Universität Leipzig, Fakultät für Physik und Geowissenschaften

Exercises for Experimental Physics 3 – IPSP

Prof. Dr. J. Käs, Dr. M. Zink

Exercise Sheet 8 (WS 2010/11)

Date of Issue to Students: Dec. 2^{nd} 2010

Date of Submission: Dec. 9^{th} 2010

Submission Place: Marked mailbox next to room 302 (Linnestr. 5)
Submission Time: 11:00 a.m. at the submission day noted above

Please note: Write your name and matriculation number on EACH sheet of paper.
Only submit the calculations and results for exercise 1-3, exercise 4 will be discussed during the instruction classes.

Exercises:

1. A beam of light in air strikes a glass slab at normal incidence. The glass slab has an index of refraction of 1.50. (a) Approximately what percentage of the incident light intensity is transmitted through the slab (in one side and out the other)? (5 Points)

2. An optical fiber allows rays of light to propagate long distances by using total internal reflection. Optical fibers are used extensively in medicine and in digital communications. As shown in Figure 1 the fiber consists of a core material that has an index of refraction n_2 and radius b surrounded by a cladding material that has an index of refraction $n_3 < n_2$. The numerical aperture of the fiber is defined as $\sin\theta_1$, where θ_1 is the angle of incidence of a ray of light that impinges on the center of the end of the fiber and then reflects off the core–cladding interface just at the critical angle. Using the figure as a guide, show that the numerical aperture is given by $\sin\theta_1 = \sqrt{n_2^2 - n_3^2}$ assuming the ray is initially in air. (5 Points)

3. A laser beam is incident on a plate of glass that is 3.0-cm thick (Figure 2). The glass has an index of refraction of 1.5 and the angle of incidence is 40°. The top and bottom surfaces of the glass are parallel. What is the distance b between the beam formed by reflection off the top surface of the glass and the beam reflected off the bottom surface of the glass? (5 Points)

4. (a) Show that for normally incident light, the intensity transmitted through a glass slab that has an index of refraction of n and is surrounded by air is approximately given by $I_T = I_0\left[\frac{4n}{(n+1)^2}\right]^2$.
(b) Use the Part (a) result to find the ratio of the transmitted intensity to the incident intensity through N parallel slabs of glass for light of normal incidence.
(c) How many slabs of a glass that has an index of refraction of 1.5 are required to reduce the intensity to 10 percent of the incident intensity?

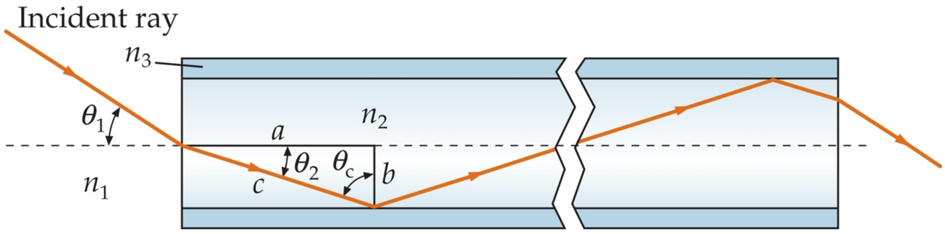

Figure 1: Exercise 2

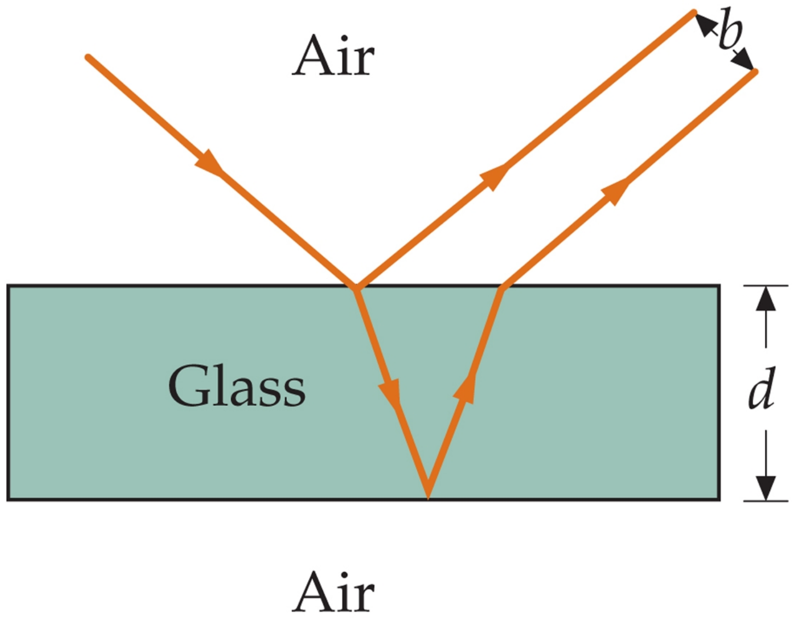

Figure 2: Exercise 3