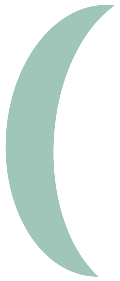




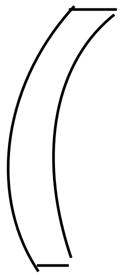
Lens Shape

- In most cases, a meniscus lens is used
  - Both lenses concave towards the eye
    - Best off axis optical quality
    - Room for eyelashes

Meniscus Convex



Meniscus Concave



Trial lenses, phoroptors etc use other types where field of view is irrelevant

Lens Power

- **Back Vertex Power** $F_v = (F_1/(1-(t/n_2)F_1)) + F_2$
  - Spectacles and contact lenses
- **Equivalent (true) power** $F_{eq} = F_1 + F_2 - ((t/n_2)F_1F_2)$
  - Low vision aids b/c relates to mag
- **Approximate Power** $F_{approx} = F_1 + F_2$
  - Ignores lens thickness “thin lens power”
- **Front Vertex Power** $F_a = F_2/(1-(t/n_2)F_2)) + F_1$
  - Obtained by hand neutralization
- **Effective Power** $F_e = F/(1-dF)$
  - Used for vertex distance

Hand Neutralization of lenses

- Plus lenses induce against motion
- Minus lenses induce with motion
- Can neutralize astimgatic lenses (each meridian separately)

Problem type

- 50 yo wm has OTC readers that work well. You have no lensometer.
  - What type of lens can you use to neutralize his glasses?
  - Which type of motion will the readers induce?
  - What will happen to the motion when the glasses are neutralized?

Identification of Lenses by Hand Neutralization

- Study the image formed by the lens!
  - Spherical lenses do not induce distortion
  - Plus lenses give against motion
  - Minus lenses give with motion
  - Astigmatic lenses cause distortion
  - Prism displaces cross marks towards the apex

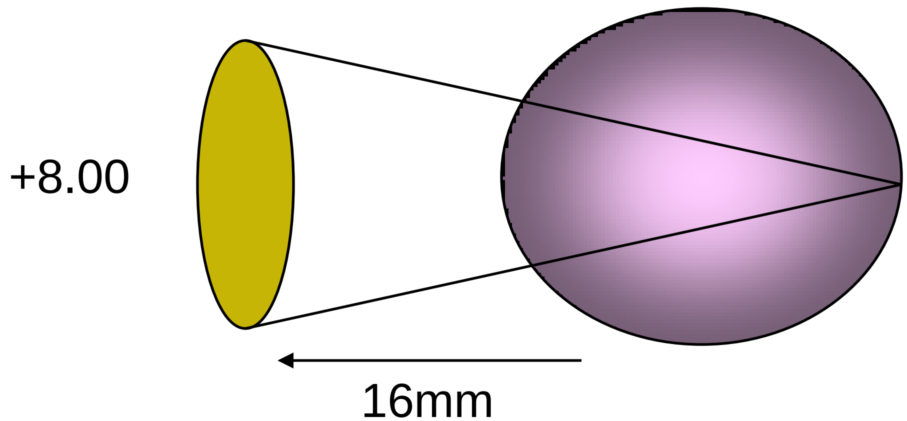
Identification of lenses

- The image formed by a lens will stop moving once the power is neutralized
  - So a +3.00 DS lens will cause against motion but when combined with a -3.00 lens, there will be no motion.
  - For torics, each meridian neutralized separately.

Effective Power

- The back vertex power varies with the position of the lens in front of the eye
  - Important for high power lenses (>4D)
  - Contact lens conversions
  - Lasik/refractive procedures!!!!!
- + lens more + as it is moved away from eye
- - lens less – as it is moved away from eye
- Affects accommodation
  - Myopes lower accom demand….
  - Hyperopes more accom demand….

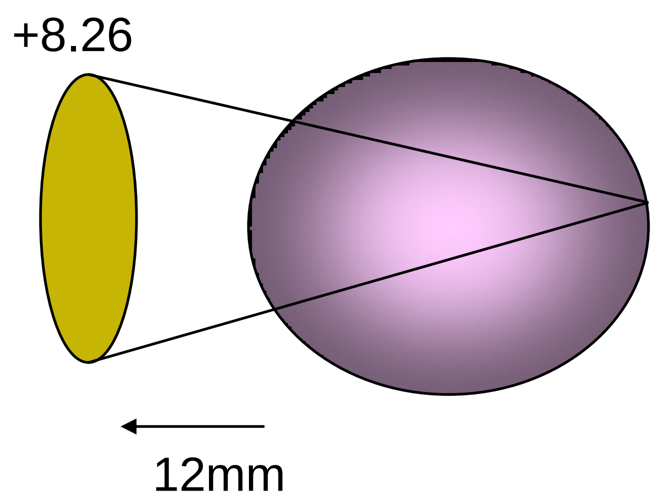
Effective Power- vertex distance



+8.00 lens has f2 of 12.5cm with 16mm vertex

The focal length needed at 12mm is 12.5 - .4, or 12.1cm

The power is then 1/.121
Or +8.26D



The focal length must be 4mm shorter so lens has to be STRONGER.

Gen Formula

Fe=F/(1-dF)

d=change in vertex (m)
+ to eye, - ex eye

DISTOMETER

Problem type- vertex

- 45 yo WF w/ Rx of -12.00 wants to know why she sees better at near with her glasses compared to her contact lenses.
- If you are to fit her with contacts for optimal distance vision, what would you prescribe for contact lens power? (-10.16)
- What if she is a +12D hyperope? (+14.63)

