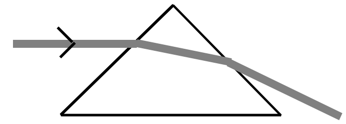
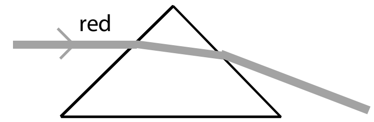
PhyzGuide: Dispersion

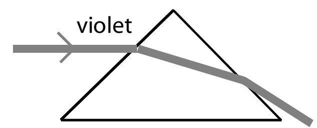
As you know, when light passes through a piece of glass, it is refracted. When the glass is shaped like a prism, it gets refracted twice in the same direction. But you also know that when white light passes through a prism, it is dispersed into a rainbow spectrum.



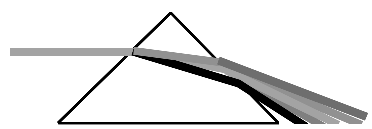
How come?

Well, when careful measurements of refraction are done, it is found that the index of refraction of glass is *not* constant ($n \neq 1.52$ for all light). *The index of refraction depends on the wavelength of light being refracted.* For red light (long λ), $n = 1.51$; red light is not bent as much as yellow light. For violet light, $n = 1.53$; violet light is bent more than yellow light. (Index of refraction numbers are usually given for yellow light given off by sodium excitation—$\lambda = 589$ nm.)



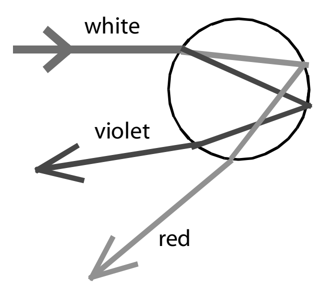


White light is a mixture of all the wavelengths of visible light (and some invisible wavelengths). Through "differential refraction," glass "sorts out" or **disperses** the colors. An "artist's conception" of the result can be seen on the cover of Pink Floyd's *Dark Side of the Moon* LP. In reality, the dispersed colors blend gradually from one color to the next, unlike the distinct boundaries shown on the album cover artwork.

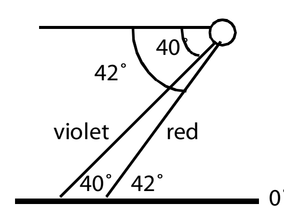


Simple lenses suffer from "chromatic aberration" for the same reason. Because different colors are refracted at slightly different angles, blue light focuses at a certain point and red light focuses at a *different* point, so when "blue images" are *in* focus, "red images" are *out* of focus, and vice versa.

Water droplets disperse light in the same way. A rainbow is produced by refraction and reflection that occurs in a water droplet. Light from the sun is refracted upon entering the droplet; the refraction disperses the light. Next, the light is reflected from the back surface of the droplet. The light is then refracted as it leaves the drop. The dispersion is enhanced by the spherical geometry of the water drop.



The result is that violet light comes out at a low angle of deviation (~40˚); red light comes out at a high angle of deviation (~42˚). Yellow light is deviated at about 41˚. This effect occurs in three dimensions, producing a light cone that originates at the droplet.



So what do you see?

If you consider the old geometric axiom of "alternate interior angles," you can see that if the sun is directly behind you, you will see dispersed light at an angle of 41˚ above the horizon. You will see red higher in the sky at 42˚, and violet lower in the sky at 40˚. Due to the 3D nature of the dispersion in the droplet, you will see light in a 41˚ arc all around you.