

Physics 319 - Optics

Lab #4

The Fresnel Equations

(Fall 2016 version)

Procedure:

1. Make a quasi-planer beam along the optical bench by (1) placing an aperture mask over the incandescent source followed by (2) a variable aperture about 20 cm from the aperture mask followed by (3) a 252 mm convex lens about 20 cm after the variable aperture. A single polarizer should be attached to the same carrier as the lens to allow you to make light that is polarized either parallel or perpendicular to the plane of incidence. A glass prism is mounted on the rotating table with its longest face along the mid line of the rotating table. The photometer probe is mounted in the table arm. Now you are ready to make measurements to verify (hopefully) reflection amplitude equations

$$r_{\perp} = \frac{n_i \cos \theta_i - n_t \cos \theta_t}{n_i \cos \theta_i + n_t \cos \theta_t} = -\frac{\sin(\theta_i - \theta_t)}{\sin(\theta_i + \theta_t)}$$

and

$$r_{\parallel} = \frac{n_t \cos \theta_i - n_i \cos \theta_t}{n_t \cos \theta_i + n_i \cos \theta_t} = \frac{\tan(\theta_i - \theta_t)}{\tan(\theta_i + \theta_t)}$$

Before recording any numbers, place the white screen on the table arm (in front of the photometer probe) and scan through as great a range of reflection angles as possible for both polarizations (parallel and perpendicular to the plane of incidence) to see roughly what the reflected beam looks like. You should find and record the polarizing angle by noting the extinction angle for the horizontal polarization.

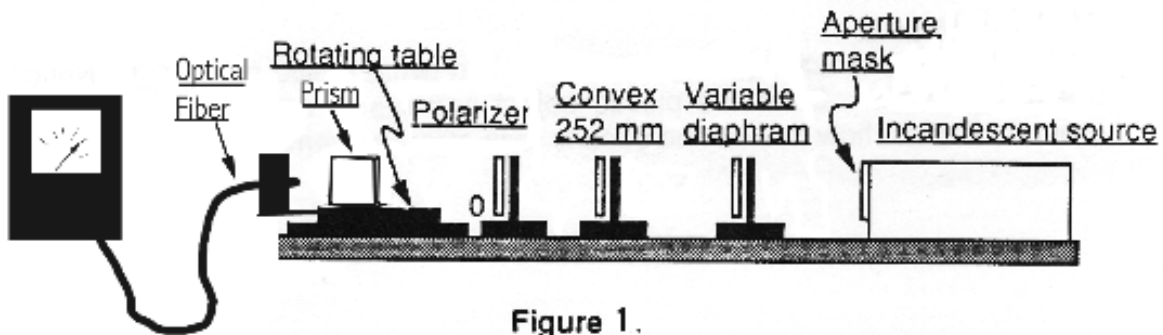


Figure 1.

2. Now try to be quantitative. For both polarizations, record the reflected intensity for at least 8 different angles of incidence. For both polarizations, measure the incident intensity on the glass plate. Plot a graph similar to figures below in Hecht.

Remember that intensity is proportional to the square of the electric vector and that the Fresnel equations give ratios of the reflected electric vector to the electric vector. A few things to be careful about experimentally: (i) be sure to re-zero the photometer when you change scales and (ii) be sure that no "funny" things are happening to your "beam" and the edge of the glass plate. You can investigate where your beam is by using a small piece of white paper to follow the beam in its travels.