- A) Fe=12/1-(0.015)(12)
- Fe=12/0.82
- Fe=14.63D

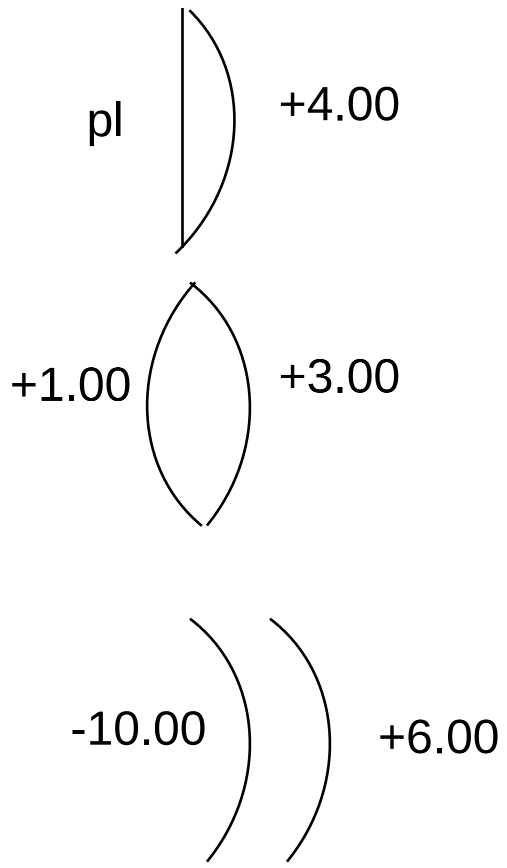
- B) Fe=-12/1-(0.015)(-12)
- Fe=12/1.18
- Fe=-10.16

Fe=F/(1-dF) d=.015

Lens Transposition

- Relates to base curve of the lens
  - Any lens power is the algebraic sum of the two surfaces (approx power)
  - Base curve defined as std curvature ground on to the lens
  - Lens aberrations (oblique astig/curvature of image) minimized with correct selection of base curve

I want a +4.00 DS lens



Lens Transposition- sphere

- You need to make a -3.00 lens.
- The front base curve is a +12.00. What is the back surface curve going to be?

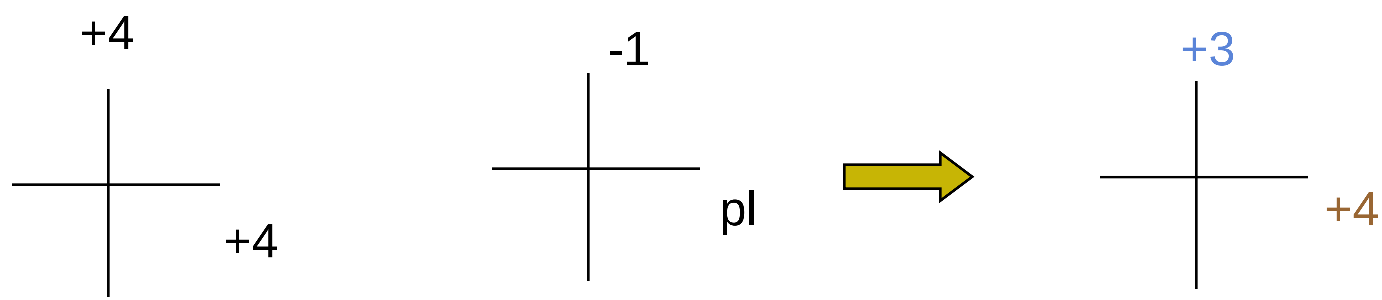
Toric Transposition

- Nearly all lenses are now made with minus cylinder, a meniscus design where front surface is sphere and the back is toric
  - -1.00 = -100x 180
  - This has been shown to have superior optics
- Plus cyl designs have the toric surface on the front and are now obsolete
  - Plano = +1.00 X 090

Toric transposition

- Made with one sph surface and one toric surface.
- The principal meridian of weakest power of the toric surface is the BASE CURVE

$$+4.00 = -1.00 \times 180$$



If the front curve is +10 D sphere

Ex from chapter

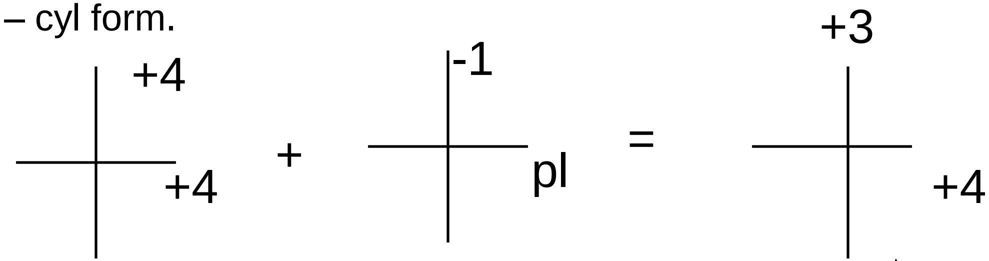
Toric Transposition

Example: Transpose +3.00 DS/+1.00x090 Base curve -6D

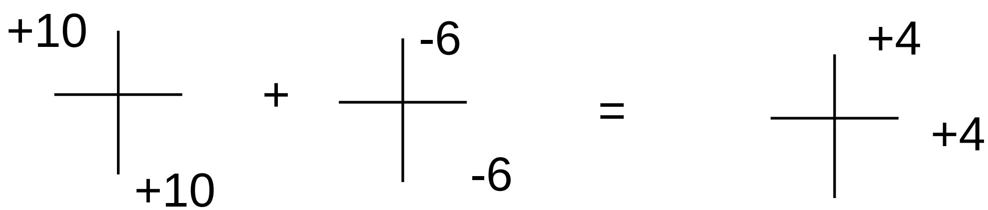
1) Put into Rx form +3.00= +1.00 x 090 note that the cyl is not the same Sign as the bc, so must transpose to – cyl form.

2) +4.00 = -1.00 x 180

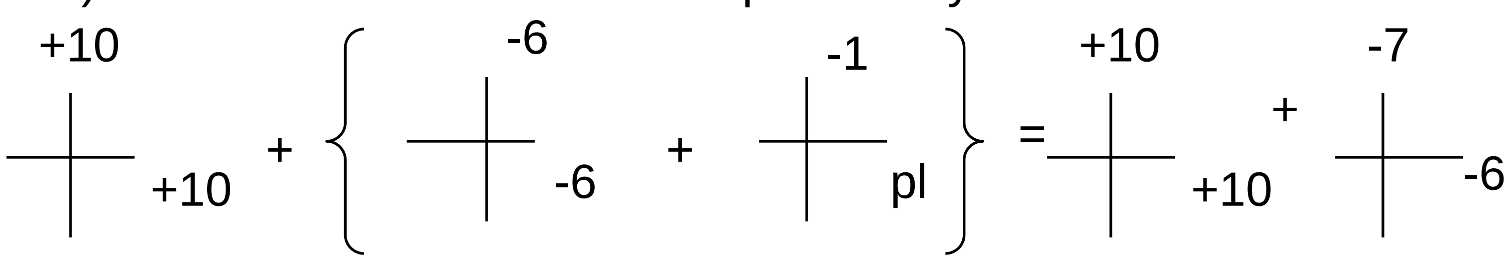
Think about this in optical crosses:



