

國立交通大學九十一學年度碩士班入學考試試題

科目名稱：電磁學(272)

考試日期：91 年 4 月 21 日 第 3 節

系所班別：電子物理學系 組別：甲組

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*作答前, 請先核對試題、答案卷(試卷)與准考證上之所組別與考試科目是否相符!!

$$(\mu_0 = 4\pi \times 10^{-7} \text{ H/m}, \epsilon_0 = 8.854 \times 10^{-12} \text{ F/m})$$

1. The bound volume charge density ρ_{ob} presents the equivalent free charge density for bound dipole charges in an ideal dielectric material such that we can treat the associated electrical problems as it in the free space. For such a dielectric, if free charges were also embedded in the dielectric with concentration of ρ_v (in addition to the bound charges), show from the Maxwell equations for electric field in free space that the equation $\nabla \cdot \vec{D} = \rho_v$ is valid for dielectric material, i.e., the electric flux density is determined entirely by the free charge density ρ_v in dielectric, not directly related to its bound charge density. (hint: $\rho_{ob} = -\nabla \cdot \vec{P}$ where $\vec{P}$ is the polarization vector. (15%)
2. In a free space, a uniform distributed, positive spherical charge Q of radius a is placed at the center of a spherical dielectric shell of inner radius b and outer radius c . The dielectric constants are ϵ_1 and ϵ_2 ($\epsilon_1 > \epsilon_2$) for central sphere and shell, respectively. Determine (a) the electric field $\vec{E}$ (b) electric flux density $\vec{D}$ (c) potential V and (d) polarization vector $\vec{P}$ in the region $0 < r < \infty$. (e) Draw carefully the intensities of electric field, electric flux density with distance r with special attention on their values at the interfaces. (20%)

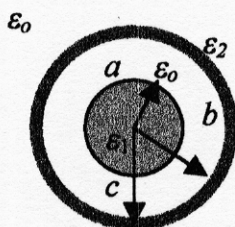


Fig. 2

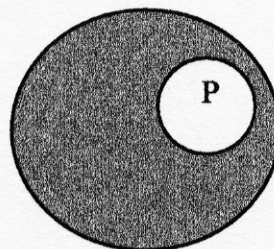


Fig.3

3. A long cylindrical conductor of radius b carrying a uniform current I in the z direction has a cylindrical hole of radius a along its entire length, as shown in Fig. 3. The center of this hole is offset from the center of the conductor by a distance d . Find the magnetic flux $\vec{B}$ at any point P inside the hole. (15%)
4. A solid cylindrical conductor of radius a carries a steady current I distributed uniformly over the cross section. The expression for electrical potential is $V = \frac{1}{4\pi\epsilon} \int \frac{dq}{r}$, (a) what is that for magnetic vector potential $\vec{A}$ as a function of

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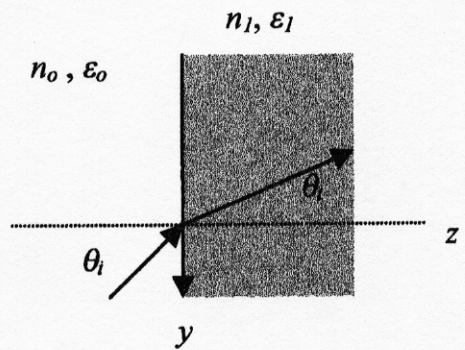
第 2 頁, 共 2 頁

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current for a conducting wire. Using this formula to find (b) the vector potential $\vec{A}$ for $r > a$ and $r < a$, respectively, and (c) the corresponding magnetic flux $\vec{B}$ directly from the vector potential $\vec{A}$. (15%)

5. A linearly polarized plane wave from the vacuum strikes on a xy -plane interface of lossless dielectric ϵ_1 (refractive index n_1) at an incident angle θ_i . (a) If the incident electric field is $\vec{E}(x, y, z, t) = \hat{a}_x E_o \exp(-j\vec{k}_o \cdot \vec{r}) \cdot \exp(j\omega t)$, and the complex reflection coefficient, transmission coefficient, refracted angle and vacuum wave number are given as $\hat{\rho}$, $\hat{\tau}$, θ_t and k_o , respectively. Using these parameters to write down reflected and transmitted electric fields $\vec{E}_r$, $\vec{E}_t$.
- (b) Find the incident magnetic field $\vec{H}_i$, reflected magnetic field $\vec{H}_r$, and transmitted magnetic field $\vec{H}_t$ with additional parameters of coordinate unit vectors $\hat{a}_x, \hat{a}_y, \hat{a}_z$ and the intrinsic impedances η_o and η_1 .

$$(\eta = \sqrt{\frac{\mu}{\epsilon}}, n_1 = \sqrt{\frac{\epsilon_1}{\epsilon_o}}) (15\%)$$



6. Since tangential field is continuous in source-free interface, using electric field boundary condition at interface and the field expression in problem 5 to prove the Snell's law (refraction law) and reflection law. (20%)