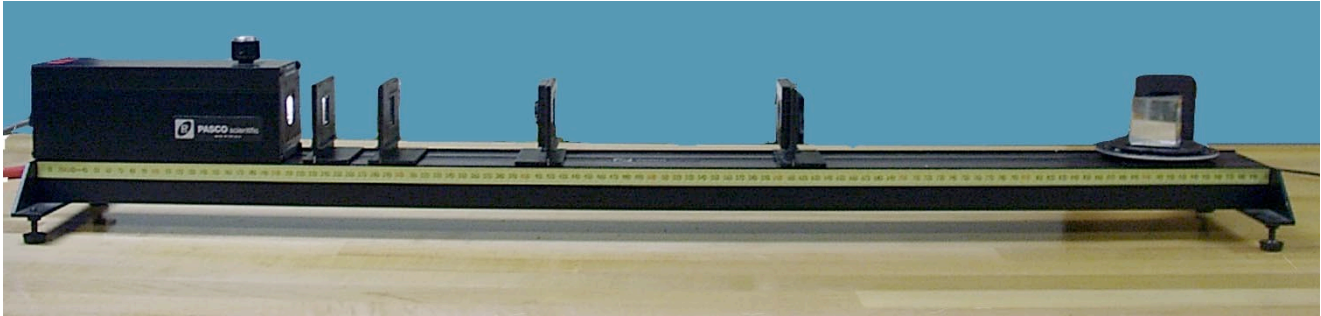


Figure 2

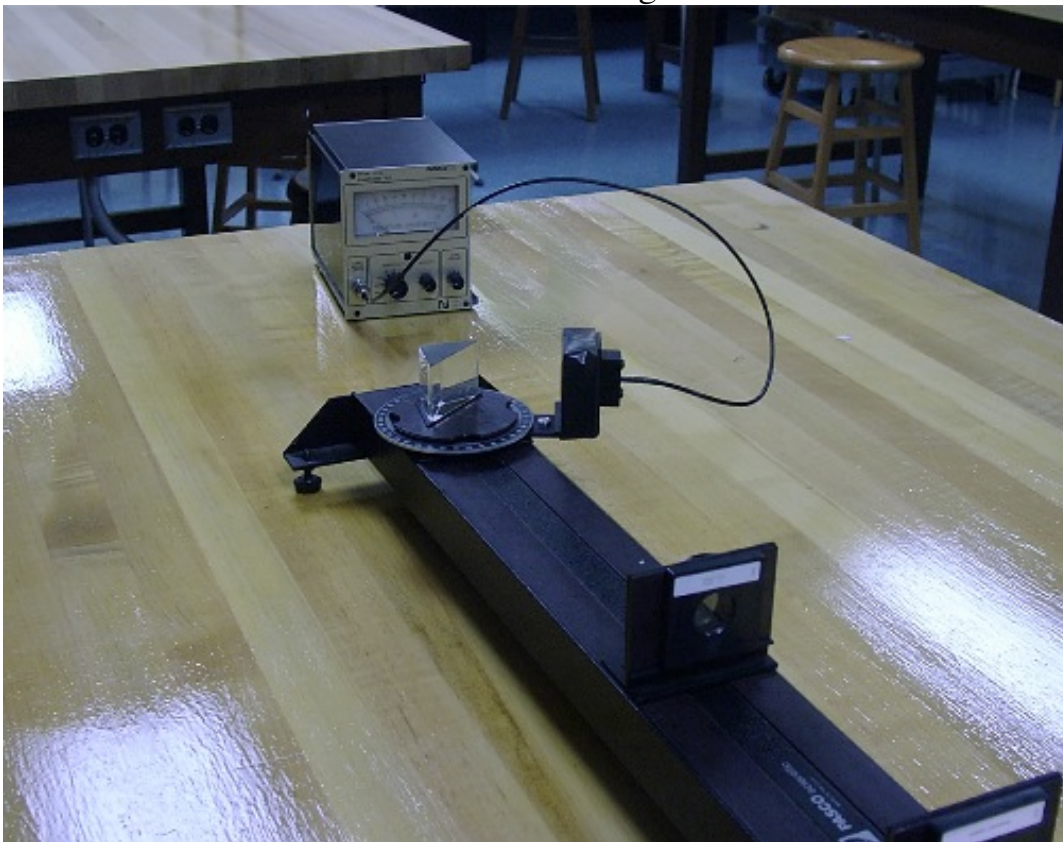


Figure 3

3. Some qualitative investigations of the Fresnel equations can be done with a glass slide. Set a slide on an open page of a book with text beneath it. Starting from normal incidence, rotate book and slide relative to your eye, thereby increasing the angle of incidence, and observe. Repeat leaving your book and eye stationary while changing the angle the slide makes to the page.

4. Look at the whiteness of the page with and without a slide tying on it; repeat with increasing numbers of slides stacked on top of each other. Now try to be quantitative, using a photometer setup similar to that used above, only looking at the intensity of the transmitted light at normal incidence as the number of slides is increased. According to the Fresnel equations, how much should the intensity decrease with the addition of each slide? See question 2 and construct the table.

