University of Calgary
Winter semester 2007

PHYS 471: Optics

Homework assignment 3

Due February 26, 2007

Problem 3.1. Find the apex angle of a triangular flint glass prism such that a ray of wavelength 656.3 nm propagates through the prism in the minimum deviation configuration without losses. What polarization does the ray need to have? Find the intensity transmission coefficient for the orthogonal polarization. Do not make any significant approximations.

Problem 3.2. Re-derive the Fresnel equations for an interface of media with non-unitary dielectric (ϵ) and magnetic (μ) constants. **Hint:** it is more convenient to express the answer in terms of ϵ and μ than in terms of n.

Problem 3.3. A laser beam enters a left side of a prism at a right angle to the surface, experiences total internal reflection at the bottom and exits through the right side (Fig. 1). Find the attenuation rate of the evanescent wave below the bottom surface if the refraction index of the prism material is (a) 1.52 and (b) 1.43. Why are the answers so different?

Problem 3.4. Refer to the configuration of the previous problem. The index of refraction is 1.52.

a) The input ray is unpolarized. What is the degree of polarization of the output ray?

b) What is the Jones matrix that maps the input polarization pattern onto the output?

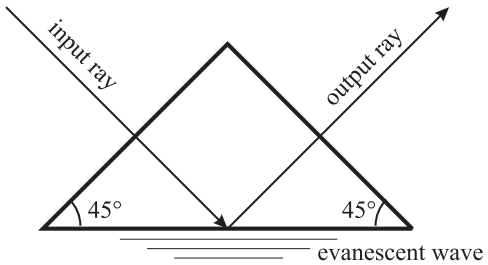

Figure 1: diagram for Problems 3.3, 3.4.

Problem 3.5. The indices of refraction for the fast and slow axes of quartz with 546 nm light are 1.5462 and 1.5553, respectively.

a) By what fraction of a wavelength is the extraordinary ray retarded, relative to the ordinary ray, for every wavelength of travel in the quartz?

b) What is the thickness of the zeroth-order quarter-wave plate?

c) If a quartz plate 0.735 mm thick functions as a multiple-order quarter-wave plate, what is its order?

d) Two quartz plates are optically contacted so they produce opposing retardations. Sketch the orientation of the optical axes of the two plates. What should their difference in thickness be such that they function together as a zeroth-order half-wave plate?

Note: this is (almost) Problem 15-19 from the textbook.

Problem 3.6.

a) Find the Jones vector associated with the elliptical polarization pattern shown in Fig. 2. The ratio of the ellipse's major to minor axes equals 3.

b) Find a unitary 2×2 Jones matrix that would map the horizontal polarization pattern onto that found in part (a).

c) Propose an arrangement of a half-wave plate and a quarter-wave plate that will implement this operation.

Note: you can use a computer and solve the problem numerically, but in your solution please explain exactly what you did.

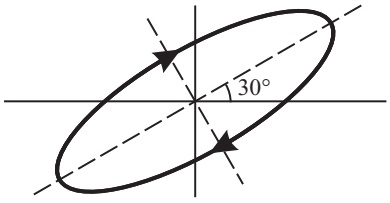

Figure 2: diagram for Problem 3.6. Trajectory of the tip of the electric field vector as viewed "head-on".

The midterm examination will take place on Wednesday, February 28