Prisms and Critical Angles:

1. How would you expect the critical angle and the angle of least deviation to change if you increase the increase refraction?

2. How would you expect the critical angle and the angle of least deviation to change if you decrease the apex angle? What if you increase the apex angle?

Some background on Light as a Wave

Thinking of light as a ray is a useful macroscopic picture for tracing out geometries, but it ignores the crucial properties of light that determine things like the Brewster angle, as well as theoretical limits on everyday instruments such as microscopes. To understand such phenomena, we need to think of light as a wave. For a full derivation of this, see an electromagnetics book. If enough people are interested I'll be happy to go through it in section. For our purposes, we'll just assert that light is a wave and look at some of its properties:

- Light is a **transverse** wave which means that the direction of the electric field of the light wave is perpendicular to the direction of propagation. This means that knowing the direction of propagation of light (which you can get by solving snell's law at various interfaces) is not enough to fully define the orientation of light–you also have to know the orientation of the electric field. Since the electric field (whose direction is usually denoted by the vector $\hat{\mathbf{n}}$) is perpendicular to the direction of propagation (denoted $\hat{\mathbf{k}}$), the polarization can point in any direction in a plane. So if the wave is propagating in the z-direction, the polarization vector $\hat{n}$ can broke up into two components, $\hat{n_x}$ and $\hat{n_y}$.

- Waves can interfere with each other. This is true for light waves as well, so you can have constructive and desctructive interference on the scale of the wavelength of light. Because of this shining light through small holes leads to interference fringes that we can see. We'll go through this later, when we talk about diffraction, and you'll see some examples of single slit diffraction in the first lab.

S- and p-polarizations

1. You place a linear polarizer in front of unpolarized light. How much of the initial intensity is transmitted through the polarizer?

2. Now you have a second linear polarizer that is oriented at 90° to the first one. How much light is transmitted?

3. Now you add third linear polarizer between the first and the second filters, with its polarization axis at 45 with that of the first filter. What happens to the transmitted intensity?

4. Now imagine you replace the third filter that you added in part (c) with a half- wave plate. The direction of the half-wave plate that has the lower index of refraction is called the fast axis. What does the half- wave plate do? How does the transmitted light intensity depend on the angle of of the fast axis relative to the orientation of the two polarizers? At what angle would you have to place the fast axis to maximize the transmitted light?

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such as Griffiths *Eletrodynamics*, Ch. 9

5. Now imagine you have a thin glass slide between the first and second polarizers. What are the possible ways you could position the glass slide? At what angle should you position the glass slide to maximize the amount of transmitted light?

Light as a Particle

The intensity of average room light in a classroom is 5 μWatt hitting a detector that has an area of 1 cm^2. How many photons are hitting the detector if they are all red photons (λ=800 nm)? How many photons is this if they are all purple photons (λ=400 nm)?

A Measurement Problem to Ponder

I want to measure the index of refraction of a unknown, transparent material. I can make a thin film of this material pretty easily, but making a thick sample (thick enough to be made into a prism) of this material is much harder. I also have an assortment of lasers that i can shine on the sample, and a photodetector that can measure the intensity of reflected and transmitted beams. What kind of measurement do you advise me to do to measure the index of refraction.

If I can measure the angle of incident light to within $\pm$ 2 $^\circ$, how accurately will I be able to measure the index of refraction? Is it worth it to try to make a thicker sample of this material?

How do the uncertainties in my measurement change when I take into account the fact that my material is probably on a microscope slide that is 0.3 mm thick?

Can polarizers help me with this measurement? if so, how?