3) Calculate power of sphere surface: sph-BC 4-(-6) = +10



4) Now combine the base curve plus the cyl



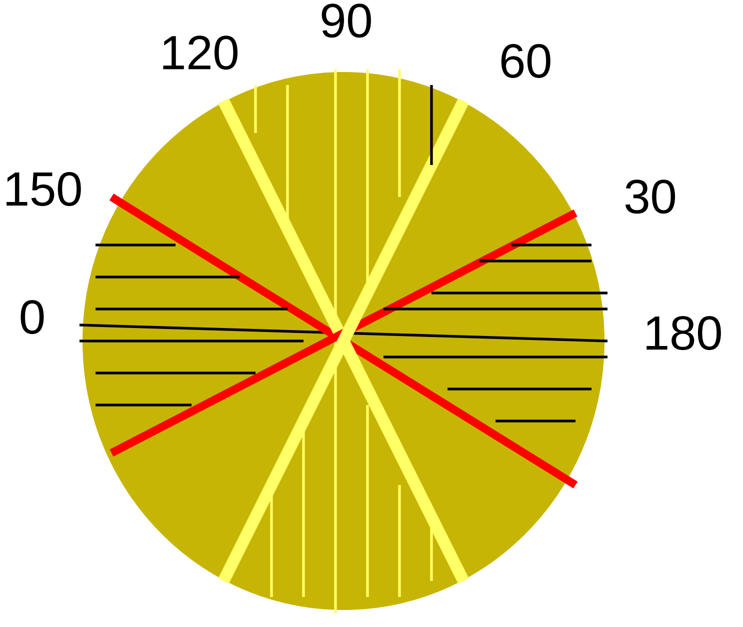
Toric Transposition- problem

- Transpose the following
- +5.00 DS/+3.00 X 180 with back surface BC - 3.00.

Format for Writing Prescriptions

- +2.00 DS means no cyl
- Toric lenses must specify both the sphere and cyl component

+2.00 = +1.00 x 180



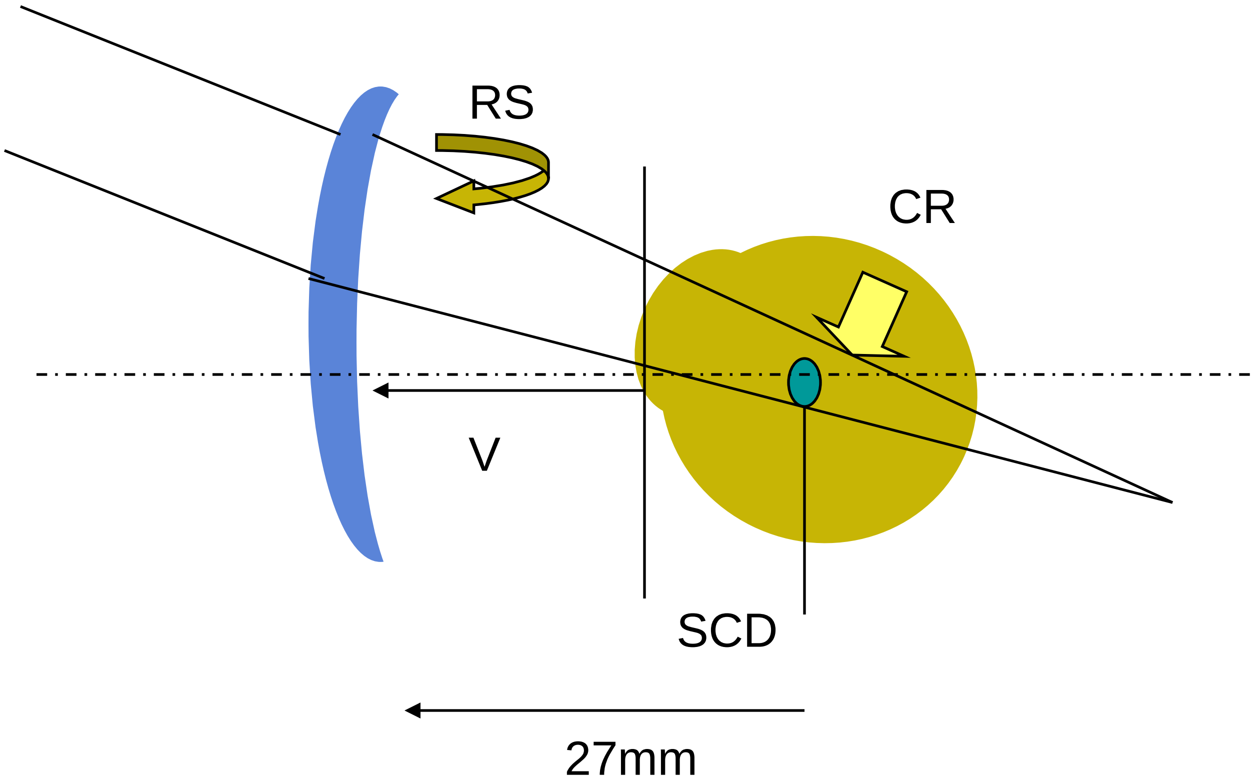
Against the rule (-) cyl convention

With the rule (-) cyl convention

Oblique is in between

Geometry of Lens Design

Off axis ray must pass
Thru CR to be focused



Why is Base Curve Important?

- Determines the shape of the lens
- Determines off axis image quality
- Power, index, thickness, vertex distance cannot really be varied to a significant degree
- This is actually a huge research field…. Lens companies pay big money to have the clearest lenses, etc. Especially progressives.

The Lens Clock

- This device is useful for determining base curve
- Can tell you if lens is front or back surface toric
- Can tell you if there is warpage of lens
- Good for patients in whom you suspect BC may be an issue- match the old glasses.

Lens Materials

- ***Glass***
  - Heavy
  - Ophthalmic crown glass n=1.523
  - Scratch resistant
- ***Plastic (CR-39)***
  - Decreased weight (1/2 that of glass)
  - ease of tinting
  - Impact resistant but scratches
  - Lower index
  - POLYCARB- shatter resist/UV protect

What is Index of Refraction?

