Dept. of EE, IIT Tirupati
EE3001 : Electromagnetic Fields (Aug - Nov 2018)
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Assignment - 2

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1. A uniform plane wave in a lossy medium has a phase constant of 1.6 rad/m at 10^7 Hz and its magnitude is reduced by 60% for every 2 m travelled. Find the skin depth and the speed of the wave.

2. A copper wire has $\sigma = 5.6 \times 10^7$ S/m, $\mu_r = 1$ and $\epsilon_r = 1$.

   (a) Determine the dc resistance of a round copper wire of radius 1.2 mm and length 600 m.

   (b) Find the ac resistance at 100 MHz.

   (c) Calculate the approximate frequency where dc resistance becomes 1/10 th of the ac resistance.

3. Find the relaxation time for the following materials:

   (a) mica; conductivity 10^{-15} S/m, $\epsilon_r = 6$

   (b) hard rubber; conductivity 10^{-15} S/m, $\epsilon_r = 3.1$

   (c) distilled water; conductivity 10^{-4} S/m, $\epsilon_r = 80$

4. If $\nabla.\mathbf{D} = \epsilon\nabla.\mathbf{E}$ and $\nabla.\mathbf{J} = \sigma\nabla.\mathbf{E}$ in a given material, the material is said to be:

   (a) linear

   (b) homogeneous

   (c) isotropic

   (d) linear and homogeneous

   (e) linear and isotropic

   (f) isotropic and homogeneous

5. The normal components of $\mathbf{D}$ are

   (a) continuous across a dielectric boundary

   (b) discontinuous across a dielectric boundary

   (c) zero

   (d) infinite

6. A composite conductor 10 m long consists of an inner core of steel of radius 1.5 cm and outer sheath of copper whose thickness is 0.5 cm.

   (a) Determine the resistance of the conductor.

   (b) If the total current in the conductor is 60 A, what amount of current flows in each metal.

   (c) Find the resistance of a solid copper conductor of the same length and cross-sectional areas as the sheath. ($\rho_{copper} = 1.77 \times 10^{-8}\Omega.m$; $\rho_{steel} = 11.8 \times 10^{-8}\Omega.m$).

7. A uniform plane wave in air is normally incident on infinitely thick slab. If the refractive index of the glass slab is 1.5, then the percentage of incident power that is reflected from the air-glass interface is

   (a) 0%

   (b) 4%

   (c) 20%

   (d) 100%

8. For a normal incidence upon the dielectric-dielectric interface for which $\mu_1 = \mu_2 = \mu_0$, we define R and T as the reflection and transmission coefficients for average powers, i.e, $P_{r,avg} = RP_{i,avg}$ and $P_{t,avg} = TP_{i,avg}$. Prove that $R = (\frac{n_1 - n_2}{n_1 + n_2})^2$ and $T = (\frac{4n_1 n_2}{n_1 + n_2})^2$ where n_1 and n_2 are the refractive indices of the medium.

9. Three different dielectrics of permittivities $4\epsilon_0$, $9\epsilon_0$ and $3\epsilon_0$ are defined in the space in Figure 1. If the leading edge of a uniform plane wave propagating in $\mathbf{a}_x$ direction is incident on the plane x = -6 m, then how much time (in μs) it will take to strike the interface defined by the dielectric 2 and dielectric 3 ?

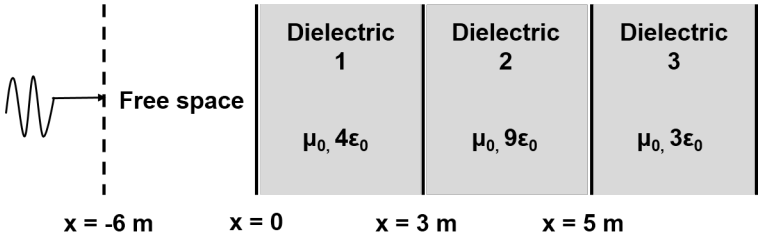

Figure 1:

10. An electromagnetic wave propagating in medium 1 (μ_0, ϵ_1) is incident on medium 2 (μ_0, ϵ_2) as shown in Figure 2 such that the electric field of the reflected wave is 1/5 times of the electric field of incident wave. Find the value of ϵ_1/ϵ_2.

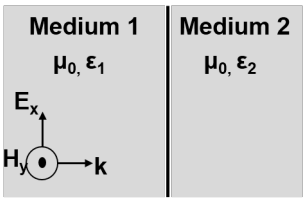

Figure 2:

11. A plane wave in free space with $\vec{E} = 3.6\ cos(\omega t - 5x)\hat{a_y}\ V/m$ is incident normally on an interface at $x = 0$. If a loss-less medium with $\sigma = 0$, $\epsilon_r = 12.5$ exists for $x \geq 0$ and the reflected wave has $\vec{H_r} = 12.5cos(\omega t + 3x)\hat{a_z}\ A/m$. Find μ_2.

12. Consider the setup shown in Figure 3 where a laser light of wavelength λ_0 is incident from medium-0 having refractive index of n_0. If $n_1 = \sqrt{n_0 n_2}$ and the length of medium-1 is given by $L_{n1} = \frac{\lambda_0}{4n_2}$, then show that the light will be transmitted without any reflection. ($n_0, n_1$and n_2 are the refractive indices of medium 1, 2 and 3 respectively). Also mention the phenomena that is responsible for this complete transmission.

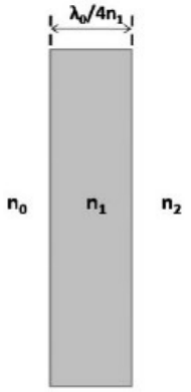

Figure 3: