TINTED LENSES

Light and its Effects on the Eye

The Electromagnetic Spectrum

To a physicist all the electromagnetic spectrum is the same sort of phenomenon, differing only in wavelength. Optometrists, etc., classify a the EM spectrum as follows:

13.6nm - 310nm	short ultraviolet
310nm - 390nm	long ultraviolet
390nm - 780nm	visible
780nm - 1500nm	short infrared
1500nm - 100,000nm	long infrared

The eye transmits radiation from 400-1400nm. The shortwavelength cut-off is due mainly to the crystalline lens. Without the lens, the short wavelength cut-off would be 300nm. About 3% of infra-red reaches the reina and "some" ultra violet reaches the retina.

Note that aphakic patients get more long ultraviolet than phakic patients, specially more than cataractous patients with yellowed lenses. Some of the newer lens implants absorb UV, but most don't.

Abiotic Effects of Radiation

A variety of abiotic effects (damaging effects as opposed to discomfort or psychological effects) are associated with the electromagnetic spectrum but for normal eyes in normal lighting these may largely be discounted, excepting possibly photo-kerto-conjunctivitis at the beach. In recent years, however, evidence has accumulated linking UV exposure in the 290- to 380 nm range with brunescent cataract formation and the conservative thing to do is to provide patients with UV protection in their lenses.
Some pathological eyes are especially susceptible to light damage, e.g. patients on certain drugs, RP patients (though the latter is doubtful).
And of course normal patients under abnormal conditions, e.g. laser light, welding arc, may experience damage without protection.

From time to time, curative properties have been claimed for light of specific wavelength. According to Borish (3rd edition, p. 1118), "Claims for therapeutic or restorative properties for the the visible spectrum are without substantiation at the present time."

Charactersitics of Tinted Lenses

Production of Tints

Through and through Tints

Through and through tints are produced by means of additives placed in glass at the time of manufacture. Various additives and the colors they produce are

blue	cobalt
green	ferrous oxides, chrome oxides
red	gold oxide
salmon	dydinium oxide
yellow	silver and uranium oxides
violet	manganese oxide
brown	cerium oxide

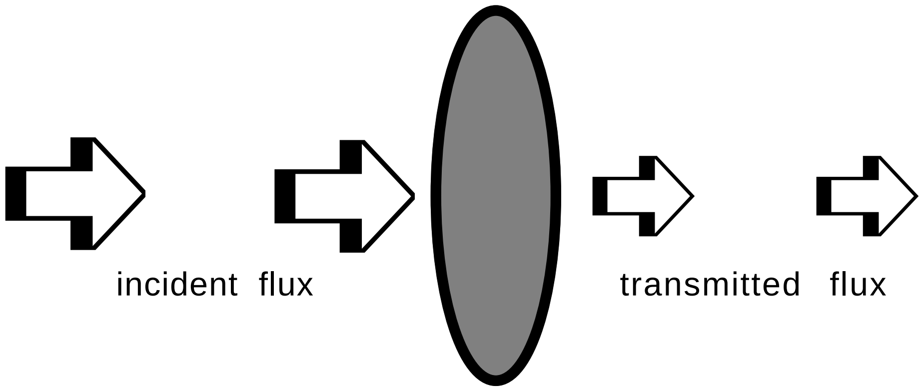
Unless a lens is of uniform thickness, optical density of the lens differs at different points. The Rx for a myope will have more tine at the edge, for a hyperope more at the center. This can be remedied by a "sandwich" in which the tint is in a small layer at the center. A better approach is coatings.

Coatings

Glass lens coatings are produced by evaporating an inorganic substance which is deposited on the lens under high vacuum. The coating is of uniform optical density regardless of the prescription. Coatings are as tough as the glass but may be damaged, though that damages the glass as well.

Plastic lenses are dyed with various organic dyes, like so many easter eggs. The process is somewhat imprecise, so it is safest to order lenses in pairs. Many optometrists do this in their own offices.

Transmission Characteristics of Coatings



The <u>transmittance</u> or <u>transmission</u> of a lens is the ratio of the light that goes through it to the light incident on it,

transmittance=(transmitted flux)/(incident flux)

The total light transmitted is the number usually tabulated for a given source. <u>Spectral transmittance</u> is the transmittance at a particular wavelength. The color of a lens under a given illuminant will be fixed and can be calulated using colorimetric methods, i.e. find x-y coordinates on CIE diagram. As we'll see, however, detailed calculations aren't generally necessary to understand the basic color characteristics of a tint.

A neutral density lens is a grey lens with more or less uniform transmittance over the visible spectrum. The density is often characterized by the ND number,

$$ND=\log_{10}(1/\text{transmittance})=-\log_{10}(\text{transmittance})$$

For example, if transmittance=10%=0.1, then

$$ND=-\log_{10}(0.1)=1.$$

Likewise, if transmittance=1%, ND=2, etc.

If transmittance=50%,

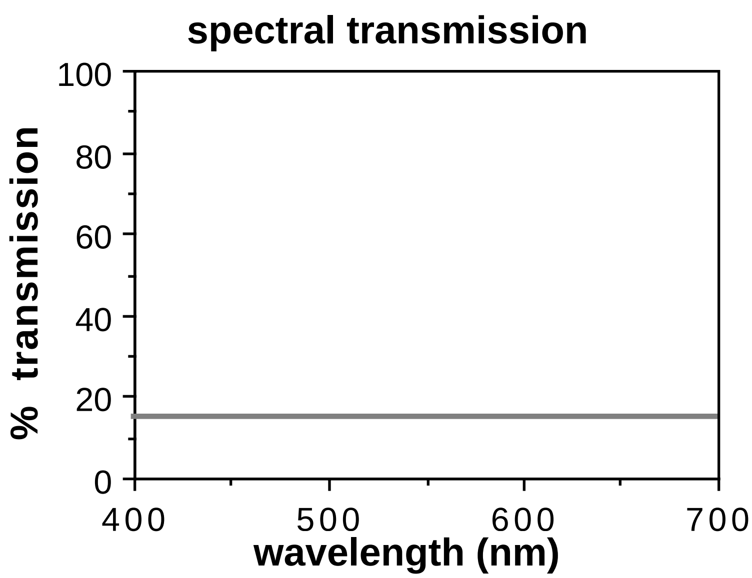
$$ND=-\log_{10}(0.5)=0.3$$

Transmission Characteristics of Common Materials and Tints

white glass and plastic

Clear lenses of glass or plastic absorb some of the electromagnetic spectrum. Spectacle Crown has 92% transmittance, reflection accounting for most of the loss. There is strong absorption in the short ultraviolet, almost none in the infrared. Plastic has somewhat higher tranmittance owing to less reflection. Absorbtion in the short ultraviolet exceeds glass. There are some absorption bands in the long infrared.

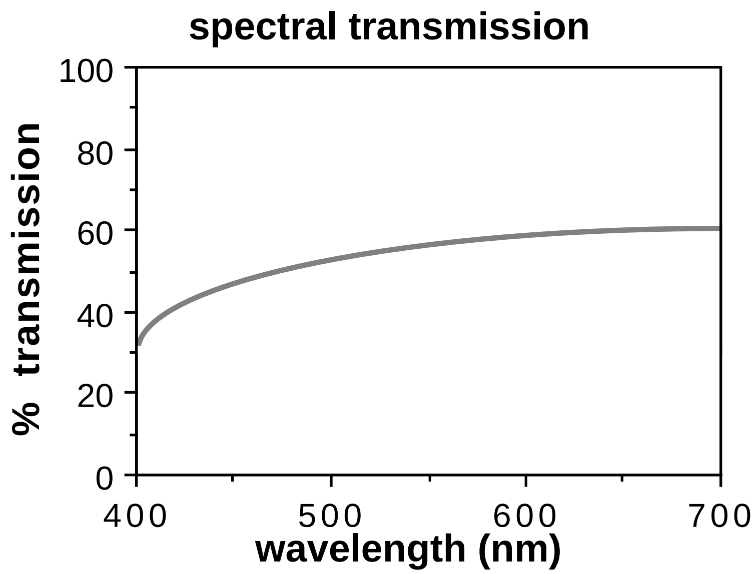
neutral density tints



Gray lenses are supposed to be neutral density. The graph above shows an idealized transmission curve for a gray lens. A famous gray tint in glass is the Ray Ban G-15 is a tinted glass with a very flat tranmission curve, nearly neutral density in visible spectrum. Its transmittance is 15%.

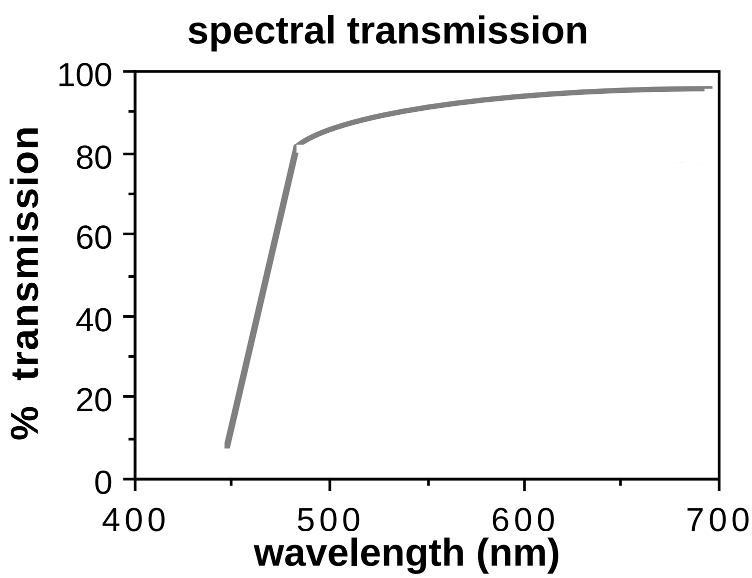
Tinted plastic often lets considerable light thru in longer wavelengths, which may give a pink tinge to scene.

brown tints



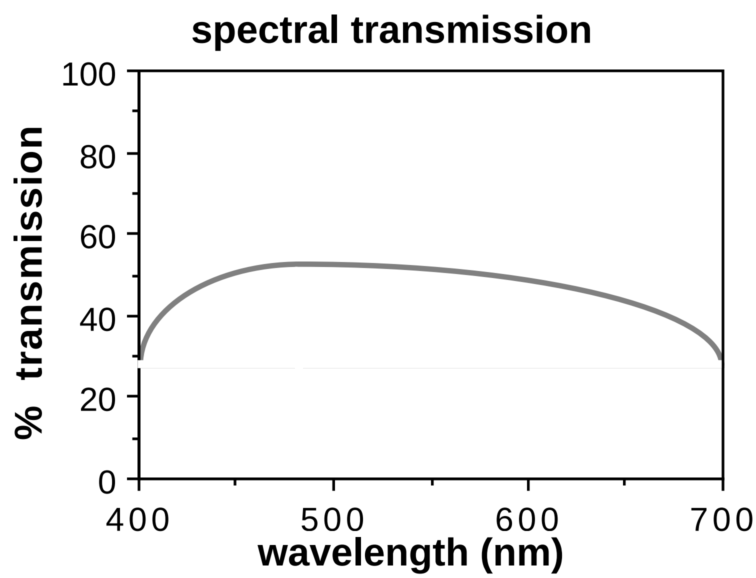
The figure shows the spectral transmission of a typical brown lens. Note the almost linear rise from ultraviolet to infrared.

yellow tints



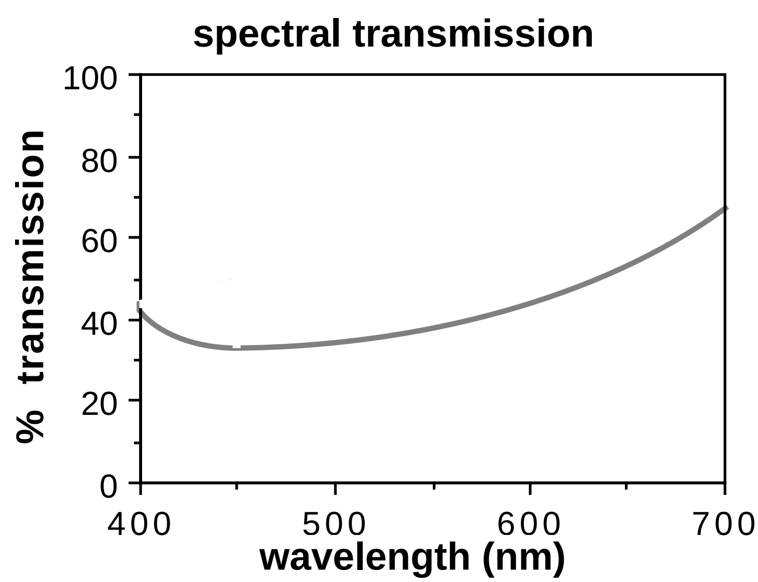
The figure shows the general features of the Kalichrome tint. Note the short wavelength cutoff. This tint is much loved by outdoorsmen. Yellow plastic tints look like Kalichrome but have a much less dramatic shortwavelength cutoff.

green tints



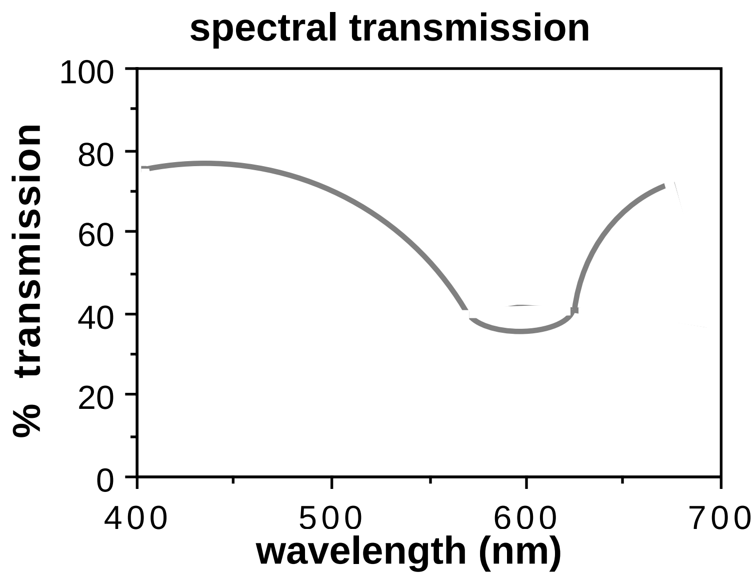
The figure shows the transmission curve of an idealized green tint. Note the peak of the curve shifted towards short wavelengths.

pink tints



A pink tint like Softlite typically has a dip around 485mm as shown in the curve above.

blue tints



The transmission curves of blue filters show great attenuation of the long wavelengths of visible spectrum.

Prescribing Tints

Sunglasses

The most common need for tint is in sunglasses. Two questions arise: (1) what color, (2) what density?

Guide to density is provided by *Peckham and Harley, A.J. Opth., 34:11, 1951*. They tested thresholds for light in Atlantic City lifeguards who wore and who didn't wear sunglasses of various densities at the beach. With exposure to sunlight the threshold went up. Tints protected the threshold, the greater the tint the the more the protection. Conclusion: the darker the tint, the better, i.e. 10-12% transmission protected best.

Sunglass tint densities are usually given as #1, #2, or #3, the higher the darker. #1 is hardly any tint, #2 is about average, #3 is quite dark as recommended in the Peckham and Harley study.