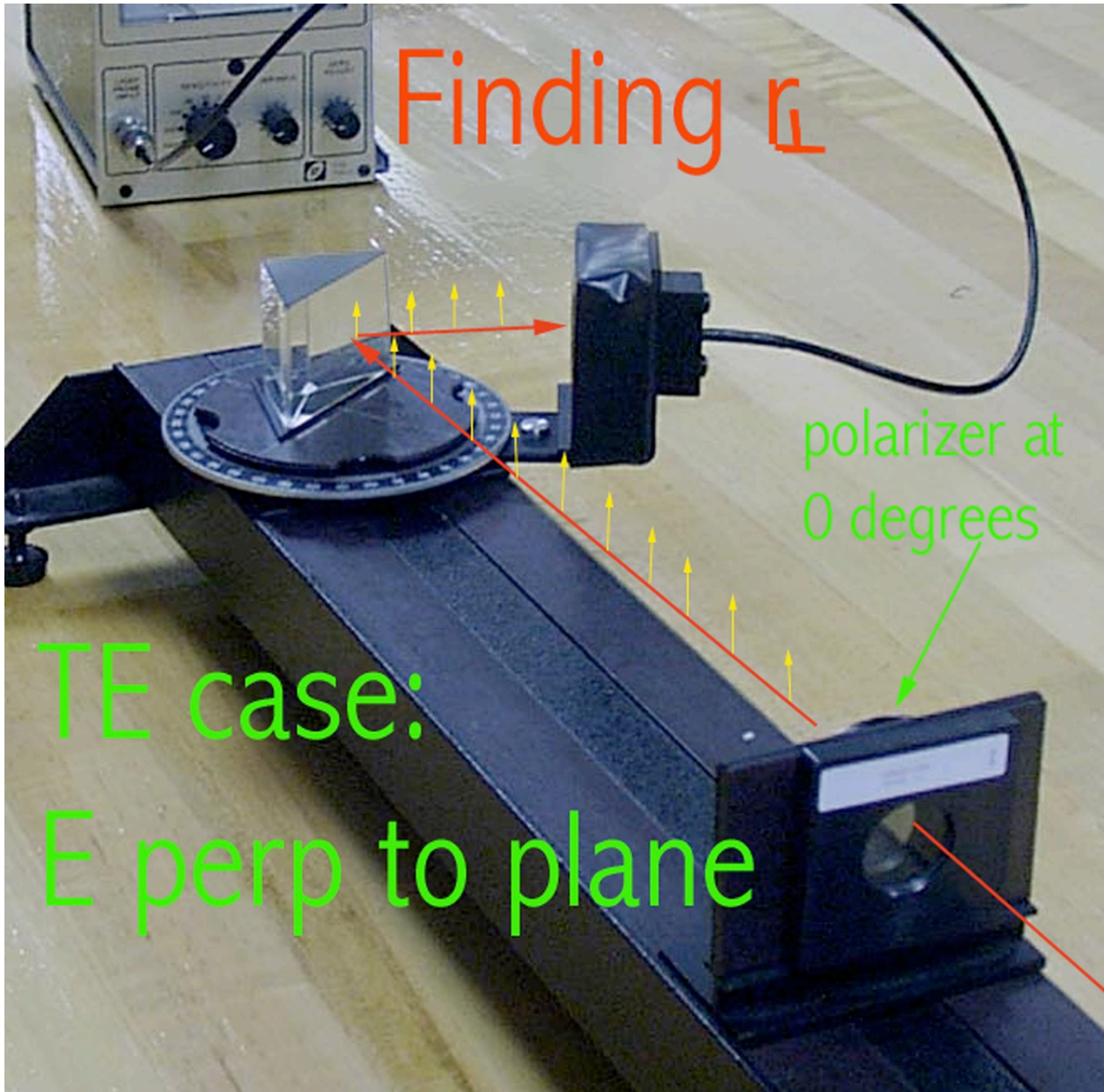


Figure 4

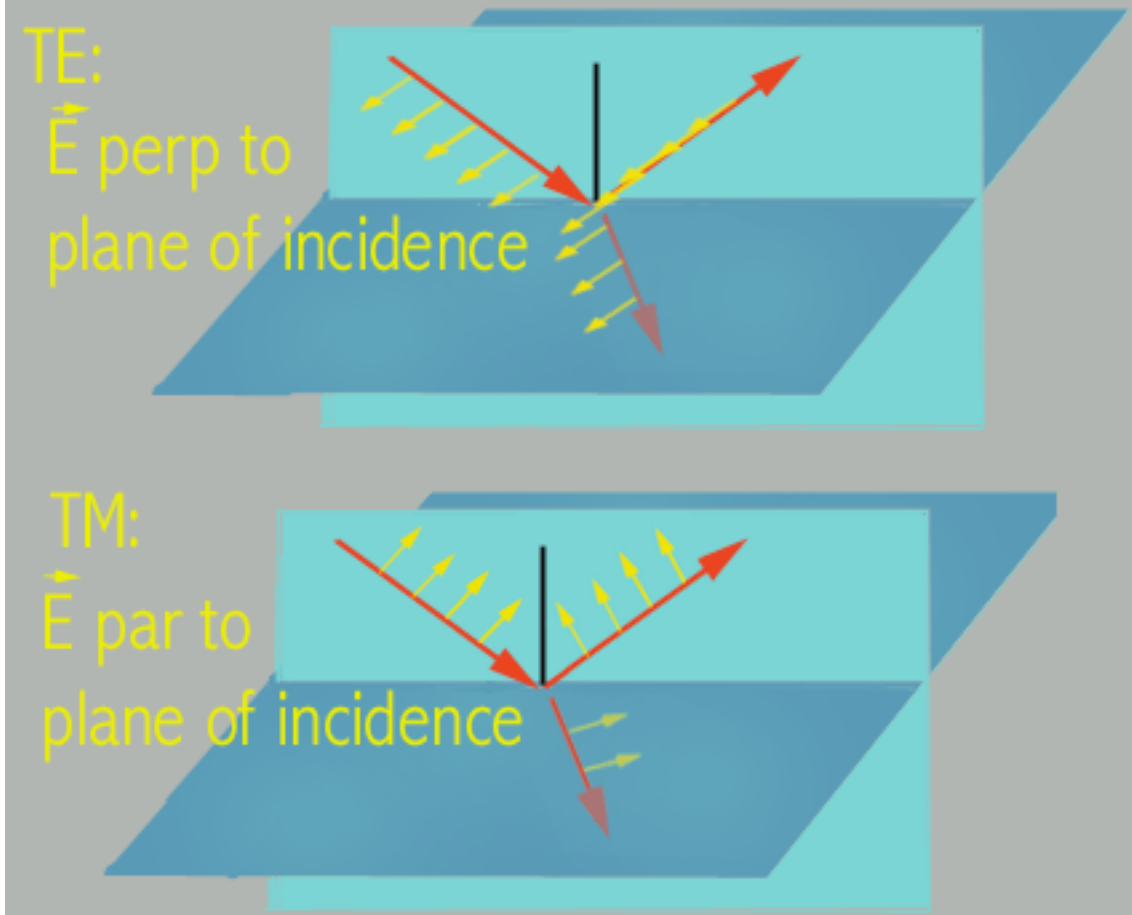


Figure 5

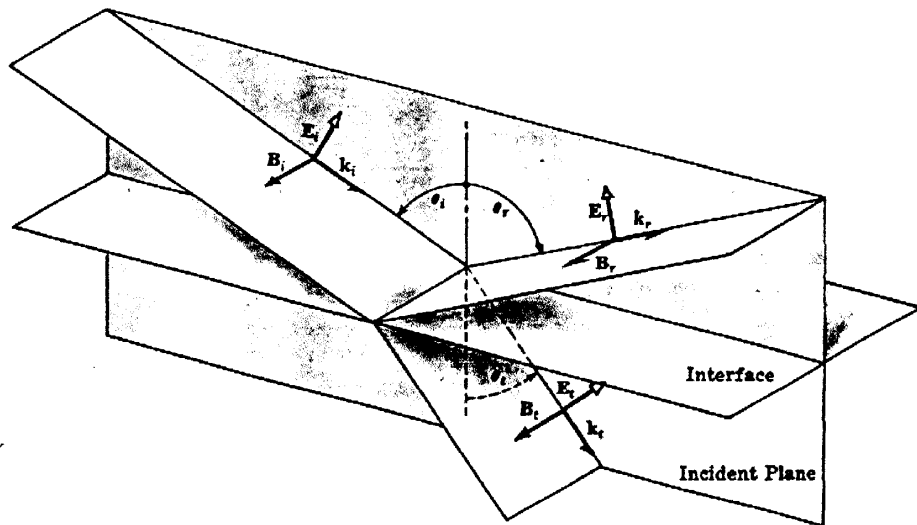
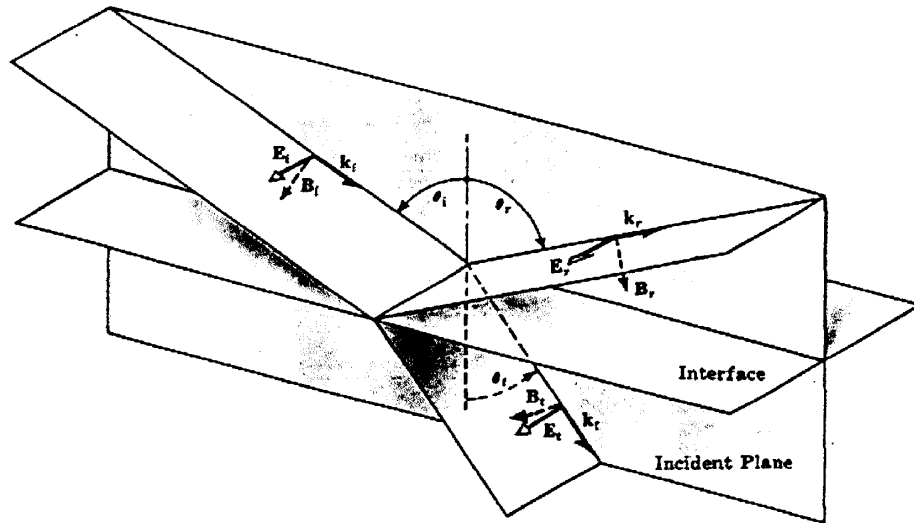
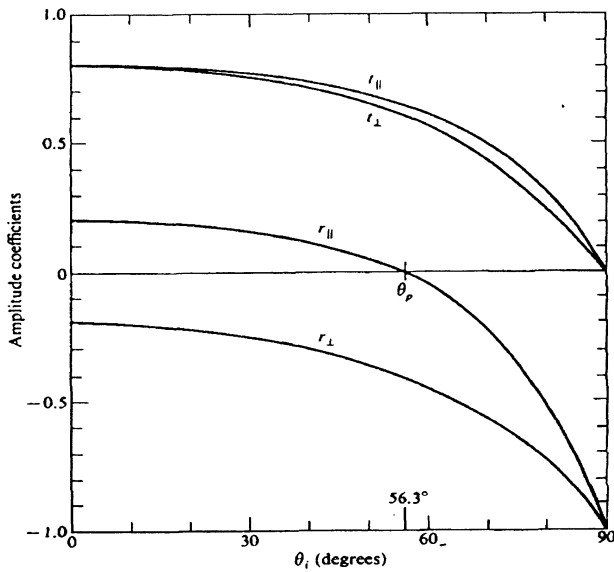


Figure 6



Questions

1) Using measurements of the distances from aperture mask to; variable diaphragm, lens and the end of the fiber optic cable respectively, construct a ray diagram to show how ‘quasi-planar’ your beam in part 1 (see Figure 1) actually was. Draw distances to scale (1/3 scale should work). It is recommended that you use an arrow (approximately one cm to represent half of light coming from aperture.)

2) Construct the following table for part (step) 4 of lab. See question 4.72 of Hecht 4th Edition

n=number of slides	Measured Relative Intensity I_n	Fraction transmitted I_n/I_0	Calculated intensity from $T_t = (1 - R)^{2N}$ Use R=0.04
0			
1			
2			
...			
10			

Discuss your results.

3) Define Brewster’s angle. What is the value of Brewster’s angle obtained using the plotted data from lab?

4) Discuss the result you obtained from part 3 of this experiment.