Guide to Solutions

Chapter 2

(1) Confirm the continuity conditions for E_z, H_x, and H_z at an interface shown in Fig. 2.9.

- Consider the yz plane and replace $x \to z$ and $z \to x$ in Eqs. (2.49)-(2.51), then one can confirm the continuity condition for E_z. The continuity conditions for H_x and H_z are confirmed as in a similar manner to that of E_z after putting $\mathbf{B} \to \mu\mathbf{H}$ in Eq. (2.26).

(2) Confirm the energy conservation expressed in Eq. (2.73) using Eqs. (2.63), (2.64), (2.67), (2.68), and (2.72).

- Using Eqs. (2.63) and (2.64), we can show an example for the s polarization. The energy conservation is confirmed using the following formula:

$$\left(\frac{m_1\cos\theta_1 - m_2\cos\theta_2}{m_1\cos\theta_1 + m_2\cos\theta_2}\right)^2 + \frac{m_2\cos\theta_2}{m_1\cos\theta_1}\left(\frac{2m_1\cos\theta_1}{m_1\cos\theta_1 + m_2\cos\theta_2}\right)^2 = 1.$$

(3) Design a Fresnel rhomb using a material having the refractive index of 1.5.

- Search an incidence angle θ where the relation $2(\phi_p - \phi_s) = 45°$ holds in Fig. 2.11b) and cut the edge faces of the Fresnel rhomb at this angle as shown in Figs. 0.1.a) and b).

(4) Explain the polarization state after a linearly polarized light beam with the 45° inclined polarization direction is reflected by a flat ideal metal plate placed at 45° to the propagation direction.

- Consider a simple case of $\mu = \mu_0$ in Eqs. (2.63) and (2.67). Since we consider an ideal metal, the relation $n_2 = i\kappa_2$ holds naturally. Further, we use the formula, $\cos\theta_2 = \sqrt{1 + (n_1/\kappa_2)^2\sin^2\theta_1}$, in p. 50 and the relation $\cos\theta_1 = 1/\sqrt{2}$. Then, putting $\cos\theta_2/\cos\theta_1 \equiv \delta$, the Fresnel equations are expressed as

$$r_s = \frac{n_1 - i\kappa_2\delta}{n_1 + i\kappa_2\delta},$$
$$r_p = \frac{i\kappa_2 + n_1\delta}{i\kappa_2 - n_1\delta}.$$

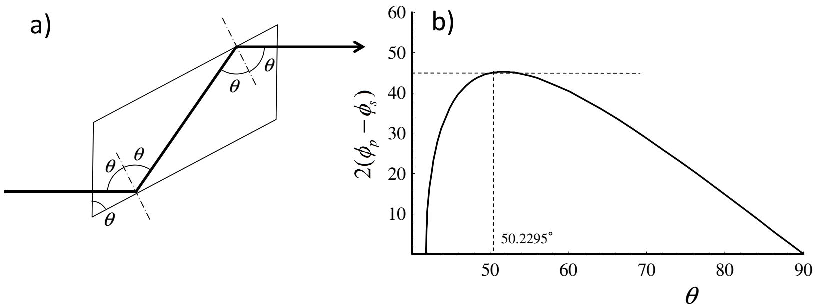

Figure 0.1. a) Fresnel rhomb and b) phase difference in total internal reflection (see Fig. 2.13b).

If we take the propagation direction of the light wave as z, the amplitudes of the x and y components of the reflected light wave are given as

$$E_x = r_p = \mathrm{e}^{\mathrm{i}\phi_p},$$
$$E_y = r_s = \mathrm{e}^{\mathrm{i}\phi_s},$$

where ϕ_p and ϕ_s are defined as $\phi_p = -\kappa_2/(n_1\delta)$ and $\phi_s = -\kappa_2\delta/n_1$, respectively. Since $\phi_p \neq \phi_s$ holds generally, the above equations express the state of elliptical polarization. When the light is incident normally to the surface, δ becomes unity so that the polarization state will not change during the reflection.

(5) Explain how to place a lens to perform the Newton's experiment shown in Fig. 2.22.

- Place a lens of the focal length of f exactly at the middle of the two prisms, where the distance between the prisms is set at $4f$.

(6) Explain the difference between the three primary colors of light and painting from a physiological point of view.

- Three primary colors of light are determined by three types of visual cells in the eyes, corresponding to red, green, and blue (RGB). When light of all these three colors is simultaneously perceived equally in the eyes, we feel the color as white, which is usually called additive color mixing. On the other hand, three primary colors of painting are determined by subtracting one of RGB colors from white by light absorption. For example, when light of red color is absorbed, we feel the color becomes cyan, because only the green and blue types of visual cells are sensed, while green or blue is absorbed, it will be magenta or yellow. Thus, if all these three colors are mixed in the painting, no light reaches the eyes so that we will feel black. This is called subtractive color mixing.

Chapter 3

(1) We have solved the mystery of missing light, when the complete destructive interference occurs in the Michelson's interferometer. The Mach-Zehnder's interferometer directly explains its presence as a light wave propagating in a different direction. Confirm that the total light intensity is actually conserved during the interference experiment.

- As shown in Fig. 0.2. (Fig. 3.4b), in the Mach-Zehnder's interferometer, light is emitted to two directions designated as A and B in the end. Thus, when a light wave with the amplitude of $\tilde{u}_0$ is incident into the interferometer, the outputs of the interferometer should be expressed as

$$\tilde{u}_A = \left(r_{ag}t_{ag}\mathrm{e}^{\mathrm{i}k\Delta x} + t_{ag}r_{ga}\right)\tilde{u}_0,$$
$$\tilde{u}_B = \left(r_{ag}r_{ag}\mathrm{e}^{\mathrm{i}k\Delta x} + t_{ag}t_{ga}\right)\tilde{u}_0.$$

On the other hand, when we consider the net energy, we cannot apply simple Fresnel's equations to r_{ag}, r_{ag}, t_{ag}, and t_{ag}, because the Fresnel's