- Amount of light bent per unit thickness
- “High index”
- Glass n = addition of titanium oxides. Increase n, but also increases chromatic dispersion (abbe #) & density (weight)

Too thin and will not pass the drop ball test

withstand impact of 5/8inch steel ball weighing 16g dropped from height of 50 inches.

High Power Spectacles

- Aphakic (>+10D)
  - Aspheric design plus flattest BC possible
  - Poor cosmesis
    - Thick
    - Eyes look huge
  - Heavy
  - Lots of Prism
  - Magnification issues 25-30%

Aphakic spectacles

- Magnification 20-30% can cause false orientation/depth /projection
- Pincushion distortion and contracture of the visual field due to higher mag in lens periphery
- Higher order aberrations from radial astigmatism, curvature of image plane, spherical aberration, coma, and chromatic aberration
- restricted peripheral visual field due to small lens size, the roving ring scotoma, and the unrefracted area outside the field of view of aphakic spectacle lenses;
- near vision problems
- weight, thickness, and cosmetic appearance
- inaccurate spectacle prescription due to faulty measurement of vertex distance, inaccurate lens duplication, pantoscopic tilt

Dabezies OH Jr. Defects of vision through aphakic spectacles Ophthalmology 1979 Mar 86(3) 52-79

Pediatric Considerations

- Lens implantation (PCIOL) is the tx of choice
  - Best VA results
  - Best binocular results
  - (protective against aphakic glaucoma)

- Can be risky and may be contraindicated in patients less than 12m.
  - Uncertain rate of refractive growth and emmetropization
  - Power calculations require sedation
  - PCO
  - OAG

Pediatric Considerations

- If IOL not an option, an aphakic contact lens should be used
  - 30% dropout due to
    - Parent/patient non-compliance
    - Infection
    - Intolerance
    - Systemic abnormalities preclude successful I&R

Pediatric Considerations

- If contact lens not an option, last resort is aphakic spectacles
  - Better than nothing, but not great due to all the optical issues
    - Amblyogenic potential
    - Poor/no binocular stimulation

High Minus Spectacles

- High Minus (>-10D)
  - Edge thickness
  - Small, round frames
  - Myopic rings
  - Minification
  - Barrell distortion
  - prism issues

Anti-Reflective Coating

- Thin layer of MgF
  - ¼ wavelength optical thickness
  - Destructive interference between front and back surface reflections- for only one wavelength unless multilayered
    - This is why it is colored
  - Decreases reflectance (to 0.5%) and increases transmittance (to 99%)

AR Coating

- plasma enhanced chemical vapor depositing (PECVD) a polymer on the substrate surfaces.
- The PECVD processes provide an AR polymer generated by introducing monomer vapors into a plasma state followed by polymerization, with assistance of plasma energy, onto the surface of a substrate.
- Chemical Vapor Deposition is also used

