University of Calgary
Winter semester 2008

PHYS 471: Optics

Homework assignment 2

Due Wednesday, February 13, 2008

Problem 2.1. Suppose the boundary condition $E_{\|,\text{above}} = E_{\|,\text{below}}$ for the electric field had the form $D_{\|,\text{above}} = D_{\|,\text{below}}$. How would Snell's law change?

Problem 2.2. In class, we checked that Fresnel's equations are consistent with the energy conservation law when the wave propagates in the direction perpendicular to the interface. Verify that the energy is conserved for an arbitrary incidence angle θ_i. Consider the cases when the electric field and the magnetic field are perpendicular to the incidence plane separately. **Hint:** the Poynting vector gives the flow of energy through the plane orthogonal to the k-vector. You have to make a correction if you wish to calculate the energy flow through a unit area of the refracting interface.

Problem 2.3. Calculate the reflection coefficient for the intensity of a wave polarized at 45° to the plane of incidence. How will the wave's polarization change after the reflection? The indices of refraction are n_1 and n_2, the angle of incidence θ_i. **Hint:** the intensity is calculated as the sum of intensities (not amplitudes) of the TE- and TM- components.

Problem 2.4. An experimentalist shines a laser through a corner of a glass cuvette containing water (Fig. 1). At which angles α will no light come out of the cuvette? Consider the cases when the index of refraction of glass is (a) 1.33 (same as water); (b) 1.50; (c) 1.20.

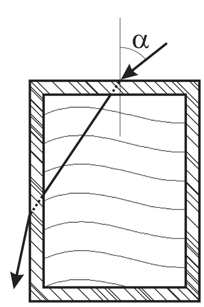

Figure 1: diagram for Problem 2.4.

Problem 2.5. You are looking at an object through a 5-mm glass window, your line of sight at a 45° angle to the window plane. How is the image displaced with respect to the actual location of the object?

Problem 2.6. The passenger side rear view mirror of a car has a sign "Objects in the mirror are closer than they appear". Can we conclude if the mirror is convex or concave? If an object located 100 m away appears 125 m away, what is the radius of the mirror?

Problem 2.7. For each of the following systems, make a drawing of the rays that generate the image (do use a pencil and a ruler), characterize the image, determine its distance from the surface of the optical instrument and the magnification.

a) Concave spherical mirror of radius 8 cm, the object 2 cm away from the surface;

b) Concave spherical mirror of radius 12 cm, the object 15 cm away from the surface;

c) Convex spherical mirror of radius 10 cm, the object 5 cm away from the surface;

d) Convex spherical lens of focal length 6 cm, the object 3 cm away from the surface;

e) Convex spherical lens of focal length 5 cm, the object 12 cm away from the surface;

f) Concave spherical lens of focal length 10 cm, the object 5 cm away from the surface.

Problem 2.8. Propose a design (i.e. optical material and curvature radii) for the lenses in Problems 2.7(e) and 2.7(f).

Problem 2.9 [Hecht 5.11]. Prove that for a thin lens immersed in a medium of index n_m,

$$\frac{1}{f} = \frac{n_l - n_m}{n_m} \left(\frac{1}{R_1} - \frac{1}{R_2} \right), \qquad (1)$$

where n_l is the index of refraction of glass.