Department of Physics

Electrodynamics and Optics (PHN005)

Tuturial 3 (September 26 , 2018)

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(1) Calculate lateral shift (d) in terms of n_1,n_2, θ_I and L as shown in Fig. 1. Also prove that transmitted wave from slab is parallel to incoming wave.

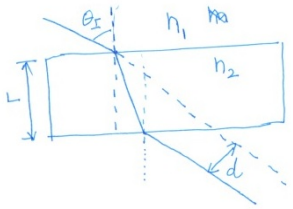

Figure 1: *A ray propagating through a slab of thickness L*

(2) An electromagnetic wave of wavelength λ =5890Å is incident on a surface at an angle θ from the surface normal. Amplitude of the electric field is 1 Vm^{-1}. If 5×10^{14} photons are passing through the unit surface area per unit time. Calculate the angle θ. Mean photon flux density is defined as $\Phi = AI/h\nu$.

(3) Fresnel equation for reflection coefficient of a TM polarized wave is $r = \frac{\alpha-\beta}{\alpha+\beta}$. Prove that $tan(\theta_B) = [\frac{\epsilon_2(\mu_2\epsilon_1-\mu_1\epsilon_2)}{\epsilon_1(\mu_1\epsilon_1-\mu_2\epsilon_2)}]$. θ_B is Brewster's angle.

(4) Prove that reflected and transmitted waves have the same polarization as the incident wave in case of *normal incidence*. (Hint: Let the polarization vectors of the transmitted and reflected waves be $\hat{n_T} = cos\theta_T\hat{j}+sin\theta_T\hat{k}$, $\hat{n_R} = cos\theta_R\hat{j}+sin\theta_R\hat{k}$ and prove from the boundary conditions that $\theta_T = \theta_R = 0$) Griffith 9.13 problem

(5) Skin depth of electromagnetic wave with 100 nm wavelength is 0.6 nm. What is the wavelength of electromagnetic wave which has 0.1 mm skin depth in copper?

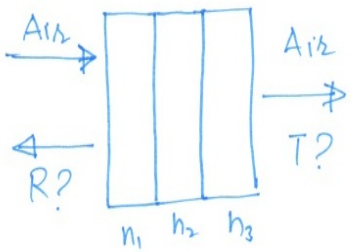

Figure 2

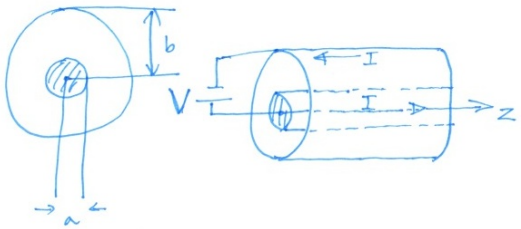

Figure 3

(6) Calculate total reflectivity and transmissivity (R,T) as electromagnetic wave is incident on three slabs having different reflective indexes (n_1=1.52,n_2=1.65,n_3=1.89). See Figure 2

(7) A linearly polarized electromagnetic wave with amplitude of 10 V/m is propagating along a line in the xy plane. Incident angle with respect to x axis is 45°. Plane of polarization is xy plane. k_x and k_y are positive Write the vector expression of electric field.

(8) A coaxial cable has two conductors separated by an insulator (Dielectric constant =ϵ andμ=μ_0) as shown in Figure 3. Radius of a inner conductor coaxial cable is a. Distance between outer and inner conductor is b. Voltage difference between inner conductor and outer conductor is +V. A current I flows inside inner conductor alone +z direction as shown in Figure 3. Same current (I flows in opposite direction in outer conductor. Calculate Poynting Vector inside the region between two conductors. Also calculate power flowing in the cable.

(9) Fresnel equations for parallel polarization: $r_{||} = \frac{n_1 cos\theta_T - n_2 cos\theta_I}{n_1 cos\theta_T + n_2 cos\theta_I}, t_{||} = \frac{2n_1 cos\theta_I}{n_1 cos\theta_T + n_2 cos\theta_I}$. Fresnel equations for perpendicular polarization: $r_\perp = \frac{n_1 cos\theta_I - n_2 cos\theta_T}{n_1 cos\theta_I + n_2 cos\theta_T}, t_\perp = \frac{2n_1 cos\theta_I}{n_1 cos\theta_I + n_2 cos\theta_T}$
An *unpolarized* electromagnetic wave is incident at 45° incident angle on a rectangular block of glass ($n_2 = 1.5$) as shown in Figure 4. Calculate the angles of incident, reflection, refraction at the each face of the glass block and show these angles in the figure. Calculate reflectivity (R) at face 2 for transverse electric as well as transverse magnetic polarization. Calculate transmissivity (T) for wave leaving face 3 with respect to wave incident on face 1. Do it for both polarizations.

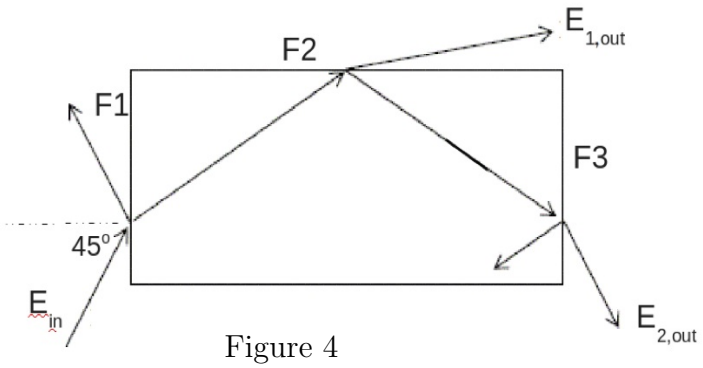

Figure 4

(10) The index of reflection of diamond is 2.42. Calculate the amplitudes of reflected and transmitted electromagnetic wave at normal incidence for air/diamond interface. Calculate Brewster's angle. Calculate angle at which the reflected and transmitted amplitudes are equal. Griffith 9.17