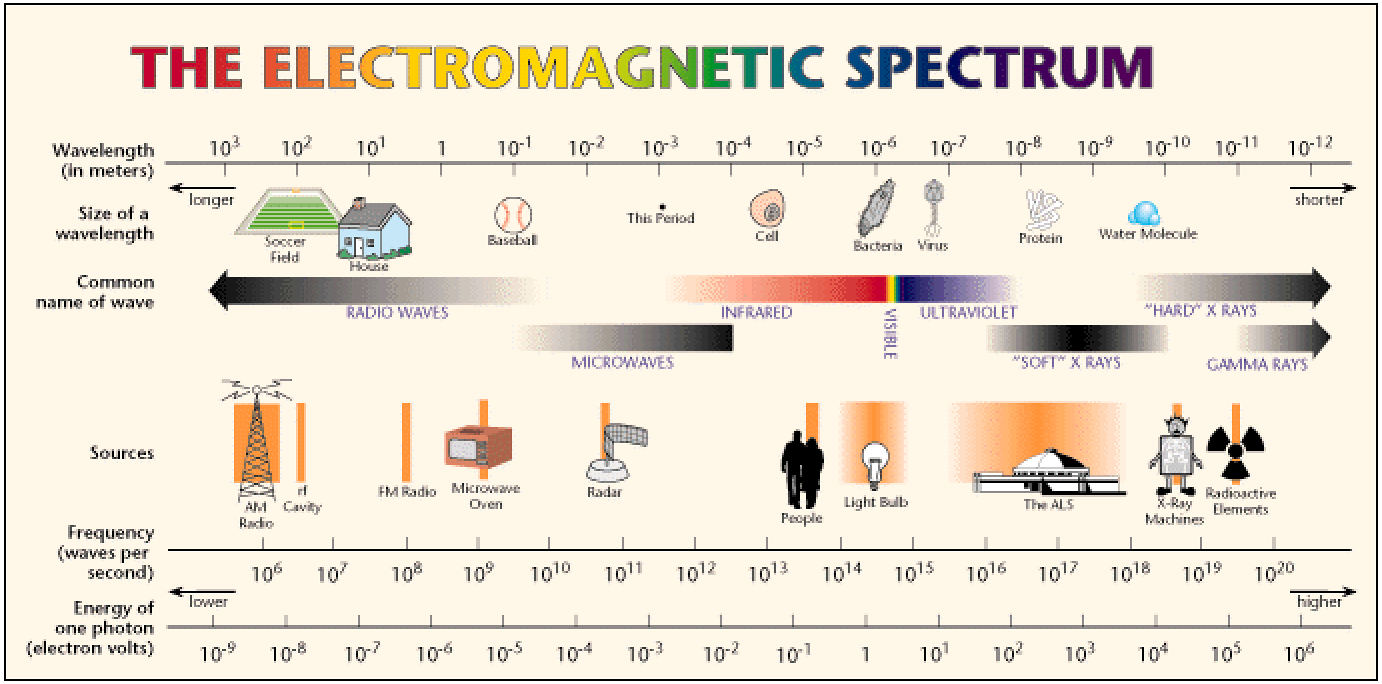
Anti-Reflective Coatings

NO-AR

AR

Effects of Radiation on the Eye

Electromagnetic Spectrum

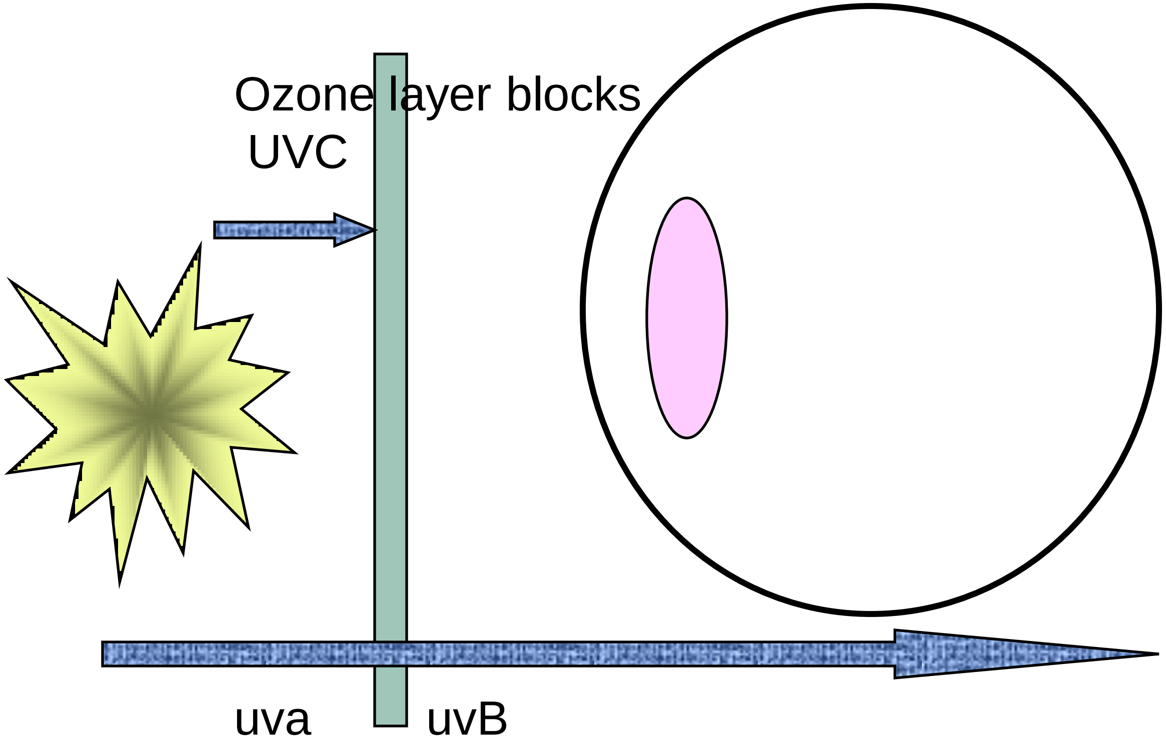


UV Light and the eye

- UVR must be absorbed to cause damage
- Photochemical Damage
  - UVB(315-290nm)   and UVC (290-200nm)
  - Cell nucleus can be damaged by single photon
- Thermal Damage
  - UVA (380-315nm)

UVR and the Eye

Absorbed by the cornea



Cornea 200-320

Conj 270-310

Uvea 295-310

Lens 295-320

Retina 310-380

UVR

- Between 10am-2pm over 50% of UVR reaches the earth
  - Green grass reflects 3.5% of UVR
  - Sand reflects 35%
  - Snow reflects 85-95%
    - Skiiers have increase of 15% increase exposure per each km of altitude above sea level

Ocular Effects of UVR

- UVC exposure up to 290nm damages K epi
- 290-135nm K stroma and endo damaged and metabolic changes occur
- Acute UVB induced cataracts in rabbits, primates

UVB can induce cats in humans via photo-oxidation of lens crytallins and membrane lipids, damage to to lens epith DNA

(Collman 1988)

Ocular effects of UVR

- Corneal damage
- Pterygium
- Pinguecula
- Climactic droplet keratopathy
- Cataract
- Retinal lesions

(Taylor 1989)

Retinal effects of UVR

- Immediate large losses in absolute retinal threshold from 350nm that did not return to normal for 6mo. (Henton and Sykes 1983)
- Compared to the cornea, the phakic retina is 2.5x more sensitive to UVR (350nm) and the aphakic retina is 14X more sensitive to UVR
- Ocular damage is mostly from UVB, which is affected by loss of ozone
- Role of UV in ARMD?

