University of Calgary
Winter semester 2008

PHYS 471: Optics

Homework assignment 1

Due January 28, 2008

Problem 1.1 [Griffiths 9.2]. Show that the *standing wave* $\vec{E} = \vec{E}_0 \sin(kz)\cos(\omega t)$ satisfies the wave equation, and express it as a sum of two travelling waves.

Problem 1.2. Write the expression for the electric field $\vec{E}(x, y, z, t)$ at each point in space and time for a plane electromagnetic wave propagating in the direction given by the vector $(1, 1, 1)$ and polarized in the (x, y) plane. Find numerical values for all symbolic constants used in your expression. The wavelength is $\lambda = 632$ nm and the intensity $I = 1300$ W/m^2.

Problem 1.3. Find the force exerted by the of sunlight upon a black horizontal plate with an area of 0.01 m^2. What if the plate is at 45° to horizontal? What if it is a mirror oriented at 45° to horizontal? What is the direction of the force in each case? The sun is at its zenith and the intensity $I = 1300$ W/m^2. Assume that the light is yellow with a wavelength of $\lambda = 590$ nm.

Problem 1.4. Two of the Maxwell equations (without free charges) are

$$\vec{\nabla} \times \vec{E} = -\dot{\vec{B}}; \tag{1}$$

$$\vec{\nabla} \times \vec{H} = \dot{\vec{D}}. \tag{2}$$

Would Maxwell equations support a plane wave solution if Eq. (1) did not have a negative sign in the right-hand side? What if Eq. (2) had a negative sign instead of (1)? If your answer is "yes", how would the universal properties of electromagnetic waves change?

Problem 1.5 [Hecht 4.23]. Light is incident in the air on an air-glass interface. If the index of refraction of the glass is 1.70, find the incident angle such that the transmission angle is to equal $\frac{1}{2}\theta_i$.

Problem 1.6. 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 1.7. A laser beam of power P is incident upon a glass plate at angle α. Part of the intensity will be reflected, and the other part will enter the glass (Fig.). After propagating through the glass, partial reflection will occur again, and so on. Find the total power of the light transmitted through the prism after very large number of reflections. The index of refraction is $n = 1.5$.

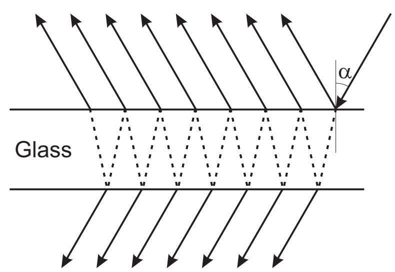

Figure 1: diagram for Problem 1.8.