

Physics 425, Spring 2012

Assignment set #3

Due January 25:

4. Circularly polarized waves: consider a superposition of waves traveling in the z direction:

$$\vec{E}(\vec{r}, t) = \text{Re}\left[E_0 e^{i\phi_1} e^{i(kz - \omega t)} \hat{x} + E_0 e^{i\phi_2} e^{i(kz - \omega t)} \hat{y}\right]$$

- (a) find $\vec{B}(\vec{r}, t)$;
- (b) calculate the average energy flux S_{avg} ;
- (c) suppose $\phi_1 = 0$, $\phi_2 = \pi/2$. Determine the direction of \vec{E} as a function of t , at a point on the xy plane. Describe the results in words and pictures.
- (d) For the same field as in (c), determine the direction of \vec{E} as a function of z at $t = 0$. Describe the results in words and pictures.

[NB: quiz on January 27 about: monochromatic plane waves and all of their properties, and boundary conditions of EM fields.]

Assignment due January 27:

5. A plane monochromatic EM wave of frequency ω polarized in x direction and traveling in z direction meets the boundary between two linear media at $z = 0$ (see Figure 9.13 in the book). A reflected wave and a transmitted wave are generated. The electric field of the incident wave and reflected wave is given in the book Equations 9.75 and 9.76.
- (a) Using Faraday's law, prove that the magnetic field of the incident and reflected waves is as given in these two equations.
- (b) From the boundary condition (Equations 9.74), show that the frequency of the reflected and transmitted waves is the same as the frequency of the incident wave.
- (c) From the boundary condition (Equations 9.74), show that the reflected and transmitted waves have the same polarization as the incident wave. See Griffiths Problem 9.14.

Assignment due January 30:

6. We are going to design a lens that transmits 100% of the light incident on it. This can be achieved by coating the lens with a dielectric film with thickness a and refraction index n_1 that is in between the air (of refraction index n_0) and lens (of refraction index n_2). Suppose that the boundary between the air and the film is at xy plane ($z = 0$), and the boundary between the film and the lens is at the plane $z = a$. A linearly polarized monochromatic plane wave is incident normally from the air at $z = 0$.

(a) write the electric field and magnetic field solutions of all the 5 waves: incident, reflected, and transmitted waves at $z = 0$, and reflected and transmitted waves at $z = a$.

(b) write the boundary conditions at the two interfaces $z = 0$, $z = a$.

(c) for total transmission, the reflected wave at $z = 0$ becomes zero. Use this condition to find the refraction index n_1 as a function of n_0 and n_2 , and the thickness a of the film.