國立成功大學

113學年度碩士班招生考試試題

編　號：43

系　所：光電科學與工程學系

科　目：電磁學

日　期：0202

節　次：第 2 節

備　註：不可使用計算機

編號： 43

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※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (20%)

(a) Write down the (i) Coulomb's law and (ii) Faraday's law of Maxwell equations

(b) Write down (i) Divergence theorem (ii) Stoke's theorem

(c) use (a) and (b) to find the boundary conditions for (i) electric field E parallel and (ii) E perpendicular components in a dielectric interface with dielectric constant of ε_1 and ε_2 on each side.

(d) Find the results of (i) $\nabla\times(\nabla V)$ (ii) $\nabla\cdot(\nabla\times\bar{A})$ (iii) $\nabla\times(\nabla\times\bar{E})$

2. (20%)

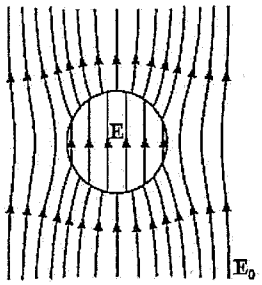
A sphere with homogeneous linear **dielectric** material $\varepsilon_r = 1+\chi_e$ and radius R is placed in a uniform electric field $\bar{E} = E_0\hat{z}$ as shown below.

(a) Use separation of variables, express the potential (i) V_{in} inside ($r<R$) and (ii) V_{out} outside ($r>R$) the sphere by using the Legendre polynomial $P_l(\cos\theta)$

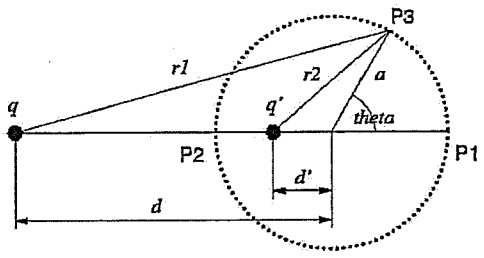
(b) what are the boundary conditions for (i) potential V at $r=R$ (ii) $\frac{\partial V}{\partial r}$ at $r=R$ (iii) V at $r\to\infty$

(c) Find the potential (i) V_{in} inside ($r<R$) and (ii) V_{out} outside ($r>R$)

(d) Find the electric field (i) E_{in} inside ($r<R$) and (ii) E_{out} outside ($r>R$)



For problem 2



For problem 3

3. (10%)

A point charge ***q*** is at a distance ***d*** from the center of a **grounded** conducting sphere of radius ***a*** as shown above. Use image charge method for ***q'*** located inside the sphere at a distance ***d'*** from the center of the sphere such that the potential on the conducting sphere is *0*.

(a) Find ***q'*** and ***d'*** by satisfying $V=0$ at P1 and P2.

(b) Find $V(r,\theta)$ outside the sphere and prove that $V=0$ at arbitrary point on the sphere such as P3

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4. (5%) Please specify the boundary conditions for the magnetic field at the interface between free space (medium 1) and a magnetic material with infinite permeability (medium 2).

5. (15%) Given the electric field intensity of a spherical wave in free space as:

$\vec{E}(r,t) = \hat{a}_\theta \frac{R_0}{r} \sin\theta\cos(\omega t - kr)$, please determine the magnetic field intensity H and the value of k.

6. (10%) (a) A plane electromagnetic wave is propagating within a good conductor along the z-axis. Please calculate the total power loss per square meter due to Joule heating within the region from $z = 0$ to $z \to \infty$.
(b) Please verify that the total power loss per square meter is equivalent to the Poynting vector at $z = 0$.

7. (10%) Please demonstrate that the instantaneous Poynting vector of a circularly-polarized plane wave propagating in a lossless medium remains constant and is independent of both time and distance.

8. (10%) In ionized gases, commonly referred to as plasma, let N represent the electron density. Please demonstrate that the equivalent permittivity of the plasma (ε) can be expressed as $\varepsilon = \varepsilon_0(1 - \frac{\omega_p^2}{\omega^2})$, where $\omega_p = \sqrt{\frac{Ne^2}{m\varepsilon_0}}$ denotes the plasma frequency. Here, ω represents the angular frequency of electromagnetic waves, m signifies the electron mass, and e denotes the electron charge.