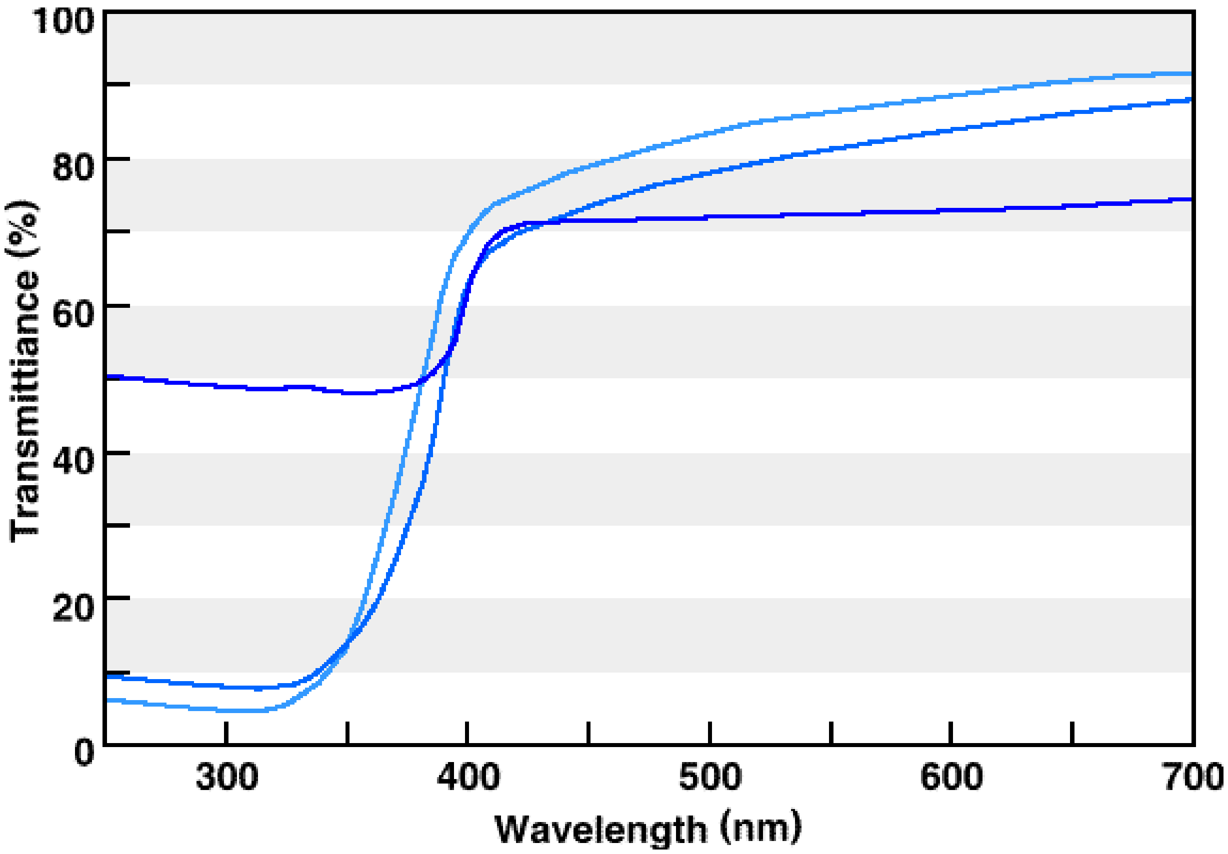
UVR protection

- Crown glass not UVR protector
- Reduced to 0.2% with UV absorbing plastic
- Protection increases with lens area
  - $13cm^2$ lens = 65% protection
  - 20 cm^2 lens= 96% protection
  - Ocular exposure increases with vertex distance

Prescription of Absorptive Lenses

- Transmittance- ratio of amount of radiant energy transmitted through the lens to the amount incident on the front surface. It is expressed as a percentage. $T \equiv \frac{I}{I_0} \times 100\%.$
- Luminous transmittance- describes the visual characteristics of tinted lens
- Optical density- another descriptor, usually for occupational tint (welders)
  - OD=-log$_{10}$T
    -

Transmittance Curve



Absorbance

- *A = 2 - log10 %T* - allows you to easily calculate absorbance from percentage transmittance data.
- So, if all the light passes through a solution (or lens) *without* any absorption, then absorbance is zero, and percent transmittance is 100%. If all the light is absorbed, then percent transmittance is zero, and absorption is infinite.

Sunglasses- eliminating the radiation not needed for vision

- ***Absorptive lenses*** subtract wavelengths
  - Reduce the intensity (brightness) of light
  - The portions of the sunlight transmitted determine the hue/color



Factors to Consider

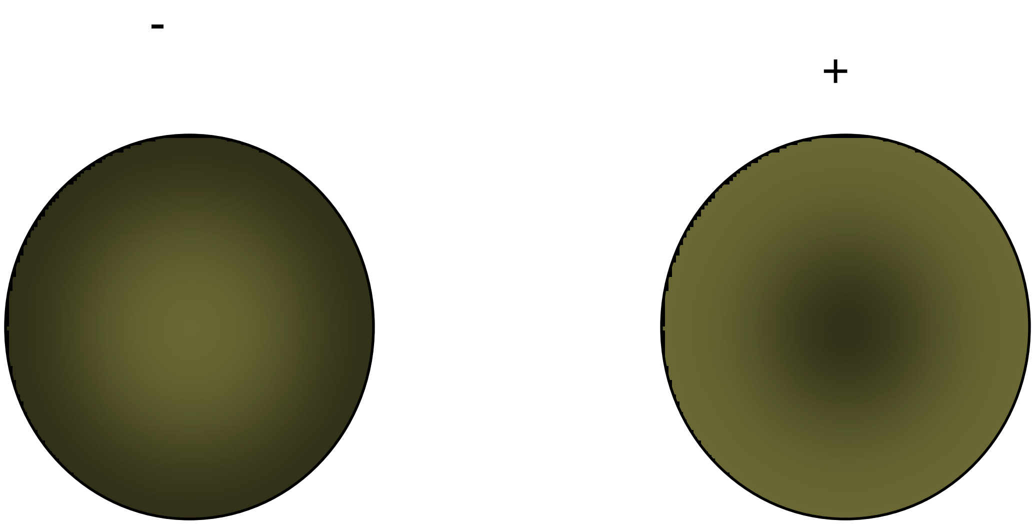
- Intended use
- Glare reduction
- Ocular health
- Pts pigmentaton
- Exposure to photosensitizers
- Environmental exposure
- Lifestyle
- Cosmesis

Characteristics of Ideal Sunlens

- Controlling solar ambient luminance
  - Provide comfortable vision in sunlight
  - Sun intensity range 1,400 cd/m^2 is comfortable (under shady tree) but can be as high as 70,000cd/m^2 on a clear day!
- Mature pt requires more transmittance b/c pupils are constricted
- Solar irradiance varies with pupil size 20W/m^2 to 140W/m^2 as pupil goes from 3-8mm

Tints- glass

- Glass tinted by adding metallic salts (16th C) and WWII gives grey lens w/o color distortion.



>+/- 3D

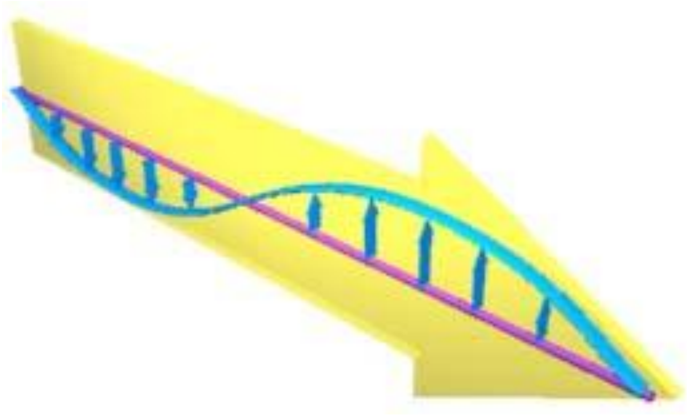
Tints- plastic

- Plastics are tinted via immersion in a hot dye bath
- Color is uniform
- Can be bleached and re-tinted
- All plastic lenses contain a UV inhibitor that protects against wavelengths below 330nm
- Some tints offer additional UV protection