The Peckham and Harley tudy provides no guide to tint since the subjects wore lenses of various colors. Advantages of different tints are as follows:

gray	neutral color rendition, protection against "harmful" infrared.
brown	transmits infrared and may cause problems for color defectives. Brown may serve as haze filter since scattered light is in short wavelength spectrum.
green	permits infrared, may cause some problem for color defectives.

Summary: for all but color defectives, any tint will do if it's dark enough.

Photochromic Tints

Photochromics vary optical density through a silver halide process similar to that in photographic film. The difference here is that the halide molecules are held in a glass matrix and the process is, more or less, reversible. The darkening is greatest in brightest light, and procedes somewhat more completely at cold temperatures.

Here are some factors influencing darkening:

☞ optical bleaching- exposure to red or infrared bleaches lens

☞ thermal bleaching - exposure to heat bleaches lens. On cold days glass may be up to 8% darker than on warm.

☞ exposure memory - breaking in period required when new and when neglected a while. With use, lenses will not lighten up as much

Photogrey and photobrown are really not dark enough at the darkest to be effective sunglasses. Photosun is better but beware that changes are slow. Since the lens reacts to short ultraviolet which is attenuated by car windshields, photosun is only fair as a driving lens.

Photogray extra seems to get around many of the preceding problems since it darkens quicker and darker and reacts to the visible spectrum.

Commonest Photochromic Tints

color	transmittance darkened (%)	transmittance lightened(%)
Photogray	83	43
Photobrown	88	42
Photosun gray	67	23
Photosun brown	64	22
Photogray Extra	78	25

The biggest dispensing problem with photochromics has been that they are only available in glass and, with the new eye sizes especially, produce nose-breaking Rx's. *Transitions*™ provides a plastic photochromic, at last. The tint changes rapidly in response to UV, but since UV can't get through windshields readily, *Transitions* is not a driving tint. Nor can the color of cannot be made darker through tinting.

Cosmetic Lenses

Any tint will do. Choose at patient's preference avoiding tints that can affect the color blind. One popular one is a #1 rose tint, a very light tint that acts to bleach the blue from beneath a patient's eyes.

UV Blockers

The evidence for UV damage of normal eyes under normal conditions has been slight. But for those who spend a lot of time at the beach, it couldn't hurt. And what if that ozone layer really is depleted, and those new studies linking UV radiation and cataract...? Ultraviolet tints are colorless and are given ratings kind of like the tanning blockers everyone is using now.

Aphakic Tints

Many doctors prescribe tints to block UV to compensate for the loss of the crystalline lens which aborbs most of the UV radiation in the eye, and also to restore a normal color perception. UV coatings are also used.

Other Uses, not well confirmed

shooters lenses	marksmen and hunters love Kalichrome and other yellow tints since they cut back on blues and greens and heighten contrast of woodsey scenes. It also cuts through ground fog and environmental haze. There is no evidence for the greater efficience of hunters with these lenses.
RP lenses	Theorising that light accelerates the progression of retinitis pigmentosa a variety of blocker lenses have been tried, blue, brown, black, even opaque. There is no convincing evidence of effectiveness.
fluorescent light protection	It's not clear that fluorescent lights are a problem and if so, why. Quartz lenses, photogray, Kalichrome have all been recommended as giving comfort and protection, but there is no proof that any work.

Polarized Lenses

Polarized lenses are made by sandwiching layer of polaroid material between 2 sheets of cellulose. Resulting lens is nealy neutral in color and filters out horizontally polarized light. Since horizontally polarized light is what bounces off highways and water, polaroids are effective in eliminating glare

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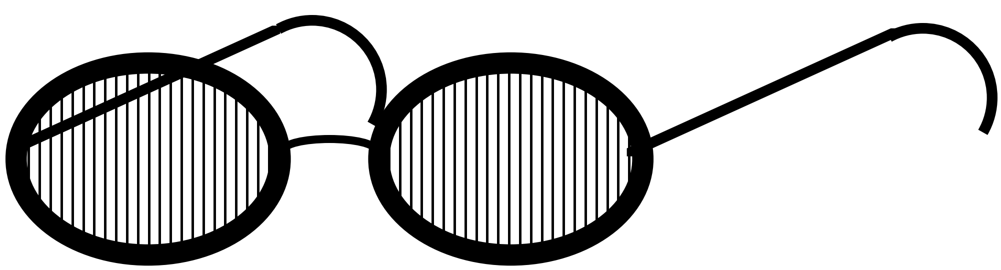
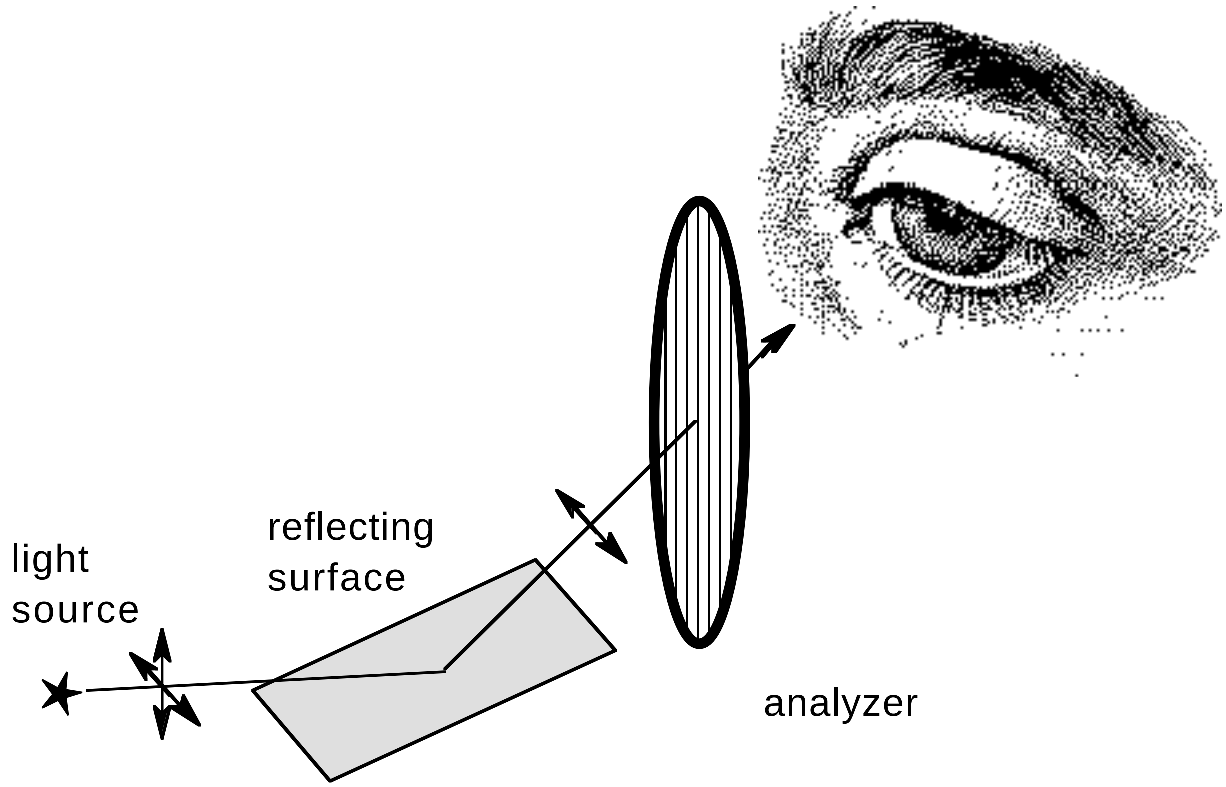


The figure above indicates that polaroid sunglasses contain vertical polarizing filters.



The diagram shows how an unpolized beam of light is polarized by a reflecting surface such as a road bed or body of water and the now horizontally polarized light is prevented from reaching the eye by the vertically polarized sunglass lenses.

