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University of Oregon; Winter 2008

# Physics 352: Problem Set 5

**Due date:** Wednesday, Feb. 13, **5pm**. (Turn in to the assignment to the box outside my door.)
**Reading:** Optics Notes Chapter 5.

**(1,** 10 pts.**) A Fresnel Relation.**

*A very brief statement of the problem:* **Derive Equation (1), below – the Fresnel reflection coefficient,** $r_{//}$, for light polarized parallel to the plane of incidence, considering the interface between typical nonmagnetic materials:

[*Equation 1*] $$r_{//} = \left(\frac{E_{0r}}{E_{0i}}\right)_{//} = \frac{n_t \cos\theta_i - n_i \cos\theta_t}{n_i \cos\theta_t + n_t \cos\theta_i}$$

*A more verbose statement.* We're interested in knowing *how much* light is reflected or transmitted at a boundary – i.e. what are the *amplitudes* of the reflected and transmitted waves. Consider light in a medium of index of refraction $n_i$ incident at angle $\theta_i$ with respect to the normal of the interface of a medium of index of refraction $n_t$. From Snell's Law we know the angle $\theta_t$ that the transmitted wave makes with respect to the normal. In class and **in the notes** we state the boundary conditions that the electric and magnetic fields must satisfy at the interface – conditions whose consequences depend on the geometry of the electric field vectors and the "plane of incidence." In the notes, I write the detailed derivation of the reflection coefficient – the ratio of the reflected wave amplitude to the incident wave amplitude – for the case of light polarized *perpendicular* to the plane of incidence. For typical nonmagnetic materials, for which the permeability is approximately equal to $\mu_0$, the permeability of free space, I showed that $r_\perp = \left(\frac{E_{0r}}{E_{0i}}\right)_\perp = \frac{n_i \cos\theta_i - n_t \cos\theta_t}{n_i \cos\theta_i + n_t \cos\theta_t}$. **Read and study this derivation well.** (One of the goals of this exercise is to help you realize that you're clever and knowledgeable enough to do this!) Your task is to do the analogous derivation for the "parallel" case, deriving Equation 1 above. Start by examining and re-drawing Fig. 5.3 of the Notes.

**(2,** 2 pts.**) Air / glass interface.** Consider light incident from air $n_i = 1$ onto glass $n_t = 1.5$.

**(a,** 1 pt.**)** Plot $r_{//}$ and $r_\perp$ as a function of angle for $\theta_i$ = 0 to 90 degrees. (You can plot this using a computer. If you do not have access to a computer, do it "by hand" in 10 degree increments.)

**(b,** 1 pt.**)** Looking at your plot, what is the Brewster Angle for this interface? (You don't have to mathematically calculate the value of the Brewster Angle, though you may wish to compare your graphical answer with the relation $\tan\theta_p = n_t / n_i$.)