Photochromic lenses

- Change optical density and hue in response to ambient UV
  - Developed during Cold War to protect in nuclear holocaust.
  - Glass made with silver halide crystal impregnation, which dissociates on exposure to UV or cold
  - Plastics are OK, but prone to scratching
  - Don’t turn dark inside the car

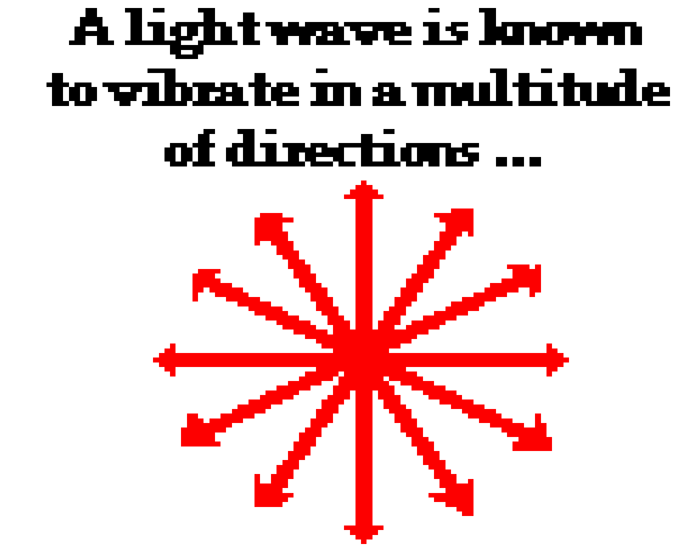
Polarization



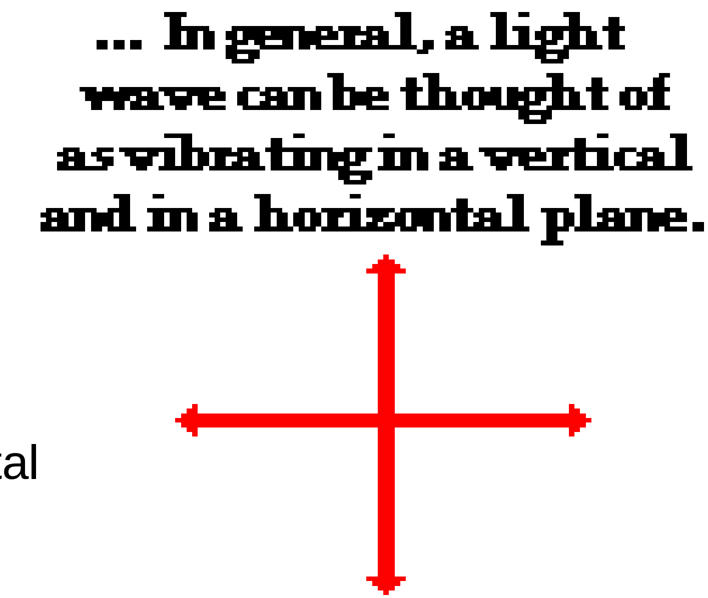
LIGHT BEHAVES LIKE BOTH WAVES AND MAGENITIZED PARTICLES

TRANSVERSE WAVE

Polarization



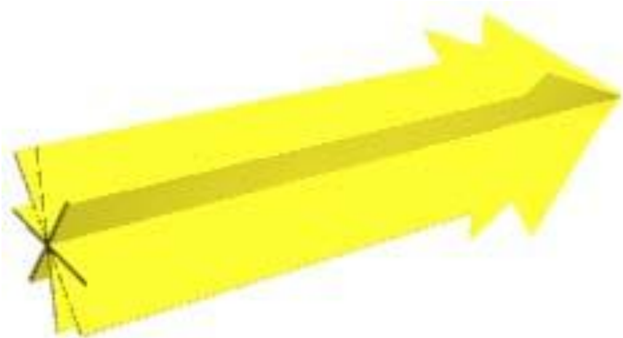
A light wave which is vibrating in more than one plane is referred to as **unpolarized light**.



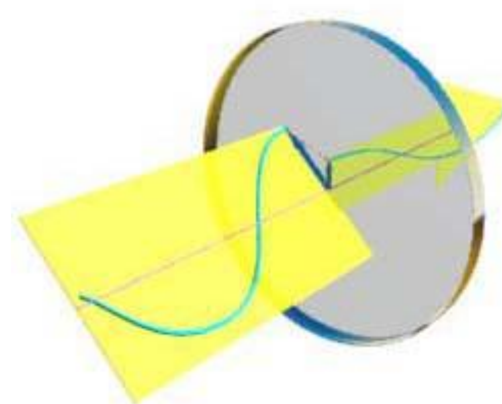
picture unpolarized light as a wave which has an average of half its vibrations in a horizontal plane and half of its vibrations in a vertical plane

