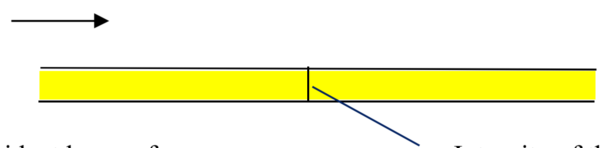
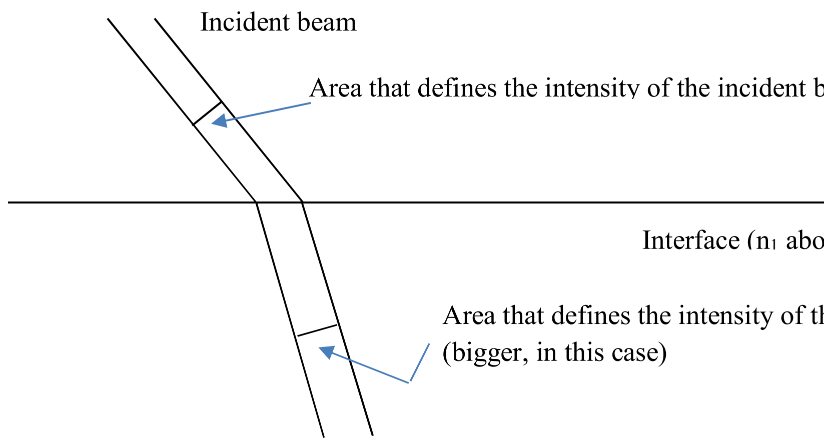
1) Non-normal incidence has one other tiny little complication we haven't talked about yet. So far we've been using the definitions $R = \frac{I_R}{I_I}$ and $T = \frac{I_T}{I_I}$, and power conservation has required that $\frac{I_R}{I_I} + \frac{I_T}{I_I} = 1$. But if you use the Fresnel equations to generate those intensities in the general, non-normal case and calculate *R* and *T*, they don't add up to 1. That's bad. Power should still be conserved in non-normal incidence problems. The issue is that intensity as we've defined it is power per unit area *assuming normal incidence*:




When light is incident on a surface at some angle, we still define intensity in the same way, but the width of a particular slice of wave *changes* as we go from incident to transmitted:




a) In order to preserve the core principle that power in equals power out for some particular ray, we need to use geometry to generalize the equation $\frac{I_R}{I_I} + \frac{I_T}{I_I} = 1$. Figure out how. You're going to need to add some trig factors here and there.

b) Using the above and the Fresnel equations, show R' + T' = 1, where r and t are the new versions of R and T that properly respect the geometry of the non-normal case. To keep it simple, just do the TE case, and let $n_1 = 1$.

2) We know enough to start to explain a lot of neat optical phenomena that we see in the world around us. Last fall, my wife and I went for a walk by the creek. We were wearing sunglasses, and noticed that the reflection of light off the water changed dramatically if we tilted our heads. We were able to faithfully capture the effect on video, as seen in the following:

https://youtu.be/5lMw-xTh8PI

https://youtu.be/SG2xUYY-mEw

The two videos involve two different pairs of sunglasses, and there's some extra information in the video descriptions.

Construct an explanation for why we saw what we saw. You're welcome to ask me questions about the circumstances.

Note in particular that I've checked each pair of sunglasses against a polarizing filter and discovered that both are strongly linearly polarized. I have another pair of sunglasses that isn't linearly polarized, and during another trip to the creek I had the opportunity to take a video of similar reflections through them:

https://youtu.be/3XCUcxDfRDA

Also, on that second trip, I got the following wider-angle video through the red-inducing sunglasses, showing some variation in the redness across the vertical:

https://youtu.be/IjEewK_d0RQ

3) (From Pollack and Stump 13.9)

a) From first principles, set up the boundary conditions for a plane wave incident normally on the surface of a conductor, coming from air or vacuum. The conductor is not significantly magnetic. Let the incident wave travel in the x direction, and be polarized in the y direction. The reflected and transmitted waves travel in the –x and +x directions, respectively. The wave vector κ in the conductor is complex, and the dispersion relation is:

$$\kappa^2 = +i\mu\sigma\omega + \mu\varepsilon\omega^2$$

Solve the boundary conditions, and show that the amplitude of the reflected wave is correctly given by:

$$\frac{E_0''}{E_0} = \frac{1-n_2}{1+n_2} = \frac{\omega - c\kappa}{\omega + c\kappa}$$

b) For a good conductor, i.e., $\sigma \gg \varepsilon\omega$, derive:

$$R \approx 1 - \frac{4\omega c\kappa_1}{c^2(\kappa_1^2 + \kappa_2^2)} = 1 - \sqrt{\frac{8\omega\varepsilon_0}{\sigma}}$$

c) Show that for a good conductor, at the surface the field of the reflected wave is approximately equal but opposite to the field of the incident wave. You may take the dispersion relation from part a as given.

Note that this problem is largely done in Pollack and Stump for you if you'd like to check it out (chapter 13.3). Then it's just a matter of going through the steps yourself and filling in the gaps.