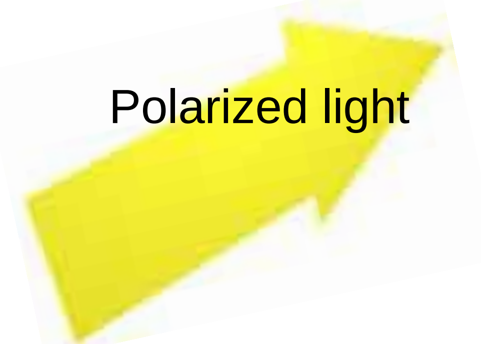
Polarization

Unpolarized light



in polarization, wavelike behavior is restricted to a single plane by a filter



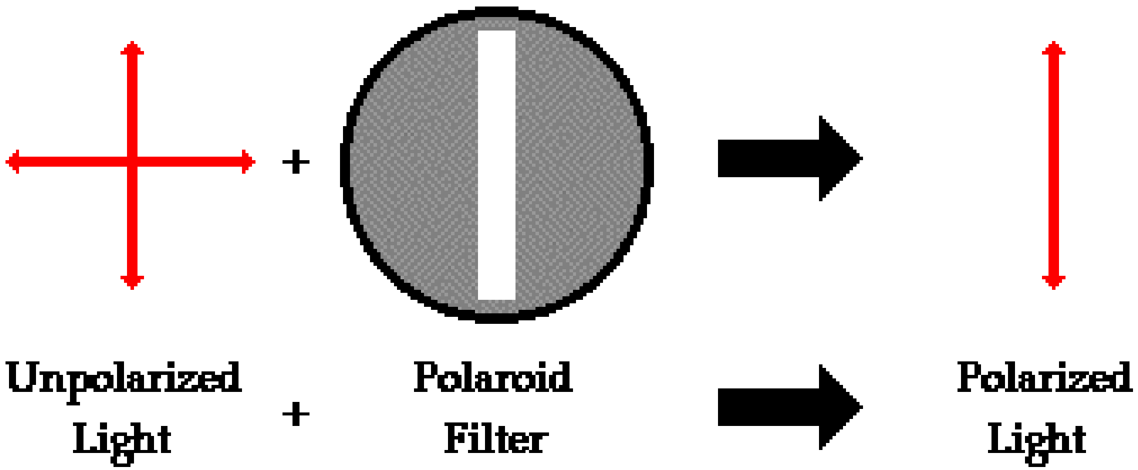


Polarized light

Polarization

- The most common method of polarization involves the use of a **Polaroid filter**. Polaroid filters have a chemical composition which can block one of the two planes of vibration of an electromagnetic wave.
  - Polarized light wave emerges with one-half the intensity and with vibrations in a single plane
  - The general rule is that the electromagnetic vibrations which are in a direction parallel to the alignment of the molecules are absorbed.

Polarizing Lenses



Any vibrations which are perpendicular to the polarization axis are blocked by the filter. Thus, a Polaroid filter with its long-chain molecules aligned horizontally will have a polarization axis aligned vertically.

Polarization

Relationship Between Long-Chain Molecule Orientation and the Orientation of the Polarization Axis

When molecules in the filter are aligned vertically, the polarization axis is horizontal.

When molecules in the filter are aligned horizontally, the polarization axis is vertical.

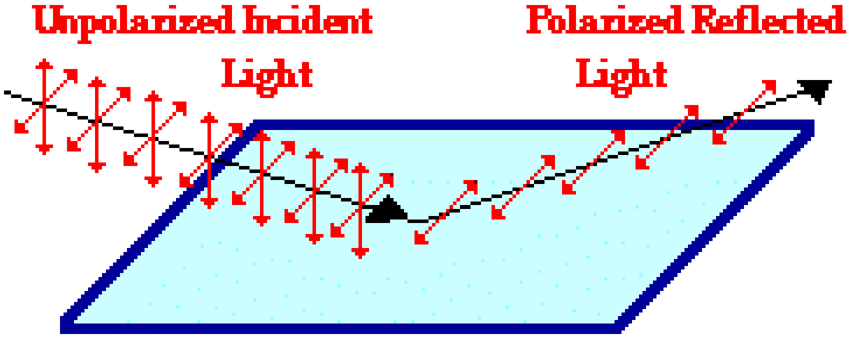
Polarization

- When light travels through a linear polarizing material, a selected vibration plane is passed by the polarizer, while electric field vectors vibrating in all other orientations are blocked.

So the filter selects one component from all of the different planes of light and lets that one component get through!

Polarization by reflection

- Unpolarized light can become polarized by reflection off of a non-metallic surface and can cause glare
  - Depends on the angle of incidence
  - Depends on the material
    - Asphalt, snow, water



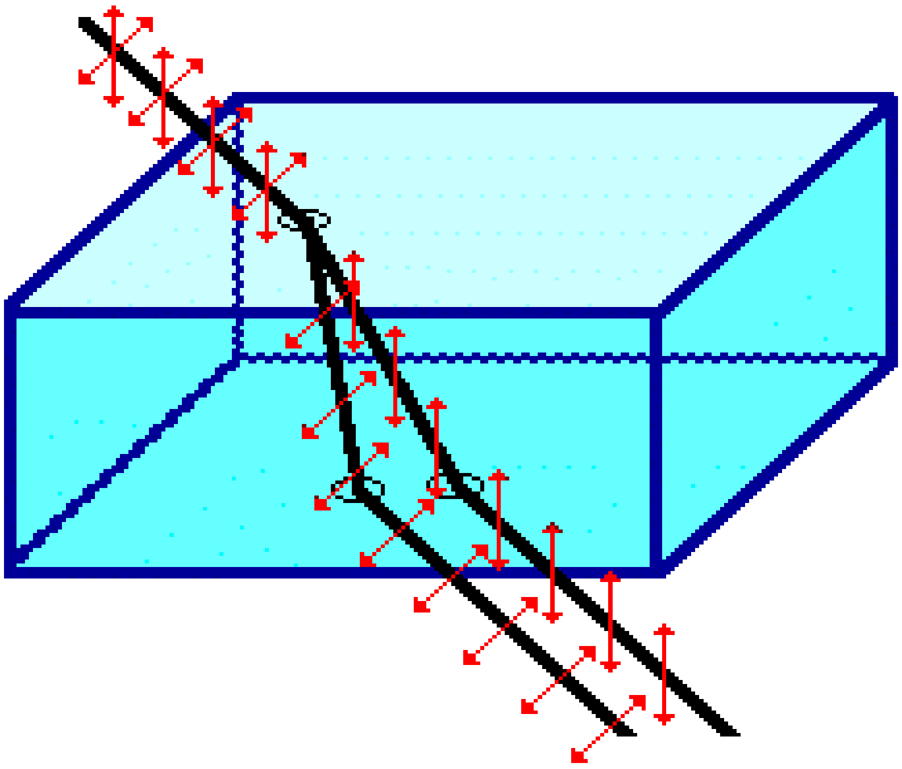
Reflection of light off of non-metallic surfaces results in some degree of polarization parallel to the surface.

Polarization cont'd

- Unpolarized light ,when reflected, seems white and can obscure vision
- Put a polarizing filter perpendicular to the reflected light and it will absorb light
- Restores the balance of light intensities and restores fidelity to surface color.
- Fishing, skiing, driving (anytime you get a lot of reflections)

http://www.colorado.edu/physics/2000/polarization/polarizationI.html
http://micro.magnet.fsu.edu/primer/java/scienceopticsu/polarizedlight/filters/

Polarization by refraction



The two refracted rays passing through the Iceland Spar crystal are polarized with perpendicular orientations.

Polarization from scatter

- As light bounces off of atoms in the atmosphere, it is scattered and becomes partially polarized
- Produces glare in the sky and washes out photographs
- This is why cameras have polarizing filters, as you rotate it, glare can be reduced.